14th anniversary

a marketing point of view

I am grateful for the chance to say hello to the research and engineer[illegible]ing community of RCA in this fashion. I have admired [illegible] the articles and the production values of the *Engineer* since [illegible] exposed to it shortly after coming here in January of last [illegible]

Of course, I probably see the *Engineer* in a slightly different [illegible] most of you. To me, such articles from the present issue [illegible] RCA color TV tape recorders, reflective liquid crystal [illegible] channel data-communications controllers, and [illegible] printing industry alert my marketing rather than my technical [illegible] Are the items discussed new, unique, more economical, [illegible] tive, more versatile? Do they offer the potential for new [illegible] new profits?

As the months ahead unfold, and as your new corporate [illegible] activity matures to its new responsibilities, you will find [illegible] tions looming ever larger in the product councils of [illegible] One more thing. You may be sure we will all be doing [illegible] you the right answers to those questions as well as the guidelines [illegible] enabling "legislation" needed to implement them.

Chase Morsey, Jr.
Executive Vice President
Staff Operations
RCA Corporate Staff

Our cover
illustrates the versatile display capabilities brought about by the discovery of the dynamic scattering effect in nematic liquid crystals (see Dr. Heilmeier's article on p. 14). Holding the numerical display is L. A. Zannoni, a member of the RCA Laboratories team that received a 1969 David Sarnoff Outstanding Achievement Award in Science for work in liquid crystals. **Photo credit:** Tom Cook, RCA Laboratories.

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

RCA Engineer

• 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.

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editorial input

by and for...

by and for the RCA engineer is much more than a slogan on the back cover of your magazine; it is the guiding influence behind each of the objectives of the journal; it shapes editorial goals and policies. With this single overriding thought in mind, the *RCA Engineer* functions—

to disseminate to the RCA engineer technical information of professional value;

to publish in an appropriate manner the important technical developments at RCA, and the part played by contributing engineers;

to serve as a medium of interchange of technical information between various engineering groups and locations;

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 technical 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.

Summarizing these established objectives, the *RCA Engineer* strives to be a primary channel for professional communications *by* engineers *for* engineers. Such communications vary as widely in character as the twelve thousand products they represent; yet, all represent a free interchange of information—and all are interrelated by a common interest in RCA.

Thus, to meet the goal of keeping the *RCA Engineer* a publication that truly serves you, the reader, the editors maintain frequent and in-depth contact with engineering trends and activities in all areas. We supplement these contacts by soliciting your ideas in reader surveys, and by regular meetings with your editorial representatives. However, it is not possible to hear from our readers as much as we desire. So, to extend our knowledge of your needs, we welcome your inquiry and comment. Send your letters to:

Editor, *RCA Engineer*
Bldg. 2-8
Front and Cooper Streets
Camden, New Jersey 08102

Or call the *RCA Engineer* office at 609-963-8000, Ext. PC 4018.

Only through candid two-way communications with you can we keep the *RCA Engineer* a journal *by and for the RCA engineer.*

Future issues

The next issue of the *RCA Engineer* features Microwave Devices. Some of the topics to be discussed are:

Advances in superconductors

Microwave applied research

Traveling-wave tube applications

New pencil tubes

Thermoelectric generators

Exportation of technical data

Modern optics

Diversity techniques for troposcatter

Combining solid-state sources

Discussions of the following themes are planned for future issues:

Microwave systems

Interdisciplinary aspects of modern engineering

Lasers

RCA engineering on the West Coast

Linear integrated circuits

Consumer electronics

Computerized educational systems

Standardizing—a program for engineers and industrial management

S. H. Watson

The Engineer and the Corporation

Engineers and engineering managers should sharpen their awareness of what can be done with standards and of the accelerating demand for world-wide standards as new technologies continue to break through. Expanding needs point to the importance of national and international standardization organizations. In the United States alone, over one-hundred major associations, the Federal government, and at least 2000 industrial companies all support vigorous standardizing programs. Prominent among the industrial companies is RCA.

THE RCA STANDARDIZING PROGRAM is designed to give the engineer and his associates every possible aid in the development, design, and manufacture of RCA products. Standard materials and finishes, standard mechanical and electrical components, and standard wires and cables can be selected and applied on a "no engineering time required" basis, because of the engineer's knowledge of the behavior and dependability of the standard items in previous product designs.

An impressive pyramiding of benefits takes place when a standard item is used, in contrast with the conception, design, evaluation and introduction of a new item. Savings begin in the engineering department where usually little or no engineering time and effort are required to decide upon a standard item. With a little ingenuity, it is often possible to use existing standards in unique ways, thereby eliminating the expense, the delays, and the uncertainties inherent in new and special items. When standards are consistently used to complement the creative work of the engineer, his productivity is increased and his performance enhanced.

Related purchasing functions

Standards have essentially the same favorable influence in purchasing as in engineering. Usually, for every standard item, two or more approved suppliers are available; prices and delivery schedules have been established; there are no tools to be made or bought; and no extra time is required for delivery because of tool design, tool making, tool tryout, and tool modification. Many standard items are maintained in stock by RCA on a "minimum and maximum" basis. Unless an unusually large quantity is required, such standard items involve no burden in purchasing, other than the established routine of reordering when stocks drop to minimum.

A large percentage of RCA standards consist of industry standard items used commonly by many other companies. Many such items are used importantly but in small quantity by RCA. Nevertheless, because of the volume generated by many using companies, these standard parts are available to RCA at attractive prices, on short notice, frequently from stocks maintained by one or more manufacturers or distributors.

Related manufacturing functions

In manufacturing, whether it be in an RCA plant or in a plant of one of the many RCA suppliers (there are about 10,000) standards continue to pay off generously. Manufacturing and process engineers find their burdens light when standard materials, standard tools, fixtures and gages, standard RCA finishes and standard parts predominate. Standard items which remain in steady demand year after year, are used effectively to level manufacturing loads. On such items, production can be started or stopped with a minimum of preparation because the tools and fixtures are available and the manufacturing craftsmen are well trained in their set-up and use.

Related quality and reliability functions

In quality control, reliability, value engineering and value analysis, the

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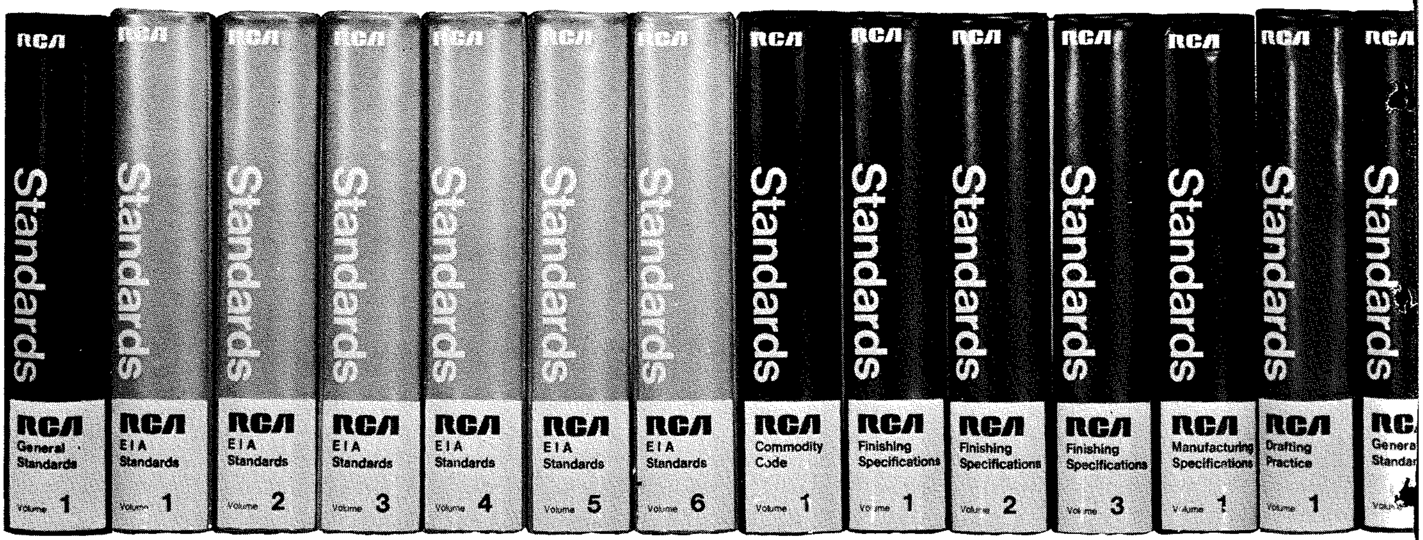
Samuel H. Watson, Mgr.
Corporate Standardizing
Corporate Engineering Services
Camden, N.J.
began his engineering career with the General Electric Company as a graduate of the G. E. Engineering School. In 1929, Mr. Watson transferred to RCA and engaged in product design and field engineering on automotive and aircraft receivers. During the war, he served as a mechanical project engineer on military communications equipment including altimeters and radar. He was appointed Manager of the Corporate Standardizing function in 1944. He currently represents RCA on the Company Member Council of the United States of America Standards Institute. He was a member of the Council Administrative Committee from 1947 to 1949, and again from 1950 to 1953. He was chairman of the Council in 1949 and again in 1952. He is a Senior Member of the Institute of Electrical and Electronics Engineers, and a charter member and Fellow of the Standards Engineers Society. In November 1960, Mr. Watson was chosen "Personality of the Month" by the staff of the United States of America Standards Institute, *Magazine of Standards*. He was awarded the USASI Standards Medal in December 1962. This is an annual award given to an indivdual who has served the voluntary standards movement through leadership in the actual development of standards. Mr. Watson was the U.S. representative to the ISO TC/10 Committee on Drawings at the meeting held in Geneva, Switzerland, in December 1962; chairman of the U.S. delegation to the meeting held in Budapest, Hungary, in June 1965; and again chairman of the U.S. delegation to the meeting held in Moscow, USSR, June 1967. In October 1967, Mr. Watson was appointed chairman of the EIA Engineering Policy Council, the management and policy arm of EIA's Engineering Department.



benefits of standardization are readily apparent. These functions do not have to spend much time on standard items which—as a rule—are of known quality, predictable reliability, and reasonable cost, but they do work actively to replace non-standard by standard items, and they make substantial contributions in the development of standards.

On the way to becoming a standard, many thousands of electrical and mechanical components have been thoroughly worked over by the quality specialists, the value and reliability engineers, the value analysts, and the product design engineers. Field service technicians also make important contributions by feeding back information on how components behave in service, what deficiencies have been noted and what improvements should be made. With this kind of background, often not only in RCA but widely in industry, RCA standard items may be and are used with a high level of confidence.

Standards lead to progressive change

Before management became so well informed concerning standardization, many feared that standardization had a tendency to stifle progress. Today, modern management relies on the standardizing function to fight obsolescence and promote change. The standardizer today is not at all backward about changing a standard even before the ink is dry on an original issue. The recent release by the Dept. of Defense of MIL-STD-12C on Abbreviations was accompanied with change notice No. 1 bearing the same date. This is dynamic standardization.

It gets the standard on the road and working, with a minimum of delay; it provides immediately for the prompt, orderly, and constructive change process so essential to keep pace with developments in the electronics industry.

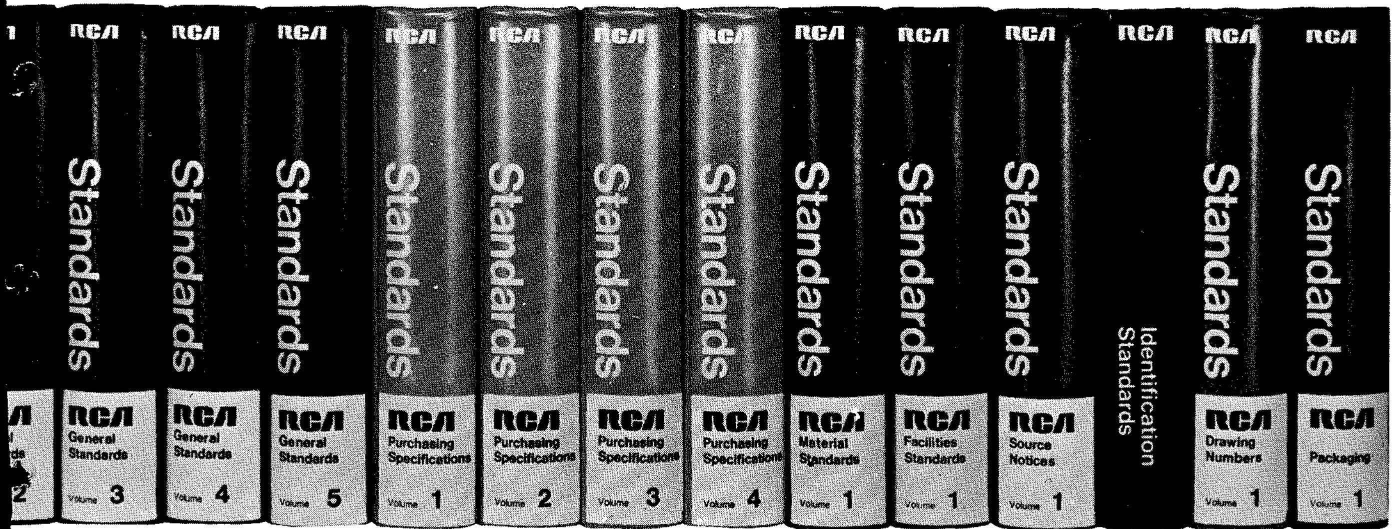
Every standard should be considered—by standardizer and user alike—as a prime target for change as soon as human ingenuity, technical advances, and new knowledge make an improvement possible and practical. Frequently, new, better, and lower cost ways of doing things are introduced. It is essential that these be promptly reflected in all existing standards, where applicable. Company management leans quite heavily upon the standards engineer to use every available technique and devise new ones when required to keep company standards up-to-date.

Standards—a world-wide influence

Management in Government, in the military, in schools, colleges and universities requires essentially the same standards as in industry. It makes the same demands upon, and employs the expertise of standards engineers to assure benefits through standardization. Teamwork among the standardizers in all these areas is essential to strong and effective national and international standardization. Evidence of this is found in a growing, select group of United States of America Standards now appearing at an increasing rate with official recognition and acceptance by both industry and government. Each is a single standard with a common jointly-used designation. At the company level in industry, the value of these documents is incalculable. Consider, for example, USA Standard Y14.5 on dimensioning and tolerancing; it enables RCA and many thousands of companies across the country to use the same dimensioning and tolerancing procedures for all customers, government, military, and commercial. This standard was developed by a team of experts drawn from government, industry (including RCA) and the universities. Management, quite understandably, will press for more of this kind of standardization—as the rule and not as the exception.

Metric measurement standards

The utilization of metric units of measure in the United States has attracted management attention in recent years. The United States of America Standards Institute has organized a *Metric Advisory Committee* to act as a focal point for industrial discussion of a broad range of information, educational programs, policies and studies related to measurement systems and standards. A primary purpose of the committee is to provide industrial sup-



port for the three year study now in progress in the National Bureau of Standards under Congressional authorization. The committee intends to cooperate with all interested organizations conducting metric studies in order that there may be a free and open interchange of information and opinion.

Many standards engineers will have opportunities to contribute to the national metric study program in the constructive, impartial and thorough manner considered by management to be characteristic of the standardization function.

Standards and safety

Two separate but interrelated subjects —the consumer or consumerism, and safety—have been very much in the news and are of sharp interest to management. The safety aspects of consumerism are of particular interest to the standards engineer. Our national standards program under the direction of the Standards Institute and its member bodies has a long and distinguished history of contribution to the health and welfare of the consumer and to the betterment of the economy. Standards engineers in industry, in government, and in the military can expect increased management demands for more and more safety-of-product in the hands of the consumer and continued emphasis on standards that make our offices and factories safer and healthier working environments.

Standards and management information systems

Perhaps no other subject is as popular in management preoccupation as the management information system (MIS). Many standardizing organizations in both industry and government are deeply involved in the development and operation of sophisticated, computer-based systems.

The disciplines and the procedures controlling and guiding the operation of computer systems will keep pace with the generation-by-generation evolution of the equipment units comprising the systems. Systems operational today will give way to the more highly refined, more efficient systems of the 1970's; and later the 1980's.

Computerization and associated management information systems have opened vast new fields of demanding responsibility for the standards engineer. He is being called upon to identify and describe items in a uniform manner both verbally and in code; and in no greater detail than that required for the efficient management of the materials and other industrial functions. The paper deluge already upon us—and frequently complained about—must be controlled and confined to essential information. Required data includes much that has been previously difficult to obtain, and which will be of great help to the standards engineer in standardization and simplification programs.

Standardization—a management function

More than ten years ago a National Industrial Conference Board (NICB) Study in business policy entitled, "Industrial Standardization Company Programs and Practices" included this statement:

> "Standardization is so well accepted that relatively little thought is given to its actual importance. There is general recognition that standards are essential in the administration of modern industrial enterprise. Those who *manage* and those who write about *management* agree that as a rational and economical way of dealing with recurring problems, standardization is an integral part of the *management* process."

Management in government, in the military, and in industry will be expecting more and more of the standardizing function. Contrary to the circumstances of several years ago as reported by NICB, much thought is given today by management to the importance of standardization. Management support and funds for standardization are being made increasingly available along with demands for high-performance levels and a maximum of effective standardization for each dollar expended. There are no dull moments ahead for the competent standards engineer with a healthy enthusiasm for standardization, and a capacity for effectiveness with people as well as with technical problems.

RCA and international markets

E. J. Dailey

Global markets represent a conglomerate of business opportunities for the American electronics industry—ranging from ordinary products to those of great technical sophistication. These product needs rapidly change as underdeveloped countries progress—and the total world market presents an elusive moving target that challenges the business aim of U.S. electronic firms; some, such as RCA will accept both this challenge and that of the intense competition provided by foreign firms. In this paper, the author discusses many of these factors: the necessary change in outlook; the retraining of American employees; and the careful market research needed. This discussion is in the context of RCA's total challenge and the role of its product divisions in the world market.

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At first glance, the relationship between "RCA and international markets" and RCA engineers may not seem to be too direct. In fact, the relationship probably isn't direct, but it does exist.

In today's commercial world, it is becoming increasingly difficult for a company to maintain a leading position domestically without playing a similarly strong role in other world markets. Traditionally, RCA's success in the US has grown from our technical and engineering innovations. Technical leadership is also important outside the US, but possibly not to the same extent; let me describe the difference.

Foreign versus domestic

Sometimes we tend to think of "the foreign market" or "the export market" as an entity, somewhat like the "domestic market." There is no such thing as an overall "foreign" or "export" market. There are, instead, some two-hundred separate markets outside our boundaries and each one is individual and unique.

For analytical purposes, these markets or countries can be classified or grouped, but only for study. When we get down to the critical point where merchandise is sold or exchanged for dollars or other currency convertible into dollars, each market must be approached and evaluated on its own terms. In theory, the world markets can generally be categorized in three major ways: by degree of sophistication or economic and cultural development; by size; and by wealth. A few countries, particularly in Western Europe, score high on all three measures, e.g. U.K., Germany, France and Italy, and Japan can also qualify. Some others are well up the scale in sophistication and wealth but are small in population and/or geographical size. Canada, Australia, South Africa, Denmark, Sweden, Norway, Switzerland and Lebanon, among others, would fall in this group.

Still other countries are relatively high in wealth (or resources) and large in area or population, but lack economic integration and development. Examples would be Brazil, Colombia, and Indonesia. Some others, unfortunately, rate low on all three scores.

Without trying to identify all combinations and permutations, and recognizing that many other variables exist in constantly changing markets, it is easy to see that we must aim from a moving platform at a "moving market target" —never an easy shot.

Products: unsophisticated and sophisticated

A few generalizations are warranted. The bulk of the world's population lives in culturally and economically underdeveloped countries, many of which lack wealth or resources. Therefore, our first marketing task in these countries involves finding products or product lines to match this lack of sophistication and low level of buying power.

We could, of course, ignore such markets, but we do so at our commercial peril. Although starting at very low levels, the rate of development in most of these countries is brisk—percentage-wise; a few are even ahead of the US and Western Europe, for example. This brings us back to the statement that technical innovation is not as important in many foreign markets as in the US.

Basic industrial economic factors in developing countries are different. Foreign exchange is scarce and costly. Interest rates are skyhigh by our standards—25 to 30% per year is not at all unusual and 50% is known. Human hands or labor can be bought cheaply, while "things" (capital goods) are generally much higher (in terms of income) than in our country. Individual purchasing power is low while prices are high.

This all adds up to potential markets for large numbers of relatively low-priced, necessarily unsophisticated products that can be produced with a minimum of capital investment, preferably using indigenous raw materials or components. However, we cannot ignore or underemphasize the more sophisticated markets of the world, but as described later, these are not so easily penetrated either. Our competitors are already well established with thoroughly up-to-date technologies.

To understand RCA's present posture in the international market, we need to look at some history, examine some of our American cultural aspects, and our national motivations. While the United States is a relatively new country, still less than 200 years old, the cultural and commercial trends that have shaped our relationships with the rest of the world go back at least a hundred years before our emergence as an independent country in 1776.

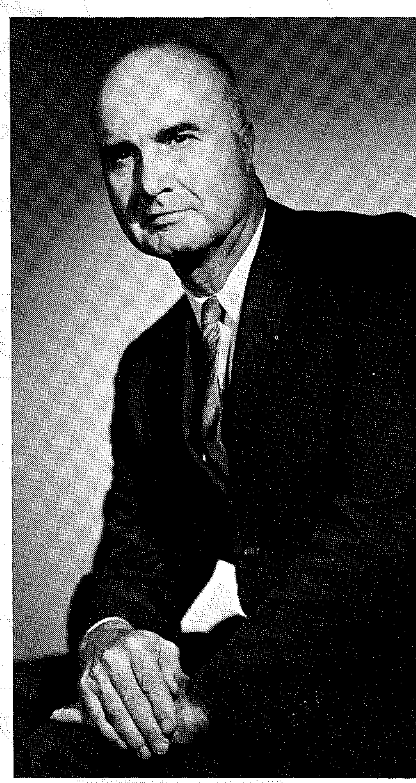
Foreign commerce

During this nearly 300-year period, as a nation, we have relied surprisingly little on foreign trade. In this sense, foreign trade in its broadest aspects includes import and export of materials and merchandise, foreign investment, financial transactions, and sale of intangibles and services.

To dramatize this point, consider that despite a phenomenal increase in our foreign commerce during the past 20 years, foreign trade still accounts for less than 8% of our total gross national product. Contrast this to traditional trading countries—for example, Britain, Holland and Denmark where foreign commerce accounts for as much as 80% of their total GNP. Thus, our total financial involvement outside our own frontiers seems almost inconsequential in numbers, but not in importance.

Again, using the U.K. and Holland as contrasting examples, both countries have always been forced to export or die; both lack significant local resources, and are forced to import in large volume.

From the beginning, the U.S. concentrated attention on its own western



E. J. Dailey
Staff Vice President
International Planning
New York, N.Y.
received the bachelor of science degrees in chemical engineering and in mechanical engineering from Iowa State University in 1933. In 1935, Mr. Dailey received his MBA from Harvard Business School. He then devoted four years as Production Engineer and Factory Manager at U.S. Gypsum—and spent three years in U.S. Military, small arms ordnance work. For seventeen years, Mr. Dailey was International Regional Vice President for U.S. Rubber Co. In 1962, he became Division Vice President in charge of foreign subsidiaries for RCA. Since 1967, Mr. Dailey has been Staff Vice President, RCA International Planning.

Period	Exports	Overseas direct investment	Other
1750-1890			Clipper ships
1750 to date	Timber tobacco		
1775-1940	Cotton	Sugar mills	
1850 to date	Coal		
1870 1940		Mining	
1890		Banana plantations	
1910 to date		Oil	Banking abroad
1919-1929	Manufactured goods		
1930-1935		Manufactured goods	
1946-1965	Manufactured goods	Manufactured goods	

Fig. 1—History of U.S. Foreign Commerce.

frontiers as the principal means for growth and development, rather than the development of trade with other countries.

This does not suggest that the United States has not had a long history of foreign commerce, because it has (see Fig. 1). However, such trade has been directed toward exporting raw materials, agricultural surpluses, and importing certain raw materials and manufactured products that we lack at any given time.

Only in the last 50 years, as a nation, have we made a concentrated effort or investment in foreign trade—principally in exports and foreign manufacturing. Before that, foreign trade investments were concentrated almost entirely in foreign raw materials and extractive industries, such as oil, mining, bananas, and sugar. Our first real thrust on manufactured exports took place only after World War I.

Foreign manufacturing

Substantial investments in foreign manufacturing were not made until late 1920's and early 30's, when the world went into a nationalistic and protectionistic cycle. The only way American manufacturers could then retain the foreign markets they had developed through exports was to erect or acquire plants in those foreign markets; many of them did this.

Argentina	Records.
Australia	Records, audio products, switching modules.
Brazil	Records, B & W kinescopes, receiving tubes.
Canada	Records, home instruments, color tues, components, communications equipment.
Chile	Records, home instruments, B & W kinescopes, receiving tubes, components.
Great Britain	Records, VTR headwheels, theatre sound equipment, color kinescopes.
India	Theatre sound equipment, 16mm projectors.
Italy	Records.
Mexico	Records.

Fig. 2—RCA's current foreign manufacturing (other than feeder plants).

The second surge of such investment occurred immediately after World War II, and a third peak in American investment in foreign manufacturing occurred in the mid-50's after the Korean War. The last wave appeared in the early 60's through 1965; mark that 1965 date since it's an important one referred to later.

Where was RCA when these foreign investment peaks were developing? Pre-war and even post-war, until about two years ago our resources in money and people were fully utilized—even stretched—to handle domestic challenges, let alone take advantage of foreign opportunities. Many will remember the resource squeezes that occurred first in black-and-white TV, then color, and most recently EDP.

It's true that RCA had some relatively small foreign manufacturing operations that were inherited when we took over Victor Talking Machine and when Photophone was formed some years ago. Also in the 50's, we opened up several new foreign phonograph record plants. In Canada, we have a small-scale, more or less fully integrated copy of RCA (Fig. 2 shows the lineup of our present foreign manufacturing other than "feeder" plants).

Although emphasis at this point is given to the fact we haven't yet done as much as some competitors in foreign manufacturing, the financial results of our foreign activities overall are rather substantial in total. In retrospect, it certainly made sense to capitalize on our technical leadership through patent licenses and technical aid abroad, which we did, when we didn't have the wherewithal to exploit our developments elsewhere.

New emphasis on world markets

Now, let's look at the situation when Robert Sarnoff decided in 1966 to redirect RCA's emphasis toward international markets. First, are foreign markets in total worthwhile? Certainly, the numbers shown in Fig. 3 speak clearly, and answer the theoretical contention frequently heard that we can choose between exports and local operations. Indeed we can, but it's not much of a choice. As you will note, with 7% of total US electronic exports—a very respectable position—RCA through exports alone enjoys less than one-half of one percent of the total world electronics market.

How does the market outside the US compare with the domestic total? You can see from Fig. 4 why Robert Sarnoff is interested in catching up abroad. Just how much catching up do we have to do? This can be answered in several ways. One indication is the total number of countries where competitors' manufacturing operations are located (Fig. 5); only the large competitors are shown; but, there are many other small competitors in some markets.

Competition in world markets

How do we stack up against our competitors in absolute size? This, of course, has a bearing on how fast we can expect to catch up; as shown in Fig. 6, some competitors are substantial. The extent to which our competitors depend on foreign sales related to their grand total sales give a measure of how easily we might match them. By this measure, many competitors are truly international or multi-national.

You'll notice from these figures that we compete not only against American firms, but with many large foreign groups as well. The fact that large international companies operate under many different flags, and have headquarters all over the world, is highlighted in Fig. 7. The geographical breadth of competitors' operations by product groupings is shown in Fig. 8.

Obviously, to grow abroad we must necessarily start with what we now have and branch out from there. Just what does our present foreign business consist of? Our eleven international activities are geographically shown in Figs. 9 and 10.

When management decided in 1966 to redirect corporate efforts and become truly multi-national, a number of things were happening in the world that didn't become fully apparent until the latter part of 1968. These world happenings now seen in retrospect could be considered partially as a negative influence on RCA's international ambitions.

World condition—1965

By 1965 (that critical year mentioned earlier) the 20-year "economic miracle" on the European continent had peaked out. Demand was finally satisfied for the moment and real competition was felt for the first time in a generation. DeGaulle was throwing his weight around. A somewhat vacillating and weak government came to power in Germany. Italy was in a recession. The consequences of dismantling the empire had caught up with Great Britain.

The US was living beyond its means internationally. Our balances of both trade and payments were shortly to experience serious difficulties.

The raw-material producing countries in Latin America, Africa, Middle East and Far East were slipping further behind due to stagnant commodity prices and booming population growth rates.

The general consequences of all such factors find many countries in balance-of-payment difficulties and politically the best expedient seems to be emphasis on protectionism, nationalism, and some "yank-go-home" attitudes.

The result of all this for RCA is that while we can and will grow abroad, the general situation and prospects are not as auspicious or favorable as they were in the preceding 20 years, and we're going to have to claw our way up step-by-step in each market. There is a widely held theory of history that no new idea is accepted or becomes effective until its time has come.[1]

World attitude toward America

Sometimes it comes as a shock to Americans that we are not accepted abroad at what we believe to be face value—sincere, attempting to be truly helpful, benevolent, and, at least through the billions of dollars of US Government aid over the last few years, unselfish, generous, and open-handed.

	Home instruments	Broadcast, test, communications	Components accessories	Total
Total market	2,411	2,356	3,150	7,917
U.S. exports—market share	2%	11%	8%	7%
RCA exports—market share	0.1%	0.8%	0.6%	0.5%
RCA share of U.S. exports	5%	8%	8%	7%

Fig. 3—1966 world electronic market outside U.S. & Canada ($ millions).

In contrast, although most people outside the US seem to like us as individuals, they do not necessarily admire us as a nation, nor do they agree with our political and economic philosophies.

Please don't shrug off as communist propaganda the phrase "economic imperialism". While most of us think it is sheer nonsense, many noncommunistic foreigners see it as a very real threat to their economic independence, cultural values, and political stability. Moreover, our friends behind the Iron and Bamboo Curtains never miss a chance to fan the fires of these antagonistic feelings against us.

Servan-Schreiber's, *Le Defi Americain* (*The American Challenge*)[1] came out just at a time to crystallize these anti-American feelings and, as so many times happens, many of the ideas and phrases in the book are being lifted out of context and quoted to bolster arguments exactly opposite to those intended by the author. Basically the book is not anti-American. *Le Defi Americain* points out that the world's attitude towards American business, coupled with the US Balance of Payments problem, will *influence* even our *domestic economy* for the foreseeable future, and these two factors will eventually *control* our *international commerce* as a country and a company.

Balance-of-payment problem

Now, a few words on the balance-of-payments problem; wide publicity was given to the British devaluation of the pound sterling slightly over a year ago and the consequent "falling-dominoe" effect on many other currencies. More recently, the run on the French franc has been the subject of headlines. In between these two events, there was a run on the dollar.

All such "runs" on currencies stem from three related factors: 1) negative balances-of-payments, 2) increases in internal costs and prices that result in inflation, and 3) fear of currency devaluation. With a few exceptions, most countries are chronically in deficit on their current accounts. The United States is now a member of the debtor nation club. In simple terms, we *spend* more on imports of goods and services, foreign aid, foreign military costs, diplomatic representation, travel and foreign investment, than we *take in* on exports, foreign interest, and dividend income.

As an individual or a company, a country can "spend" more than it "earns" for only a limited time. When it continues to do so, creditors become suspicious and nervous and attempt to collect on "notes" they hold—the negative current account balances. Again, as with individuals or companies, creditor countries (in addition to their collection efforts) shut off further credit. These actions all result in the creditor nations refusing to accept the currency of the debtor country at its face value (the agreed or official exchange rates).

Financial dealings between nations, the parity of currencies and world

	(in $ billion)		Growth rates		% of 1966 GNP
	1966	1971	61-66	66-67	
U.S.A.	19.9	29.5	12%	8%	2.7%
Rest of free world	11.9	18.4	11%	9%	2.1%
Total	31.8	47.9	11½%	8½%	2.4%

Fig. 4—Electronic production in the free world.

Company	Number of countries
CBS	16
EMI	28
General Electric	23
IBM	16
ITT	41
Philco-Ford	6
Philips	45
RCA	11

Fig. 5—RCA and competitors' manufacturing locations abroad.

foreign trade in general in the non-communist world, are all carried on today under a set of rules agreed at the Bretton Wood's World Monetary Conference in 1944.

Monetary exchange: the gold standard

Under these rules, relatively inflexible rates of exchange are assigned among national currencies with the pound sterling and the US dollar serving as the principal "reserve" or basic reference currencies of the world (the French and Swiss francs, particularly the latter, have also attained "reserve" status from time to time).

In a practical fashion, the system works as follows: when a country "exports" more than it "imports", it earns a net positive balance which traditionally could be converted into pound sterling or US dollars from other currencies, and by agreement, the US Government stood ready to exchange or redeem dollars held by other countries for gold at the fixed rate of $35 per ounce. Thus, while for political reasons we contend that the world is not on a gold standard, in a practical sense other nations (most of whom honor gold above all else) continue to feel that world trade does operate essentially on a gold base.

Traditionally, the US has run a positive balance on its foreign trade account (export of products has normally exceeded import of products) while in contrast, for at least the last 25 years, we have traditionally run negative on our overall balance of payments or current account when *invisibles* are added to *trade*. These invisibles are principally tourism, insurance, interest on equity and debt securities, private foreign investment, foreign aid, cost of maintaining military and diplomatic establishments abroad.

In 1967 and 1968, when the United States found that its gold supply was rapidly being depleted by foreign governments' demands to "cash" dollars they held, the so-called two-price gold system was introduced. Once more in an over-simplified fashion, this means that in transactions between sovereign governments, gold is still bought and sold at the old rate of $35 an ounce. For all other purposes, gold is freely traded as a commodity at prices determined essentially by supply and demand in a free market. In recent months, this price has fluctuated from $38 to $43 per ounce with momentary peaks and valleys outside this range.

Foreign companies	Country	1966 total sales	foreign sales	percent
Philips	Netherlands	2241	2020	90
Siemens Group	Germany	1958	755	39
Hitachi	Japan	1149	125	11
Toshiba	Japan	911	100	11
English Electric	U.K.	757	174	23
Aeg-Telefunken	Germany	1215	356	29
Bosch	Germany	3100	1152	36
U.S. Companies				
General Electric	U.S.A.	7177	1490	21
IBM	U.S.A.	4247	1318	31
ITT	U.S.A.	1962	1060	54
RCA	U.S.A.	2996	313	11

Fig. 6—Competition (sales in $ millions).

Status of the dollar

While the US dollar is not directly under attack at the moment, the incipient weaknesses caused by our poorer balance-of-trade position, our continuing negative balance of payments overall, and the higher rate of internal inflation could result in the current calm being upset at most any time by a concerted drive on the dollar.

One consequence of the overall weakness of the dollar was the imposition of the foreign investment rules put into effect by the US Federal Government at the beginning of 1968. These rules are intended to reduce the outflow of US industrial investment and at the same time speed up remittance back to the US of funds generated by US industrial and commercial activities abroad.

Short range, these restrictions are probably the only resort the Government had, but over the long pull, they tend to "kill the goose that lays the golden egg" since, historically, US foreign investments have returned to the US in the form of dividends, license and technical aid, and increased exports of raw and semi-fiinished product, many times the value of the original investment. The US Balance of Payments deficit arises from the public sector of Government spending abroad (Governmental aid and military expenditures are the major items), while the private sector (business and commerce) has traditionally returned —and continues to return—a surplus.

Foreign investment restrictions

The Government deficit by its nature is relatively inflexible, which left only the private sector susceptible to control and thus the visible outflows for private foreign investment have been reduced. It is generally agreed that the present foreign investment restrictions are treating the symptoms rather than the disease, but until Vietnam and other foreign military expenditures can be reduced, the Government has little other choice.

Under the foreign investment restrictions, a company can invest in various areas of the world only a fixed-ceiling percentage of the amount it invested in those areas in a set of base or reference years. Companies that made large investments in those years thus have relatively greater flexibility to continue to make new investments. On the other hand, those companies, like RCA, that made relatively small investments during the base years, now have very limited scope or maneuvering room for new investments. Now when we would like to expand, we are caught in a squeeze not of our own making. This again emphasizes the fact that it is going to be harder for any American company to expand abroad now than it would have been several years ago. In 1968, RCA established an investment corporation for purposes of selling a $50 million Euro-dollar bond issue. This money will be used for investment in those countries where the

Country	Companies
Germany	Bosch; Siemens; Fernseh; Grundig; AEG/Telefunken
U.K.	English Electric; Thorn; Plessey; EMI; Decca; GEC; Rank; ICT
France	CGE; CSF, Thomson-Brandt; Schneider; Cocelam
Sweden	Ericsson
Japan	Nippon Electric; Toshiba; Hitachi; Matsushita; Sanyo; Sony
Netherlands	Philips
Australia	AWA
Switzerland	Brown-Boveri
Mexico	Rivero-Majestic Group

Fig. 7—Leading non-American electronic companies—home countries.

Television sets	
Grundig	Portugal
General Electric	Mexico, Argentina, Brazil, Venezuela
Philco	Mexico, Argentina, Brazil, Venezuela, Peru
Philips	France, U.K., Germany, Italy, Argentina, Brazil, Mexico, Peru
Admiral	Mexico, Canada
ITT	U.K., Germany, Portugal, France
Television Components	
Grundig	Portugal
General Telephone	Belgium, Mexico, Brazil
Philco	Italy, Brazil
Philips	France, U.K., Germany, Italy, Argentina, Brazil, Mexico, Peru
ITT	U.K., Germany, Portugal, France
Semiconductors	
Fairchild	U.K., Italy, Australia, Hong Kong
Texas Instruments	Japan, U.K., Germany
Motorola	France. U.K.
ITT	U.K., France, Germany, Portugal
Philips	U.K., Germany, France
Broadcast & Communications	
General Electric	Argentina, Brazil, Venezuela, Mexico, Spain
Ampex	Belgium
ITT	Germany, U.K., Belgium, Austria, Denmark, Finland, Italy, Norway, Spain, Australia, Switzerland, Argentina, Brazil, Chile, South Africa, Mexico
Siemens:	Italy
Records	
EMI	Germany, France, Italy, Spain, Sweden, Argentina, Brazil, Chile, Mexico, Venezuela, Singapore, India, South Africa
Philips	Germany, France, U.K., Italy, Spain, Sweden, Argentina, Brazil, Chile, Mexico, Venezuela, Singapore, South Africa
CBS	U.K., Germany, Italy, Spain, Argentina, Brazil, Chile, Mexico, Venezuela, Japan
EDP	
IBM	U.K., France, Germany, Italy, Switzerland, Belgium, Japan
Honeywell	U.K., Germany
GE	France. Italy
Sperry Rand	U.K., France, Germany

Fig. 8—Leading international competitors.

government restrictions now prevent us making direct investment from US sourced funds.

Ignoring these financial restrictions for the moment, there are several basic ways RCA can move into manufacturing abroad: start our own wholly-owned operations from scratch; start new joint venture operations with local partners; or acquire partial or total equity in existing operations. There are clear pros and cons to each of these which vary widely from product-to-product, country-to-country and time-to-time—a lot of variables to grind into each decision equation.

Factors in entering foreign markets

In connection with decisions as to the best means for entering a given market, account must be taken of a rapidly accelerating world-wide trend toward mergers in the electronics industry. In most countries, particularly in the more sophisticated markets of Western Europe, there will soon be only a few large, fully integrated electronic "groups" or combines in each country (Fig. 11).

It is emphasized that the companies shown in the groupings of Fig. 11 are not just outstanding or important ones among numbers of other small companies. This will be it! There won't be any small companies to speak of.

On a completely different subject, some changes must be made and shifts in outlook are required when a domestic company moves abroad. The transition finds generally smaller markets where domestic product designs and domestic scale of manufacture can not be transferred without change.

Product modifications for export

In theory, one of the chief reasons for establishing or acquiring operations abroad is the opportunity to exploit domestic research and development, domestic product engineering, and domestic marketing and distribution know-how. All of these factors are valid, but substantial alterations are generally required before domestic approaches can be used outside the United States.

Increasingly, it is the exception rather than the rule when a product or major component designed for the US market can be sold abroad without some modification, ranging all the way from minor appearance or style alteration to major variations in technical standards or performance requirements.

As long as RCA's principal international marketing thrust was through exports from the US, this problem could be ignored to an extent by adopting a "take it or leave it" sales attitude. When an old market was lost due to our inability or unwillingness to provide an export product uniquely suited to a local requirement, there generally was a newly developing market opening up in another country where customers were willing to accept US designs, at least temporarily. This, in fact, is a capsule history and pattern of export sales—a more or less continuous shifting from one market to another.

A somewhat similar pattern exists with regard to license and technical aid agreements where we offer US product design and knowledge on an "as is" basis. Differing from exports, however, is the fact that most licensees are willing and able to modify our domestic product and major component designs, as well as production methods to suit local tastes and requirements.

In the future, when greater emphasis is to be placed by RCA on manufacturing its own products abroad, we must provide a systematic means for adapting or altering products and components to meet local foreign market tastes and requirements, and, more importantly, to utilize locally available components and raw materials.

Style and model changes

A second factor to be reconciled is frequency of style or model changes. Abroad, as in the United States, the cost of product design, production engineering, model promotion, and introductory marketing costs must be liquidated against the number of units sold. Since the foreign markets, with few exceptions, are small, economics will not support either a broad line of models or frequent model changes. As an example, in many countries TV producers will offer no more than three or four furniture styles of essentially one chassis model and will keep these in the line almost without change for as much as two or three years, and then any change may be only a superficial face lifting.

Exports
Distribution
Manufacture
Feeder plants
License & technical aid
1) Matrix license handled by record division
2) All other products handled by Patents & Licensing
Global Communications (RCAC)
Broadcasting (NBC)
Service (RCAS)
Car rental (Hertz)
Procurement
Research & Development

Fig. 9—RCA's international activities.

	No. of countries
Export product through 200 distributors	150
Subsidiary manufacture	9
Feeder plants	5
License and technical aid	
1) Record matrix	40
2) All other	24
Global Communications (RCAC)	17
Broadcasting (NBCI and NBC News)	13
Service (RCAS)	21
Car rental (Hertz)	26
Procurement offices	2
R&D Laboratories	2

Fig. 10—How and where RCA conducts its foreign businesses.

Technical standards problems

RCA and other US electronic producers are faced by another problem, however, through the lack of uniform technical standards. For example, as most engineers know, Europe has adopted two color television systems, PAL and SECAM, both different from our NTSC. While we can adapt our components, sets, broadcast, and studio equipment to these standards, the US domestic product cannot be sold as such.

Production considerations

Another aspect of scale of economics is the fact that most foreign markets are not large enough to support US-type, highly-automated, large-capacity production operations.

In many cases, the difference in scale is so great as to require a different technical approach. It is not simply a matter of using a fewer number of standard domestic production units or equipment. It is a different production world where human hands can be bought cheaply, while the minimum capacity of the smallest US-type machine can be in excess of the market requirements. In a slang term, only "bucket and stick methods" can be justified economically.

From a practical standpoint, the problems in this regard are similar to those involving design and adaptation of products and components for smaller markets; the results may not appear to be worth the effort from the viewpoint of the domestic engineer or production manager who is concerned with evermore highly automated and larger capacity production devices and methods here at home. But again, we have only the two choices:

1) Forego these smaller markets; or
2) Adapt domestic production techniques to local needs or devise new ones consistent with small local scale.

New breed of specialists needed

Like the special products needed for foreign markets, these small production techniques cannot be developed effectively by the "left hands" of domestically-orientated engineers whose primary experience and responsibility is US production process design and improvement. We must develop small plant specialists—a rather unique breed.

Normal domestic performance ratios and "yardsticks" many times become meaningless under the different size scale, different laws, different customs, different cultural traditions, and restricted economic factors that prevail abroad. A domestically trained production or technical man has to "unlearn" many of his instinctive guidelines, before he acquires an effective set of replacements that apply in the foreign environment.

It's also not enough to shrug this problem off by assuming we can employ "locals" who are already accustomed to local peculiarities. First, the "locals" generally have to be trained in our products and technology. Moreover, and despite any pious generalizations to the contrary, American corporations can seldom leave the entire management responsibility for one of its foreign operations to a wholly non-American management staff.

Some place in every foreign operation, whether as top man, finance officer, technician, or elsewhere, there must normally be an American "presence" to provide a required two-way communication bridge between parent and subsidiary and "interpret" one to the other.

Training for foreign markets

Therefore, foreign indoctrination of a minimum number of domestic people becomes a must to achieve the unlearning of most normal domestic "yardsticks".

Ratios of direct-to-indirect labor, male-to-female, wage-to-salary, and workers per supervisor aren't very useful where laws or industry-wide contracts define the following:

1) How many people are to do a certain job;
2) How many aides or assistants are to be provided for so many "operators";
3) Specific prohibitions against discrimination or distinction in any way between men and women; and
4) Operators on salary while supervisors are on wage and other seeming contradictions.

Because of much higher material costs (both absolute and relative) against much lower labor costs (again both absolute and relative) a ridiculously low ratio of employees per supervisor (by domestic standard) is practical; it can be true economy, and improve yield as well as conserve expensive materials that may require up to as much as 12 months to replenish.

In the States, thousands of dollars can be spent economically to achieve unit savings in the third and fourth decimal place, because the millions of units produced quickly liquidate the required expenditures. In contrast, known large unit inefficiencies in a small plant can be tolerated because of the small number of units produced and because the unit cost to correct them would be exorbitant.

A different outlook on fixed asset investment is also necessary when money costs or earns 24 to 36% per year, while labor costs a few cents an hour. Most times, a better profit return comes from use of labor (even excess labor) rather than investment in fixed assets. These are only a few examples of why product divisions must develop production and technical support people, expert in and specifically assigned to foreign operations.

Color tube production—an example

Production of color tubes can be used to illustrate the foreign manufacturing

	General electronics	Computers	Solid state
United Kingdom	Thorn-Radio Rentals Philips-Mullard STC-ITT EE-GEC-AEI	IBM EEC-ICT-Plessey	Texas Instruments Fairchild ITT Philips Plessey English Electric Ferranti
Germany	Siemens-Telefunken-Bosch Philips Grundig SEL-ITT Sylvania (GTE)-Saba	IBM Siemens	Texas Instruments ITT Philips Siemens Bosch Brown-Boveri
France	CSF-Thomson Houston Philips-Radiotechnique-Schneider LMT-ITT	IBM Bull-GE "Plan Calcul"	Texas Instruments Fairchild ITT Transitron Sprague Electric Motorola Philips CSF-Thomson Houston
Belgium	Philips-MBLE A.C.E.C. Sylvania (GTE)	IBM Philips	Philips
Netherlands	Philips	Philips	Philips
Italy	Philips FIAR-GE Voxson-Admiral ITT Sylvania (GTE)	Olivetti-GE IBM	Philips Siemens-ATES

Fig. 11—Consolidation of European electronic manufacturers.

scale problem. Aside from the U.K., the European Common Market, Japan, and Canada (the latter of which is, in fact, borderline), there are no other markets in the world that can support a Scranton- or Midland-size color tube plant requiring an investment of from $20 to $25 million.

Most other markets, such as Australia, Mexico, or Brazil, would be hard pressed to support a color tube plant investment in the foreseeable future of more than $2 or $3 million. Here, we come to a problem where the differences in scale are so great as possibly to require a fundamentally different technological or production approach. Some of our competitors have used rather unique but effective approaches to this question of scale-down and technical time lag in developing markets.

One of our particularly successful competitors radically adjusts such factors to match the local economic scale, the optimum ratio of labor-to-capital and the skill level of the host country; and, this means deliberately using crude, antiquated methods instead of the latest technology. This company maintains a pilot plant where it trains management and developing country nationals in methods that have not been practiced in its home plants for decades.

At any one time in the pilot plant, there is a skeletal permanent staff serving as worker-instructors, a small group of people from developing countries who will later take over middle-management posts in their new factories, and one or two home office men who will be assigned top management positions in the new factories.

Production in the pilot plant is on exactly the same level as it will have to be in the developing land. Tools and equipment are simple and standardized; problems have to be solved on the spot by the workers; the new factory equipment is designed, set up and tried out in the pilot plant before being sent out to the new host country

This example does not imply that RCA should start electronic manufacturing or assembly activities only in small, less developed countries, or confine its new foreign projects to primitive parts of the world, but it does emphasize that in relatively more developed areas, such as Latin America and Canada, scaling down, simplification and minimization of paperwork and administration, plus new ready-reference performance ratios are needed.

Involvement of product divisions

RCA's new organization for international activities puts the responsibility for all phases of exports, foreign manufacturing and foreign marketing directly on each of the product divisions for its own products.

This means that perforce a great many people must become involved with international opportunities and problems in a minimum time. This contrasts with RCA's former organization wherein the activities outside the US were carried on by a relatively small staff of specialists in the old International Division.

The involvement of these larger numbers of people in all the product divisions, as well as the various Corporate Staff activities, is all to the good and will certainly hasten RCA's development abroad. On the other hand, it would be easy to find ourselves reinventing the wheel or relearning some of the hard lessons from the past about international business. It is precisely to avoid this happening that the International Division is now a staff function, charged with the responsibility of planning and coordinating the Corporation's overall international activities on a region-by-region basis and also responsible for providing overall Corporate planning activities outside the US.

In its overall international planning, the corporation is faced with a set of variables that would tax a large computer.

Summary

As is true of all other companies, RCA's resources while large, are finite. Therefore, priorities must be established between opportunities and available resources. Efforts must be made to optimize returns on investments. Accurate forecasting of political, economic and financial trends in each country is necessary, on both absolute as well as comparative bases. Lastly, we have to take into account in each foreign investment decision the effect of US Government rules, regulations and restrictions, as well as US anti-trust laws which apply the same to US companies operating abroad as at home.

In today's world, a company cannot expect to remain a leader in the US unless it's also a leader multi-nationally. That's just what RCA is on the road to becoming.

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Liquid crystals—the first electronic method for controlling the reflection of light

Dr. G. H. Heilmeier

Few technological advances cause one's imagination to wander quite as far as the liquid-crystal display concept. Such displays allow, for the first time, electronic control of the transmission and reflection of light. Further, the display itself is a flat, rugged, low-power device that is economical and easily fabricated. Obvious applications are electronic windowshades, numeric displays (see the front cover), and all-solid-state television; and, although this concept is barely beyond the laboratory-development stages, RCA already has several proprietory contracts to study further applications for customers in the Petroleum, Advertising, Automotive, and Avionics industries. This paper describes the dynamic light scattering effects in certain classes of nematic liquid crystals which make these applications possible. Several applications are also described along with the basic characteristics of the display itself.

THERE ARE TWO MAIN CLASSES OF DISPLAYS: those that emit light, such as the cathode ray tube or the neon bulb; and those that reflect or modify light, such as the printed page or the photograph. There are many ways to electronically control the emission of light but few, if any, to control the reflection of light. Reflective displays might be expected to have at least two obvious advantages: first, since the contrast is a constant independent of the ambient light intensity, they should be viewable in a wide range of ambients including direct sunlight; second, since the addressing circuitry does not have to supply the power necessary to emit light, the potential addressing power requirements are much lower. In this paper, a new reflective display concept is presented based on a new electro-optic effect in certain classes of nematic liquid crystals.[1] We have called this new effect *dynamic scattering.*

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Liquid crystals

The subject of liquid crystals is sufficiently esoteric that perhaps some introductory material is required. A liquid crystal is defined as an organic material that has the mechanical properties of a liquid, that is, it pours like a liquid and fills its container as a liquid does, and yet possesses the optical properties of a crystalline solid. For the purposes of this discussion, the liquid is considered to be made up of cigar-shaped molecules as shown in Fig. 1.

Isotropic and nematic states

In an isotropic liquid state, the cigar-shaped molecules are oriented at random with respect to one another. As a nematic liquid, the cigar-shaped molecules align with their axis in a common direction. The term nematic comes from the Greek word meaning "thread-like". If one were to look at the nematic liquid crystal under a moderate power microscope (60X), one would see tiny threads throughout the liquid. Materials which are liquid crystals exhibit this behavior only over very specific temperature ranges. Below the liquid crystalline range they are solids; they melt sharply, reversibly, and reproducibly to form the nematic (or liquid cyrstal) state, and at higher temperatures they make a transition to the isotropic liquid state. This transi-

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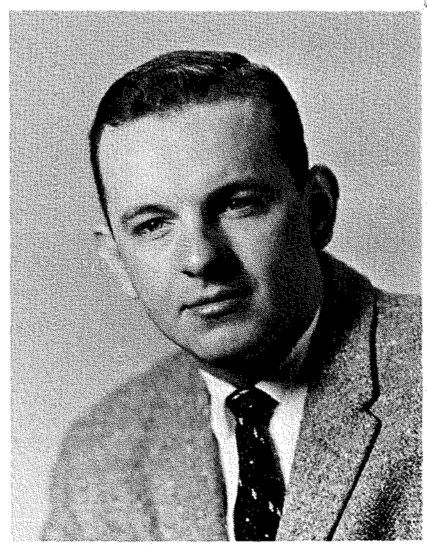
received the BSEE with honors from the University of Pennsylvania in 1958, and the MSE, MA, and PhD in solid state materials and electronics from Princeton University in 1960, 61, 62, respectively. His work at Princeton University was done under the sponsorship of the RCA Laboratories. In the past, he worked in the general area of the solid state microwave devices for amplification, generation, and conversion with emphasis on distributed parametric and tunnel diode structures. He has published six papers in this area. He has also studied the electrical, optical, and electro-optical properties of molecular crystals and thin films having also done his PhD dissertation in this area. He is the author of 13 publications in this field. In 1963, he initiated work at RCA Laboratories on thin film ferroelectric field effect devices. His current interests lie in the field of liquid crystals and he has published eight papers on the physical properties of these materials. His work in this area has resulted in the discovery of three new-electro-optic effects and the development of the first electronically controlled reflective displays. Dr. Heilmeier has twelve U.S. Patents issued or pending in the areas of adaptive thin-film ferroelectric devices, solid-state devices, optical modulators and displays. In 1960 he received the RCA Laboratories Achievement Award for his work in parametric and tunnel diode devices; in 1962 for pioneering work in the field of crystalline organic semi-conductors; and in 1965 for research in the area of liquid crystalline phenomena. In 1969, he was part of the team that received a David Sarnoff Outstanding Achievement Award in Science "for basic studies of liquid crystals with imaginative ideas for their application to practical displays." Dr. Heilmeier is a member of Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and a senior member of the IEEE. He is also listed in American Men of Science and Who's Who in the Electronics Industry. In March of 1968 he was the recipient of one of the "Outstanding Young Electrical Engineer" awards of Eta Kappa Nu. In March of 1969, he received the Eta Kappa Nu Award as the "Outstanding Young Electrical Engineer in the USA."



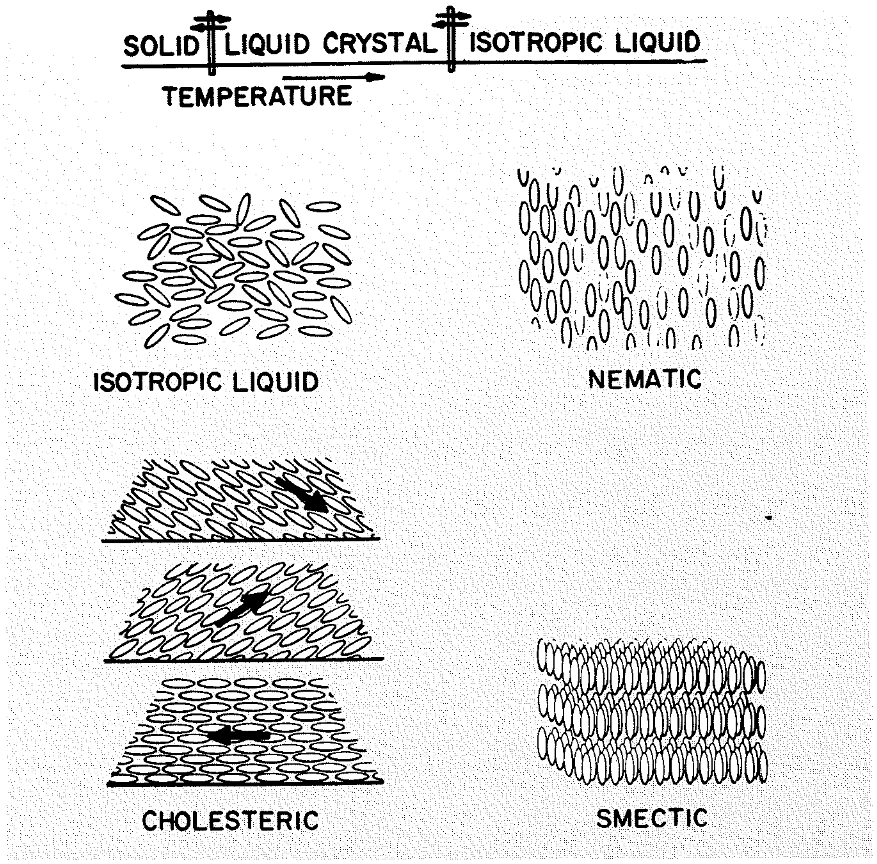


Fig. 1—Molecular arrangements in the liquid crystalline state.

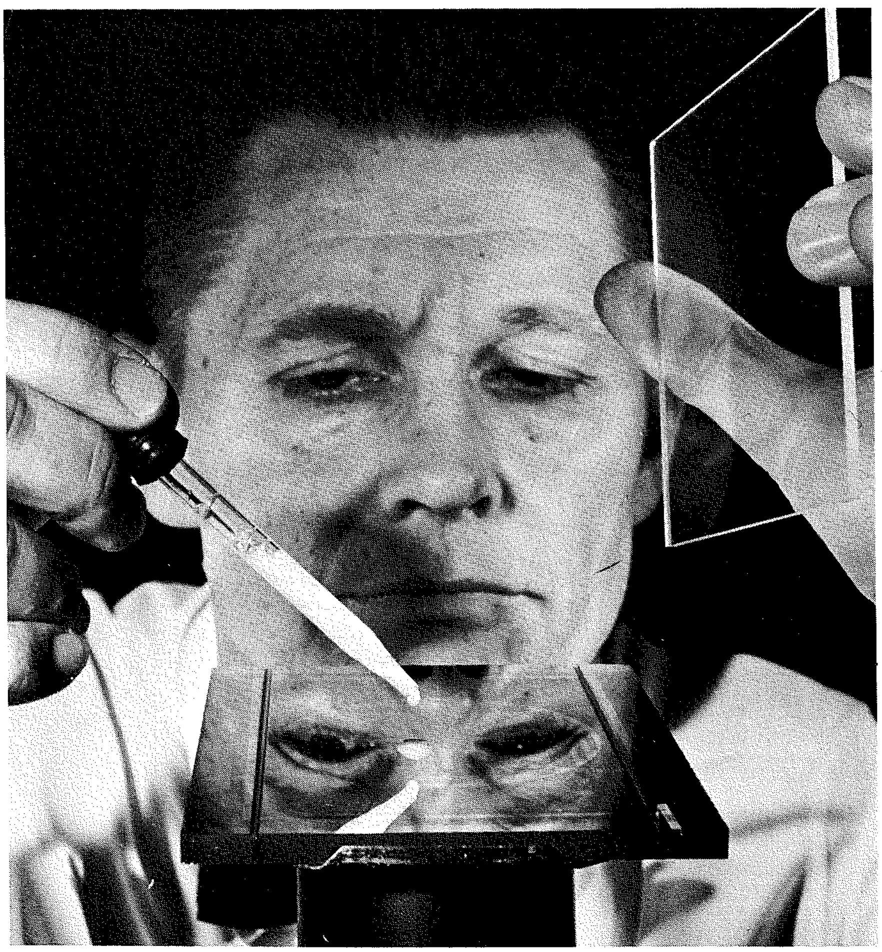


Fig. 2—Fabrication of liquid-crystal display.

tion temperature is also sharp, reversible, and reproducible.

Smetic and cholesteric states

For the sake of completeness, it is appropriate to mention that there are two other classes of liquid crystals. These are also shown in Fig. 1. In the nematic state, the molecules are free to slide with respect to one another; however, this is not true of liquid crystals in the smectic state (smectic comes from the Greek word meaning "soap-like"). This class of liquid crystals is characterized by a layered structure. The cigar-shaped molecules in this class are once again parallel, but are not free to slide with respect to one another. In the liquid crystals of the so-called cholesteric class, the molecules are once again found in layers. Within each layer, however, the axes of the molecules are parallel, and there is a twist in this preferred axis as we go from one layer to another. Unfortunately, when the term liquid crystals is found in the trade literature, no distinction is made between the classes and the term refers almost exclusively to the cholesteric class. These materials have been of recent interest, because they possess the property of being able to change their color as a function of temperature, thus they have been used as temperature indicators of various kinds.[2]

Dynamic scattering

The structure used to demonstrate dynamic scattering consists of two pieces of glass, one with an inner coating of transparent conducting material (tin oxide), the other with a coating of reflecting, metallic material (nickel or aluminum). To fabricate the cell, a drop of the liquid crystal material is placed on one of the plates and a sandwich is formed by placing another plate on top of it (Fig. 2). Since the layer of the liquid is only roughly 1/1000 of an inch thick and is maintained between the plates by capillary action, the conventional problems of handling liquids are not experienced. With no field applied, the structure is transparent; when a DC voltage is applied it becomes milky white. This is *not* due to a chemical change. It is due to the scattering of light. The sample returns to its transparent state when the voltage is removed. Since the size of the

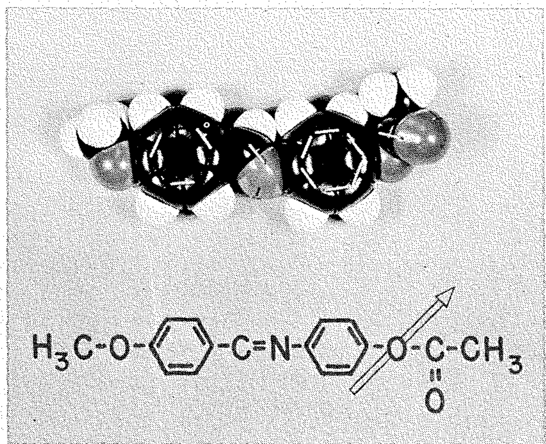


Fig. 3—Anisylidene-p-aminophenylacetate—a material that exhibits dynamic scattering.

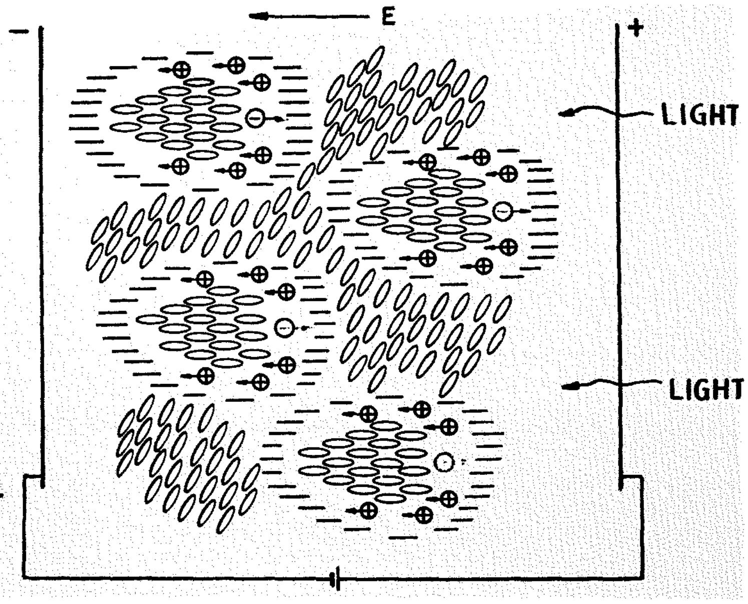


Fig. 4—Schematic representation of dynamic scattering.

scattering centers are approximately 5 microns, white light is scattered as white light[3] (there is no wavelength dependence in the scattering process for visible radiation).

Fig. 3 illustrates a particular compound which exhibits dynamic scattering. The material in question is anisylidene-p-aminophenylacetate. This material is nematic between the temperatures of 82° and 110°C although we have developed proprietary materials which are nematic at room temperature. There is something very specific about the structure of this molecule. The main electric dipole moment does not lie along the main molecular axis. This can be seen also in the model which appears in Fig. 3. Note the cigar-shaped character of the molecule and note also the appendage which represents the main molecular moment which finds itself at an angle with respect to the main molecular axis, With this as background, it is now possible to discuss the mechanism of dynamic scattering.

Consider once again a plate electrode (planar electrode) structure: basically, a parallel plate capacitor with a liquid-crystal dielectric as shown in Fig. 4. When one applies a DC voltage, the initial tendency of the molecular swarms of the nematic state is to align with their permanent moment in the direction of the field. For the materials in question, the main dipole moment does not lie along the main molecular axis. Consequently, the axes of the cigar-like molecules find themselves at an angle with respect to the electric field and the electrodes.

If we now permit an ion to move through this ordered structure, it tends to disrupt the ordering, and in its wake it tends to produce an alignment with the main molecular axis along the direction of ion transit. Since these molecules are highly birefringent, a region of discontinuity exists between those molecules inside the wake and those molecules outside the wake. This discontinuity, since it represents a region of changing index of refraction, can effectively scatter light. It is characteristic of scattering centers which are of the order of 5 microns in diameter that most of the light is forward scattered[3]—that is, scattered in the same general direction in which the light was initially traveling. Hence, if the effect is to be maximized for reflected light, a specular reflecting back electrode must be used to redirect the light back toward the viewer.

Display characteristics

It is appropriate to review briefly some display-related parameters of which this new effect is capable. The equivalent circuit of the device is that of resistor (~1 megohm/cm²) in parallel with a capacitor (~200 pF/cm²). The mode of operation can either be reflective or transmissive depending on whether the back electrode is a specular reflector or a transparent conductive coating.

Contrast

Contrast ratios greater than 15:1 in reflection have been obtained. This contrast ratio is independent of the ambient light, thus displays based on dynamic scattering will not wash out even in direct sunlight.

Power required

The maximum power necessary to operate the display is approximately a milliwatt per square inch of display area. The operating voltages are between 6 and 60 volts DC. The 60-volt level is that which one must use to obtain maximum contrast; the 6-volt level is the threshold level for the effect. Since the contrast varies between 6 and 60 volts, there is gray scale capability.

Response

The maximum reflection efficiency for this effect is 40 to 45% of the standard white ($MgCO_3$). The addressing time or the time necessary to impart information to the display is less than 60 microseconds. The response time of the effect is in the range of 1 to 5 milliseconds. The natural image decay time, or the period which it takes for the display to revert back to its initial state after the field is removed, can be varied from 30 ms to one second depending on the temperature, the specific materials used, and the method of fabrication. Since the active layer of the liquid is only of the order 1/1000 of an inch thick, the total thickness of a liquid crystal display panel can be less than a quarter of an inch. The temperature range of useful operation using RCA-proprietary material is 20°F and 212°F. While the materials are nematic below 20°F, the response is sluggish.

Resolution

The resolution for the effect is roughly 500 TV lines/inch. There are field-of-view restrictions due to the necessity for a specular-reflecting back electrode but these seem to be tolerable for a wide range of applications.

Reliability

Life studies are presently in progress. Results do look encouraging, and we have obtained over 3,000 hours of continuous life to date.

Applications

Several experimental devices that could lead to important new electronic products have been fabricated to demonstrate the versatility of this new display concept. These include a simple numeric indicator, an all-electronic clock with no moving parts, and an electronically controlled window.

Electronic window

The electronically controlled window is perhaps the simplest device. Basically, it is a parallel plate capacitor with transparent electrodes (tin oxide on glass). With no voltage applied the window is clear. When approximately 50 volts is applied the window becomes opalescent (Fig. 5). It is possible that this opalescent effect could be used to provide glass door panels and windows that could be frosted at the touch of a button to insure privacy for the users. A step away from that is the possibility that liquid crystals can be used to provide electronic curtains that will automatically control the amount of sunlight admitted into our homes.

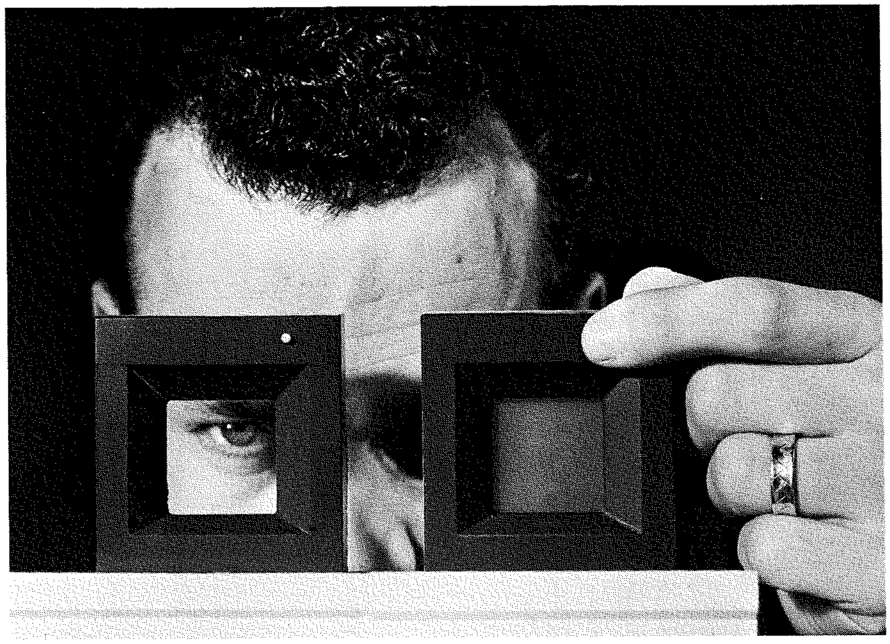


Fig. 5—Electronically controlled window.

Numeric indicators

If one wishes to operate the liquid crystal panel as a reflective display, a specular reflecting back electrode is needed as previously mentioned. Edge lighting is possible for viewing under conditions of complete darkness. A seven-segment numeric indicator (capable of displaying the numerals 0 through 9 by application of excitation voltage to the proper segments of the cell) has been constructed which uses commercially available integrated circuits for the clock (TIS43), counter (TISN7490) and decoder (Fairchild L930759). Discrete transistors (2N40084) were used for the segment drivers. The panel consisted of the glass/liquid-crystal/glass sandwich discussed previously with segmented electrode defined by photoresist techniques. The device and associated electronics is shown in Fig. 6.

All-electronic clock

The liquid crystal display concept could lead to quite different approaches for some fairly conventional commercial products. One such product which falls into this classification is the familiar time indicator or clock. A clock has been constructed which has no mechanical moving parts. The basis of this clock is the seven-segment liquid crystal numeric display cell. Four of these cells arranged in a row

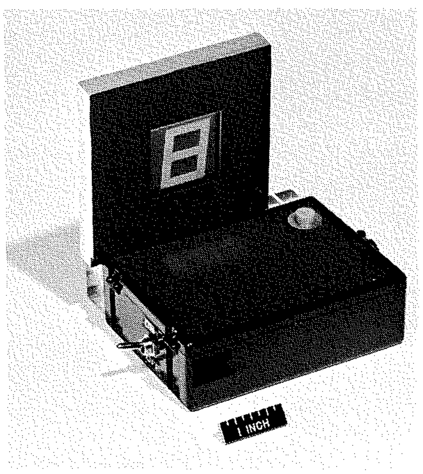


Fig. 6a—Battery operated liquid-crystal numeric indicator.

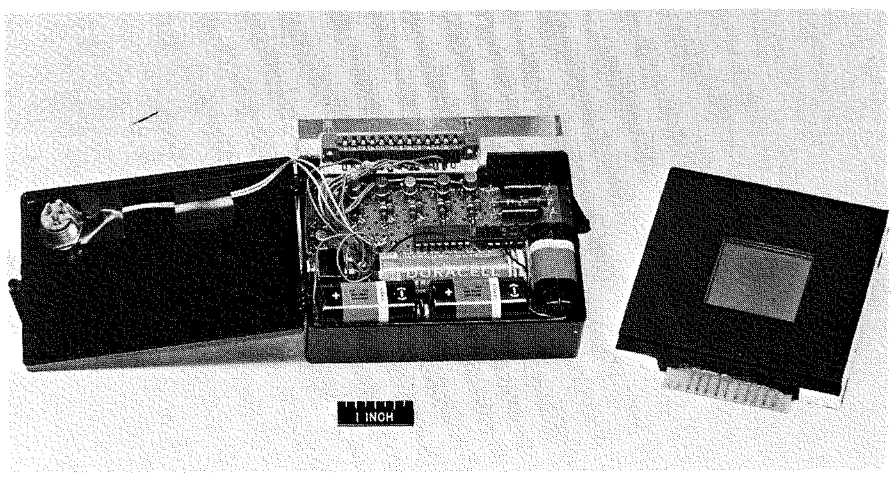


Fig. 6b—Electronics for the numeric indicator.

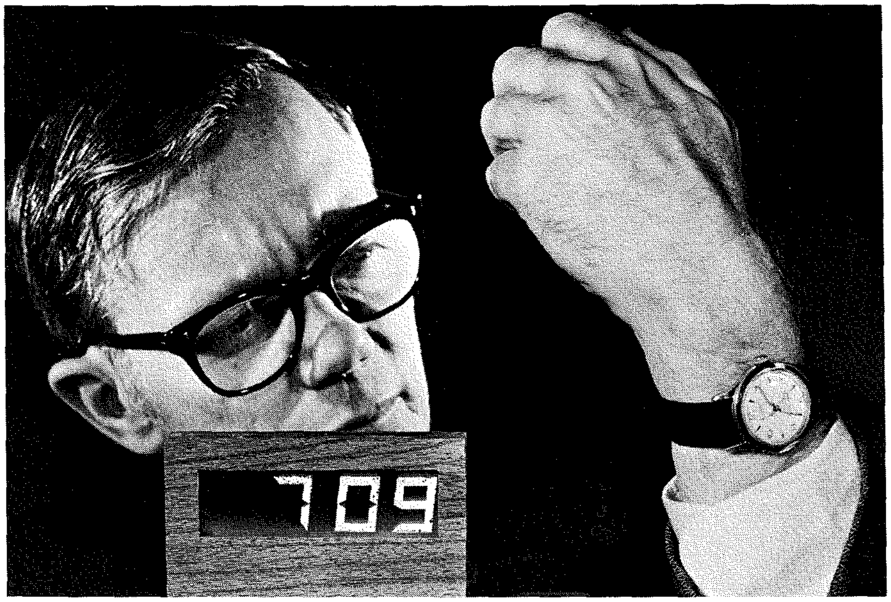


Fig. 7—All-electronic clock based on the liquid-crystal display.

can then be used to present the time in hours and minutes or, with two additional cells, the seconds can be displayed.

The electronics to control the display numerals are a rather straight-forward application of presently available integrated-circuit counters. The time reference can be either a crystal oscillator or, as in conventional clocks, the 60-Hz line frequency. In the case of the line reference, the 60 Hz is first divided by a 60-to-1 counter to produce pulses at 1 Hz. These 1-Hz pulses are then counted by 10 and 6 to produce the seconds and the tenths of seconds information. The output of the counters used in this clock occurs in binary-coded-decimal (BCD) form and therefore must be decoded into a form suitable for driving the seven-segment display. This can be accomplished with a series of binary gates or perhaps the easiest way is to use a commercially available BCD-to-seven-segment display integrated circuit mentioned previously.

In similar fashion, the output of the seconds counter is further divided by 10 and 6 to produce the minutes and the tenths of minutes. Likewise the minutes counter is divided by 10 and 2 to produce the hours and tenths of hours. Of course when the hour count reaches 12, it is necessary to include logic to recognize this condition and arrange to reset the hours to 1 rather than 13 upon receipt of the next count pulse.

Initially, the clock display is set by means of bypass switches which allow 1-Hz pulses to be fed directly into each numeral counter and thus index that particular numeral at a 1-Hz rate until the proper numeral is displayed. A crude prototype of such a clock is shown in Fig. 7. The low-power and flat construction characteristics of the liquid-crystal cell are such that in the future it may be possible to extend this concept to an all-electronic wrist watch.

Television

In years to come, the liquid-crystal display concept may yield a practical thin-screen competitor to the cathode ray tube used in radar and TV displays. The low voltage and power requirements certainly lend themselves to integrated circuitry for the complex addressing function instead of the electron beam. In this case, the electrodes would form an X-Y matrix with the selection of a given element performed by the scanning signals. The cost and complexity of the addressing circuitry, however, make this application impractical at the present time.

Liquid crystals versus electroluminescent cells

The circuit characteristics of liquid-crystal devices are similar to that of a field-effect electroluminescent cell. Both liquid-crystal cells and electroluminescent cells behave essentially as a linear capacitor in parallel with a high resistance. In addition, liquid-crystal analogs to the well known photoconductor - electroluminescent image converters and light amplifiers can be prepared by similarly coupling a photo-conductive layer in series with a liquid-crystal cell. The resultant image converter and/or light amplifer will differ from its electroluminescent-photoconductor analog mainly in that the liquid-crystal device operates by the reflection and/or scattering of light from an ambient light source while the electroluminescent device obtains its light by the luminescence of the electroluminescent material.

The liquid-crystal display, however, possesses several important advantages over electroluminescent phosphors:

1) Reflective or transmissive operation;
2) Contrast is independent of the ambient;
3) Lower voltage and power requirements;
4) The DC operation simplifies the addressing function (audio frequency used in electro-luminescent cells for best results); and
5) One is not restricted to a specific color for the display.

Conclusions

Liquid-crystal displays based on dynamic scattering offer:

1) Reflective operation—hence a contrast ratio that is independent of the ambient light;
2) Low-power low-voltage operation making them attractive for solid state addressing schemes;
3) Rugged flat construction; and
4) Potential low cost (the liquid crystal material costs less than a tenth of a cent per square inch of display).

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The use of computers in editing and composition

A. H. Coleman

The modern digital computer is rapidly permeating all areas of our highly industrialized society—from agriculture to education—from process control to zoology. Printing and publishing and allied fields involved in graphic communications have been changing rapidly in this decade as the digital computer and associated peripheral devices have made rapid inroads in the graphic communications process. This paper describes the nature of the impact which the digital computer has had, and is making, upon today's graphic communications, particularly upon the editing and composition functions. A prediction of the future impact is also presented.

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THE GRAPHIC COMMUNICATIONS PROCESS or system may be defined as the totality of men and machines by which the information created by a few is disseminated to many in a written or graphic form. Some of the forms of information in today's industrial society include newspapers, magazines, books, encyclopedias, directories, and catalogs. Most modern *graphic* communication systems (other than private, person-to-person communications) are of the *broadcast* or *batch* variety, as shown in Figs. 1 and 2. In a *broadcast* graphic communication system, a large quantity of a standardized printed product is created, printed, and distributed. This type of system differs in concept from a selective inquiry or on-line system where individuals request and obtain specific information.

Fig. 1 illustrates the creative segment of the graphic communications process. Information is created, obtained, and/or compiled by authors, reporters artists, draftsmen and similar personnel in the form of a rough manuscript. This manuscript is then edited and organized into a final manuscript of the complete printed product-to-be. The final manuscript is then composed into a single set of typeset pages on metal or on film. These pages contain the selected typefaces and have been properly justified, hyphenated, paginated, footnoted, etc., and are identical in overall appearance with the final printed product. Depending upon the time available, the composed pages may be proofread and corrected via one or more correction cycles.

Fig. 2 illustrates the production segment of the graphic communications process. Printing plates are made from metal "chases," or film sheets which are produced during composition. These are mounted upon high-speed letterpress or offset printing presses. The resulting printed product is folded, bound and addressed and distributed to the ultimate consumer by a variety of transportation methods. The consumer "requests" the specific printed product directly or indirectly by subscription and payment or by direct purchase.

Some of the printed products produced by this broadcast graphic communications systems are newspapers, magazines, encyclopedias, directories, guides, catalogs, and parts lists. Timely products, such as newspapers and magazines, are beginning to develop regional editions to provide a degree of customizing for geographically grouped consumers. Other products such as encyclopedias, dictionaries, etc.,

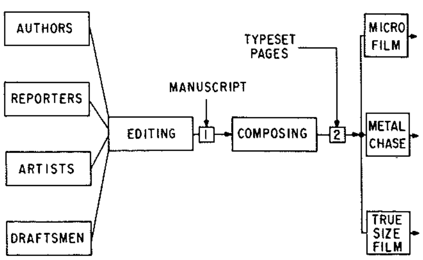

Fig. 1—Graphic communications process—Part I (creation).

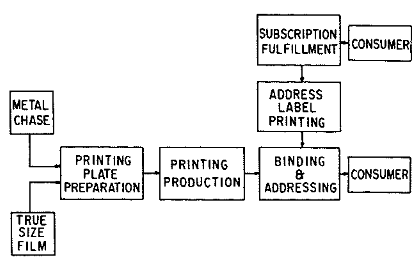

Fig. 2—Graphic communication process—Part II (production).

require more frequent revisions so as to keep abreast of the rapidly increasing acquisition of new knowledge.

The modern digital computer has assumed the function of subscription fulfillment for the larger firms engaged in the production of magazines and other periodicals. It has also made a significant entry into the area of text composition in conjunction with phototypesetting equipments. The remainder of this paper will be concerned with the nature of the latter impact.

Generating galley proofs

The first and most common application of digital computers in the composition of printed products is in the generation of galleys for proofreading and for paste-up onto a page. In this type of system (see Fig. 3) keyboard operators type the rough manuscript and enter at the same time the typographic or composition instructions which designate typeface, point size, line measure, body lead, etc. As the operators type, a paper tape is perforated. This paper tape contains digital codes representing both the text characters and the typographic instructions. Upon completion of a "take" or section of a manuscript, the paper tape is inserted into a paper-tape reader which converts the perforated digital codes into electrical signals which are entered into the computer. The computer justifies and hyphenates the text within the specified line measure and perforates a second paper tape which contains instructions for a linecaster or phototypesetting equipment. The paper-tape output of the computer is fed into the paper-tape reader which is part of the linecaster or of most first-generation phototypesetting equipments. The linecaster machine casts lines of metal characters of the specified typeface and point size; the phototypesetting equipment exposes film or photosensitive paper from photographic character matrices by projection. Galley proofs are read; corrections are made; entered via the keyboard and produced on a line-by-line basis; and, then correction lines are inserted and merged with the original galley. The corrected galleys or columns of type are then assembled within a metal chase for "hot" linecast or are pasted up to form a complete page.

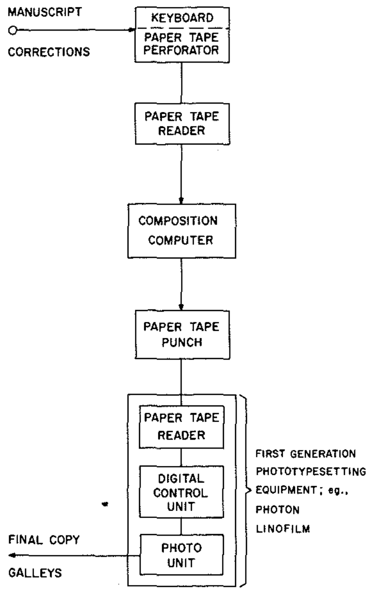

Fig. 3—Early generation computer composition system.

What role does the computer play in the above described computer composition system? Primarily, it simplifies the task of the operator who formerly keyboarded text and instructions directly into the linecaster or phototypesetting equipment. He is relieved of the time-consuming tasks of line justification and hyphenation and of generating repetitive typographic formats. The computer does not perform the tasks of merging corrections to update a galley or of composing pages from galleys. When used in conjunction with first-generation phototypesetting machines, the computer composition system shown in Fig. 3 does provide for substantial increases in labor productivity as compared to manually operated linecasters.

Early typesetting systems

The computer composition system shown in Fig. 3 may be used with paper-tape operated linecaster machines or phototypesetting equipments. The linecaster composes lines of metal type. It was embodied into a practical

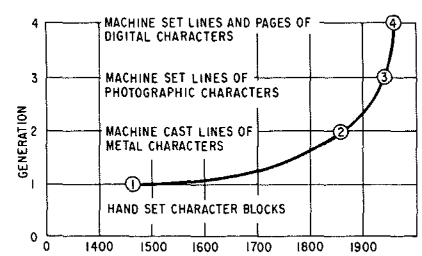

Fig. 4 — Evolution of basic composition methods.

production equipment in 1886 by Mergenthaler. It may be considered (as shown in Fig. 4) as the second generation of basic composition methods or techniques—the first generation being represented by the handset blocks of type as conceived by Gutenberg in the 16th century.

The third generation of basic composition equipment did not arrive until approximately 60 years later with the advent of the first phototypesetting equipments. In these phototypesetters, the characters of a specific typeface are stored on a photographic grid or matrix contained within the equipment. A specific character is selected from the grid by a combination of mechanical and optical techniques and is projected onto film or photosensitive paper. A line is formed by mechanical motion of a lens or of the film or paper. This type of phototypesetter has been manufactured since World War II and is finding increasing usage as offset printing grows in popularity.

Fourth-generation typesetting system

The availability of high-speed composition computational capability in the 1960's has stimulated the development of the *fourth* generation of basic composition equipment with speed and flexibility commensurate with the modern digital computer. In this type of composition equipment, characters are *not* stored as physical analogues of the characters to be printed; instead, a sequence of digital numbers is used to represent each character. These numbers define the length of the alternate white and black segments contained in each of a series of vertical strokes comprising a character (Fig. 5). High-quality printed characters are obtained if the number of vertical strokes per inch exceeds 700 or 800. A lesser number of strokes per inch may be used for proofing purposes.

This type of phototypesetting equipment (Fig. 6) stores characters digitally in computer-type magnetic memories (such as magnetic tape, disc, or core memory) and exposes film via a cathode ray tube as the basic light source. The CRT electronic beam is moved in a series of adjacent vertical strokes and the beam is turned on and off to form specific characters. Thus, alphanumeric and special characters are generated with speed and flexibility commensurate with comparable characteristics of the digital computer.

In these fourth-generation systems, keyboard operators type the rough manuscript on punched paper tape, and enter the typographic corrections and composition instructions, using a composition language which facilitates man-computer communications.

The keyboard data is entered into the computer and stored on a magnetic disc file. When a complete article is entered and stored, the computer interprets the words of the composition language and translates into basic typographic instructions. It then justifies, hyphenates, and converts the basic typographic instructions into phototypesetting equipment commands. At the same time, the required typeface characters (which are stored on the disc file) are rapidly read into the high-speed core memory of the computer. The phototypesetting equipment is then directed to generate the composed galley, page proofs, or final pages.

When galley or page proofs are read and corrected, corrections are entered via the keyboards and are automatically merged to update the previously stored manuscripts. The final manuscript is then recomposed by the computer and final photocomposed film sheets are generated.

The fourth generation composition system described above provides a number of significant performance improvements over the first generation system.

1) Keyboard operation is greatly simplified by the use of a composition language.
2) Corrections are automatically merged with stored manuscript which is subsequently recomposed.
3) A complete library of typefaces may be stored on a magnetic disc file. Any typeface may be retrieved within a fraction of a second for use in output generation.
4) Galley proofs are generated at high speed.
5) Proof and final pages are automatically generated at high speed in response to page layout instructions.

RCA's role

Videocomp—70/820 and 70/830

The Graphic Systems Division was formed in early 1965 to develop systems and equipment for the improvement of the graphic communications process. Since that time, the Graphic Systems Division has emphasized the

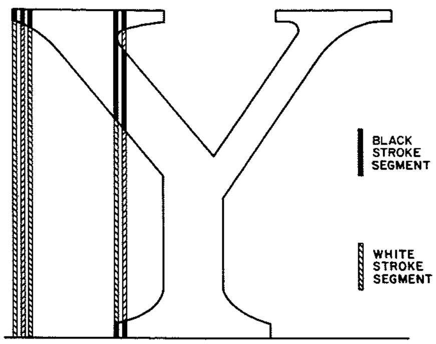

Fig. 5—Digital character representation.

improvement of the editing and composition functions with their VIDEOCOMP systems. These systems are high-speed, cathode-ray-tube phototypesetting equipments which employ typographic characters stored as digital numbers. The first equipment—the 70/820 VIDEOCOMP—was announced in June 1966. Fourteen equipments were delivered in 1967 and 1968, and are currently in use throughout the country in various typesetting applications. The second equipment—the 70/830 VIDEOCOMP—was announced in February 1968; three equipments were delivered to large printing organizations in 1968 and 1969; at this writing, more than twenty are on order.

Both VIDEOCOMP phototypesetting equipments generate high-resolution alphanumeric characters on photosensitive material in response to text and command codes stored on magnetic tape input.[1] The characters to be generated are stored as digital numbers in the high-speed memory which is part of each equipment. In response to

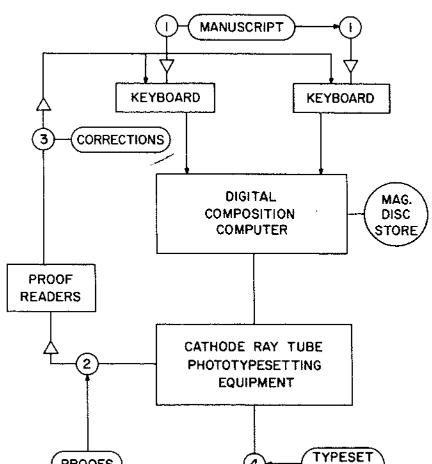

Fig. 6—Page composition computer system.

character codes on the input magnetic tape, a specific character is retrieved from memory. The digital numbers comprising the character are used to control the length and position of vertical strokes of light generated by a high-resolution cathode ray tube. These strokes of light are imaged upon phototypesetting film, paper, or paper offset plate to form the desired characters along a baseline. Successive baselines are generated by precise vertical motion of the photosensitive material. The combination of high-resolution cathode-ray-tubes; high-speed, random-access computer memories; and extremely sensitive phototypesetting film and paper has made these equipments feasible and practical at this time. The major comparative performance characteristics of these equipments are summarized in Table I.

Videocomp—70/840

The new VIDEOCOMP 70/840 system, announced on May 1, 1969, is the third member of the growing VIDEOCOMP product line. This system provides modular and functional capabilities beyond the 70/830 systems which include:

1) Disc storage of fonts, electronic forms, and logotypes;
2) Drawing scanning — allowing any drawing to be digitized in a compact format and recorded on magnetic tape; and
3) Drawing writing.

Thus, a drawing may be positioned electronically to any location and in any size within a page. The 70/840 is also the first VIDEOCOMP system which writes in a page-by-page mode (no film motion during page writing) in addition to the currently employed line-by-line writing mode.

The VIDEOCOMP phototypesetting equipments constitute the high-speed output element of the fourth generation composition system. An equally important element of this system is the general-purpose computer which performs the major composition functions. This computer accepts keyboarded text and corrections; stores and updates manuscripts; composes pages; and generates output data for VIDEOCOMP equipments. In order to make the speed and flexibility of the computer / VIDEOCOMP combination readily available to book designers, editors, etc., a composition language (known as PAGE-1) has been developed. This language facilitates com-

Major characteristic	70/820 VIDEOCOMP	70/830 VIDEOCOMP	70/840 VIDEOCOMP
Type output	True size	True size and micro size	True size and micro size
Text characteristics			
Information output	text	text	text, forms, or drawings
Random access storage	no	no	yes
Writing mode	line-by-line	line-by-line	line-by-line and page-by-page
Maximum line	5.4 inches	11.7 inches	11.7 inches
Character size	4 to 24 points	4 to 96 points	4 to 96 points
Character resolution (strokes/inch)			
Mode A	——	900 to 1800	900 to 1800
Mode B, C	450 to 900	450 to 900	450 to 900
Mode D	——	225 to 450	225 to 450
Maximum speed (characters/second)*	up to 600	up to 3,800	up to 3800
Minimum vertical increment	1 point	1/32 point (0.4 mils)	1/32 point (0.4 mils)
Minimum horizontal increment	1/50 em	1/50 points (0.3 mils)	1/50 point 0.3 mils
Drawing characteristics			
Scan rate (drawings/hr.)	——	——	15
Write rate (drawings/hr.)	——	——	600

* Without font changes: depends upon line length, leading, character size/and resolution, typeface, character mix, etc.

Table 1—Major performance characteristics of Videocomp phototypesetting systems

munications between editors and book designers on one hand and the computer composition program and VIDEOCOMP on the other hand.

Composition language

Each page to be printed is considered as a typographic entity which is composed of one or more *blocks* of text or graphics. The composition language is based upon the premise that there are a finite number of text blocks in use and that these blocks are highly repetitive in a typographic sense and in a given printed product. Therefore, it is advantageous to prepare in advance a format statement of processor program (known as a VIDEOFORMAT) which will be used by a processor to control the generation of text blocks and pages with specific composition characteristics.

Each VIDEOFORMAT is, in turn, composed of a string or sequence of basic typographic control words, known as VIDEOWORDS. These VIDEOWORDS consist of two alphabetic characters followed by a numeric parameter. VIDEOWORDS are used to control the generation of elementary composition functions, such as:

Boundary control,
Text manipulation
Typographic control,
Arithmetic and conditional control, or
Overall composition control.

Each VIDEOWORD has a unique and positive meaning which causes the computer to execute a particular function. For example, the word, new line (indicated by NL in the composition language) will cause the computer to terminate setting in the current line and begin setting in the next line without justifying the current line. All VIDEOWORDS in the language are spelled by a unique combination of two letters, e.g.:

Body lead	BL
Page number	PN
Point size	PS
Typeface	TF

Many of the VIDEOWORDS require a qualifier, or a *parameter,* in order to completely define their function. For example, the VIDEOWORD, PS, will specify the point size for the text, but until the exact point size is specified, the computer will not have sufficient information to perform its function. Thus a user of the language may write PS, 10, and the computer will then set all type in 10 point until further instructed (i.e., the number 10 is the parameter of the word PS) and it may vary each time the word is used. In this case, the parameter is simply a number or constant.

The user may wish to write a word, but not wish to specify the value of the parameter at the moment. To do this he uses a *variable* rather than a constant as the parameter. A variable in the composition language is merely the name of a location in the computer where the parameter is stored. There are 200 variables available at any one time, and they are named GV 1 through GV 200. To use a variable rather than a constant to specify point size, the user would write PS, GV5. In order to make the general variable number five equal to the proper point size (e.g. 10 point) the user would simply write GV5, 10.

When the computer executes the VIDEOWORD PS, it will notice that the parameter is a variable, look up the specified value in location GV 5, and set the text in 10 points. The benefit to be gained by the use of variables is the elimination of re-keyboarding of instructions for formats which are repetitive.

In this discussion of the composition language vocabulary, the first rule of punctuation is: that a VIDEOWORD is always separated from its parameter or variable by a comma (,). If a control word has more than one parameter, they are each separated by commas. There is another rule of punctuation: A control word and its parameters are separated from the text to be set by brackets ([]). Since the VIDEOWORD is spelled with letters from the same alphabet as used for text, the brackets merely indicate, to the translation program in the computer, which characters are data and which are control codes. A number of VIDEOWORDS may be strung together—e.g. [PS, 10] [BL, 12] [TF, 6]. In order to reduce keystrokes, the Composition Language has made a semicolon (;) equivalent to the double bracket. Thus, the above string could be written as [PS, 10; BL, 12; TF, 6]. In the composition language, these punctuation marks are referred to as *delimiters.*

The above example represents the method for building strings of words, or sentences, in the Composition Language. Unlike most other languages, here it is possible to build meaningful strings of words independent of their order. For example, the user will experience the same results whether he writes [PS, 10; BL, 12] or [BL 12; PS, 10]. It is evident that a similar example in English would either produce nonsense or a legitimate sentence but with a different meaning. In the composition language, it can be said that generally the string of VIDEOWORDS, parameters, and delimiters is legitimate if each control code is legitimate. There are exceptions where certain codes must follow in a sequence.

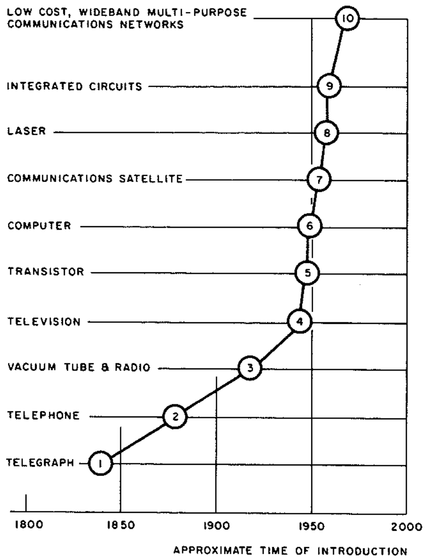

Fig. 7—Evolution of communication methods and techniques vs. time.

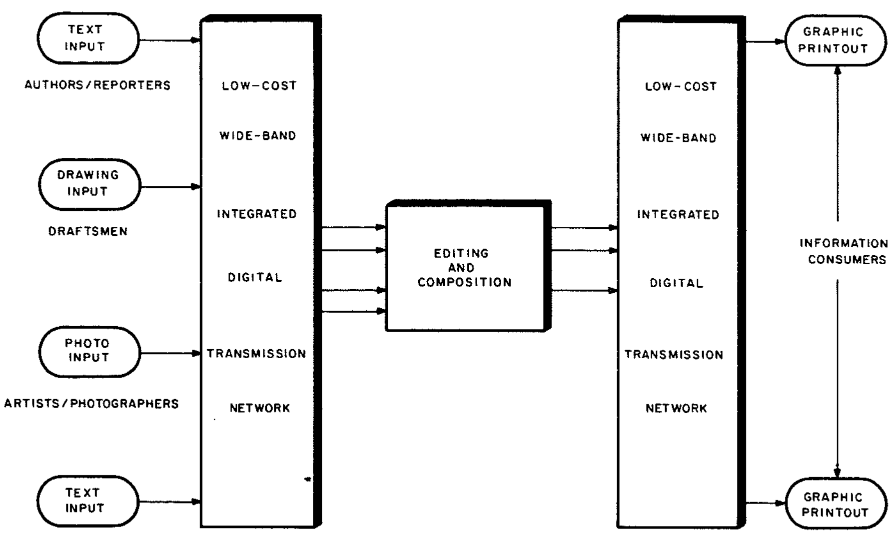

Fig. 8—Graphic communications process tomorrow.

Each string has a specific meaning which results in a unique typographical event, such as, a line of certain type set on a certain measure, or a space of certain dimensions located on a printed page. For this reason, sentences which are written in the Composition Language are called *format statements* or VIDEOFORMATS.

Many format statements are repetitive, that is, they are used with different composition. In that case the user would enter the format into the computer only once and thereafter would refer to it each time it applies. Rather than keyboard it every time he wishes to "say the same thing," the composition language provides the facility to refer to a format by a *defined name* consisting of one letter followed by one digit, e.g. c8. Using the 26 letters of the alphabet and 9 digits, there are 234 unique names available for formats. These are divided into two groups, A through S for formats and T through Z for synonyms.

The markup procedure used with the composition language is summarized below.

1) Define and store VIDEOFORMATS required.
2) Prepare and enter job specification; assign numeric values to general variables in VIDEOFORMATS.
3) Markup manuscript with VIDEOFORMATS and VIDEOWORDS; write name delimited by brackets at appropriate point in copy.
4) Keyboard marked-up manuscript.

This procedure permits a wide variety of complex typographic styles and formats to be developed and stored in the computer; then, with a minimum of effort on the part of both the designer or editor and the keyboard operator, these formats are designated to the composition computer.

Future systems

The combination of the modern digital computer with the modern high-resolution CRT as applied to the editing and composition functions has resulted in composition systems of high speed, flexibility, and productivity. These systems will facilitate the rapid composition and recomposition of graphic information at lower and lower cost. At the same time, as shown in Fig. 7, the evolution of communication technology and systems is rapidly leading to the widespread availability of low-cost, wideband multipurpose communication lines or links. What effect will these trends have upon the graphics communication process as we know it today?

To answer this question fully, it is necessary to recognize that the broadcast-type of graphic communications which we utilize today will become more efficient as the impact of the digital computer is felt in increasing depth. However, the accelerating knowledge explosion will place increasingly greater demands upon this process and upon each individual. The need for systems which provide central storage of continuously updated information and rapid access at reasonable cost to such information will become more and more pressing. It is therefore not inconceivable that the graphic communications process of tomorrow may be of the type shown in Fig. 8. In this system, the creators of information (authors, reporters, artists, draftsmen, etc.) will feed their information into a rapid access storage bank after editing and composition. From this storage bank, certain types of information will be distributed via mass-production broadcast methods as we know them today. Other types of information may be made available to individuals upon selective inquiry on an on-line basis. There are trends in several areas which foretell the advent of such on-line information systems. Systems, such as airline reservations, stock market quotations, ticket reservation/sales and other similar on-line information systems, are indicative of what the future graphic communications process may be. The development of fourth generation composition systems using *digital* typographic characters should facilitate the storage, manipulation and transmission of information of graphic arts quality and should contribute marterially towards on-line information systems of tomorrow.

Reference

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Computer-assisted instructional systems

R. W. Avery

This paper describes a Computer Assisted Instructional System which has been designed by RCA Instructional Systems for use in Elementary and High Schools for drill and practice in mathematics and the language arts. The system has been installed and is in daily use in the New York City public school system.

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received the BSEE from Purdue University in 1947. He joined Engineering Research Associates where he participated in the development of computer systems. Later at IBM he was in charge of the development of intermediate scale data processing systems including the IBM 650 and IBM 7070, as well as data communications products. Mr. Avery joined RCA in 1960 on the staff of the Chief Defense Engineer, Defense Electronic Products, where he participated in the independent research and development program and coordination of data processing projects. With the activation of RCA Instructional Systems he was transferred to that activity as Manager of Engineering. Mr. Avery is a member of IEEE, ACM, and the American Association for Advancement of Science.

USING THE RCA-DESIGNED INSTRUCTIONAL SYSTEM, individual instruction can be given to 6000 students on a daily basis by the use of 192 student terminals located in various schools and connected to a central processor via leased communications facilities. During each drill, a series of questions are presented to the student, and he enters his response on an alphanumeric keyboard. The student is then informed of the accuracy of his response; thus, the material presented is immediately reinforced, avoiding the delays necessary when similar work is done by the student on paper and corrected by the teacher.

Organization of the curriculum

The curriculum material provided for mathematics lessons is organized as a series of concept blocks. A concept block is a set of material relating to a particular idea, or concept; for example, division of fractions. Some concept blocks (seven 10-minute sessions at the terminal in the case of mathematics) are constructed to provide drill and review material to students at various levels of difficulty.

In the mathematics curriculum now in use, the pretest given on the first day of a concept block establishes the level of difficulty for the second day's drill. If a student scores 85% or higher on a daily drill, he is moved to the next higher level the next day. If he scores from 60% to 84%, he stays at the same level. If he scores below 60%, he is given material at the next lower level the following day. The student's individual progress dictates the level at which he is currently working.

After a student has completed four concept blocks, he is given review material in addition to drill material. Review material is selected from that previously drilled concept block on which the student made his lowest post-test score. This score establishes the level of difficulty for the next four days. The review test score is substituted for the previous post-test score for that concept block. A student may review a concept block up to four times, receiving different material each time.

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Equipment configuration

The system which is designated to serve a school district or group of school districts consists of a central processor with up to four line concentrators and as many as 192 student terminals as shown in Fig. 1. Each line concentrator serves 48 student terminals. It buffers messages transmitted between the terminals and the processor and is normally located near the terminals. The link between the processor and line concentrator is a 2400 bit-per-second full-duplex circuit. The links between the line concentrator and student terminals are 110 baud full-duplex circuits.

The central processor consists of a Spectra 70/45G Processor Unit with 264,000 byte core storage, disc storage, communication controller, and input/output equipment. Lesson materials and student performance history summaries are stored in disc storage. The operating system is in core storage. The communications multiplexor interfaces the communications facilities which handle messages from the four line concentrators. The student terminal shown in Fig. 2 includes a teleprinter mechanism with special keyboard. It is mounted in a sound absorbing enclosure and it has an adjustable stand to accommodate students of various ages. The character set includes the numeric digits, alphabetic capital letters and 23 special characters. Of these, eight special characters are used for mathematics drill and practice. They are as follows:

- $\cup$ union of two sets
- $\cap$ intersection of two sets
- $\subset$ subset of ....
- $\rightarrow$ implies
- $\neg$ logical negation
- $<$ less than
- $>$ greater than
- $\neq$ not equal to

The line concentrator is a small-scale real-time digital computer with associated communications circuit buffering facilities and interface electronics. Messages from the control processor are stored in the 4,000-word core memory until required at the terminal. The student's response is also stored in the core memory prior to transmittal to the central processor.

Operating system

The Operating System which controls on-line CAI processing, is divided into four subsystems: the Control Monitor, the Interpreter, the Communications Input/Output Control System, and the Disc Input/Output Control System. These subsystems provide the capabil-

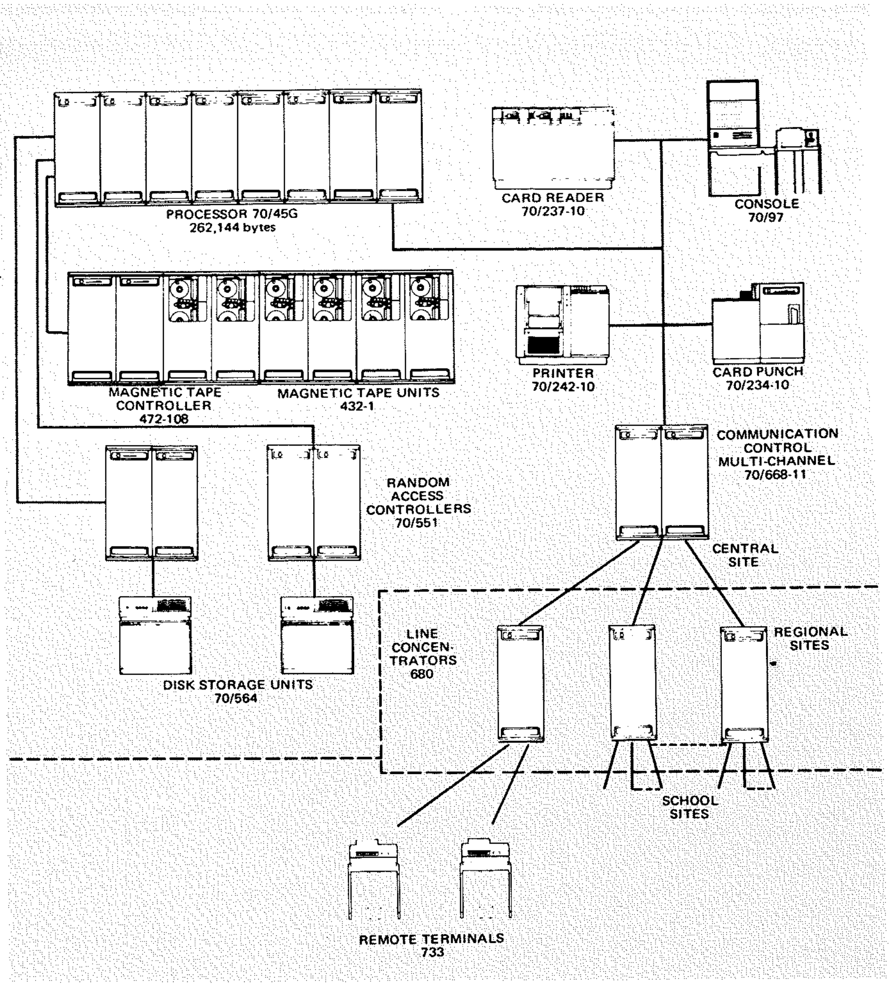


Fig. 1—Basic system for serving a school district or group.

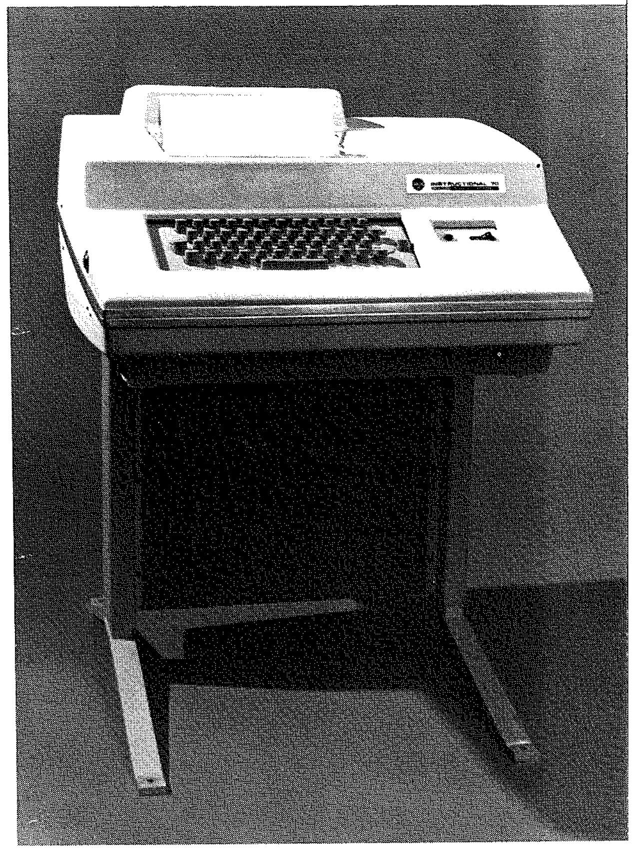


Fig. 2—Student terminal.

ities needed to execute the procedure program and handle the transfer of data between the disc, the central computer, and the remote terminals.

The Control Monitor receives control at the time the system is activated, at the start of each day's real-time run. Upon receiving control, the Control Monitor begins scanning an internal table called the Terminal Status Table (TST). Each remote terminal has an entry in the TST. When a student signals a request for action by pressing the START key at a remote terminal, an indication is made in the TST. The TST carries other information about the remote terminals; some of this information, such as file identification for a particular student, is obtained from the Student History Vector file.

When the Control Monitor finds an indication of an active terminal, it passes control to the Interpreter to begin execution of the procedure program which contains the logic for handling student registration, lesson processing, and assignment and updating of student history records.

The Interpreter continues to execute the procedure program until a request for transfer of data is encountered. At this point, the Interpreter returns control to the Control Monitor, which calls the Communications Input/Output Control System, if disc/computer transfer is requested. Since the transfer of data takes a relatively long time, compared to the execution of computer instructions, and can proceed independently of this execution, data transfer is initiated and control is returned to the Control Monitor.

The Control Monitor then continues to scan the TST, initiate the Interpreter, and supervise the CAI operations. Supervising this very complex interaction of data transfer and procedure program processing for 192 remote terminals is the main task of the Control Monitor. The other subsystems perform their various functions as a result of Control Monitor processing.

The Student History Vector contains information about each student's progress in the CAI program. The Class History Vector identifies each class participating in the CAI program; it also defines the course progression—the sequence in which the concept blocks for a course are presented for a particular class. The sequence is determined by the teacher, or by a curriculum expert, and may be modified during the Update Run. The Concept Block Name file contains information identifying and describing each concept block; this information is used in printing reports. The CAI Student Master tape contains information from all three of the previously mentioned files; it is used in producing reports and provides complete information on each student's progress for the year. The Student Master tape also provides a basis for recovery in case the other files are accidentally destroyed.

Report and update programs

The Report and Update Programs are utilized in the off-line processing cycle which produces the reports on student and class progress as shown in Fig. 3. In addition to these reports, these programs update and maintain information files and prepare the curriculum data base for the next day's real-time run.

Update Run processing occurs after each day's real-time processing. The reports produced are the Daily Status Report and the Student Map Report.

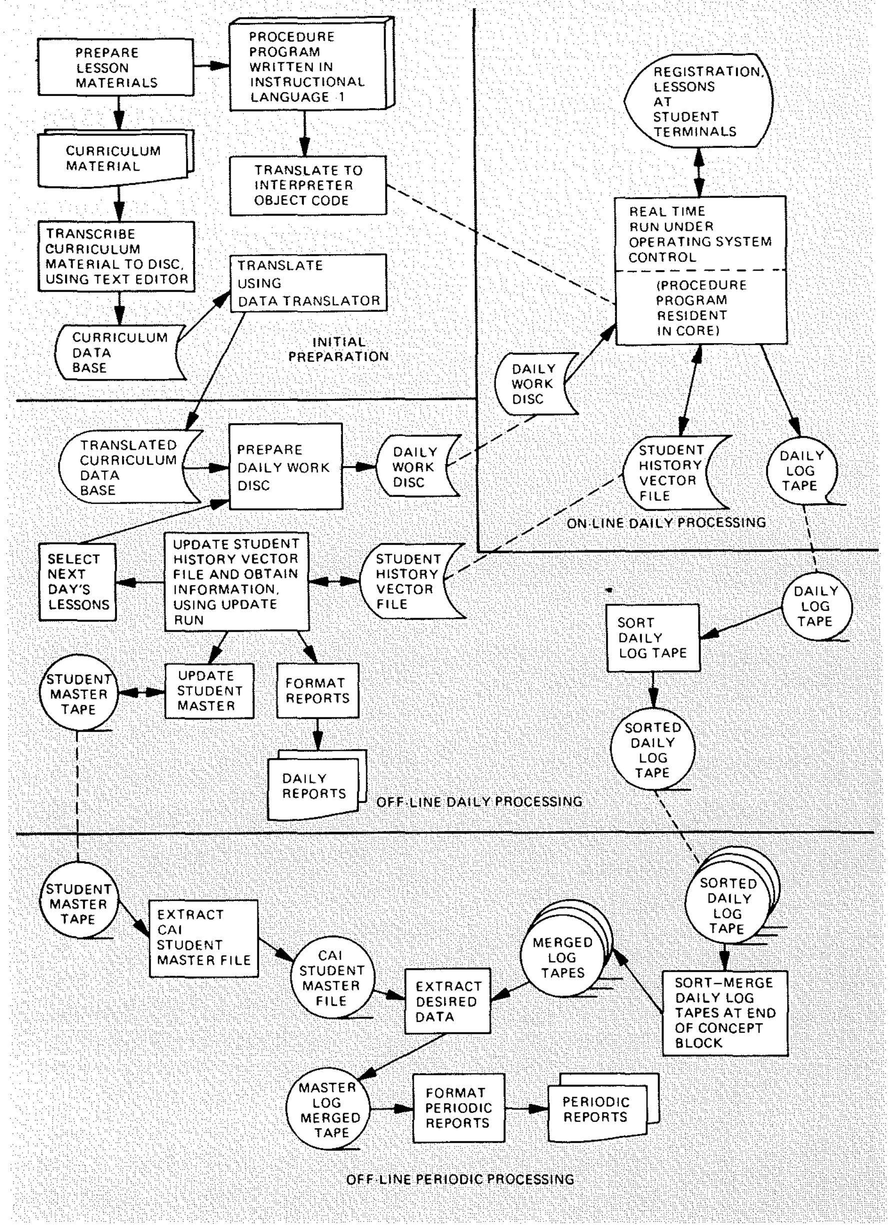


Fig. 3—Report and Update programs produce the reports on student and class progress off line.

The information files, which are updated and maintained, are the Student History Vector file, the Concept Block Name file, and the CAI student master tape. Information for the report generation is obtained from those parts of the Student History Vector file which are introduced by the mathematics procedure program as a part of the day's real-time processing.

Update Run processing is accomplished in four passes. During the first pass, a tape is created from the Student History Vector file, containing information about each class and each student's progress for that day. During the second pass, the tape produced during the first pass is sorted by class identification, and within class, by CAI student number. During the third pass, the Daily Status Report and Student Map Report are produced. Any changes to be made to the Class History Vector and Concept Block Name file are made at this time. Upon completion of a concept block, the Student History Vector file must be updated to the next concept block. An indication of the next concept block to be processed for each of these students is recorded in the Student History Vector file. After all updating, the Student History Vector, Class History Vector, and Concept Block Name files are copied onto the CAI Student Master tape. Finally, a tape is written containing the file identification codes for each file required for the next day's processing.

During the last pass, the tape containing the file identification codes is sorted, and the necessary files removed from the curriculum data base file, where they are stored as a result of Text Editor processing. These files are then translated by the Data Translator program, and placed in the daily curriculum file, ready for the next day's real-time processing.

The Daily Status Report provides class and individual information for the previous day's CAI processing. The report is headed by identification lines giving the school, teacher, subject, class, grade, and date. The items listed are:

1) List of concept blocks on which the class is working.
2) Names of students behind in a concept block.
3) Names of students who did not participate that day.
4) Names of students who scored above 90% on their current drill.
5) Names of students who scored below 30% on their current drill.
6) Names of students whose performance on their current lesson is more than 20% above their individual averages.
7) Names of students whose performance on their current lesson is more than 20% below their individual averages.
8) List of average percent correct on the post-test for each concept block.
9) List of each student's next lesson.
10) Number of students reviewing concept blocks, listed by concept block.
11) Names of students who have been temporarily rejected because of a system malfunction.

The Student Map Report is issued daily. The report presents a composite relationship between drill and review, total elapsed time and percentages, and each student's status in his concept block. Students are listed by student number. The report is headed by identification lines giving class, school, and date. The following information is given for each student, listed by student number:

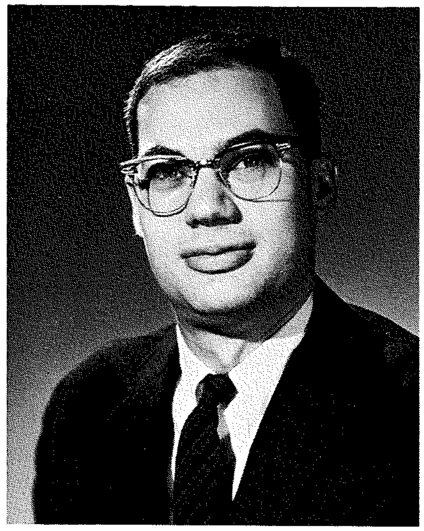
1) *Drill information:* Date, concept block, and level with grade and elapsed drill time for the pretest, the last lesson, the concept block to date, and the year to date.
2) *Review information:* Date, concept block, and level with grade and elapsed drill time for the last lesson, the concept block to date and the year to date.

This Computer-Assisted Instructional System represents an important initial step toward the development of highly productive and cost effective aids to education.

Remote data terminal

L. Sickles

A remote data terminal has been constructed for on-line operation with a Spectra 70/45 digital computer. The terminal, in conjunction with specially written subroutines, allows mixed analog and digital data generated by actual experiments in real time to be sampled and stored in the digital computer. Also, computer-generated data can be written to the remote terminal and reconstructed into analog data with the time base preserved. The terminal is free of computer operator interaction and can operate in a multiprogramming environment.



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received the BSEE from Lehigh University in 1957 and the MSEE from University of Pennsylvania in 1963. From 1957 to 1960, he was employed by Honeywell, Inc., where he was engaged in the research and development of nuclear instrumentation and A/D converters. In 1960, he joined the Advanced Technology activity at RCA and was engaged in research on parametric amplifiers and varactor multipliers for tactical radio gear, MOS transistors, and correlation techniques. In 1965, he was awarded a David Sarnoff Fellowship for studies toward a PhD in EE at the University of Pennsylvania and completed the course requirements in June of 1967. Since his return to Advanced Technology, Mr. Sickles has been engaged in various speech processing studies including techniques for the automatic evaluation of speech intelligibility. He has received two patents and has one pending.

THE REMOTE DATA TERMINAL was constructed for the purposes of

1) Inputting real time analog and/or digital data into a digital computer and
2) Reconstructing computer-generated data into its original form (be it analog or digital) in real time with the time base preserved.

The real-time requirements were fulfilled with A/D and D/A converters in conjunction with suitable control logic and interfacing logic. The converters and control logic are part of the remote data terminal and the interfacing logic is part of the graphic display system (GDS) in the computer center.

System configuration

Fig. 1 shows the relationship between the remote data terminal and the interfacing logic in the graphic display system (GDS) and the Spectra 70/45 central processor (CPU). The GDS provides the interfacing to the physical level software of the CPU, checks and generates parity for all data traveling between the remote data terminal and the GDS, and provides one level of buffering for the input portion of the terminal.

Input terminal

Data processing

Data is processed through the input terminal as shown in Fig. 2. Ten bits of digitized analog data and 6 bits of digital data (or up to 16 bits of digital data) may be transferred to the computer on each clock pulse. Analog data is supplied to an adjustable-gain differential amplifier, passed to a sample-and-hold circuit, and converted to a 10-bit parallel digital word by an A/D converter, with a 10-μs conversion time. The A/D converter is strobed whenever there is a positive-going level on the CONVERT input. At the conclusion of conversion, the A/D converter generates a positive-going END CONVERT signal. If analog data is being processed, the END CONVERT signal is connected to the SEND input. A clock signal applied to the CONVERT input then automatically triggers the A/D sample-and-hold circuit and generates a data strobe 0.5-μs following the conclusion of A/D conversion, transferring the contents of both registers to the GDS buffer. If it is desired to transfer digital data simultaneously with the analog data, the digital data may be strobed into the 6-bit register by applying a STORE signal. This signal may be coincident with either the CONVERT or SEND signal or may occur at any time between the two. If all digital data is to be sent, then the SEND and STORE inputs connected together are used alone. These signals will strobe the inputs into the two registers and automatically generate the data strobe 0.5 μs following the SEND signal.

The terminal can be operated in either an 8-bit mode or a 16-bit mode. In the 8-bit mode, each data strobe developed from the SEND input transfers the contents of the 6-bit register, the two lowest order bits in the 10-bit register, and a parity bit to the buffer register in the GDS. In the 16-bit mode, each data strobe transfers the entire contents of both registers and two parity bits to the buffer register in the GDS. The 8- or 16-bit option is useful when maximum speed is desired from the terminal or optimum data packing is desired.

Data is transferred from the remote data terminal to the CPU through a buffer register in the GDS interface. Depending upon mode, either 8 or 16 bits of data plus parity is transferred to the buffer on each data strobe from the remote terminal. Data is transferred from the buffer to the CPU 8 bits at a time. This is accomplished by initiating a service request to the CPU upon receipt of the data strobe. The 8 bits of data are transferred when the service request is honored. In the 8-bit mode, transfer of the first 8 bits frees the buffer for more data input. In the 16-bit mode, transfer of the first 8 bits initiates a second service request. Following transfer of the second 8 bits of data, the buffer is freed for further data input.

Operation

Operation of the input terminal starts when the processor executes a READ instruction addressed to the multiplexer channel to which the input terminal is attached. Data words are then sent to the computer under control of a local clock. The operation may be manually terminated at any time from the terminal panel by the user. Transmission parity errors and dropped data are indicated by lamps on the terminal front panel.

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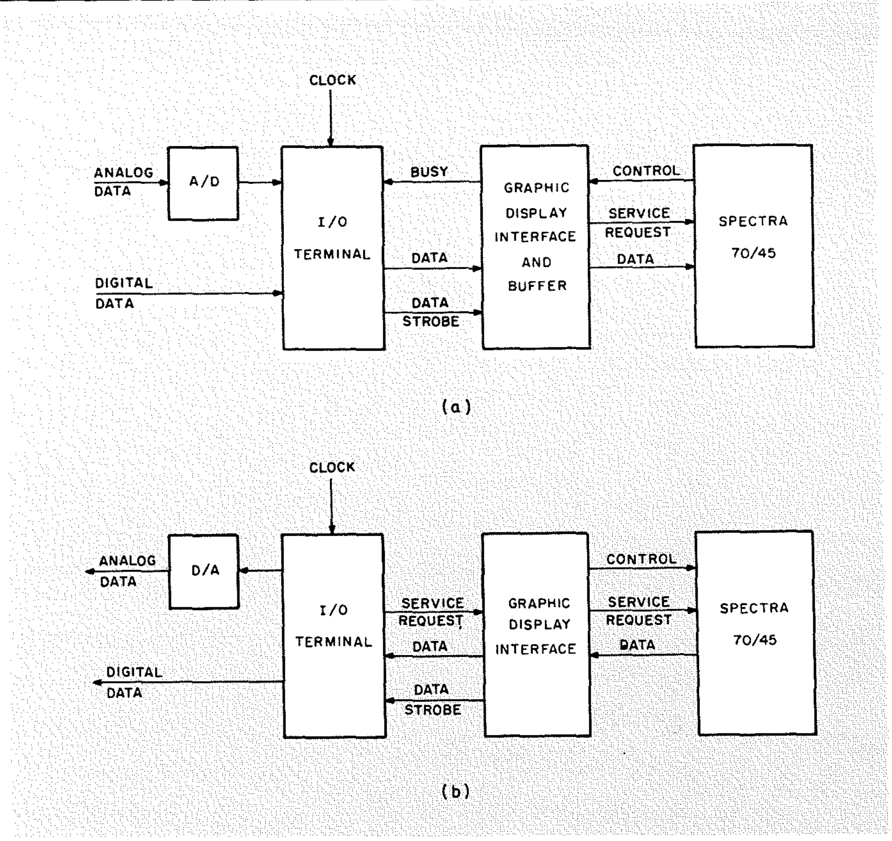


Fig. 1—System configuration for a) input terminal, and b) output terminal.

Programming for the input terminal is done in physical level file control processor (FCP) with the user doing all error recovery. The input interface will recognize a read or sense command in either the burst or multiplex mode with maximum data rates of 416 kbytes/second and 70 kbytes/second respectively.

Output terminal

Data processing

The output terminal (Fig. 3) consists principally of a packing register and a 12-bit D/A converter. The data terminal receives one byte (8 bits) of data from the computer for each data request. To obtain variable resolution from the D/A converter, two switch selected modes of operation are offered in the terminal. In the 8-bit mode, the user-supplied clock pulse is used to enter a service request to the processor through the GDS interface. A single byte of data plus a parity bit is then sent directly from the computer to the output terminal together with a data strobe, filling the output terminal HI register. The 16-bit mode operation is identical to the 8-bit mode except that the data strobe received by the terminal from the computer in response to the clock pulse is regenerated and sent as a second service request. A second byte of data is sent with its parity bit and routed to the LO register. Thus, in this mode, 16 bits of data are received for each clock pulse. A jitter-free time base is achieved for the reconstructed analog signal by strobing the D/A converter with a pulse that is delayed 9 μs from the clock pulse—the delay being set equal to a time greater than the maximum response time of the computer (which is 4.5 μs/byte).

The received data may be taken in digital form or from the 12-bit D/A converter. Depending upon whether the 8- or 16-bit mode is selected, either 8-bit or 12-bit resolution is obtained from the D/A converter.

Operation

Operation of the output terminal starts when a WRITE CONTROL instruction is executed, addressed to the selector channel to which the output terminal is connected. This instruction clears the output terminal for subsequent data to the terminal (depending on operating mode) upon application of each clock pulse. Manual termination of the WRITE instruction from the output terminal causes the processor to examine the status of two sense bits which are set by the user from the output terminal panel. These sense bits are used for program control and can affect a four-way branch in the main computer program. The WRITE instruction may also be terminated from the program in which case a WRITE CONTROL instruction must follow to again clear the output terminal. Parity errors are indicated by a lamp on the terminal panel. As with the input terminal, programming is done in physical level FCP with the user doing all error recovery. The output interface will recognize a write, write control or sense command. The maximum data rate through the output terminal is limited by the magnetic tape units from which the data is read; in the Spectra 70/45, these are 60,000-byte/s machines.

Applications

The impetus for construction of the input facility was due to a requirement for inputting a combination of analog and digital data from speech-recognition apparatus into the computer for analysis and plotting. The extension of the terminal to other applications was visualized and resulted in the addition of the output terminal.

As previously discussed, the terminal will handle a wide variety of input and output signal formats. Data transfer is on-line. Data is sent to, and received from, the computer synchronously with the user's own clock. This assures integrity of the data time base. Program control from the terminal can be achieved through a combination of programming and control lines. The terminal can operate in a multiprogramming environment if certain restrictions are met. It is apparent that the terminal is suitable for applications involving systems simulations as well as data input and output. At this point, three programs have been written for the terminal; a general-purpose input program (READER), a general-purpose output program (BLURP), and a special-purpose output program (SICKLE).

Reader

A general-purpose program called READER has been written by W. B. Schaming for the purpose of taking input data from the terminal and writing it on magnetic tape. The program writes data in 5,000-byte blocks to tape at any rate up to 40,000 bytes/s. It uses approximately 80,000 bytes of memory. Up to 10 tape writing errors are recovered by a tape edit routine built into the program. End files can be placed on the tape at any time by a signal from the remote data terminal. Termination of the program is manual from the remote terminal at which time a normal halt takes place.

The data written on tape by READER are read from tape and formatted by a series of FORTRAN callable subroutines: OPENUP, REWIND, and READIN. The basic format is a segmentation of each two consecutive bytes into a 10-bit word and a 6-bit word. The format of the 6-bit word is adjustable by selection of a parameter in the routine.

This series of programs is being used as general input program for the terminal. The program is presently being used to record data from speech recognition apparatus. The input signal consists of three time-division multiplexed signals. One, an analog signal which is the processed outputs of a 20-channel filter bank; the other two signals are digital and represent feature outputs and sync. The clock rate is 15 kHz. Another present application is the recording of atmospheric noise for the purpose of analyzing its statistics on the digital computer.

Blurp

A general-purpose program called BLURP has been written by C. R. Pendred for the purpose of outputting computer-generated data to the remote terminal. The program reads a magnetic tape and fills a 180,000-byte section of core memory with the data. If an end file is found on the tape before the entire 180,000 bytes are read, the remaining section of core is filled with the hexidecimal symbol '80' (zero volts for the D/A converter). Upon filling the allocated core, the program writes the data to the remote terminal synchronously with the applied clock pulse. Six seconds of speech sampled at 15,000 samples/s (30,000 bytes/s) can be written to the terminal with one WRITE instruction. No formatting routines are yet available as this is an interim program. A sequel program will allow continuous reading from tape and will have certain program control features.

Sickle

A program SICKLE has been written by C. R. Pendred for the purpose of operating a CalComp No. 560R plotter through the Remote Data Output Terminal. This program operates in a multiprogramming mode. The plotting rate is 150 increments/second.

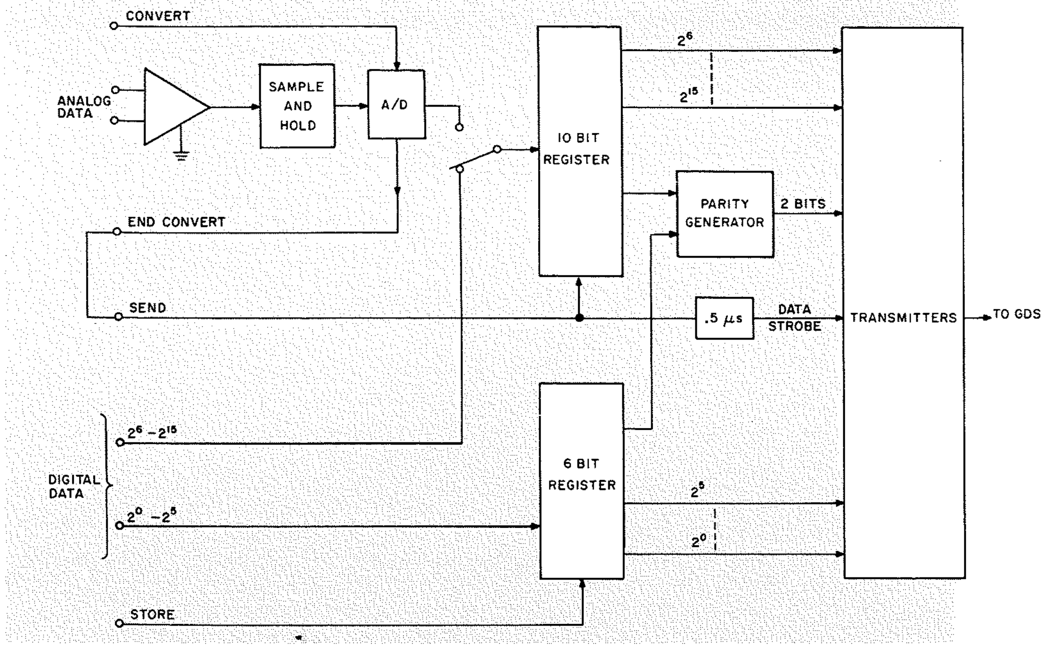


Fig. 2—Input data processing.

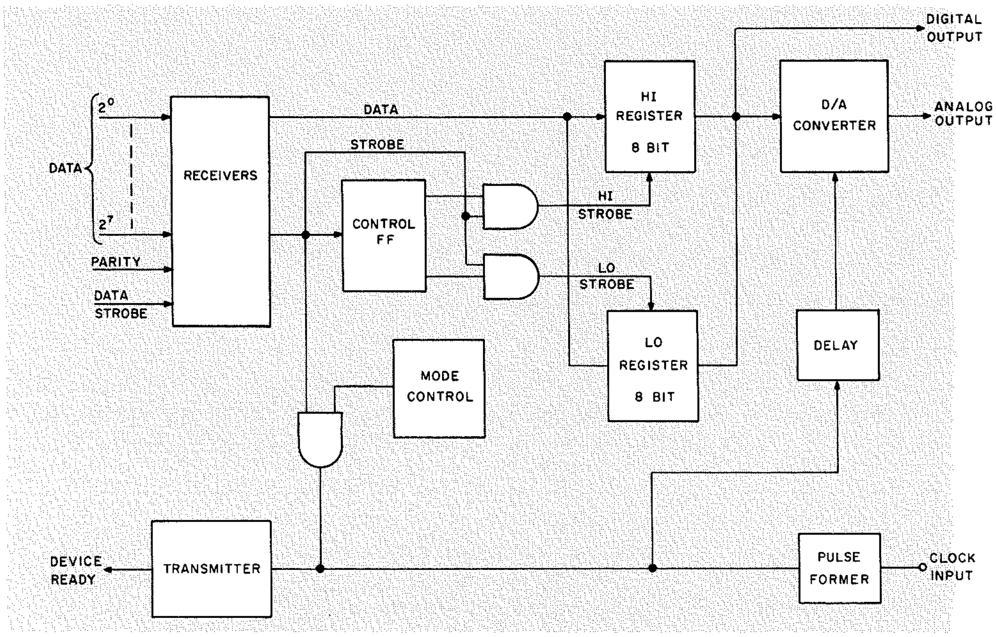


Fig. 3—Output data processing.

Multiprogramming

The Spectra 70/45 computer has a multiprogramming capability which is extremely advantageous for some applications of the remote data terminal because of the potentially lower computer charges. These applications would generally fall into areas where the data rates through the terminal are low but operation over an extended period of time is required and where the memory requirements are not too great. This is a typical requirement when real-time experiments are to be monitored. A very important feature for the experimentalist is that sample times may be directed by either the computer or by the experiment.

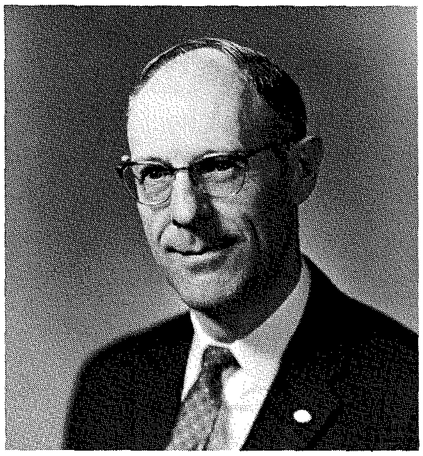
Regarding the memory requirements, a 5-kHz byte rate represents less than 10% of the Spectra 70/45 multiplexer channel load. A memory requirement of less than 40,000 bytes utilizes only 20% of the high speed computer storage. Although the present input program uses 80,000 bytes of memory, it is readily reduced for lower speed requirements and can be made less than 40,000 bytes. As mentioned previously, the plotter routine was written expressly for a multiprogramming environment.

Acknowledgment

The author is grateful to J. Barger for contributing to the design of the terminal; W. Clapp for assistance in interfacing; and W. Schaming for creating the bulk of the computer programs.

Professional societies and the engineer

C. W. Sall



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received the AB from De Pauw University in 1935, and the AM from New York State College for Teachers in 1942. Between 1936 and 1943 he taught high school science at Saugerties and Baldwin, N.Y., coming to the RCA Industry Service Lab as a Technical Editor in 1943. Mr. Sall transferred to RCA's Industrial Electronic Products Division in Camden in 1958 to assume the duties of Manager of Technical Publications. In February 1960, he was appointed to his present position at RCA Laboratories, Princeton, N.J. Mr. Sall is a Senior Member of the IEEE and a charter member of the IEEE Group on Engineering and Speech. He was Chairman of the Group in 1963. For the past 10 years he has served as Editor of the IEEE Transactions on Broadcast and Television Receivers.

Usually around the time that the annual dues bills start coming in, the average engineer does a little soul searching about the value of his membership in this or that professional society. Is he getting his money's worth? Are the benefits sufficiently good to warrant his continued support of the organization? Do the journals, or proceedings, or other documentary materials, carry articles of enough interest and value to be worthy of his few hours of reading time? Do the various conferences contribute enough to make his attendance worthwhile, even if the company does pick up the tab? Does the rubbing of professional shoulders, or just the prospect of being seen at a conference, add anything to his career or his status? If he presents a technical paper, or participates in a panel discussion, or gets a paper published in the society's journal, is he any better off?

These questions and others certainly do run through an engineer's mind when he tries to assess his annual contribution against the returns he may expect or hope to receive. No matter how you size it up, whether in time, money, interest, energy, or aptitude, his budget is limited. How to parcel it out most effectively?—that is the question. And that, of course, is where the professional society comes into play. Apparently, after he has weighed all the evidence, Mr. Average Engineer has decided that he cannot afford to stay out of those organizations that speak to his particular discipline or line of work. Let us examine some typical evidence for one engineering society, the IEEE.

At latest count, better than 160,000 electrical engineers (or those in some affiliated activity) have found it to their advantage to join the IEEE. Why? Prestige certainly plays a part in this decision. Being a member of so large an international organization whose standards are reasonably high is something of an honor. But you can't eat prestige any more than you can eat the aroma from a roast. Something more substantial must be offered on the bill-of-fare. Here are some of the meatier items on the menu:

- Thirty-one interest groups (from antennas to vehicular technology);
- Forty-three electronically oriented technical journals;
- Electrical and electronics abstracts;
- The International Convention;
- WESCON, NEC, NAECON, NEREM, WINCON, SSCC, INTERMAG, SWIEEECO, EASCON—and nearly 100 other major technical conferences;
- Local meetings by more than 200 sections;
- Miscellaneous educational programs, seminars, and colloquia;
- The services of the IEEE Headquarters Staff available to all members;
- The opportunity to up-grade one's self;
- The opportunity to serve on professional committees of world-wide significance; and
- The opportunity to be selected as a candidate for Fellow of the IEEE.

From so impressive and varied a list of selections, practically any appetite or taste can be satisfied.

Thus far we have considered only a rather one-sided argument for technical society membership—the personal benefit to the engineer. But by its very definition, a society is made up of more than one individual, hence the benefits multiply enormously through the interplay of one member's contributions to the whole. As each one gives or participates, hundreds or thousands become the benefactors. This transillumination or cross fertilization works both ways, thus making each individual member the recipient of a vast outpouring of ideas and information even as he adds his contributions to the common lot for others to share.

Another angle should be mentioned. Most members of professional societies are employees of engineering organizations that invest considerable time and money in supporting employee partici-

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pation in society activities. RCA is such an organization.

"It is a long-standing RCA Corporate policy to encourage our engineers and scientists to participate in professional societies and to write and present technical papers," according to Dr. James Hillier, Executive Vice President, Research and Engineering.

"We do this," he maintains, "not because attending professional meetings makes our engineers and scientists feel better, but because such activities make them better engineers and scientists."

Enlightened management, in RCA and throughout the electronics industry, realizing the mutual benefits that accrue to man and company encourages its technical staff to write papers for conference presentation and journal publications. It provides the time and the money for committee and conference attendance. It buys reprints of employee-authored articles. It publicizes the achievements of its people in society affairs, which often leads to special honors being settled on outstanding individuals. What we are really saying here is that what is good for the member is also good for his company—and for the whole society.

As a company, RCA does quite well in society participation. As an indication of this, citations of Professional Activities are given in each *News and Highlights* section of the RCA ENGINEER; also credit for actual participation by presentation and publication is given in the *Pen and Podium* section.

We have chosen the IEEE as a representative society because it most directly ties in with the general interests of electrical engineers. For the more specific disciplines we might have cited a host of similar, although smaller professional groups that serve a vast total membership to advantage. A sizable list of those societies and organizations of interest to RCA ENGINEER readers appears at the end of this article.

Most divisions of RCA have Technical Publications Administrators (TPAs) available to advise and assist the engineer in selecting the societies that will provide the best outlet for his work. Most TPAs receive regular notifications of society events and objectives; a complete list of TPAs is given on the inside back cover of each issue of the RCA ENGINEER.

Keeping abreast of the many activities sponsored or promoted by these many societies is a sizable chore of itself. Even to scan the notices, flyers, announcements, calls for papers, and similar literature can be somewhat burdensome for the busy engineer. To help him, at least for IEEE events, each issue of the *IEEE Spectrum* carries a summary listing of special conferences, special issues of journals forthcoming, calls for papers, and similar information. Likewise, RCA ENGINEER, under its *Dates and Deadlines* section at the rear of the magazine, summarizes important engineering events. Other journals carry similar data of interest to their readers. So—keeping yourself informed isn't too difficult after all. And in keeping informed you will be able to take advantage of the many excellent activities and services offered you by these professional societies.

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Some scientific and technical societies of interest to RCA

Included herein are about 30 professional societies and a similar number of IEEE groups. Names and addresses of the secretaries and group chairmen and list of society publications are given as a convenient reference; contact these sources for membership and program information.

The societies included are associated with many of the branches of engineering found at RCA. Most of these societies hold annual meetings and local chapter meetings. Nearly all of them publish professional society journals for the benefit of society members. This list was compiled from the *Directory of Engineering Societies and Related Organizations*—1966 Edition.

Acoustical Society of America
335 East 45th Street, New York, New York 10017
Secretary: Wallace Waterfall
Purpose: To increase and diffuse the knowledge of acoustics and to promote its practical applications.
Meetings: Semi-annual
Publications: *Journal*, monthly; *Noise Control*, bi-monthly.

American Ceramic Society, Inc.
4055 North High Street, Columbus, Ohio 43214
General Secretary: Frank P. Reid
Purpose: To promote the art, science, and technology of ceramics.
Meetings: Annual in spring; division meetings also annual in fall.
Publications: *Journal*, monthly; *Ceramic Abstracts*, monthly; *Ceramic Bulletin*, monthly.

American Chemical Society
1155 16th Street, N.W., Washington, D.C. 20036
Executive Secretary: B. P. Stanerson
Purpose: To encourage in the broadest and most liberal manner the advancement of chemistry in all its branches; to promote research in chemical science and industry . . . etc.
Meeting: Semi-annual
Publications: *Chemical and Engineering News*, weekly; *Chemical Abstracts*, semi-monthly; *Journal of Physical Chemistry*, monthly; *Journal of Agriculture and Food Chemistry*, bi-monthly; *Journal of American Chemical Society*, monthly.

American Institute of Aeronautics and Astronautics, Inc.
1290 6th Avenue, New York, New York 10019
Executive Secretary: James J. Hartford
Purpose: To encourage original research; foster dissemination of new knowledge; improve public understanding of the profession; and stimulate outstanding professional achievement.
Publications: *Astronautics and Aeronautics*, monthly; *AIAA Bulletin; AIAA Journal; Journal of Aircraft; Journal of Spacecraft and Rockets; International Aerospace Abstracts.*

American Institute of Chemical Engineers
45 E. 47th Street, New York, New York 10017
Secretary: F. J. Van Antwerpen
Purpose: The advancement of chemical engineering in theory and practice and the maintenance of a high professional standard among its members.
Meetings: Annual
Publications: *Chemical Engineering Progress*, monthly; *Journal*, quarterly; *International Chemical Engineering*, quarterly; *Monograph and Symposium Series.*

American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.
345 E. 47th Street, New York, New York 10017
Purpose: To promote the arts and sciences connected with the economic production of the useful minerals and metals; to hold meetings for the reading and discussion of professional papers and to circulate by means of publication among its members the information thus obtained.
Meetings: Annual
Publications: *Mining Engineering*, monthly; *Journal of Metals*, monthly; *Journal of Petroleum Technology*, monthly; *Transactions of the Metallurgical Society*, monthly; *Quarterly Transactions of the Society of Mining Engineers, Journal of the Society of Petroleum Engineers*, quarterly.

American Institute of Physics
335 East 45th Street, New York, New York 10017
Director: Van Zandt Williams
Purpose: Advancement and diffusion of knowledge of the science of physics and its applications to human welfare.
Publications: *Journal of Applied Physics*, monthly; *The Review of Scientific Instruments*, monthly; *Journal of Mathematical Physics*, monthly; *Physics Today*, monthly; *Applied Physics Letters*, semimonthly; *Applied Optics.*

American Management Association
135 West 50th Street, New York, New York 10020
President: L. A. Appley
Purpose: To provide the training, research publications, and information services required by managers to do a better job. To organize and encourage exchanges of management thinking and experience with the profession.
Meeting: 1100 meetings annually
Publications: Books, reviews, and pamphlets, etc., *Management Letter, Management News, Management Review*, etc.

American Mathematical Society
Box 6246, Providence, Rhode Island 02904
Executive Director: Gordon L. Walker
Purpose: The encouragement and advancement of mathematical scholarship.
Publications: *Bulletin, Transactions; Mathematics of Computations; Chinese Mathematics; Mathematical Review; Proceedings.*

American Nuclear Society
244 East Ogden Ave., Hinsdale, Ill. 60521
Executive Secretary: O. J. DuTemple
Purpose: The integration and advancement of nuclear science and technology.
Meeting: Semi-annual
Publications: *Nuclear Science and Engineering Journal*, monthly; *Transactions of American Nuclear Society*, semi-annual; *Nuclear News*, monthly; *Nuclear App.*, bi-monthly.

American Physical Society
Columbia University, New York, New York 10027
Executive Secretary: K. K. Darrow
Purpose: The advancement and diffusion of the knowledge of physics.
Meetings: Annual meeting in January in New York; six to eight other meetings each year.
Publications: *Bulletin*, six to eight per year; *Physical Review*, semimonthly; *Reviews of Modern Physics*, quarterly.

American Radio Relay League, Inc.
38 LaSalle Road, Hartford, Conn. 06111
Secretary and General Manager: John Huntoon
Purpose: Promotion of interest in amateur radio communication and experimentation; relaying of messages by radio; advancement of the radio art.
Meetings: No meetings of League as a whole; Board of Directors meets annually.
Publications: *QST*, monthly.

American Society of Mechanical Engineers
345 E. 47th Street, New York, New York 10017
Executive Secretary: O. B. Schier II
Purpose: To promote the art and science of mechanical engineering and the allied arts and sciences; to encourage original research; to foster engineering education, to advance the standards of engineering; and, in cooperation with other engineering and technical societies, to broaden the usefulness of the engineering profession.
Meetings: Twice a year
Publications: *Mechanical Engineering*, monthly; *Journal of Applied Mathematics and Mechanics*, bimonthly; *Applied Mechanics Review*, monthly; *Basic Engineering Quarterly; Engineering for Industry*, monthly; *Engineering for Power*, monthly.

American Society for Metals
Metals Park, Ohio 44073
Managing Director: Allan Ray Putnam
Purpose: Service of members in the metal producing and consuming industries through dissemination of technical information on the manufacture, treatment and use of metals.
Meetings: Annual; monthly chapter meetings
Publications: *Metal Progress*, monthly; *Metals Review*, monthly; *Transactions*, annual; *Review of Metal Literature*, monthly; *Metals Engineering*, quarterly.

American Society for Quality Control, Inc.
161 West Wisconsin Avenue, Milwaukee, Wisconsin 53203
Managing Editor: George R. Foster
Purpose: To create, promote, and stimulate interest in the advancement and diffusion of knowledge of the science of quality control and of its application to industrial processes.
Publications: *Quality Progress*, monthly; *Journal of the Electronics Division*, quarterly; *Technonmetrics Quarterly Journal.*

American Standards Association, Inc.
10 East 40th Street, New York, New York 10016
Managing Director: Roger E. Gay
Purpose: To provide systematic means by which organizations concerned with standardization work may cooperate in establishing American standards in those fields in which engineering methods apply to avoid duplication of work and promulgation of conflicting standards.
Meetings: Annual
Publications: *Magazine of Standards.*

American Society for Testing and Materials
1916 Race Street, Philadelphia, Pennsylvania 17103
Executive Secretary: T. A. Marshall, Jr.
Purpose: The promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing.
Meetings: Annual
Publications: *Book of ASTM Standards*, annual; *Proceedings*, annual; *Year Book*, distributed to members only; *Materials Research of Standards*, monthly.

Association for Computing Machinery
211 East 43rd Street, New York, New York 10017
Executive Secretary: Mrs. Irene Hollister
Executive Director: J. D. Madden
Purpose: To advance the sciences, study, design, development, construction, and application of modern machinery, computing techniques, and appropriate languages for general information processing, for scientific computation, for the recognition, storage, retrieval, and processing of data of all kinds; to promote free interchange of information about the sciences and art of information processing, both among specialists and the public.
Meetings: Annual
Publications: *Journal*, quarterly; *Communications*, monthly; *Computive Reviews.*

Audio Engineering Society
P.O. Box 383, Madison Sq. Gardens, New York 10010
Editor in Chief: Mrs. Jacqueline Harvey
Purpose: The advancement of the theory and practice of audio engineering and its closely related arts, and the dissemination of important information in that field.
Meetings: Semi-annual
Publications: *Journal*, quarterly.

Data Processing Management Association
505 Busse Highway, Park Ridge, Illinois 60068
Executive Director: R. Calvin Elliot
Purpose: To foster, promote and develop education and scientific interest in the fields of data processing and management.
Meetings: Monthly
Publications: *Journal of Data Management*

Electrochemical Society, Inc.
30 E. 42nd St., New York, New York 10017
Executive Secretary: Ernest G. Enck
Purpose: The advancement of the theory and practice of electrochemistry, electrometallurgy, electrothermics, and allied subjects.
Meetings: Semi-annual
Publications: *Journal*, monthly; *Electro-Chemical Technology*, bimonthly.

Electronic Industries Association
1721 De Sales Street, N.W., Washington, D.C.
Secretary: James D. Secrest
Purpose: To support and strive to advance the defense of our country, the growth of our economy, the progress of technology, and all interest of the electronics industry compatible with the public welfare. To operate at all times within the framework of law, ethics, and the national interest.
Meetings: Annual conventions and section meetings.
Publications: Bulletins and Standards.

Electron Microscopy Soc. of America
Olin Hall, Cornell Univ., Ithaca, New York 14850
Executive Secretary: Dr. George C. Cocks
Meetings: Annual

Institute of Environmental Sciences
34 S. Main Street, Mt. Prospect, Illinois 60057
Executive Secretary: Henry F. Sander
Publications: *Journal of Environmental Sciences; Annual Proceedings, Technical; Annual Proceedings, Tutorial.*

Institute of Management Sciences (Th)
Box 273, Pleasantville, New York 10570
Executive Director: Harold M. Cauvet
Purpose: To identify, extend, and unify scientific knowledge that contributes to the understanding and practice of management.
Meetings: One general meeting per year.
Publications: *Management Science, Bulletin*, and *Monographs.*

Instrument Society of America
530 Wm. Penn Place, Pittsburgh, Pa. 15219
Purpose: To advance the arts and sciences connected with theory, design, manufacture and use of instruments in the various sciences and technologies.
Meetings: Annual
Publications: *Journal*, monthly.

Mathematical Association of America
University of Buffalo, Buffalo, New York 14214.
Secretary: H. L. Alder, Univ. of Calif.
Executive Director: Harry M. Fieliman
Purpose: The promotion of collegiate mathematics.
Meeting: Semi-annual
Publications: *American Mathematical Monthly*, 10 issues a year; *Mathematical Magazine*, 5 issues a year.

National Association of Broadcasters
1771 N. Street, N.W., Washington, D.C. 20036
Secretary-Treasurer: Everett E. Revercomb
Purpose: A non-profit organization, to foster and promote the development of the arts of aural and visual broadcasting in all its

forms; to protect its members in every lawful and proper manner from injustices and injust exactions; to do all things necessary and proper to encourage and promote customs and practices which will strengthen and maintain the broadcasting industry to the end that it may best serve the public.
Meetings: Annual spring conventions and eight fall conferences.

National Electronic Conference, Inc.
228 N. LaSalle St., Chicago, Ill. 60601
General Manager: R. J. Napoliten
Meetings: Annual Conference and exhibition
Publications: *NEC Proceedings*

National Society of Professional Engineers
2029 K Street, N.W., Washington, D.C. 20006
Executive Director: Paul H. Robbins
Purpose: To promote the professional, social and economic interests of the engineer by means of education, legislation, and public relations; and to advance the interests of the public in matters pertaining to engineering.
Publications: *American Engineer*, monthly; *Legislative Bulletin*, monthly; *Engineering Employment Practices Newsletter*, monthly; *Private Practice News*, monthly; *Engineering in Government Newsletter*, monthly.

Society of Packaging and Handling Engineers
14 East Jackson Boulevard, Chicago, Illinois 60604
Executive Secretary: E. B. Crandell
Purpose: To further the application of good engineering practices in the industrial packaging and materials handling fields.
Meetings: Annual
Publication: *News Trends*, bimonthly

Society of Technical Writers and Publishers, Inc.
Box 3706, Beechwold Station, Columbus, Ohio 43214
Executive Secretary: Mrs. Normal J. Kennedy
Purpose: To advance technical communications.
Publications: *STWP Review.*

Standards Engineers Society
170 Livingston Avenue, New Providence, New Jersey 07974
Treasurer: C. Euffa
Purpose: To provide a means by which standards engineers and others interested in standardization may, in meetings and in publications of the Society, discuss the principles, techniques, effects and other professional aspects of standardization.
Meetings: Annual
Publications: Standards Engineering, monthly; Proceedings, annual.

The Institute of Electrical and Electronics Engineers, Inc.
345 E. 47th Street, New York, New York 10017
General Manager: Donald G. Fink
Membership Service: Emily Sirjane
Purpose: To advance the theory and practice of electrical and electronic branches of engineering and related arts and sciences, and maintain high professional standings among members.
Meetings: Local and national
Publications: *Proceedings of the IEEE, IEEE Student Journal, IEEE Spectrum*, and IEEE Group Transactions.
The various IEEE groups and their purposes are listed below:

Aerospace and Electronic Systems
RCA Box 588, Burlington, Massachusetts 01803
Managing Editor: David Dobson
Interest: Equipment, procedures and techniques applicable to the organization, installation and operation of functional systems designed to meet high-performance requirements of earth and space system.
Publications: *Transactions*, issued bi-monthly starting with January.

Antennas and Propagation
Air Force Cambridge Res. Labs. (CRDG), L. G. Hanscom Field, Bedford, Mass. 01730
Editor: Dr. Allen C. Schell
Interest: Theory and practice in antennas, wave propagation, scattering and diffraction, electromagnetic theory, plasmas and radio astronomy systems.
Publications: *Transactions*, issued bi-monthly starting with January.

Audio and Electroacoustics
Teradyne, 183 Essex Street, Boston, Mass. 00211
Editor: Frederick Van Veen
Interest: Technology of communication at audio frequencies and of the audio-frequency portion of radio-frequency systems, including the acoustic terminations and room acoustics of such systems, and the recording and reproduction from recordings.
Publications: *Transactions*, issued quarterly starting with March.

Automatic Control
Electrical Engineering Dept., Pennsylvania State University, University Park, Penna. 16802
Editor: Professor J. B. Lewis
Interest: The theory and application of automatic control techniques including feedback control systems.
Publications: *Transactions*, issued bimonthly starting in February.

Broadcasting
Sunset Lake Road, R.D. 1, Box 67, Sparta, New Jersey
Editor: Mr. Robert M. Morris
Interest: Broadcast transmission systems engineering including the design and utilization of broadcast equipment.
Publications: *Transactions*, issued quarterly starting in March.

Broadcast and Television Receivers
RCA Laboratories, Princeton, N.J. 08540
Editor: Chester W. Sall
Interest: The design and manufacture of broadcast and television receivers and components and activities related thereto.
Publications: *Transactions*, issued aperiodically.

Circuit Theory
School of Electrical Engineering, Philips Hall, Cornell University, Ithaca, New York 14850
Editor: Professor Ben Leon
Interest: Design and theory of operation of circuits for use in radio and electronic equipment.
Publications: *Transactions*, issued quarterly starting in February.

Communication Technology
Teletype Corp., 5555 Touhy Ave., Skokie, Ill. 60076
Editor: R. D. Slayton
Interest: Technology of telecommunications (theory and application) including telephony, telegraphy, and the transmission of other data; also point-to-point radio and television; treatment of systems and subsystems using one or a combination of means of transmission.
Publication: *Transactions* issued bimonthly starting in February.

Computers
Cory Hall, University of California, Berkeley, Calif. 94700
Editor: Professor Harry Huskey
Interest: Theory, design, and practices relating to digital and analog computation and information processing.
Publication: *Transactions*, issued monthly starting in February.

Education
Dept. of Electrical Engineering, New York University, University Heights, Bronx, New York 10453
Editor: Professor Sidney S. Shamis
Interest: Fostering improved relations between the electrical and electronic and affiliated industries and schools, colleges and universities.
Publication: *Transactions*, issued quarterly starting in February.

Electrical Insulation
Technical Services Lab., Plastics Department, E. I. duPont de Nemours & Co., Inc., Wilmington, Delaware 19898
Editor: J. R. Perkins
Interest: Electrical insulation common to the design and construction of components and equipment for use in electrical and electronic circuits and distribution systems at all frequencies.
Publication: *Transactions*, issued quarterly.

Electromagnetic Compatibility
HRB-Singer, Inc., 1000 Connecticut Ave., N.W. Washington, D.C. 20036
Editor: A. H. Sullivan, Jr.
Interest: Origin, effect, control, and measurement of radio-frequency interference.
Publication: *Transactions*, issued quarterly starting with February.

Electron Devices
Dept. of Electrical Engineering, University of California, Santa Barbara, Calif.
Editor: Dr. Glen Wade
Interest: Electron devices including particularly electron tubes, solid-state devices, integrated electronic devices and energy sources.

Engineering in Medicine and Biology
Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania 19104
Editor: Dr. David B. Geselowitz
Interest: Theory and application to engineering problems in medicine and biology.
Publication: *Transactions*, issued quarterly starting in January.

Engineering Management
Dept. of Industrial Engineering. The Technological Institute, Northwestern University, Evanston, Illinois 60201
Editor: Professor A. H. Rubenstein
Interest: Engineering management and administration as applied to technical, industrial, and educational activities in the field of electrical and electronics engineering.

Engineering Writing and Speech
RCA Astro-Electronics Division, Princeton, N.J. 08540
Editor: I. M. Seideman
Interest: The study, development, improvement, and promotion of the techniques for preparing, organizing for use, processing, editing, collecting, conserving, and disseminating any form of information in the electrical and electronics fields.
Publication: *Transactions*, issued aperiodically.

Geoscience Electronics
Computer Center, Box 30030A, Texas Christian University, Fort Worth, Texas 76129
Editor: Dr. A. A. J. Hoffman
Interest: Research, development, and techniques in instrumentation for geophysics and geochemistry, especially gravity measurements, seismic measurements, magnetics, well logging, spaceexploration, meteorology, oceanography and aerology.
Publication: *Transactions*, issued quarterly.

Man-Machine Systems
Massachusetts Institute of Technology, Cambridge, Massachusetts 02139
Editor: Thomas B. Sheridan
Interest: Development and application of knowledge germane to integrating human elements into man-machine systems.
Publication: *Transactions*, issued quarterly starting in March.

Industrial Electronics and Control Instrumentation
IMPAC Instrument Service Inc., 201 East Carson Street, Pittsburgh, Penna. 15219
Editor: Dr. R. B. Spooner
Interest: Application of electricity in industry, transportation, commerce and the home.
Publication: *Transactions*, issued aperiodically.

Industry and General Applications
General Electric Co., Schenectady, New York 12305
Editor: D. S. Brereton
Interest: Application of the electricity in industry, transportation, commerce and the home.
Publication: *Transactions*, issued bimonthly starting with January/February.

Information Theory
Applied Electrophysics Dept., University of Calif., San Diego, Box 109, La Jolla, Calif. 92037
Editor: Dr. Carl W. Helstrom
Interest: Information theory and its application in radio circuitry and systems.
Publication: *Transactions*, issued bimonthly starting with January.

Instrumentation and Measurement
Dept. of Electrical Engineering, North Carolina State University, PO Box 5275, Raleigh, N.C. 27607
Editor: Professor George B. Hoadley
Interest: Measurements and instrumentation utilizing electrical and electronic techniques.
Publication: *Transactions*, issued quarterly starting with March.

Magnetics
IBM Corporation, Old Orchard Road, Armonk, N.Y. 10504
Editor: Mr. E. W. Pugh
Interest: Magnetic phenomena, material and devices as applied to electrical and electronic engineering.
Publication: *Transactions*, issued quarterly starting in March.

Microwave Theory and Techniques
Airborne Instruments Laboratory, Melville, New York 11749
Editor: S. Okwit
Interest: Microwave theory, microwave circuitry and techniques, microwave measurements and the generation and amplification of microwaves.
Publication: *Transactions*, issued monthly.

Nuclear Science
14 Coronet Court, Schenectady, New York 12309
Editor: R. F. Shea
Interest: Nuclear science and engineering including instrumentation, plasma and high-energy physics, reactor controls and radiation effects.
Publication: *Transactions*, issued bimonthly starting with February.

Parts, Materials, and Packaging
Engineering Electronics Section, National Bureau of Standards, Washington, D.C.
Editor: Gustave Shapiro
Interest: The physical properties, performance characteristics and procedures and techniques pertaining to component parts, materials, and circuit packaging and manufacturing.
Publication: *Transactions*, issued quarterly starting with March.

Power (apparatus and systems)
Sage Building, Room 201, Rensselaer Polytechnic Inst., Troy, New York 12181
Editor: Professor R. T. Smith
Interest: Planning, research, development design application, construction, installation, and operation of apparatus, equipment, structures, economic generation, transmission, distribution, conversion, and control of electric energy for general industrial, commercial, public and domestic consumption.
Publication: *Transactions*, issued monthly.

Reliability
Research Triangle Institute, Post Office Box 12194, Research Triangle Park, North Carolina 27709
Editor: Dr. Ralph Evans
Interest: Principles and practices used in reliability of electric and electronic equipment.
Publication: *Transactions*, issued quarterly.

Sonics and Ultrasonics
Raytheon Submarine Signal Division, P.O. Box 360, Newport, R.I. 02840
Editor: Oskar E. Mattiat
Interest: Sonics, including ultrasonics and phonon technology.

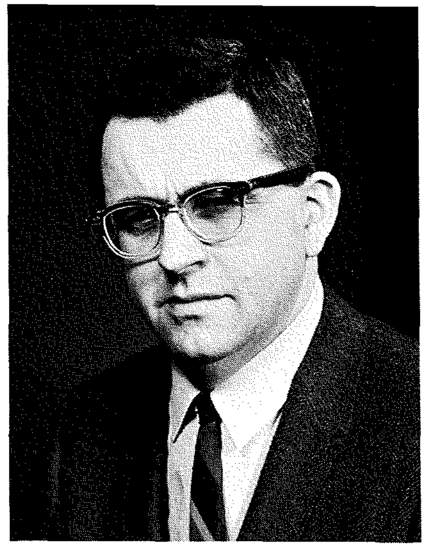
Systems Science and Cybernetics
Battelle Memorial Inst., Columbus, Ohio
Editor: Mr. John N. Warfield
Interest: Science common to large collections of interacting functional units that together achieve a defined purpose. Areas include interdisciplinary subjects such as bionics, artificial intelligence, and self-organizing systems; and such aspects as modeling optimization, reliability, and general theory.
Publication: *Transactions*, issued quarterly.

Vehicular Technology
Organization 3720/31, Northrup Norair, 3901 West Broadway, Hawthorne, Calif. 90250
Editor: Carl N. Brooks
Interest: Vehicular technologies, which include communications and automotive electrical and electronics engineering. Communications include land, airborne, and maritime, as well as personal paging and citizen's communications services, when used as an adjunct to a vehicular system. Automotive includes all functional systems related to the vehicle and its operating medium, excluding systems associated with public transit.
Publication: *Transactions*, issued aperiodically.

Reducing resonant amplifications on printed-circuit boards

E. D. Veilleux

Controlling destructive resonant amplitude of printed-circuit boards in electronic systems is a common problem. This paper describes various methods available for reducing these amplitudes and presents data to show the effectiveness of each method when compared with a standard printed-circuit board.



Eugene D. Veilleux
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received the BSME from the University of Massachusetts in 1955. In 1963 he was awarded the MS in Mechanical Engineering from Northeastern University. From 1955 to 1957 Mr. Veilleux was assigned to the Air Force's Air Technical Intelligence Center at Wright Patterson Air Force Base. He performed technical analyses on various problems in the field of aircraft structures. From 1959 to 1964, Mr. Veilleux was employed by Sanders Associates, Inc. in the Mechanical Engineering Department where he performed analyses in the fields of structures, shock and vibration, and heat transfer. He was also responsible for the packaging of several major ECM systems. Prior to leaving Sanders, Mr. Veilleux was Project Mechanical Engineer for two Electronic Countermeasures Systems and responsible for their mechanical design and development to meet military environments. Since joining RCA, late in 1964, Mr. Veilleux has specialized in the Field of heat transfer, and has had the responsibility for thermal design of LM Rendezvous Radar and Transponder packages. He has also performed thermal analyses on several laser cavities, and is currently involved in the thermal design of an advanced computer system. He is a registered Engineer in the state of Massachusetts and a member of several professional societies.

Vibration control of structural elements has been treated comprehensively in the literature. Earlier in the technology, emphasis was placed on structural responses in the frequency of 0 to 500 Hz. However, with the introduction of advanced military aircraft, military requirements have increased the vibration frequency spectrum to 2000 Hz and have introduced the random-noise vibration input. Previously, it was common practice to increase the stiffness of a structure to move a destructive resonant frequency from just below 500 Hz to slightly above 500 HZ; however with the new frequency spectrums, this approach becomes impractical and, in some cases, impossible because the added structural mass becomes prohibitively large. To overcome this deficiency, the state-of-the-art shifted first to materials with high inherent damping properties, then to the concepts of extensional damping, and finally to shear damping by the use of the laminated structure. Today, this approach to vibration control in structural elements is a proven concept and is well documented.

Vibration control of printed-circuit boards has not had, up to the present, extensive treatment accorded structural elements. The normal procedure to eliminate resonance is to increase printed circuit board stiffness by mounting it at several points. It has been shown that mounting a printed-circuit board with average component density on approximately two inches center-to-center mounting pads, in both directions, will eliminate any resonances up to 2,000 Hz[1]. This means many pads for an average size board. Another approach for reducing the destructive resonance amplification is isolation by mounting on rubber pads. This reduces amplification somewhat and has its place in the technology—provided the sensitivity of the components is not too great. A third method is to use the concept called extensional damping whereby a heavy coat of damping compound is placed on one or both sides of a plate in a manner similar to that in which undercoating is applied to an automobile[2]. This concept reduces resonant amplifications, but is limited somewhat in what it can do. A final method is the concept of viscoelastic shear damping previously discussed for structural applications[2,3,4]. It is felt that maximum resonant amplification reduction can be accomplished with this technique. The following discussion describes in detail the results of the test program and delineates how much resonant amplification reduction can be obtained.

Reprint RE-15-1-16
Final manuscript received March 15, 1968.
This study was initiated while Mr. Veilleux was employed by Sanders Associates, Inc.

Test setup

The complete test setup for this study is shown in Fig. 1a. The printed-circuit boards were mounted on eight cylindrical pads and one rectangular pad. The cylindrical pads (Fig. 1b) simulate anticipated casting bosses while the rectangular pad simulates a rigidly mounted right-angle connector. Seven accelerometers were mounted to the printed circuit boards. The total weight of the accelerometers was approximately seven ounces. With regard to accelerometer mounting on laminated boards, it should be indicated that one layer of laminate and adhesive was removed by counterboring in order that the accelerometers could be rigidly attached to one of the laminated boards without interfering with the damping process (Fig. 1c). The frequency spectrum of vibration was 5 to 2000 Hz with an input of 2 g's. All boards were tested at three distinct temperatures: −60°C, +35°C, and +100°C. Once the desired temperature was reached and stabilized, the sample was soaked for approximately thirty minutes before starting frequency sweep.

The following types of boards were tested:

1) $\frac{3}{32}$-inch, unclad, epoxy fiberglass board;
2) $\frac{3}{32}$-inch, unclad, epoxy fiberglass board, coated on one side with a 0.010 to 0.015 inch thickness of silicone-based damping compound (Dow Corning Sylgard 182).
3) Commercially laminated board, copper clad both sides, (2 oz copper) 0.085 to 0.099 inches thick, with 0.020 adhesive thickness. Thickness of each board is 0.32 inch and fiberglass is NEA-G-11.

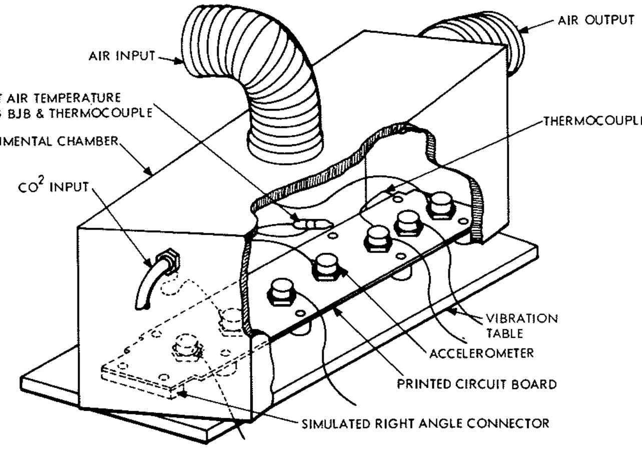

Fig. 1—Environmental test setup for system damping study.

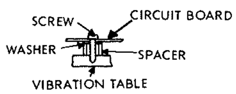

Fig. 1b—Simulated casting mounting boss.

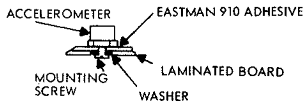

Fig. 1c—Accelerometer mounting.

4) 1/16 and 1/32-inch epoxy fiberglass boards, unclad, and laminated with Minnesota Mining and Manufacturing Co., Damping Compound EC-801, Class B, with Accelerator No. EC-807 (approximate thickness of Damping Compound is 0.005 inch).
5) 1/16 and 1/32-inch epoxy fiberglass boards laminated with same compound as in 4), but with the laminating board (1/32 inch) cut away in the area of the casting boss mounting points as shown in Fig. 2.

In addition to testing laminated boards, a simple isolation system using the 3/32-inch thick fiberglass board (1 above) was also tested. In this system, the same mounting pads were utilized. The isolation of the board was accomplished by placing a piece of square-shaped rubber on top of the pad, covering this rubber with a steel washer, and mounting the printed circuit board on top of the washer (Fig. 3). Compression of the rubber was regulated by measuring the thickness of the rubber. Before each test, all rubber thicknesses were made equal. More damping was obtained by simply tightening all screws.

The type of rubber used was silicone rubber having a Shore A Durometer hardness of approximately 60. Rubber thickness was approximately 0.094 inch before compression. It was compressed 0.010, 0.030, and 0.050 inch.

Test results

The 3/32-inch printed circuit board with seven accelerometers mounted to it was subjected to the frequency spectrum and the temperature environment. This board is used in this discussion as a standard for comparison with other resonant amplification reduction methods. Fig. 2 is a drawing of accelerometer locations with the number of each accelerometer shown. It should be noted that accelerometer locations are the same for all boards tested. The test data indicates that this printed circuit board configuration has two major areas of resonant frequencies. The first of these, located at the center of the board and midway between the eight mounting pads, is indicated by accelerometers 3, 5 and 7, with accelerometer 5 usually indicating the highest output, the accelerometers 7 and 3 indicating lower outputs respectively. The second resonant point, at a higher frequency, is indicated by accelerometers 2, 4, 6 and 8. These accelerometers show that the resonant point is at the center of the board and directly opposite the mounting pads. Because of the large number of outputs, it is impossible to discuss in detail all resonant points. Therefore, the discussion will be limited to accelerometer 5 only. This accelerometer has been selected because it is located in the center of the board and subjected to the most symmetrical boundary conditions.

Transmissibility reduction

The basic parameter of discussion is the amount of transmissibility reduction that can be attained by the various damping techniques available. We will limit ourselves to the +35°C test condition because it appears to be the most severe, and because of the plurality of data. Figs. 4 and 5 show transmissibility versus frequency of accelerometers for all of the types of boards tested; transmissibility reduction is self evident. Fig. 6 shows transmissibility reduction at the fundamental resonance point only. Further, Figs. 4, 5 and 6 show that there is available, to the designer, tools to reduce destructive amplitudes on this printed circuit board by approximately 50 to 90% depending on the technique chosen.

Environmental temperature effects

The variation in resonant transmissibility with environmental temperature is shown in Fig. 6 for the rigidly mounted epoxy fiberglass board as well as for all the damping techniques considered. From what is shown, the resonant transmissibility of rigidly mounted epoxy fiberglass board is not a constant and is affected to a considerable degree by temperature. A convex curve with a peak of +35°C is shown, however, it is not known if the peak of this curve is at this point or at a lower or higher temperature. Because tests were not performed to determine where the peak is located, the shape of this convex curve could be altered

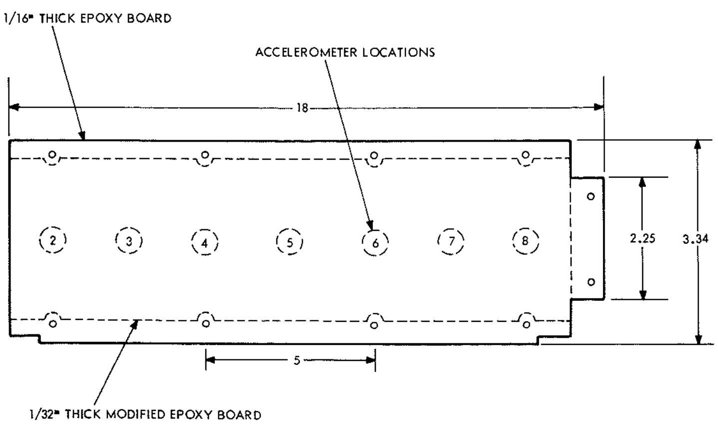

Fig. 2—Modified board laminated with 3M EC-801 damping compound.

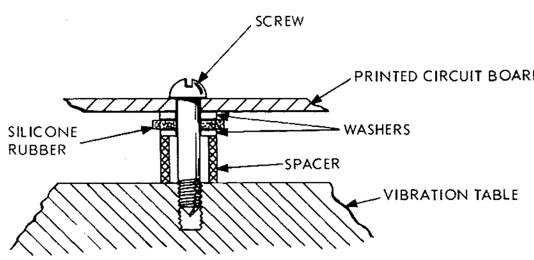

Fig. 3—Isolation mounting system.

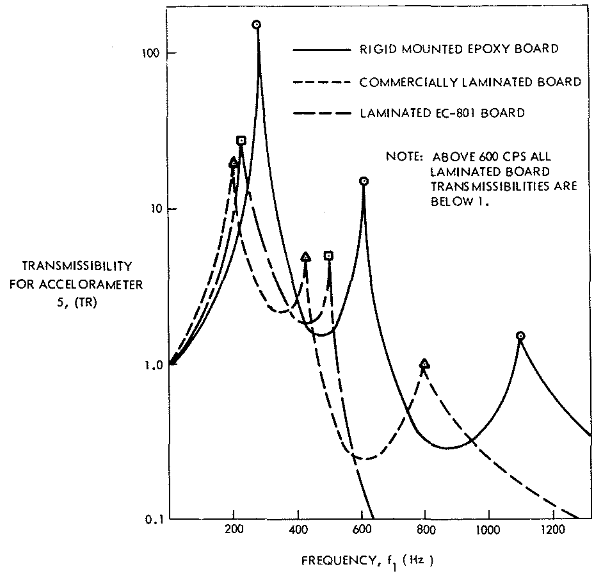

Fig. 4—Transmissibility versus frequency for accelerometer 5 at 35°C.

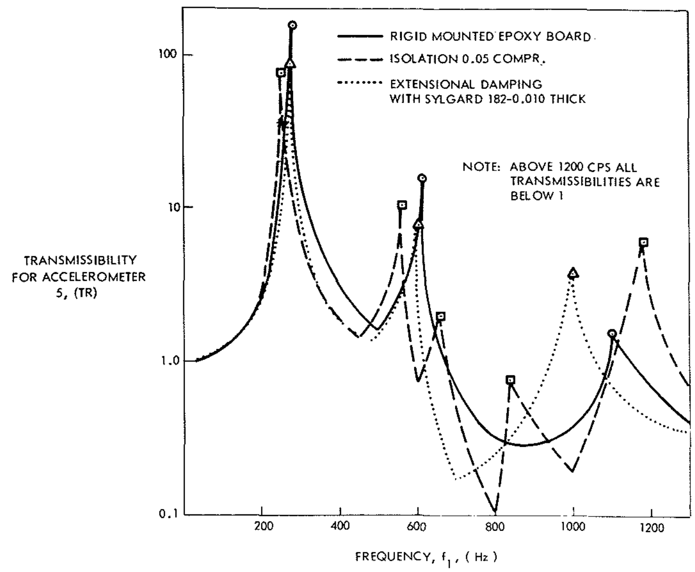

Fig. 5—Transmissibility versus frequency for accelerometer 5 at 35°C.

with the introduction of new data. Regardless of where the peak is located, the fact remains that at or near room temperature the transmissibility of an epoxy fiberglass board is considerably larger than at either the low or high end of the temperature spectrum. No explanation for this wide transmissibility variation can be given other than a change in physical properties of the material and possibly some friction damping at the mounting points.

Considering the isolation extensional damping techniques, it can be seen that the convex transmissibility curve resulting from the homogeneous epoxy fiberglass board is still evident, but that the damping techniques have resulted in reducing by a considerable amount the +35°C transmissibility point. It should be noted that the transmissibility curve plotted for the isolation system is for 0.010-inch compression. Also included in Fig. 6 are the +35°C points for compressions of 0.030 and 0.050 inch. However, it is not known how much more the convex curve would be flattened at extreme temperatures by the additional rubber compression. Considering next the viscoelastic shear damping techniques, it can be seen that the EC-801 laminated printed circuit board still possesses the characteristic convex type transmissibility curve over a wide temperature range, but that the curve has been flattened considerably due to the shear damping mechanism. A look at the transmissibility curve of the commercially laminated board reveals that it is approximately a straight line sloping down from the horizontal and slightly to the right. The reason for this difference in curves is not readily apparent; however, it may be attributed to the relative thickness of the damping compound and the thickness of the epoxy fiberglass laminates. In the EC-801 laminated board, the damping compound thickness is approximately 0.005 inch thick, and in the commercially laminated board it is approximately 0.020 inch thick. Likewise, the EC-801 laminated printed circuit board is a 1⁄16 and 1⁄32 laminate, and the commercially laminated board is composed of two 1⁄32 laminates. The combination of additional thickness of epoxy fiberglass (0.031) and thin coating results in a stiffer board that retains the convex properties of the rigidly mounted homogeneous epoxy fiberglass board. Because of the thin laminates and the large amount of damping compound between the laminates, the commercially laminated printed-circuit board, by its very nature, is less stiff and would tend to be less affected by extreme temperatures.

Resonant frequency shift due to extreme temperatures

In the previous section it has been shown that there is a change in transmissibility with a change in temperature. This change in temperature also has an accompanying effect of changing the natural frequency of the system. A look at Fig. 7 indicates that the rigidly mounted epoxy fiberglass board goes through a shift in resonant frequency. The shift is from a higher resonant frequency at a low temperature to a lower resonant frequency at a higher temperature. The curve shape appears to be slightly convex.

A look at the effects of isolation indicates that the shift in frequency is quite small as compared to the rigidly mounted board. This is an indication that the silicone rubber used as isolators is not affected by wide temperature variations.

It should be noted that the isolation curve shown in Fig. 7 is for a 0.10 compression. Rubber compressions of 0.030 and 0.050 inches at 35°C are also shown in Fig. 7. Because of the apparent resistance to temperature of the silicone rubber, it can be assumed that the shape of the 0.030 and 0.050 compression frequency-temperature curve would be similar to the 0.010 compression frequency-temperature curve.

Edge mounting effects on laminated boards

An effort was directed toward determining if variation in edge-mounting conditions of the laminated board affected the resonant transmissibility of the laminated board. The normal mounting procedure for laminated boards was to screw them rigidly to the simulated casting boss shown in Fig. 1b. In doing this, both laminates are squeezed together by the fastening screw. No effort was made for torquing screws to a given tightness. Technicians tightened screws in such a manner that there was no loosening during tests. There was no noticeable squeeze-out of damping compound on the laminated EC-801 board, but with the commercially laminated board the damping compound squeeze-out was quite noticeable. This squeeze-out was not permanent, however, and upon release of screw pressure the damping compound appeared to return to its normal position.

To investigate the effects of edge mounting, a laminated board was fabricated

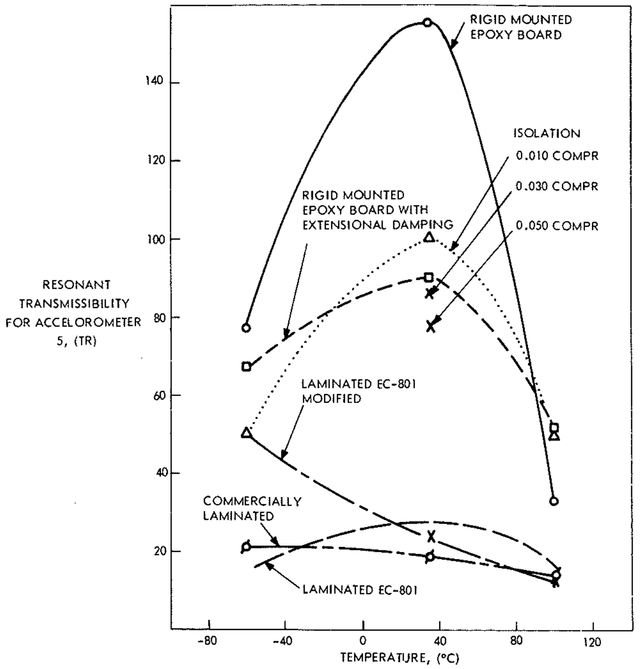

Fig. 6—Resonant transmissibility of accelerometer 5 as a function of environmental temperature.

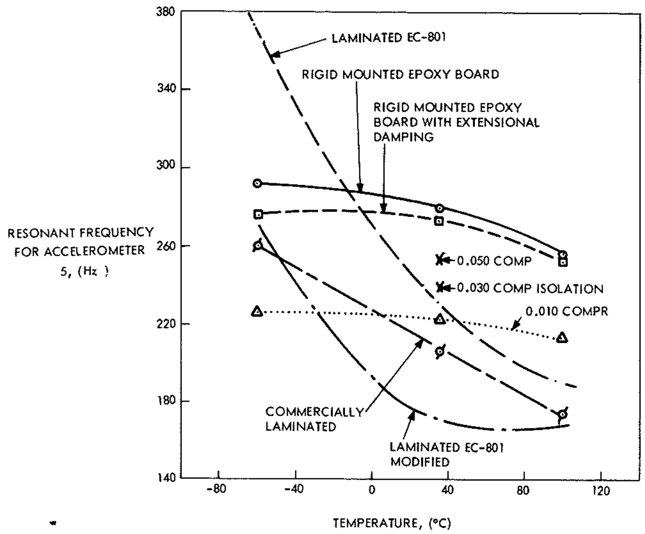

Fig. 7—Resonant frequency of accelerometer 5 as a function of temperature.

utilizing EC- 801 as the damping compound. The laminating board (1/32 inch thick) was modified such that it was cut away in areas of casting boss mounting points and connector mounting area. This laminated board is called "laminated EC-801 modified" on Figs. 6 and 7 and is shown in Fig. 2. From Fig. 7 it is apparent that the resonant frequency is much lower throughout the temperature range as compared to the conventional EC-801 board. This is an indication of a softer system than the laminated EC-801 board, and that the "laminated EC-801 modified" board has the characteristics of an ordinary 1/16-inch epoxy fiberglass board rather than an ordinary 3/32-inch epoxy fiberglass board. A look at the higher temperature also indicates that the natural frequency does not change appreciably with respect to room temperature natural frequency.

Apparently at high temperature, the natural frequency of the system does not change because of the softness of the damping material. Therefore, the spring constant of the system is unaffected and the resonant natural frequency is unaffected. The reverse occurs at low temperatures. Here the material becomes hard or glassy and, because of this phenomena, increases the spring constant and results in an increased natural frequency. The action of the "laminated EC-801 modified" board seems to indicate that the laminating layer (1/32-inch thick) is being limited in its damping capacity because it is not rigidly held at any one place and is just going along for the ride. This thought can be further strengthened by referring to Fig. 6.

Here it can be seen that the transmissibility of the rigidly mounted laminated EC-801 board is quite low at the low temperature indicating considerable shear damping. The same does not apply for the transmissibility of the "laminated EC-801 modified" board; the transmissibility is higher by approximately 150%. If shear damping were occurring in the "laminated EC-801 modified" board to any magnitude, the transmissibility should be lower than for the laminated EC-801 board. This would occur because the resonant frequency of the modified laminate is lower by approximately 100 Hz. A lower resonant frequency means larger relative displacements and more damping. The above indicates the reverse of this and, therefore, indicates that the laminating layer, although damping the system somewhat, is going along for a ride because it has no other choice. At the high temperature end, the transmissibility reduction is apparently quite good, and the fluidity of the damping compound allows enough relative movement between the laminates to reduce transmissibilities that are as good or better than for rigidly mounted laminated EC-801 boards.

In summary, then, it appears that maximum transmissibility reduction over the temperature range occurs when both laminates of the laminated printed circuit board are rigidly attached to the mounting surface.

Conclusions

Isolation and extensional damping techniques are limited in their ability to reduce amplified acceleration inputs, while viscoelastic shear damping techniques offer the best solution at this point in the state-of-the-art of vibration control. In addition, there are commercially available adhesives that can be effectively used in the viscoelastic shear damping concept.

The previous discussion emphasizes, however, that the state-of-the-art in vibration control with respect to printed-circuit boards has reached the point where high resonant transmissibilities are secondary problems in the packaging of electronic equipment.

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High-quality quadruplex tape recorders for color TV

L. V. Hedlund | K. Louth

This paper describes the basic differences between the NTSC color system used on the North American continent and the PAL color system widely used throughout Europe and Australia. The manner in which the capstan servo, CATC and video processor subsystems of a typical RCA quadruplex recorder are designed to accommodate these differences is also described. To supplement the discussion, a useful glossary of television terms is also provided.

In the television broadcast industry, at one time or another practically all programs seen on television have been recorded and reproduced on magnetic tape. The video tape recorders that perform these functions are almost all of the *quadruplex transverse scan* type, and are of such high quality that the tape playback is indistinguishable from the live camera pick-up. A photograph of the RCA TR-70 quadruplex delux video tape recorder is shown in Fig. 1.

Quadruplex system

The term quadruplex comes from the fact that the scanning device has four magnetic heads, and these heads are mounted 90° around the circumference of a two inch-diameter rotating wheel. The rotational velocity and phase of this scanning device, commonly called a *headwheel*, is controlled by a very sophisticated electro-mechanical servo system normally referred to as a *headwheel servo system.* As the headwheel transversely scans the tape, the tape is pulled longitudinally past the headwheel assembly at a very precise velocity and phase by another sophisticated electro-mechanical servo system known as the *capstan servo system.* The rotational scanning velocity of the headwheel across the two inch wide magnetic tape is such that the television picture is segmented into 16 groups per television *field* and each segment contains 16 (or 17) television lines. In the recording process, we have then literally torn the picture apart and recorded these groups of 16 television lines in what can be referred to as transverse magnetic strips, called tracks, across the tape. In addition to the above segmenting process of the video, there are several longitudinal tracks recorded simultaneously. The most significant of these is the track commonly called the *control track,* which is analogous to the sprocket holes used in film. This track contains two essential pieces of information:

1) The location of each video track,
2) The start of a television *frame.*

Playback mode

Now with the aid of Fig. 2, we can describe very briefly the re-assembly of the recorded information in the playback mode. The capstan servo system locates the start of a frame (using the control-track signal) in such a manner that the video track will be in the correct location when a specified head scans across the tape. The headwheel servo must then have the proper head in the proper position when the track is located under the headwheel. Although the two servos just described are highly sophisticated electromechanical servos, there is sufficient lack of time-base stability still remaining in the reassembled picture, that two more degrees of correction are required. These two correction devices are called *MATC (monochrome automatic timing corrector)* and *CATC (color automatic timing corrector)* and perform the required correction entirely electronically and operate on the line rate and the color subcarrier rate

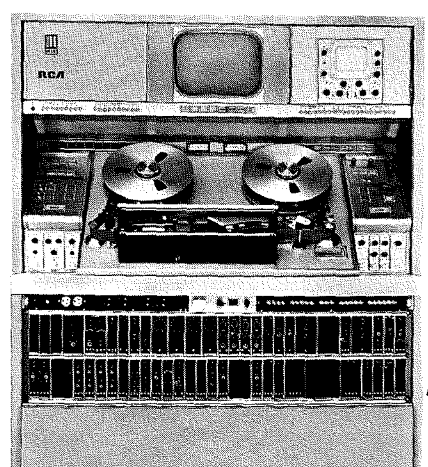

Fig. 1—TR-70 quadruplex delux video tape recorder.

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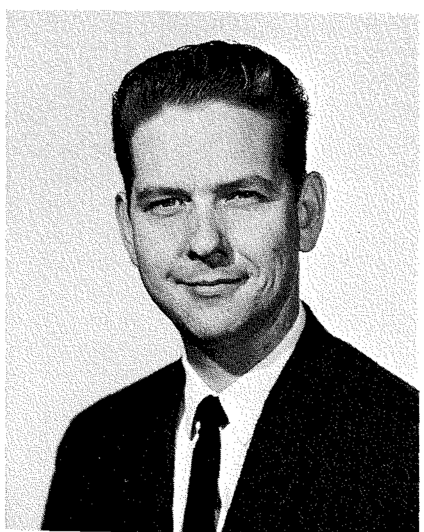


information respectively to produce a totally corrected and time-base-stabilized color-television signal.

Operational requirements

Although the basic requirement of a quadruplex color-television tape recorder is to record and later play back a color television signal, there are several types of color playback modes, the most significant of which is the fully synchronous mode. This mode permits fully *synchronous switching* and *special effects* between the tape playback and the studio.

To achieve synchronous playback, various phasing operations must be accomplished by the servo subsystem described above. The first order of phase correction is obtained by comparing reference (studio) frame pulse with playback frame pulse, using the resultant error in the capstan servo to move the tape position, thereby gaining the required frame coincidence. The result of this action is a picture which is framed vertically when compared to a studio-generated picture. Next the reference horizontal pulse is compared with a playback horizontal pulse, and the resultant error is used in the headwheel servo to change the phase of the headwheel thereby gaining horizontal coincidence. The playback picture will now be positioned horizontally as well. Finally a comparison of reference subcarrier and playback *color burst* is made and the resultant error fed via the CATC and MATC to the headwheel servo to make the final precision positioned adjustment of the headwheel phase.

In addition to the positional servos described above, further time base correction is required at a line-by-line rate to reduce time-base instability to within broadcast standards. Simply, the MATC and CATC are open-loop time-base correctors. The MATC operates by first comparing reference horizontal phase with that of tape horizontal and allowing the resultant error voltage to modulate an internal *EVDL* thereby reducing the error. This process is repeated in CATC using reference subcarrier and playback color burst. This is the normal mode of studio operation and applies equally to NTSC and PAL.

Two color TV standard recorder

The International version of the RCA TR-70 quadruplex tape recorder is cap-

Glossary of television terms

NTSC: National television system committee.

PAL: Phase alternate line.

Quadruplex transverse scan: A system of scanning a longitudinal moving magnetic tape where the scan is across the width of the tape and the scanning device is a two inch diameter rotating wheel with four magnetic heads mounted 90° apart of the periphery of the wheel.

Headwheel: An assembly which contains the four magnetic heads mounted on the two-inch diameter wheel and a motor for servo control.

Headwheel servo system: An electromechanical servo system which accurately maintains the rotational speed and position of the headwheel to effect a precise scanning of the magnetic tape for both recording and reproducing.

Capstan servo system: An electromechanical servo system which accurately maintains the linear speed and position of the magnetic tape as it is pulled passed the headwheel assembly.

Field: One of the two (or more) equal parts into which a frame is divided in interlaced scanning.

Control track: The electronically recorded longitudinal track which contains the recorded linear tape speed information. On playback, the control-track information is used by the capstan servo as the controlled variable.

Frame: A complete picture which is made up of an electrical signal which has basic repetitive rate of 30 Hz in the NTSC system and 25 Hz in the PAL system. A frame consists of two interlaced fields of the same picture and contains 262.5 (312.5 in PAL) horizontal lines. A frame, therefore, also consists of 525 (625 in PAL) horizontal lines.

MATC (monochrome automatic timing corrector): A time-base corrector which uses an electronically variable delay line (EVDL) to correct for errors introduced in the quadruplex record-playback process. The correction results from comparing tape horizontal sync pulses against the stable horizontal sync pulses from the studio.

CATC (color automatic timing corrector): A time-base corrector which uses an electronically variable delay line (EVDL) to correct for errors introduced in the quadruplex record-playback process. The correction results from comparing tape-burst phase pulses against the stable reference subcarrier pulses from the studio.

Synchronous switching: A video switch between any two video sources which have their vertical, horizontal, and subcarrier synchronizing elements time coincident.

Special effects: A simultaneous display of portions of two television pictures which are fully synchronous in such a manner as to permit an insert of one picture into another or a wipe between the two pictures.

Color burst: That portion of the composite color signal, comprising a few cycles of a sine wave of chrominance subcarrier frequency, which is used to establish a reference for demodulating the chrominance signal.

EVDL (electronically variable delay line): A delay device in which the delay time can be changed by a change in the control voltage which is applied to the line.

Standard conversion: The conversion of a television signal of one standard such as the 525 NTSC television standard to another standard such as the 625 PAL television standard.

Color-difference signal: An electrical signal which when added to the monochrome signal produces a signal representative of one of the tristimulus valus (with respect to stated set of primaries) of the transmitted color.

Quadrature modulated: A form of modulaion where two carriers which differ in phase by 90°, in quadrature, are modulated with the intelligence to be transmitted.

Color subcarrier: The carrier which is modulated by the chrominance information.

Hue: The attribute of color perception that determines whether it is red, yellow, green, blue, purple, or the like. [**Note 1:** This is a subjective term corresponding to the phychophysical term dominate (or complementary) wavelength. **Note 2:** white, black, and gray are not considered as being hues.]

Hue error: An error in the color encoded signal which will produce a change in the transmitted color is termed a hue error (usually due to a phase shift error).

Saturation change: A change in the intensity of a color and is directly proportional to the change in magnitude of the color subcarrier.

R-Y commutation: R-Y is one of the color difference signals on PAL and NTSC; however, on PAL this color difference signal is alternated in phase by 180° on each successive line or it is "commutated" on each line.

Synchronous color playback: A synchronous color playback is achieved when **all** the corresponding time repetitive elements are time coincident with that of the Reference (studio).

Vertical sync: A pulse generated to be coincident with the second broad pulse in each field.

Burst flag—also called burst gate: A keying pulse which is used in coders to gate in the color bursts on the back porch following each horizontal sync pulse and in receivers to gate the bursts into the color-sync circuit.

Vertical interval: That portion of a television signal which contains the vertical timing information used for alignment of the signal to a reference.

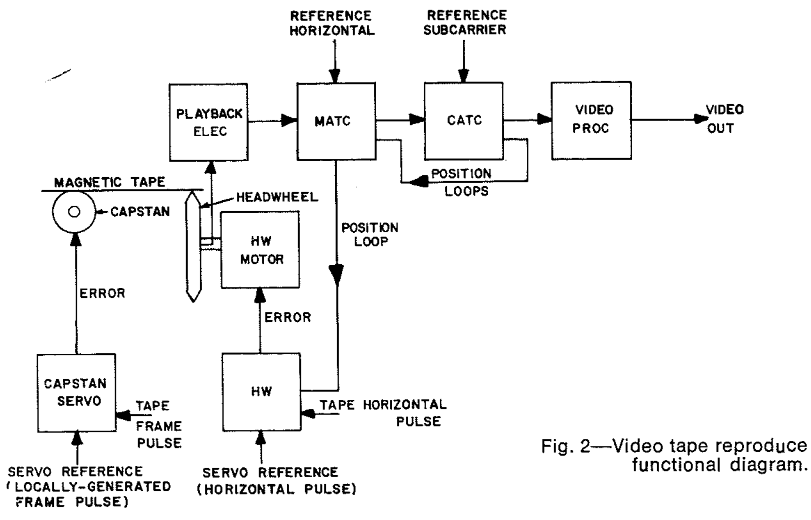


Fig. 2—Video tape reproduce functional diagram.

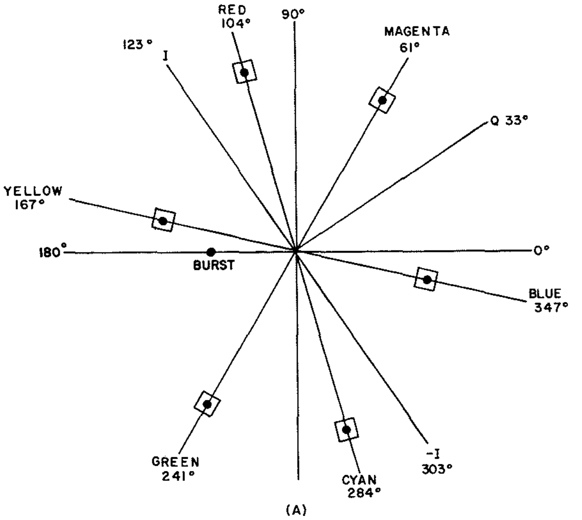


Fig. 3a—525 NTSC color bar.

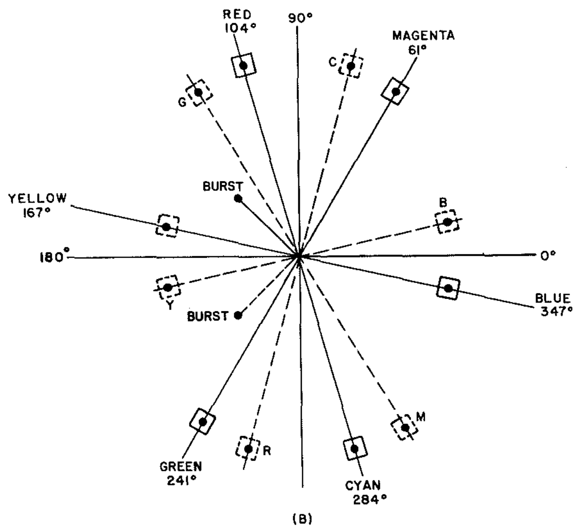


Fig. 3b—625 PAL color bar.

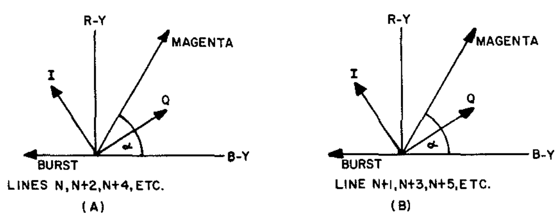


Fig. 4a—PAL color magenta vector diagram.

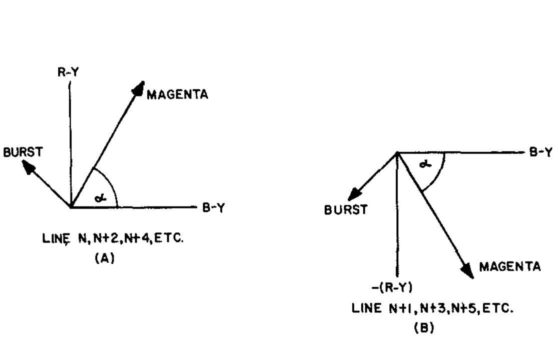


Fig. 4b—NTSC color magenta vector diagram.

able of recording and reproducing either the NTSC or PAL color television signals. The difference between the two color systems necessitates changing certain functions within the TR-70. This is automatically accomplished by pushbutton selection of the appropriate operating standard. This built-in flexilibility and convenience is highly desirable in applications where the program source could be live or pre-recorded and may be on either standard, and final *standard conversion* would be used just prior to broadcasting. Another application involves transmission of programs between continents via satellite. The transmission could occur on either standard—with the sending and receiving machines having the flexibility to handle either standard—and final standard conversion would again occur prior to broadcasting at some delayed time, if desired. To understand the areas of the machine which are affected when switching between NTSC and PAL, it is first necessary to understand the difference between the two systems.

Comparison of NTSC and PAL

The PAL color system is similar to the NTSC system in that the *color-difference signals* are *quadrature modulated* on a *color subcarrier.* The fundamental difference between the two systems is shown vectorially in Fig. 3. Fig. 4 shows the NTSC and PAL color vector diagram for the color magenta on successive television lines. As can be seen in Fig. 4b, the "phase" of the transmitted color is mirrored about the *B-Y* axis on "alternate lines"; hence the abbreviation PAL is used for phase alternate line. The effect of the phase alternation cannot easily be seen on a normal voltage-vs-time display as seen by a comparison in Fig. 5. However, the vectorial display in Fig. 3a shows that each color is mirrored about the *B-Y* axis in the PAL system.

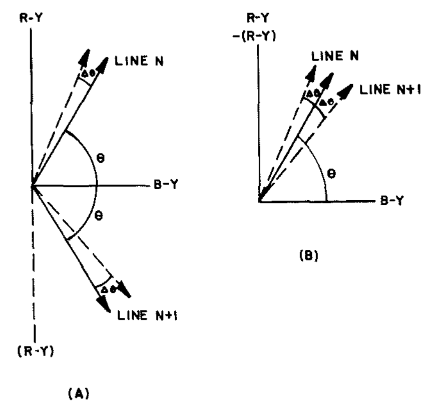
The advantage gained in the PAL method of color encoding is that phase errors introduced in the transmission of the signal are seen as saturation errors, and not as a *hue error.* Only a few degrees phase error in an NTSC signal produces a very noticeable *hue error* at the receiver, whereas the same phase error on PAL results in only a small *saturation change* which is relatively unnoticeable.

The mechanism by which the advantage is gained can be explained with aid of Fig. 6 which shows two alternate lines of the PAL encoded signal. A phase error is seen in Fig. 6a to have been in the same phase rotation on both lines, but because the *R-Y* signal is alternately switched by 180° in the receiver the phase error is reversed as shown in Fig. 6b. This effectively nullifies the phase error but results in some desaturation, as seen by the fact that the resultant color vector is somewhat shortened. The above described *R-Y commutation* in PAL requires that the full color-encoded sequence occupy eight complete television fields. In the NTSC system, however, the full color sequence occupy only four fields. The TR-70 was designed to be switchable between both NTSC and PAL color television standards and will automatically switch the relevant circuits in the machine to the correct mode of operation on selection of the desired standard. Subsystems of the machine affected when switching between NTSC and PAL are described in the following paragraphs.

Capstan servo

As previously stated, the first order of phase correction required for a fully *synchronous color playback* is to obtain coincidence between tape frame pulses and reference (studio) frame pulses. For a normal monochrome signal the lowest repetition frequency is the frame rate, which is 30 Hz for NTSC standards and 25 Hz for PAL standards. For a NTSC color signal, the lowest repetition frequency is 15 Hz which is one half of that for a monochrome signal. The reason for this change is that the color subcarrier frequency is interlaced with respect to

Fig. 6—PAL color vector diagram of phase error effect.



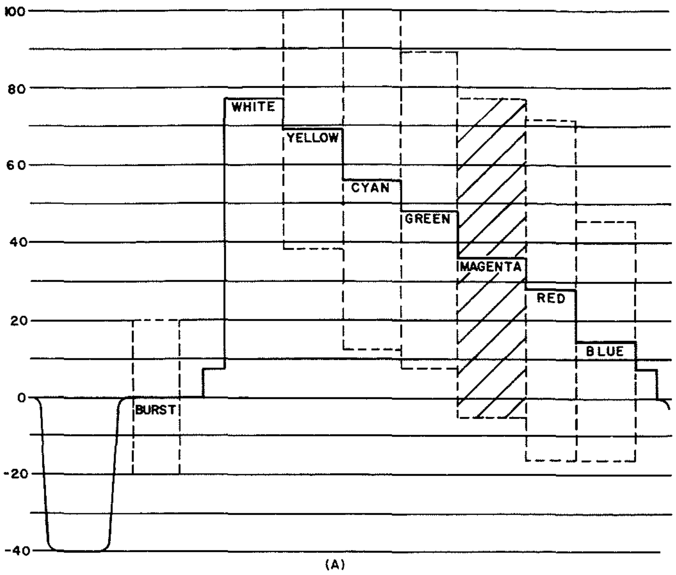


Fig. 5a—525 NTSC color bar.

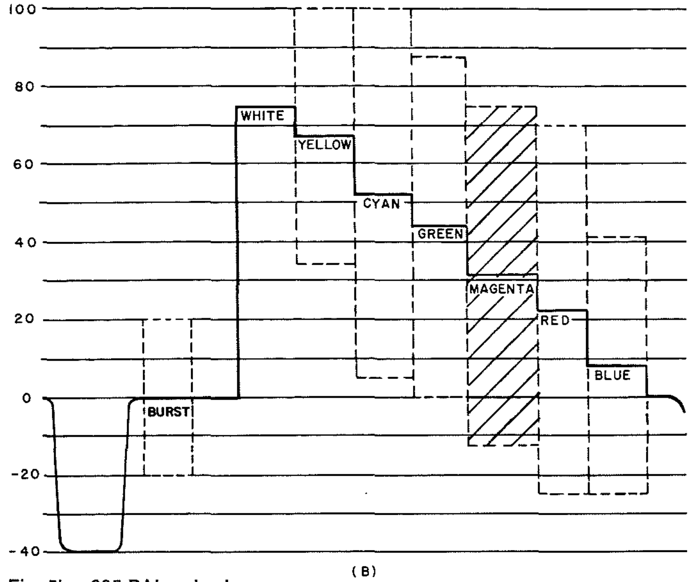


Fig. 5b—625 PAL color bar.

the monochrome frame sync frequency in such a manner as to be phase repetitive at a 15 Hz rate. This interlace of color subcarrier and monochrome sync is necessary so that the dot structure produced by the color subcarrier on a monochrome monitor is at an angle (45°) which is least visible to the eye. Now if the PAL color signal were interlaced in the same manner as the NTSC color signal, then the lowest repetition frequency on PAL would be 12.5 Hz. In fact, because of the alternation of the *R-Y* color difference signal on PAL, the interlace frequency between color subcarrier and monochrome sync must be further modified in order to maintain good monochrome compatibility, i.e., a 45° dot structure. Therefore, on PAL the color subcarrier is phase repetitive with respect to monochrome sync at a 6.25 Hz rate which is the lowest repetition frequency. Apparently then for a fully synchronous color playback it is necessary to lock the capstan servo with a 15-Hz reference on NTSC and a 6.25-Hz reference on PAL; however, because the color subcarrier phase is exactly 180° out of phase half way through the color sequence it is possible to use twice the lowest frequency rates, i.e. 30 Hz on NTSC and 12.5 Hz on PAL. The 180° phase error may be removed by rotation of the reference color subcarrier by 180°.

From the above it is seen that there is no difference between the capstan reference rate between 525 monochrome and 525 color. On PAL, the capstan reference rate is 25 Hz for a 625-line monochrome system and 12.5 Hz for a 625-line color system. Now, to obtain a 12.5 Hz reference for PAL color, it is necessary to specify one field in four as the reference. The field chosen is No. 4 (Fig. 7). This field is used as a reference and its timing is recorded on the control track as the 12.5-Hz edit pulse.

The capstan lock-up cycle can be described with the aid of Fig. 8. To guarantee a fully synchronous color playback in PAL, it is necessary to initially control the capstan by comparing the 12.5-Hz reference-frame pulse and 12.5-Hz pulse derived from the control track. Normally the machine will achieve the desired fully synchronous playback within the first 6 seconds of playback; however, 12.5 Hz sampling is maintained for the first eight seconds. If any disturbance occurs during this eight second period, or at any time that a fully synchronous color playback is required, the capstan servo will check itself and return to 12.5-Hz sampling if necessary.

The third field of the PAL color sequence is detected by the coincidence of *vertical sync* and *burst flag*. The resulting coincidence pulse is then used to set the reference frame divide-by-two circuit to give an output on the fourth field; this pulse is used as the 12.5-Hz PAL reference. The 250-Hz control-track pulses, which are normally divided by ten to give a 25-Hz signal, are divided by twenty for the first 8 seconds. The division phase is set by the recorded 12.5-Hz edit pulse. This edit pulse is coincident with the fourth field of the recorded video information on the tape.

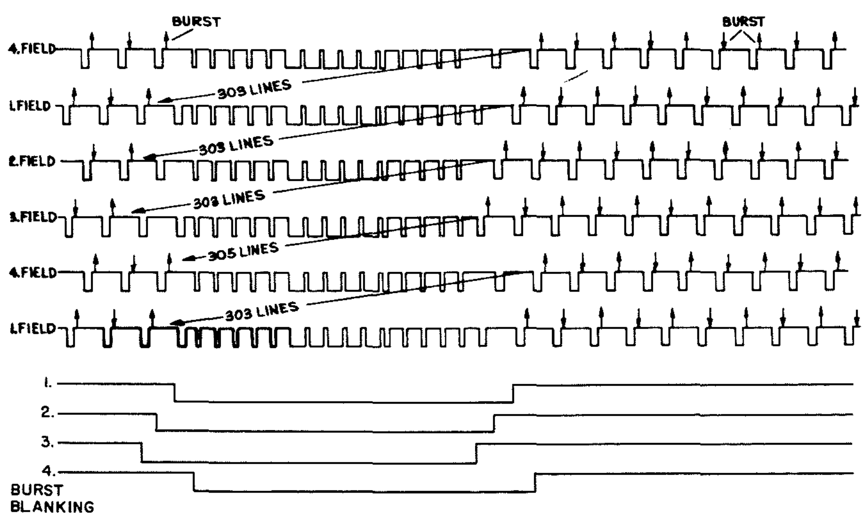


Fig. 7—PAL color field sequence and burst blanking sequence.

Color automatic timing corrector

Fig. 9 shows a simplified block functional of the CATC system and includes in the dotted lines the signal path difference between NTSC and PAL. In NTSC operation, the system compares directly the reference-subcarrier phase with the tape-burst phase and uses the resultant error to time correct the video in the electronically variable delay line (EVDL). The PAL signal path is different in that reference subcarrier is switched on alternate lines by ±45°. This is necessary because the tape burst in the PAL stan-

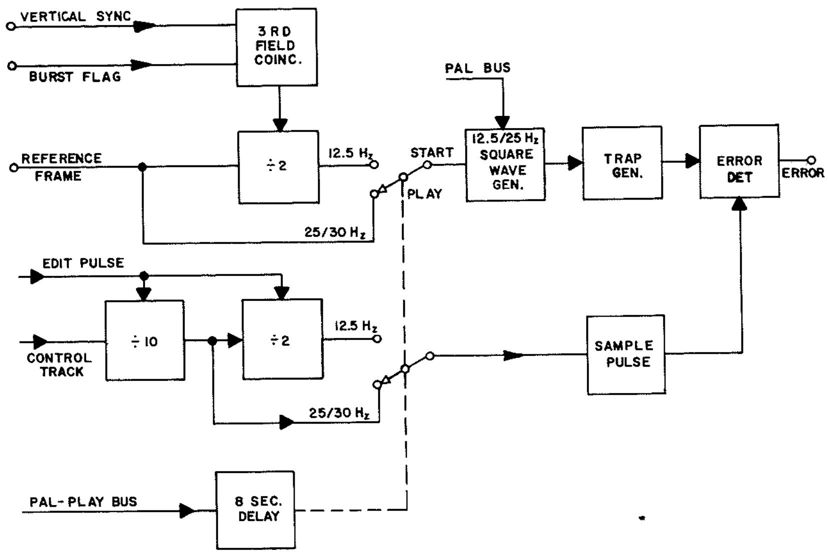


Fig. 8—Capstan servo functional diagram.

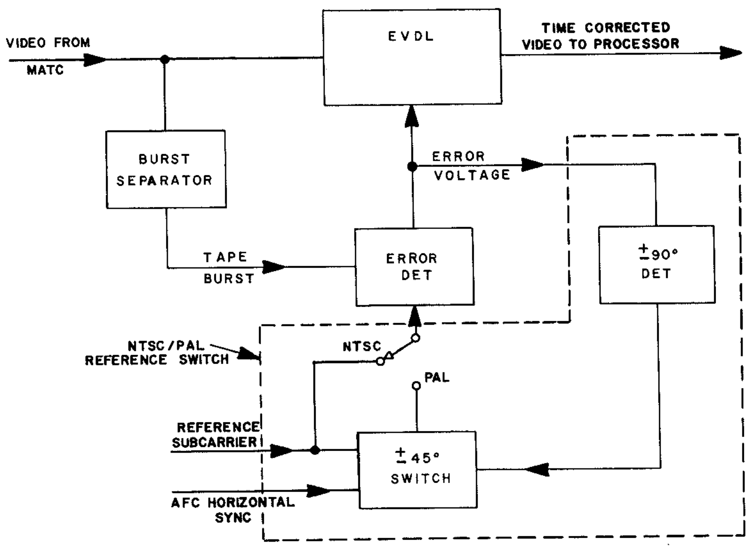


Fig. 9—CATC functional diagram.

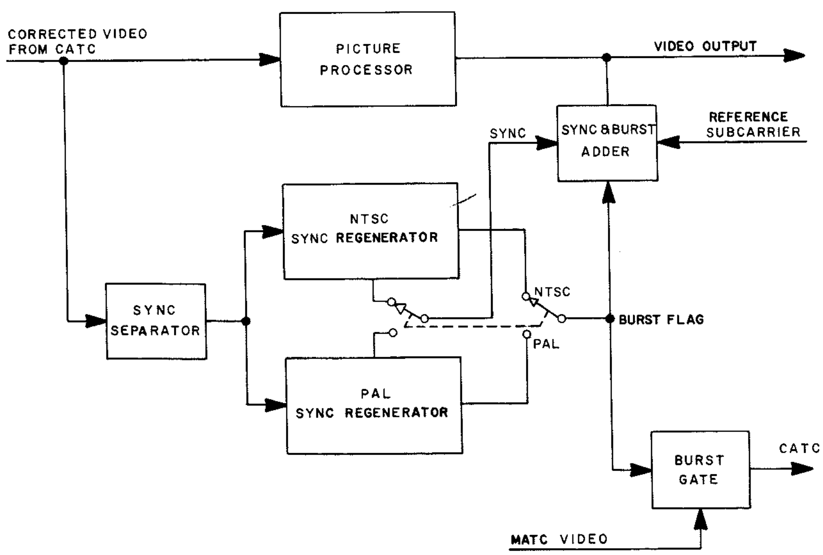


Fig. 10—Video processor functional diagram.

dards is switched ±45° on alternate lines by the commutation affect of the *R-Y* component as is seen in Figs. 3 and 4. To assure that the reference subcarrier is switched in the same sequence as the tape burst, a ±90° detector is used. This detector will reset the sequence correctly after detecting twenty lines of continuous ±90° CATC error. With the sequence correct, the normal CATC error will be zero.

Video processor

Video processing of the PAL signal is essential the same as for NTSC. The only difference is in the burst-gate signals which are used to gate the playback color burst to the CATC and reinsert color burst into the video output signal. This difference can be explained with aid of Fig. 10. In NTSC, the burst-gate signal is derived from the regenerated horizontal sync pulses and is blanked during the *vertical interval* for a period of nine horizontal lines. The PAL burst-gate signal is also derived from the regenerated horizontal and is blanked similarly during the vertical interval, for a period of 8 ¾ horizontal lines, however, the vertical blanking timing meanders over a four-field period and differs by ½ horizontal line on each of the four fields (Fig. 7).

Conclusion

The RCA international version of the TR-70 deluxe video tape recorder is capable of playing either of the two color standards (NTSC or PAL) with a picture quality nearly equal to that of a live studio camera, and the standard selection is achieved at the press of a button.

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Broadband, high-gain, L-band, power amplifier module

R. L. Bailey | J. R. Jasinski

Increasingly sophisticated radar systems, such as phased arrays, have created a need for RF power amplifiers that have wide bandwidths together with excellent phase stability and uniformity of characteristics. This paper describes the unique design and fabrication of the RCA Dev. No. Y1043*, a six-stage, L-band amplifier module that has performance characteristics which fulfill these requirements.

AMPLIFIERS utilizing grid-controlled tubes have been operated successfully in *narrow-band* phased-array radars for a number of years; only recently, however, have their full capabilities in *broadband*, high-gain applications been demonstrated. The development of the Y1043 amplifier module has substantially advanced the state-of-the-art in this area. The compact, wide-band, pulsed amplifier module uses gridded electron tubes, and is designed for operation at a center frequency of 1300 MHz with an instantaneous electronic bandwidth of 10% measured at the 1-dB points.[1] Performance objectives included a peak power output of 5 kW and an overall gain of 45 dB utilizing a minimum number of stages. The amplifier module was limited to 24 inches in length and 4½ by 4½ inches in cross section. In this particular phased-array application, each amplifier module was to drive an individual radiating element. For proper antenna spacing, this modular approach required that the amplifier not exceed one half wavelength in cross section.

The degree of phase variation from input to output as a function of drive level, frequency, and supply-voltage variation was required to be small to minimize the cost of auxiliary operating equipment.

Conventional amplifiers

Analysis of the specifications described above indicated that conventional cascading techniques would not yield the desired results, particularly if the overall size and gain-bandwidth requirements were to be achieved. Conventional L-band (390-to-1550-MHz) gridded power-tube amplifiers typically consist of tuned input and output cavity or stripline resonators in conjunction with the appropriate bypass circuits required for operation. A typical 5-kW unit may be 5 to 7 inches on each side in cross section and 12 to 15 inches in length. These amplifiers are normally single-tuned, and yield characteristic gains of 10 to 15 dB. Gain is increased when two or more independent stages are cascaded with interconnecting coaxial cables. An impedance-matching transformer at the load end of each interconnecting cable permits transmission of interstage power at the cable surge impedance (usually 50 ohms) and thus makes interstage performance independent of cable length. Interstage loading and tuning adjustments are made with an impedance transformer at the generator end of each cable. The overall gain of the amplifier chain increases with the addition of each new single-tuned stage, while system bandwidth continually decreases; desired gain-bandwidth characteristics may be achieved by changes in the degree of coupling between stages and/or by the use of stagger-tuning.

Fig. 1 shows a single-tuned, single-stage amplifier, RCA Dev. No. Y1015. This amplifier uses an RCA-7651 tube, delivers a minimum peak power output of 6 kW, and can be mechanically tuned across the 950-to-1225-MHz band with an average instantaneous bandwidth of 3%. The RCA-7651 is capable of a peak power output of 39 kW at 1200 MHz when operated at its maximum ratings in a narrow-band circuit (less than 1% instantaneous bandwidth). The threaded coaxial fittings

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was an honor graduate of the T-3 Engineering curriculum, RCA Institutes in 1958. He joined RCA in 1958 as an electronics technician at the Lancaster plant, where he was engaged in the evaluation of RCA's new line of Cermolox tetrodes to establish their capability in pulsed RF service at L-band frequencies. In 1962, Mr. Jasinski was assigned to evaluation of the S-band coaxitron being developed for the Air Force. Compilation and organization of data from this evaluation led directly to the successful development of external broadband circuits for Cermolox tubes designed to operate at L-band frequencies. In 1964. Mr. Jasinski was assigned to the developmental L-band module program. He was upgraded to Engineer in 1967 and is presently responsible for the prototype development of all new module variants and the manufacture and testing of existing module types.

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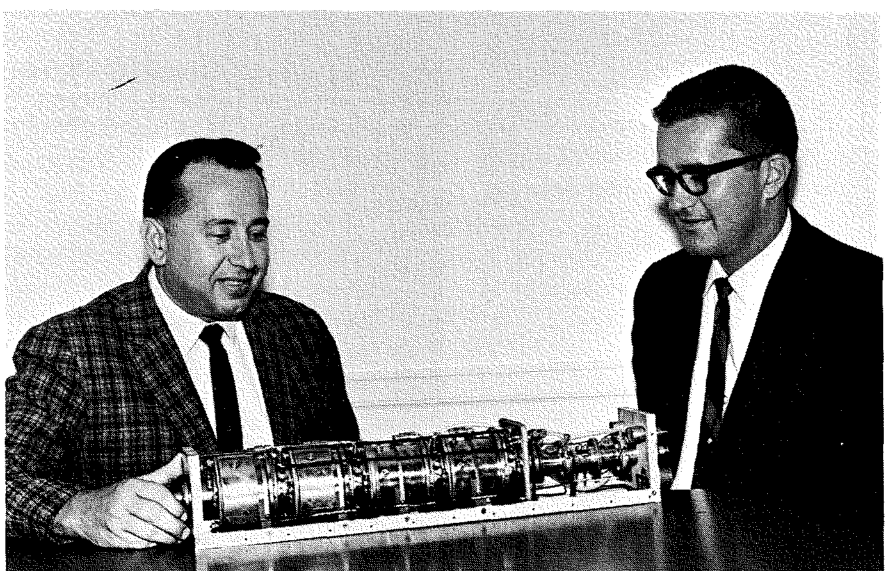
The development of the gridded-tube L-band, power-amplifier module was supported by U.S.A.E.L., Evans Laboratories, under Contract DA36-039-AMC-03203(E).



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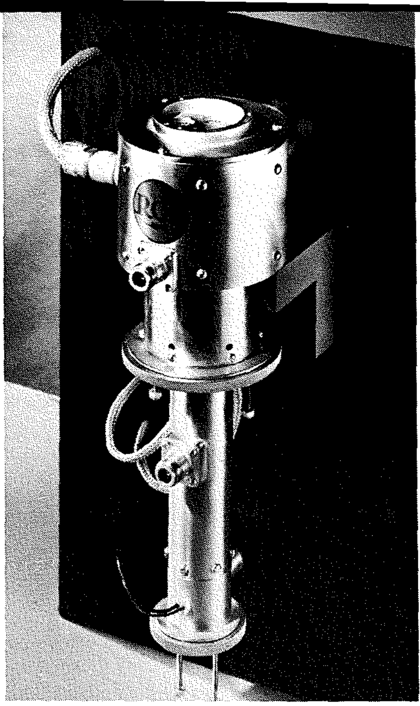


Fig. 1—Conventional Y1015 single-tuned, single-stage amplifier.

shown in Fig. 1 permit connection of standard 50-ohm RF drive and RF output cables to the cavity; however, because the cables join the coaxial resonators at right angles to the main cavity axis, they add considerably to the cross-sectional dimension. This cavity measures about 6 inches at its major cross section. When the cavity is tuned to its lowest operating frequency of 950 MHz, the input tuning rods extend 2 inches below the cavity and produce an overall length of 14½ inches.

This type of amplifier is generally not satisfactory for use in multistage *broadband* chains. Because the unnecessary impedance transformations to the 50-ohm interconnecting cable surge impedance severely limits gain-bandwidth product, double- or triple-tuned circuits cannot be utilized to best advantage, and the resulting size of the cascaded amplifier chain exceeds the requirements of many applications.

New cascading technique

Fig. 2 shows the RCA Y1043 "totem-pole" amplifier. This amplifier incorporates techniques which enhance the inherent gain-bandwidth capabilities of gridded tubes and, at the same time, achieves a considerable size reduction over classical cascaded amplifier chains. The amplifier is shown with the external housing removed to illustrate the end-to-end configuration as viewed from the input end. In this system, six stages of gridded power tubes provide a peak power output of 5 kW at 1300 MHz with a gain of 53 dB. The system uses two commercial 7768 planar triodes (small tubes) and four cermolox tetrodes (two each 8226 and 7651 generic types), samples of which are shown adjacent to the module. The cermolox tetrodes used in this amplifier differ from other tubes of the same generic type in that they use integral conduction-cooling aluminum jackets instead of air-cooled radiators. The RF drive, liquid coolant (high purity at ½ GPM), and all operating voltages are applied through the five connectors at the input bulkhead. Output power of the amplifier is extracted through a coaxial connector at the opposite end. A 3-kV DC power supply, the highest voltage required for operation, provides plate voltage for the four tetrodes. The tetrodes are modulated by a 1-kV pulse which is applied to the screen grids. The plate voltage for the 7768 triodes is provided by a 300-volt DC supply; the grids are modulated by a small 6-volt bias pulser. All voltages are applied through bus lines which are located in the corners of the module. A few of these bus lines are visible in Fig. 2. The module is packaged in an aluminum container which measures 4⅜ x 4⅜ x 23 inches. This size satisfies the required dimensions for use in a 1300-MHz phased-array radar.

Fig. 3 shows the instantaneous bandwidth characteristic of the module for an applied peak drive power of 25 mW. The module measured produced a nominal peak power output of 5.75 kW at 2% duty, with a ripple factor of less than 1 dB and an instantaneous bandwidth of 10.5%.

Fig. 4 shows the final amplifier package. The absence of connectors on the large surfaces allows many such modules to be inserted side-by-side, "honeycomb" fashion, into an array panel to form a multi-megawatt phase-steerable beam. Fig. 5 shows a cross-sectional view. No conventional, lengthy interstage circuits are used in the amplifier chain; instead, the stages are stacked in a "totem-pole" fashion, and each of the stages is directly interconnected by a full-electrical-wavelength circuit. Minimum system dimensions are produced with this coaxial, in-line configuration. A considerable portion of each interstage circuit, especially in the tetrode stages, is contained within the internal output and succeeeding input sections of the tubes; as a result, the amplifier stages have an average length of only 4 inches. Two overcoupling elements are contained in the interstage circuit external to the tube (about one-half wavelength) to provide optimum gain-bandwidth in a minimum amount of space. In each stage, these elements consist of shunt inductance and series of capacitance. The inductor is composed of several ¼ inch-diameter spokes shunted across the cavity. In each tetrode stage, two of the spokes are hollow to allow anode coolant to flow into and through the anode seat, which is a portion of the coaxial center conductor. The series overcoupling capacitor is formed by a break in the center conductor of the interstage coaxial line. This capacitor also isolates the plate voltage of a particular stage from the cathode potential of a driven stage. The module contains mica RF radial bypass capacitors which provide DC isolation for the various tube elements.

Basic design techniques

Overcoupled RF circuits

The RF circuits used throughout the module are overcoupled resonant coaxial cavities which are aligned to produce triple-tuned, maximally flat responses. Each stage in the chain has the same response. This approach provided full freedom to change the number of stages at any time during the development of the module. The alternative approach, stagger tuning of individual stages, would have restricted this freedom.

The overcoupled circuits have an inherently greater gain-bandwidth product than the simple single-tuned circuit; the improvement is a function of the number of circuits coupled together. A useful figure of merit for broadband circuits is the resistance-times-bandwidth *(R* x *BW)* product which the circuit presents to the fundamental component of the tube beam current. A circuit can be evaluated on the basis of the ratio of the *actual* *R* x *BW* product to the *maximum* *R* x *BW* product for a simple parallel resonant circuit having the same amplifier output capacitance. A valid comparison, however, must include a specification of the shape of the actual response. For this discussion, it is assumed that the response is maximally flat and, further, that the *R* x *BW* value is the product of the resistance and bandwidth both referred to the points 1/6 dB down from the peak value of R. (Because the module has six stages, this reference provides the overall $R \times BW$ product at the -1-dB points.) For the single-tuned circuit, the $R \times BW$ product is the half-power resistance times the half-power bandwidth.

On this basis, an optimized double-tuned circuit can provide an $R \times BW$ product as great as 1.22 times that of a single-tuned circuit. A triple-tuned circuit can provide up to 1.66 times as much $R \times BW$ product. The limit approaches π as the number of tuned circuits is increased. (These numbers were calculated from tabulated data for ladder networks given by Weinberg[2]; verification of the extension to high-frequency bandpass circuits was made by Green.[3]) Because the circuit complexity increases directly with the number of coupled circuits, a triple-tuned circuit provides a good compromise between $R \times BW$ improvement and circuit complexity.

The triple-tuned coaxial circuits employed in the Y1043 L-band module are very similar conceptually to the double-tuned circuits employed in RCA super-power coaxitrons.[4,5,6,7]

Tube selection and computer calculations

Because the $R \times BW$ product for the simple parallel resonant circuit can be easily calculated for a hypothetical lumped-constant circuit, it is possible to estimate the performance of any tube used with triple-tuned circuits. Tubes for use in the amplifier module were selected on this basis. For interstage analysis, the dynamic drive-point impedance was measured at the input terminals of each tube at the required drive power. A modified version of the 7651 cermolox tetrode was chosen for the final stage; an equivalent circuit for this stage is shown at the top of Fig. 6. The impedance and admittance plots for such a circuit can be obtained from straightforward but tedious calculations. A program was written for the RCA-301 digital computer to greatly improve the calculation time. The program included provision for 15 different sections of transmission line, and made allowances for lumped reactive elements at various line junctions. The output data provided the impedance as a function of frequency at key line junctions.

The impedance and resistance plots in Fig. 6 are comprehensive presentations of data obtained from computer analysis of the conceptual design of the final output stage. The particular values listed for the circuit parameters produced the Smith plot variation in impedance $Z_T Z_0$ as a function of frequency shown at the lower right. Within the passband, the impedance response follows a constant R locus, indicating a maximally flat condition. The resistive component of Z_T is plotted at the lower left. Obviously, the first set of parameters used in the computer calculation did not produce this optimized response, because the values of the parameters were chosen primarily by educated guesses. However, with the Smith plots used as guides, successive computed sets of data converged rapidly.

During the series of computer calculations to determine the specific set of parameter values for the optimum response, much valuable insight was gained on quantitative effects of varying each parameter. This information was later found to be very useful for circuit alignment. The computer re-

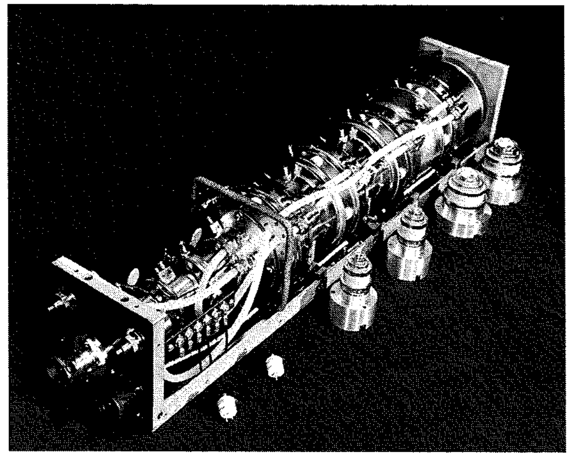


Fig. 2—Y1043 amplifier module with cover removed to show the end-to-end configuration.

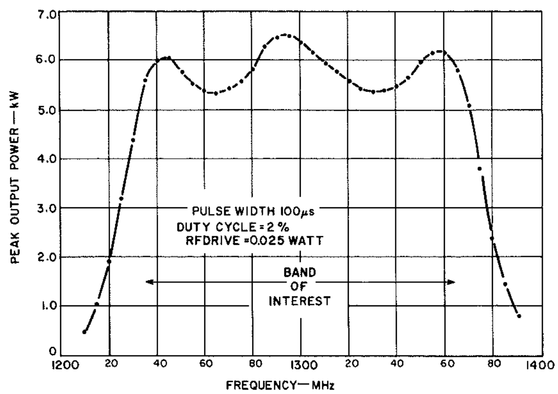


Fig. 3—Y1043 typical output response.

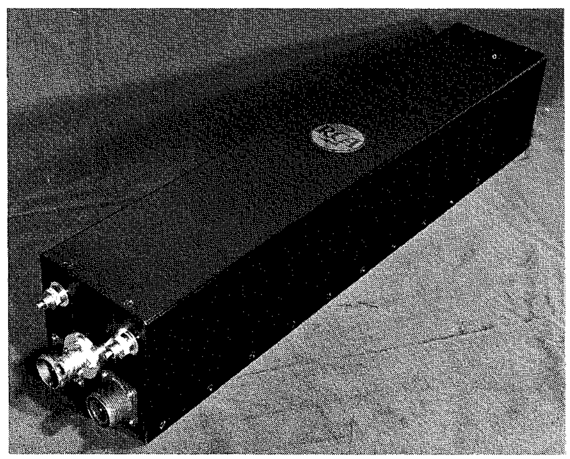
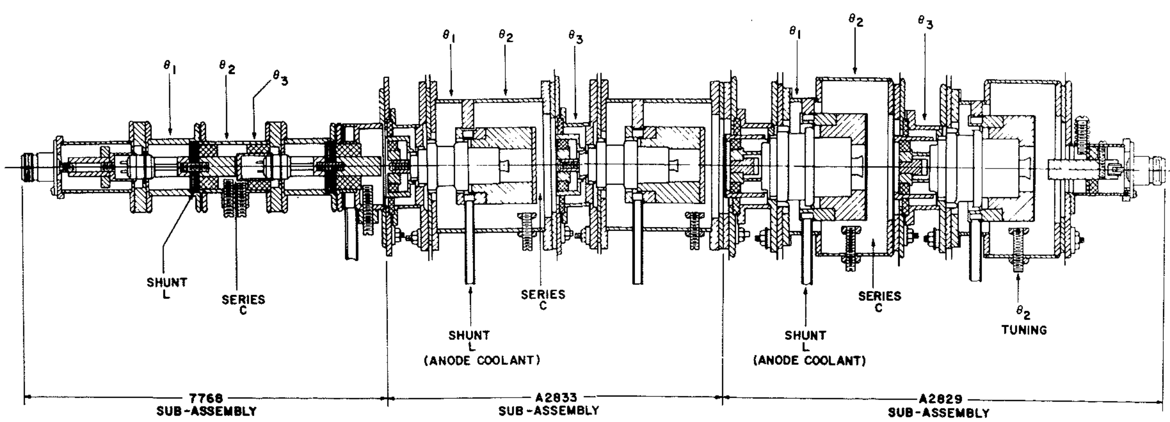


Fig. 4—Y1043 shown fully housed to illustrate its modular concept.

Fig. 5—Tube cross section.



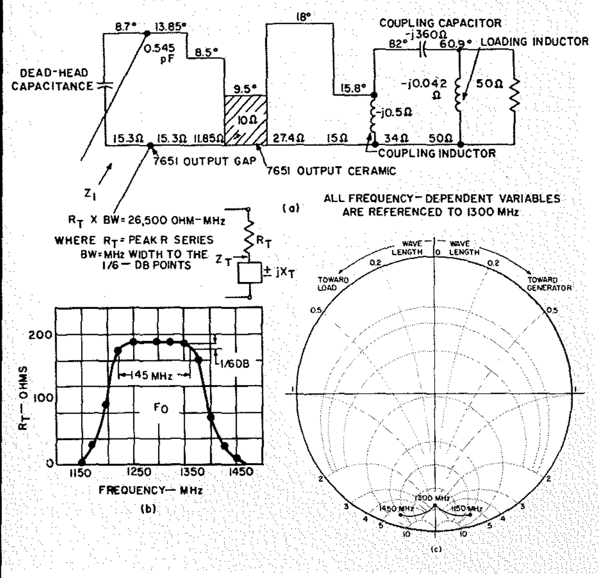


Fig. 6—Smith-chart plot of impedance versus frequency.

sults were used to calculate projected operating conditions for each stage. In practice, it is necessary to derate the computed value of R_T by approximately a factor of 30% to compensate for the practical limits on circuit efficiency and for the smearing of the RF current pulse because of transit-time effects.

Cold-probe verification of amplifier design

After paper designs of circuits were available, cold-probe models were fabricated and analyzed to verify predictions based on computer calculations. These models consisted of cavities that included provisions for variation of every parameter external to the tube; they used dummy tubes consisting of only screen-grid-and-anode assemblies.

The output gap of the dummy tube was energized with approximately 1 watt of frequency-swept power, and a crystal detector was used to monitor the transmission response of the cavity into a 50-ohm load. The output of the crystal detector was then displayed as an oscillogram. Variation of parameters while the instantaneous display was monitored allowed swift attainment of a flat response with the desired center frequency and bandwidth. Results obtained with models of the final output and the interstage circuits verified that the computer program accurately simulated the RF circuitry.

Amplifier assembly and alignment

The final design and fabrication of all the amplifier stages were based completely on computer and cold-probe results. As shown in Fig. 5, the module consists of three basic subassemblies. Each subassembly contains two stages of amplification, and each was extensively tested as a single-stage and then a two-stage broadband amplifier to confirm successful operation of each tube at the required power level. The input to the first stage was not triple-tuned, but used a shunt capacitive "matching slug" that produced a single-tuned transformation to 50 ohms. Because the transformation ratio was relatively low, the input VSWR is better than 1.5:1 (4% reflected power) across the 1200-to-1400-MHz band.

Final assembly and alignment proceeded progressively, one stage at a time, starting with the low-power stages. With this method, two stages were operated into a passive load, then three stages and finally up to six stages so that alignment of the most recently added stage could be accomplished at the correct drive level. The DC grid-current response of the driven stage served as an excellent indicator of interstage performance. The use of swept-frequency drive at all times provided comparative ease of circuit adjustment.

Phase measurements

The phase characteristics of the module are of major interest for use in phased-array systems. Two independent measurements of these characteristics were made with nearly identical results, one at MIT Lincoln Laboratories and the other at RCA Lancaster. These measurements were made with a differential phase bridge which had a resolution capability of better than three degrees. The measured phase-sensitivity data are presented in Fig. 7. As expected of any device that utilizes gridded power tubes, phase sensitivity of the module is extremely low. The most sensitive operating parameter, the tetrode screen-grid voltage, produced an approximate shift of only one degree per 1% change in voltage. As a result of this high degree of phase stability, power-supply costs are reduced because voltage-regulation requirements are minimized. As a direct comparison, a velocity-modulated device, such as a traveling-wave tube typically exhibits a twenty-degree phase change for a 1% change in anode voltage[8]; these results show that much better voltage regulation is required for the same degree of phase stability. Variations of DC voltages, the filament voltage, and drive power produced negligible phase changes through the module.

The phase characteristics as a function of frequency, shown in Fig. 8, indicate that extreme linearity (±2°) exists over 75% of the pass band with no significant irregularities appearing in the curve.

Extended applications

Since the successful prototype development of the Y1043 module, customer interest has warranted the establishment of a manufacturing facility for fabrication of such modules on a continuing basis. Although the module was primarily designed for phased-array applications, present interest includes other areas where small size and high gain-bandwidth requirements are also of prime concern. The Y1043 module, and variants thereof, have either been proposed for or are presently being used in RF pulse-coded systems for command and guidance, phase-stable broadband drivers for higher-power radar systems, multi-channel airborne navigational beacons, and broadband applications where the major interest is in frequency agility.

As an illustration, the RCA Y1048C amplifier shown in Fig. 9 was designed specifically to operate in one of the above application areas and is an extension of Y1043 techniques. The module consists of 5 cascaded tetrode stages. It is designed to operate at a center frequency of 1375 MHz with an instantaneous 1-dB bandwidth of 5%. The peak power output is 10 kW with a gain of 47 dB. Because this module was not to be used in a phased array, the cross-sectional dimensions were allowed to increase to 5x6 inches; the length is 22 inches. The increased cross-sectional area was required for secure mounting of the module and its auxiliary components within the aluminum container to meet shock and vibration specifications.

RCA Dev. Nos. Y1057 and Y1049 modules (not shown) are the one- and two-kilowatt versions of the Y1043. The Y1057 delivers 1 kW of peak power at a center frequency of 1270 MHz with an instantaneous 1-dB bandwidth of 70 MHz and a gain of 37 dB. The Y1049 delivers 2 kW of peak power at a center frequency of 1088

Parameter varied	1235 MHz	1265 MHz	1300 MHz	1335 MHz	1365 MHz
I. 3,000-V supply (tetrode plate)					
Lowered 10%	+ .3				− 4.25
Lowered 16.7%	− .45				
II. 1,000-V supply (tetrode screen)					
Lowered 10%	+ 6.7	+ 5.5	+ 7.2	+ 9.75	+11.1
Lowered 20%	+16.9	+13.5	+15.6	+24.8	+23.6
III. 300-V supply (triode plate)					
Lowered 10%					+ 3.76
IV. Filament supply (all stages)					
Lowered 8.75%			− 4.38		
V. Drive power					
Lowered 2dB					− 2.8
Lowered 4dB					− 7.2
VI. Drive Lowered 1dB 3,000-V, 1,000-V, and 300-V supplies					
Lowered 10%	14.		12.7		4.9

Fig. 7—Phase sensitivity data

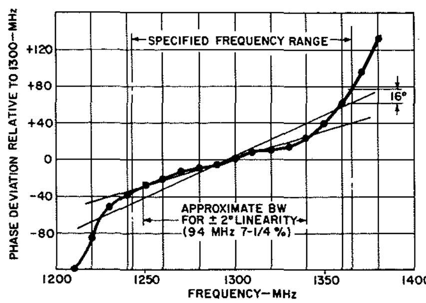


Fig. 8—Measured shift in phase with frequency for the module.

MHz with an instantaneous 1-dB bandwidth of 70 MHz and a gain of 37 dB. Both modules are capable of operating at 5% duty and each contains a single tube type, the RCA Dev. No. A2833; the Y1057 has four stages and the Y1049 only three. Proposals have recently been written for design and fabrication of 50k W and 100k W modules to cover the 750-to850 MHz and the 405-to-450 MHz bands, respectively.

All of the above circuits use the same triple-tuned, coaxial, "totem-pole" circuit concepts described for the Y1043 module. For a particular tube type, the high-frequency limit is determined by the internal screen-grid-to-anode "strap resonance" of the tube, i.e., the frequency at which the shunt-over-coupling inductor appears just at the tube terminals. Attempts at circuiting at frequencies above "strap resonance" would produce a loss of this shunt-inductor "tuning handle". For a given frequency, the ideal circuit has the shunt overcoupling inductors very close to the output terminals of the tube. This condition produces interstage circuits of the shortest possible length and optimizes the dimensions of the module. The upper frequency limits of the tetrodes used in the Y1043 are approximately 1410 MHz and 1600 MHz, respectively. Thus, the 1235-to-1365-MHz operating spectrum for the Y1043 permits use of the ideal circuit configuration. The larger tube types, because of their greater power capability, have inherently lower strap resonant frequencies. The upper frequency limit is approximately 600 MHz for the 100kW module and about 890 MHz for the 50kW module.

Cross-sectional size and total length primarily determine the lowest practical operating frequency. Lower frequencies require an increase in cross section for maintenance of effective RF radial bypassing of the mica DC blockers. A typical 800-MHz module would have to be increased to 8x8 inches in cross section to prevent blocker radiation. Another consideration for lower-frequency operation is water-cooling requirements. As the operational frequency is decreased, the shunt inductors move further from the tube and anode seat; hence, a more complex mechanical configuration is required for cooling.

Conclusions

High-gain, broadband amplifiers using triple-tuned coaxial resonators in combination with gridded power tubes can be arranged in a very compact circuit. The design and analysis of these complex circuits are facilitated by the use of a digital computer. Several stages of power tubes with maximally flat responses can be cascaded or stacked "totem-pole" fashion to form a compact, high-gain amplifier module. Recent circuit refinements have produced overall gains of 60 dB, corresponding to 2.6 dB per linear inch of module.

Measurements on a six-stage module have proven that the excellent phase stability of gridded power tubes is preserved through as many as six stages of amplification. The phase-versus-frequency characteristics of the module are such that phase-linearity compensation can be accomplished easily.

Acknowledgments

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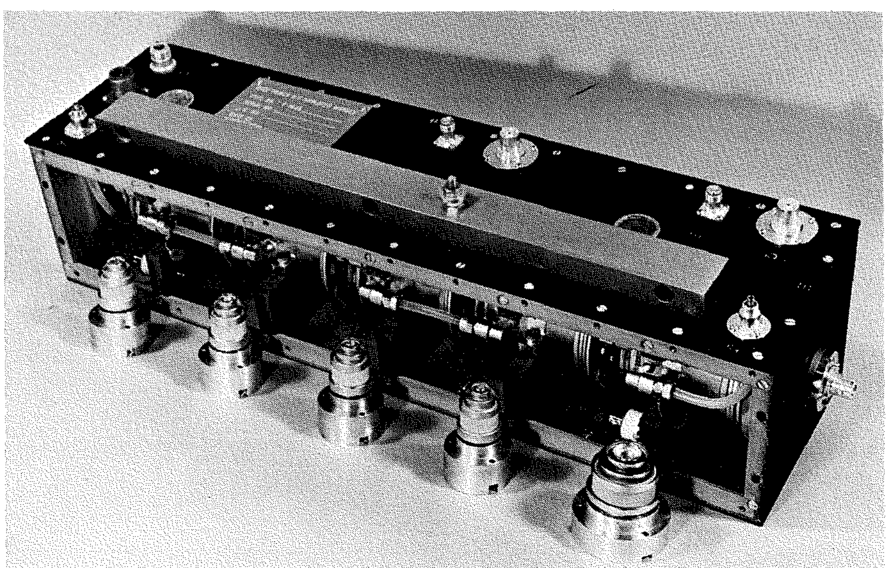
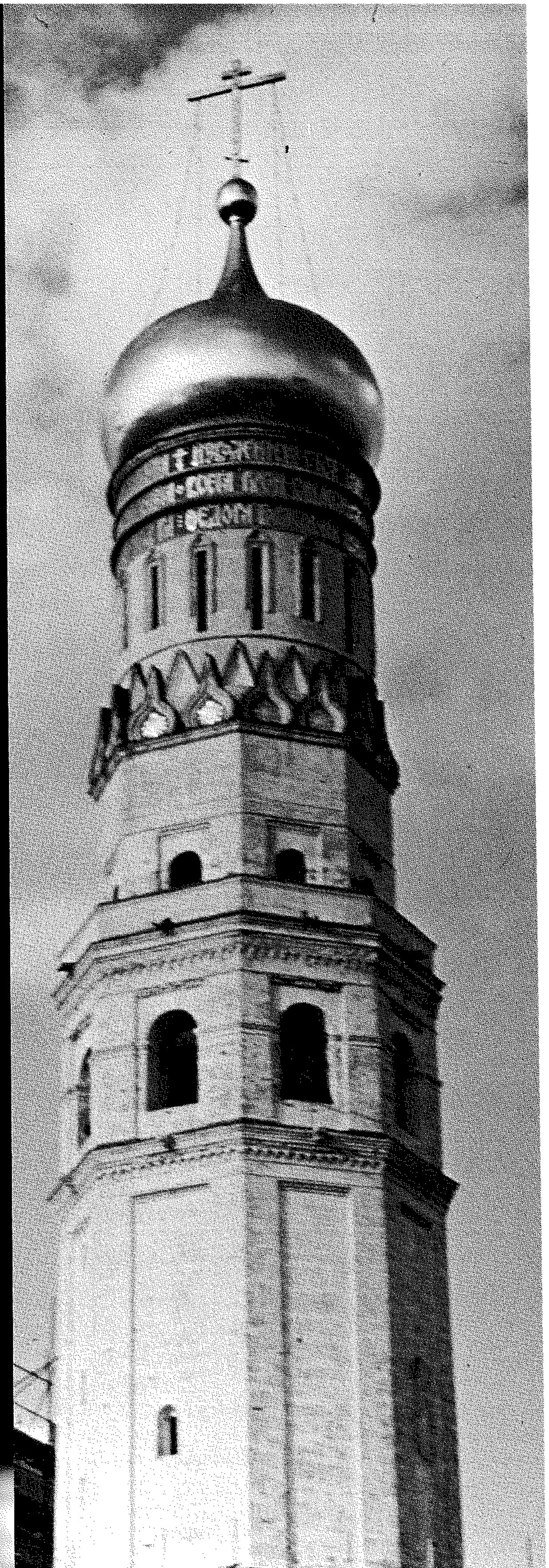


Fig. 9—Y1048C five-stage ruggedized module with side cover removed.



Ivan-the-Great Belltower—inside the Kremlin.

USSR revisited

Dr. J. I. Pankove

Dr. Pankove visited the USSR in 1963.[1] Now, returning to the USSR five years later, the author finds the effort on semiconductor lasers tremendously expanded, where, in fact, the Russians are ahead by far in peak power output and in some laboratory facilities. Electroluminescence in *SiC* has reportedly given 1% efficient yellow light emission at room temperature. Several aspects of life in the USSR are discussed and a passage through Czechoslovakia elicits comments.

My previous visit occurred five years ago. On that occasion I toured a number of laboratories. This time, in July of 1968, during the International Conference on the Physics of Semiconductors, Moscow, I returned to several of these laboratories and saw some new ones. I also had the opportunity to compare life and attitudes in today's Russia to that of five years ago. The trip ended with a stop in Czechoslovakia at the conclusion of the Czerna talks.

General impressions

Some progress and improvement is evident, but not spectacular. Life is still grimly primitive by western standards. It is true that the queues are shorter than they used to be, but people still line up for almost everything. There are more cars on the streets, while public transportation is becoming inadequate; this is especially evident in the areas of new housing development which are far from the center of town. The taxis, being cheap, are in great demand, hence there is always a queue at the taxi stands and it usually takes at least half an hour to get a cab.

Housing

The main emphasis of Soviet internal economy seems concentrated on housing. Many people live in abject slums, a whole family with their few possessions in one room, sharing bath and kitchen with sometimes seven other families. Dark, smelly, mucky places gradually deteriorating while their tenants are sustained by the elusive hope that they will get a new apartment. The government is trying to provide complete facilities for each family.

In spite of substantial progress made in many directions—progress which the Soviet people appreciate with pride —living conditions are still appalling. When this wonderful day for moving comes, it means having a complete flat to oneself: several rooms, a kitchen, and a complete bath, and, if there are more than five stories, even an elevator. Hence, new apartments are mass produced at an increasing rate. All sorts of short cuts are used: no waste on esthetics, prefabricated wall panels, slapped-together finish, the nozzle of a single set of faucets in the bathroom to be swung either over the tub or the adjacent sink. It takes two months to build a 16-story apartment house in Moscow; each floor contains seven apartments. For a family of four, the apartment consists of two small bedrooms, living room, dining room, kitchen, tiny bathroom and a toilet in the traditional closet. The labor cost is said to be $1100/floor. Yet to the westerner's eye the new construction is roughly finished; the paint on the window frames is already peeling, the tiling uneven. However, to the tenant's eye this is delightful luxury, although some are already eyeing their next move.

During my previous visit most scientists were living in communal apartments and so did not invite me to their homes. This time, many scientists, having priority for housing, have already moved into a new apartment. Although in the USA such small apartments are found only near our ghetto areas, to the Russian who has moved his family out of a single room this represents tremendous progress. Hence this year there were more invitations to visit at home than time could allow. Not everyone is willing to wait several years to get his new apartment; some build their own house in the suburbs or buy an apartment in a cooperative house. To buy one's own apartment, a 40% down payment is needed; the rest can be paid in 20 years at an interest rate of less than 2%. The monthly cost of an $11,000 apartment is about $33,

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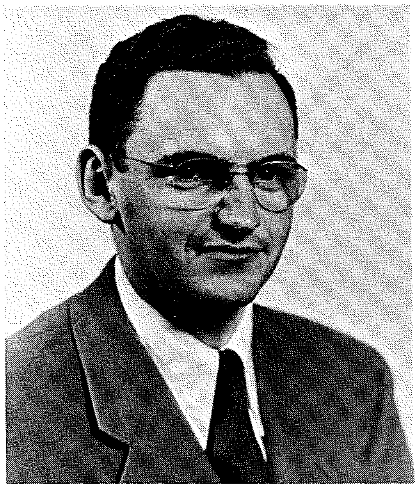

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received the BSEE in 1944 and the MSEE in 1948, both from the University of California. In 1948 he joined the RCA Laboratories; in 1956, he received a David Sarnoff Fellowship to study at the University of Paris, France, where his doctoral topic was infrared radiation from surface processes in germanium. Since his return to RCA Laboratories, he has worked on superconductivity, where he has evolved several new device concepts and has done research on silicon carbide. He has investigated the optical properties of degenerate germanium and the electrical properties of tunnel diodes in germanium. Currently, he is concerned with injection luminescence and the laser action in gallium arsenide and other compounds. Dr. Pankove has published over 20 papers and has over 30 issued patents. In addition to IEEE, he is a member of the APS, the Electrochemical Society, and Sigma Xi.

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of which $8 goes toward heat and services and $25 toward the mortgage. This contrasts to a rental fee of $14 per month for a government-issued apartment—but the purchased home can be available much sooner.

Hotels

Many new hotels have sprung up in the large cities to accommodate increased tourism and business travel. The most modern of these hotels is the Rossiya in Moscow. I was told that the Hilton people had been consulted prior to designing the Rossiya. Their advice had been that operating efficiency drops down rapidly above 6000 guests. So, to accommodate 8000 people, the Rossiya was built as a complex of four interconnecting hotels each designed for 2000 guests. These four components form a huge square enclosing a plaza which when finished will comprise a vast swimming pool, a theater, and shops. The corridors are then very long forming a square about 600 feet on the side. Every corner has a buffet. The ground floors comprise identical lobbies, several restaurants, and administrative offices. Before exploring this maze, I found out that you don't tell someone to meet you in the lobby at 7 P.M.; you have to specify *which* lobby. The lobbies do not interconnect, so if you want to scout through the other lobbies to locate your friend, you have to either go out in the rain or up to a connecting floor and down again to the next lobby.

When a Russian checks into a hotel, he just rents a space for one. If he gets a double room, chances are that the other space will be occupied by a stranger. If he is lucky, the room will have twin beds, but it has happened that after falling asleep in a double bed, the guest is awakened by the strange feeling that someone is crawling in to use the next spot.

Although the Russian in transit never knows who will be his bed-time companion, he can be sure it will be someone of the same sex. In one case I witnessed, the clerk would not let a husband and wife occupy the same room because she had forgotten her identification card and therefore could not prove her relationship.

Food

Food is almost as expensive as in the US. Bread is cheaper due to government subsidy which makes the bread available at half its production cost. Alcohol which is consumed at an astounding rate (one to two ounces per gulp) costs about $6 per 80 proof quart. In spite of the low wages, one finds "plastered" faces and staggering bodies in every crowd. In a ten-minute interval at the hotel buffet during breakfast, I would invariably see several guests order 150 cc of cognac as their first beverage to start the day. Luxury foods such as caviar are not available to the public on the open market; two years ago it was earmarked for export to get hard currency.

Income

Most prices and wages have not changed since 1963. A starting engineer still gets about $100/month, a doctorate is worth about $350/month, and a laboratory directorship about $500 (plus a chauffeur-driven car). Exceptional people like a Nobel laureate may get as much as $850. There is no merit raise system in the research labs, but industrial laboratories pay a

New apartment houses on the fringe of Moscow (mostly for scientists of the Lebedev Institute).

bonus for exceptional performance. Authors get paid for publication; referees and editors of scientific journals also get paid for their service.

Laboratories

Five years ago, my hosts in every laboratory would point out how much their laboratory had grown in the last year or two. This time, of all the labs I visited, only Dr. Basov's was a new expansion. However, the facilities of all the other laboratories are about to be enlarged. Thus, the Physico-Technical Institute in Leningrad will be housed in a huge new building in a campus-like setting, with a large hotel to be built nearby and the Physico-Technical school (equivalent to MIT) in another new building in the same park. A plastic model of his new complex was on display in Dr. Tuchkevich's office.

Also in Leningrad, at the Institute of Physics of Semiconductors, Dubrovski and his group of 15 people (8 PhD's) comfortably spread over five rooms are studying the properties of *SiC*. Boron is diffused into *SiC* to form a PN junction whose injection luminescence is quite bright yellow with a maximum power efficiency of 1%.

A demonstration unit showed ¼-inch squares emitting yellow, green and reddish-orange lights and a yellow stripe numeric display in a ¼-inch wafer.

The Lebedev Physical Institute in Moscow is a vast installation comprising 20 laboratories distributed over many buildings. One half of the Institute is devoted to nuclear problems. The non-nuclear labs comprise: a spectroscopy lab, a semiconductor lab (B. M. Vul), a luminescence lab (V. S. Vavilov), low temperature plasma lab (Sobolev), a radio astronomy lab, an "oscillations" lab (Prokhorov) where CO_2 lasers and non-linear optics are studied, and the quantum electronics lab (Basov).

Uspenski Cathedral, inside the Kremlin.

Basov's lab is located in a new building (3 stories and basement). It is staffed with 200 people. The rooms are spacious, well lighted, and well equipped. Basov, a dynamic scholar, is well liked by his staff; he pays great personal attention to their work and is very sharp and perceptive about technical and scientific detail. His lab is divided as follows:

High power lasers (Khrokhin)
High-energy plasmas (Sabelman)
Theory (Arayevski)
Chemical lasers (Nikitine)
Frequency standards
Semiconductor lasers (Yu. Popov)

High power lasers (Khrokhin)

They study the interaction of radiation with materials. A four-stage *Nd* amplifier yields 20 joules in one nanosecond. By a mode-locking scheme they obtain a burst of pulses less than 3×10^{-12} sec in duration. These giant pulses are used to heat a plasma for controlled thermonuclear reaction. Although a heating time of 10^{-10} sec is needed, they have already obtained neutron emission from the radiation-heated plasma. This amplifier generates a 30 cm long spark which travels with the velocity of light. They are intrigued at the possibility of using this phenomenon as a moving mirror.

Semiconductor lasers (Yu. Popov)

This group (like all the others above) is divided into sub-groups. These are:

P-N *junctions (Eliseev)*—They study *GaAs,* other 3-5 compounds and their alloys. Eliseev demonstrated *GaAs* and $GaAs_{1-x}P_x$ lasers, daringly looking into the beam (they have no routine medical eye-check). A microscope projected a bright image of the red laser on the wall. The image was about 6 inches long, and one could easily resolve the filaments. There were at least three identical microscopes in that room, each one having a built-in IR image converter. Later I saw in other rooms several more such microscopes, all factory made.

Laser dynamics (a different Nikitine) —They are devising a great variety of opto-electronic logic based on interaction between injection lasers, amplification and quenching: gates, multi-vibrators, switches, clock generator, etc. . . .

Brillouin scattering (Marsh and Babilinski)—They cascade coherent radiation, using ruby or *Nd* lasers to excite liquid N_2. The first Stokes-shifted radiation occurs at 8281Å and can be used to pump *GaAs* which then emits 8350Å with a 50% efficiency. When the output from *GaAs* reaches 15 MW/cm² damage sets in: the Fabry-Perot facets are full of cracks, and the pumped facet appears erroded as if by thermal etching. They find that the damage depends on the energy delivered to the material (power × time) and believe it results from thermal shock. With the *GaAs* sandwiched between a *Cu* block and a sapphire window, an average power of 20 W is obtained.

Electron Beam Excitation (O. V. Bogdankevich)—They are trying to perfect the "radiating mirror" and to obtain UV lasing in solid rare gases. They have two systems:

1) A machine capable of 70 keV, 1 amp, 10 A/cm², and a repetition rate of 50 to 10^3 Hz; this machine covered with lead plates has a control rack of the same size as RCA Lancaster 50 kV machine;
2) Another machine capable of producing a 10-A, 1-MeV beam at 30 A/cm². The pulse length can be set at 250 nsec or 50 nsec. The repetition rate is 25 Hz. This machine, a copious source of x-rays (lethal dose in 3 sec at 1 meter), is located in separate room in the basement with a heavy steel door and interlocks.

A large adjacent room has a control console from which they conduct the experiments. Much of the equipment is new-looking and factory made. The 1-MeV machine was designed and made in the laboratory of Dr. Boutker in Novosibirsk for 300,000 roubles. This type of machine should be available now at a lower rate since development costs have already been written off and probably can be bought in the western world. I was told that Boutker has made an arrangement with Kosygin for marketing abroad several of his products with a commission for his institute.

The 1-MeV generator is a spherical chamber about four feet in diameter containing a giant pulse transformer. The primary has a few turns across which a 40-kV pulse is applied, the secondary has a few hundred turns with taps to a central cylindrical core consisting of a cascade of accelerating electrodes. A barium lanthanide cathode is used. The inner part of the electron accelerator is evacuated, but the transformer itself is pressurized with 8 atmospheres of a mixture of nitrogen and freon. The general principle seems simple but there are many complex design subtleties.

"Rocket" hydrofoil on the Moscow Canal.

The 1-MeV machine is used to excite electron-hole pairs in crystalized rare gases to get emission ranging from 10 eV (xenon) to 25 eV (helium). Of course, they hope to get coherent emission and therefore they grow the crystals in a Fabry-Perot cavity by slowly cooling the liquified rare gas. Up to 40W of radiant power at 1630Å has been obtained with *Xe,* using an excitation of 10 A to 600 keV (but no coherence yet).

Radiating mirror

Another important project is the "radiating mirror," a wafer of *GaAs* emitting coherent radiation transversely to this large surface. I recall that they first proposed the large-area cathodoluminescence laser in 1964 at the Paris meeting, and they have been "talking" about it ever since. But now they are getting interesting results: 900 watts peak power (50 nsec, 10 Hz repetition rate) which corresponds to a power density of 2.6 MW/cm^2; the output consists of a central spot surrounded by concentric rings. Most of the power is in the central spot which has a divergence of only 30 minutes.

Swept-beam image converter

Another interesting instrument is the swept-beam image converter, which is abundant at the Lebedev Institute as well as in other laboratories. These image converters are factory made and come in several sizes. The most common one is identical to the one made in England under the trade name *Imacon.* The electrons from the photocathode converge into an aperture and, as they emerge, two pairs of electrostatic deflection plates control the angular trajectory toward the phosphor screen. With such a device, one can "strobe" either a single frame or several frames spatially separated, or one can have a continuous scan during the event to be observed. This instrument is used to study the uniformity of a material under coherent illumination or the time-resolved emission spectrum everywhere along the junction.

Although they do not yet have the equivalent of the Polaroid camera to record their oscillograms, the equipment is plentiful and some of it very sophisticated. There is a Hungarian-made oscilloscope that is a copy of an American-made instrument (even to the English inscriptions at each knob) and the plug-in units are interchangeable with the American equipment.

Moscow viewed from the Rossiya Hotel.

Health and education

In medical services and education, the USSR presents an impressive picture:

Medical services

These are free, good, and readily available. In Leningrad there are 1500 hospitals and clinics (i.e., one hospital clinic per 2000 people). Everyone is required to have a yearly checkup—this involves 2 to 3 days of a variety of tests. Although their salaries are low, Russian doctors are dedicated people. They are allowed to do private practice part-time, but even then their fees are not expensive.

Education

The desire for more education is a popular movement. Everyone knows that the better jobs are opened only to those with adequate education. Hence night schools are very popular. Another factor for making night schools popular is that the stipend for daytime schooling is lower than the wages earned on a job. Hence many people find that they can be more comfortable by working during the day and studying at night. There is no shortage of teachers because everyone who completes the equivalent of the baccalaureat must give to the state two years as a teacher in return for the many years of stipend.

Czechoslovakia

Since I was due to leave the USSR via Czechoslovakia in already troubled times, I kept inquiring about the status of the interaction between the two countries. Day after day I would get the same answer: "a meeting is to take place in Czechoslovakia; there is no problem." When I got to Prague, the meeting at Czerna in a railroad car had just terminated with a granting of Prague's demand for more autonomy. Everyone was jubilant; students marching down the main street at midnight shouting in unison; mass meetings in the main square with orators perched on top of John Huss's monument; posters announcing a demonstration in support of Dubceck.

I stopped at the same restaurant where I had eaten eight years earlier. Remembering the long wait, an interminable wait one still experiences in most Russian restaurants, a wait made tolerable only by pleasant companions or by talking with those waiting at the next table, I had brought a book as a potential companion. But I was rather promptly seated and the service was amazingly smooth and efficient. Later, I was told that the hotels this year were operating nearly independently and not as a tightly run government chain and that they had profit-sharing plans for employees.

Private conversation revealed that for the first time, the old-time communist leaders having been retired, the people were unanimous in backing their new government. Although there was elation at the success of the Czerna talks, there was also a bit of apprehension at the thought of all those Soviet troops still near the border. Now we know how much those apprehensions were justified.

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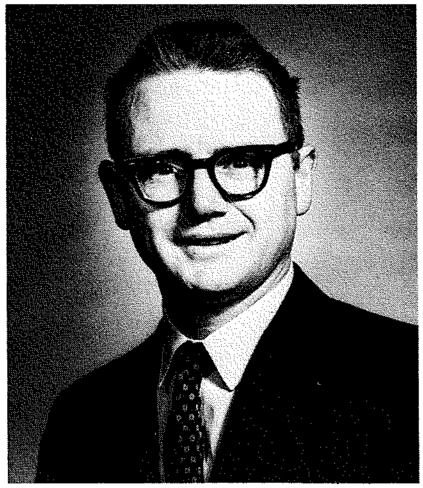
Switching-device requirements for a new horizontal-deflection system

D. E. Burke

A new solid-state horizontal-deflection system that uses silicon controlled rectifiers (SCR's) and fast-recovery diodes to provide the required switching functions has been designed for large-screen color television receivers.[1] To capitalize fully on the innovations of this new system in production instruments, new SCR's were developed to provide exceptionally short turn-off time, low switching dissipation, and high blocking capabilities for rapid rates of rise of applied forward voltage (i.e., high dv/dt capabilities). The availability of these new low cost SCR's opens many new possibilities for power switching at frequencies up to 30 kHz. This paper provides a brief description of the deflection circuit and then discusses the significant features of the SCR's and the fast-recovery diodes used to provide the switching functions of this circuit. The characteristics and performance capabilities of the SCR's and diodes are discussed in relation to deflection-circuit applications within the context of the new deflection system.



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received the BSEE from Nova Scotia Technical College in Canada in 1954. From 1954 to 1962, he was employed by Canadian General Electric Apparatus Division and worked on the design and application of large rectifier equipment and systems for variable-speed drive and bulk power conversion. In 1963, he joined RCA Electronic Components in Somerville, N.J., as an Engineering Leader in thyristor and rectifier applications engineering. Mr. Burke is a member of the JEDEC Committee for Thyristor Standards.

THE NEW HORIZONTAL-DEFLECTION SYSTEM employs two bidirectional switches, each consisting of an SCR and a diode in an inverse-parallel connection (Fig. 1). The RCA 40640 SCR and the RCA 40642 diode are used to control the current in the yoke winding L_y during the trace interval, and the RCA 40641 SCR and the RCA 40643 diode provide the commutating action required for retrace.

At the beginning of the trace interval, the trace-switch diode D_T conducts the yoke current established during previous circuit action. The trace-switch diode conducts a linearly decreasing current until the yoke current reaches zero to produce the first half of the scan current. Before the zero-yoke-current point is reached, the trace-switch SCR is made ready to conduct by application of a positive pulse to its gate electrode. When the yoke current crosses the zero point from negative to positive, the current transfers the trace-switch diode to the trace-switch SCR. Capacitor C_y then begins to discharge through the trace-switch SCR to supply current to yoke winding L_y during the second half of the trace interval. The voltage across capacitor C_y remains essentially constant throughout the trace-retrace cycle. This constant voltage results in a linearly rising current through the yoke winding to complete the trace period.

Just prior to the end of trace, the commutating-switch SCR is gated on by the horizontal oscillator. Capacitor C_R then discharges a pulse of current through inductor L_R and the trace-switch SCR and also supplies the yoke current for the last portion of the trace interval. This current pulse, referred to as the commutating pulse, reverse-biases the trace-switch SCR for a sufficient period to allow it to turn off. When the commutating pulse is no longer sufficient to sustain the yoke current (and with the trace switch now turned off), the energy in the yoke winding produces a current that charges the retrace capacitors C_R and C_A during the first half of retrace. This current then rings back into the yoke winding during the second half of retrace. The circuit for the ringing oscillation during the second half of retrace is completed through the commutating-switch diode and allows sufficient time for the commutating-switch SCR to turn off. When the yoke current reaches its peak negative value, the trace-switch diode begins to conduct to start the trace interval.

During the time the commutating switch is closed, the input inductor L_{CC} is connected across the B+ supply, and energy is stored in this inductor. This stored energy charges the retrace capacitors C_R and C_A to replenish the energy loss in the circuit.

Fig. 2 shows the current and voltage waveforms applied to the trace and commutating switches as a result of the circuit actions described in the preceding paragraphs.

Deflection-circuit switching devices

A major factor in the design of solid-state horizontal-deflection systems for large-screen color television receivers is that that switching devices may be subjected to volt-ampere products that exceed the capability of readily available and economical transistors. Diodes and SCR's are economical devices that have excellent volt-ampere capabilities. For example, the product of the peak current and voltage applied to the switching devices in the new deflection circuit ranges up to 6000 volt-amperes. The transitions from full current to full voltage, however, are made through the reverse recovery of high-voltage rectifying junctions so that it is unnecessary to consider the effect of an active turn-off load line, which is an important factor when linear amplifying devices are used in switching applications.

Practical deflection circuits that take advantage of thyrathron-like switching elements require devices that have

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turn-off times an order of magnitude less than those of previously available electronic switches. The size and cost of the additional circuitry required to turn off the switching devices are approximately proportional to the turn-off time of the switching devices. The development of fast-turn-off SCR's, designed to provide optimum performance in deflection-circuit applications, makes it possible to overcome these obstacles.

Secondary limitations on the use of SCR's at deflection-circuit frequencies are imposed by the turn-on switching dissipation and dv/dt characteristics of the SCR's. Design innovations are incorporated into the SCR's used in the new deflection circuit to overcome these limitations.

Characteristics of the switching SCR's

Turn-on characteristics

Switching losses in an SCR are proportional to the operating frequency. For this reason, the turn-on dissipation, which often may be neglected in SCR circuits operated at power-line frequencies, is an important factor in deflection-circuit applications. For example, the dissipation in the commutating-switch SCR is approximately 4W, the majority of which can be attributed to turn-on losses.

Turn-on in an SCR occurs in three stages. The first stage is a delay of up to several microseconds that immediately follows the initial application of the gate signal. During this period, electrons injected by the cathode (N-type emitter) cross to the anode and accumulate sufficient charge to cause hole injection by the anode (P-type emitter) to start the regenerative turn-on process. The length of this initial delay period is most strongly influenced by the magnitude of the gate-to-cathode trigger current. This delay is considered when the phase of the output pulse from the horizontal oscillator is established.

The second stage of SCR turn-on is the reduction of the forward blocking voltage. During this period of voltage reduction, referred to as fall time, the electrons and holes are injected at a level sufficient for regeneration, and the SCR conducts. This period, however, represents the transition stage during which the electron-hole concentration in the N-type base changes from essentially zero to the high level required in the low-impedance ON state of the SCR. The voltage drop across the N-type base, therefore, is initially high, but it decreases rapidly as the electron-hole concentration increases. The majority of the decrease in forward blocking voltage occurs within a few tenths of a microsecond before the SCR current reaches an appreciable magnitude. Dissipation during this interval is generally low.

The first two stages of turn-on are illus-
this SCR is 0.2 µs and the anode-voltage
trated in Fig. 3 for the commutating-
switch SCR. The initial delay period for
fall time is about 0.3 µs.

The final stage of turn-on is the major contributor to switching dissipation. During this period, the ON-state voltage is greater than its normal magnitude, and many microseconds are required before this voltage decreases to the comparatively small steady-state value. This voltage-current relationship is illustrated for the commutating-switch SCR by the oscilloscope photograph shown in Fig. 4. Fig. 5 shows the variation in power dissipation P_D during the period of the current pulse. If the steady-state value of the ON-state voltage were used to calculate the power dissipation during this period, the lower dashed-line curve P_D' would be obtained. The shaded area between the curves P_D and P_D' represents the added turn-on dissipation.

The added power dissipation represented by the shaded area in Fig. 5 is the result of several factors. At the beginning of the third stage of turn-on, the current in the SCR is concentrated in a small area under the cathode adjacent to the gate. The initial current density, ON-state voltage, and power dissipation are high. In the limited area in conduction, the high power density may raise the temperature sufficiently to affect blocking capabilities, turn-off time, and dv/dt characteristics or, in extreme cases, may cause irreversible damage to the SCR.

Several techniques are employed in the design of the new SCR's to ensure small turn-on losses. The use of a large gate electrode (15% of the pellet area) located in the center of a circular pellet

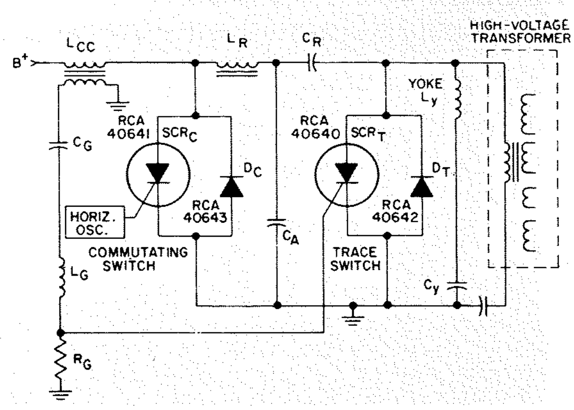

Fig. 1—Basic circuit for generation of the deflection-current waveform in the horizontal yoke winding.

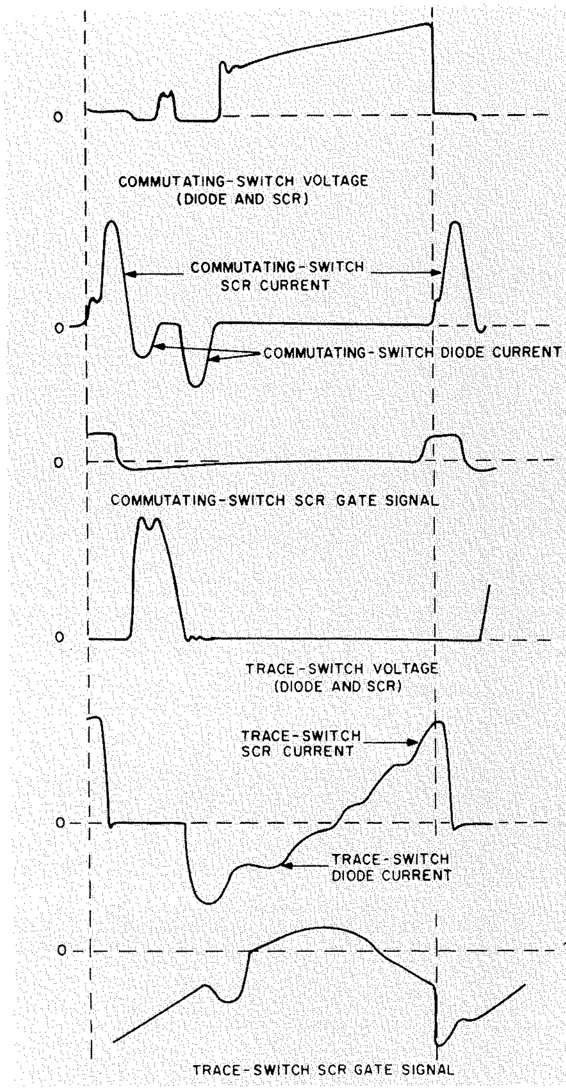

Fig. 2—Voltage and current waveforms applied to the switching SCR's and diodes in the horizontal deflection system.

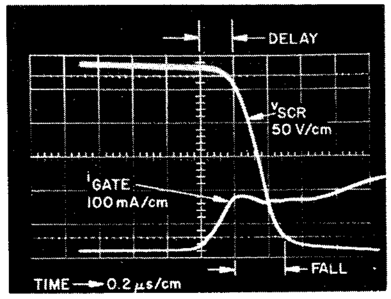

Fig. 3—Turn-on waveforms for the commutating-switch SCR.

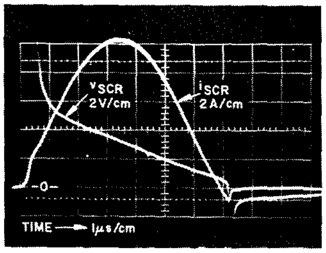

Fig. 4—Turn-on dissipation in the commutating-switch SCR.

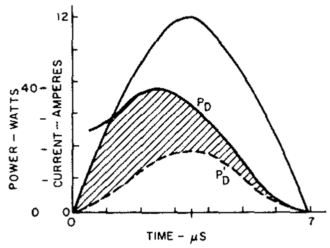

Fig. 5—Comparison of switching (P_D) and steady-state (P'_D) turn-on losses in the commutating-switch SCR.

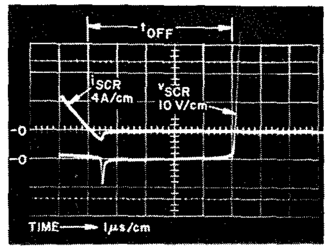

Fig. 6—Turn-off interval for the commutating-switch SCR.

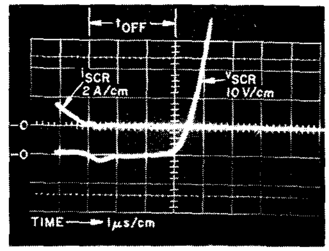

Fig. 7—Turn-off interval for the trace-switch SCR.

provides the thermal capability required to handle relatively large gate trigger pulses. With an adequately large gate signal, the entire gate-cathode periphery may be started into conduction. This condition results in the smallest value of initial ON-state voltage.

The area in which conduction is initially established spreads radially, over a short distance, until it covers the total cathode area. The rate of this spreading governs the time required for the reduction of the ON-state voltage from the high initial value to the steady-state level. Although this rate cannot be affected from the external terminals of the SCR, voltage gradients internal to the pellet can be introduced during the design of the junction geometry to facilitate the spreading action. The combination of low initial values of ON-state voltage and fast spreading action reduces the switching dissipation to an acceptable level of just a few watts.

Turn-on losses in SCR's have a slightly degenerative relationship with temperature. Thermal runaway because of turn-on losses, therefore, is not a problem in these devices.

The turn-on losses in the trace-switch SCR are negligible because of the slow rate of rise of current through this device. As a result, although the average and RMS currents are substantially higher in the trace-switch SCR, the total power losses in this SCR are less than those in the commutating-switch SCR.

Turn-off characteristics

The turn-off time of an SCR is the period immediately following conduction during which a reverse bias must be applied between anode and cathode to permit the device to regain its ability to block a reapplied forward voltage. The reversal of the circuit driving voltage to reduce the ON-state current to zero must be accomplished by the external circuitry. This requirement adds a distinguishing complexity to SCR DC switching circuits.

Failure of an SCR to block a reapplied forward voltage has no harmful effects on the SCR. Such failure simply means that an excess of free charge carriers exists at the end of the turn-off interval. When the forward voltage is reapplied, these charge carriers may be accelerated across the gate-cathode junction in a sufficient quantity to initiate SCR turn-on in much the same way as would a gate signal.

In the new deflection circuit, the time allowed for complete turn-off of the trace-switch SCR, under worst-case conditions, is approximately 3 μs; for the commutating-switch SCR, this time is about 5 μs. Although the time available for turn-off of the commutating-switch SCR is longer, the electrical conditions for turn-off of this device are much more severe than those for the trace-switch SCR. The minimum available turn-off time occurs at zero picture-tube beam current, high line voltage, high oscillator frequency, and worst component tolerance. Fig. 6 shows the turn-off waveforms for the commutating-switch SCR, and Fig. 7 shows these waveforms for the trace-switch SCR.

Increases in temperature, forward blocking voltage, peak current, the rate at which a forward blocking voltage is reapplied, and slope of the current prior to turn-off all contribute in varying amounts to an increase in turn-off-time requirements of the SCR. Reverse blocking voltage and negative gate bias improve turn-off capability. Because of the stringent turn-off characteristics of the horizontal-deflection circuit, gold-doping was employed in the design of the SCR's to reduce minority-carrier lifetime. Short minority-carrier lifetime, however, adversely affects turn-on losses, ON-state voltage, gate sensitivity, and forward blocking current. For this reason, the gold-doping must be precisely controlled and junction parameters must be modified to achieve a desirable compromise in SCR characteristics.

The forward blocking voltage that is reapplied to the SCR at the end of turn-off establishes a depletion region across the middle P-N junction. Any minority charge carriers that are still present are accelerated out of the region by the voltage field. The current that then flows between the principal terminals of the SCR to deplete this region is similar to the charging current for a voltage- and time-dependent capacitance. If the rate of rise of reapplied forward voltage (dv/dt) is too great, this current can be large enough to trigger the SCR into conduction.

The charging current produced in SCR's when the forward blocking voltage is reapplied can be diverted around the

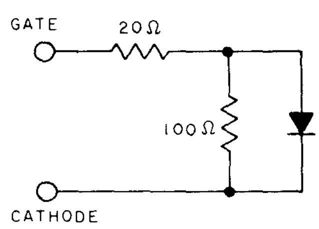

Fig. 8—Gate input equivalent circuit.

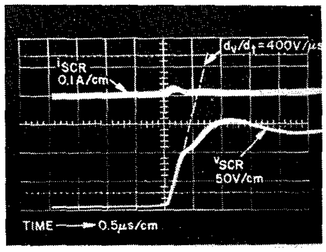

Fig. 9—*dv/dt* requirements of the commutating-switch SCR.

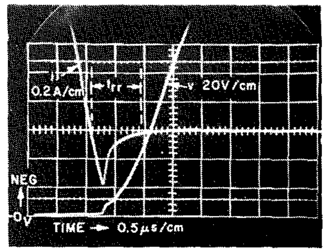

Fig. 10—Reverse-recovery characteristics of the trace-switch diode.

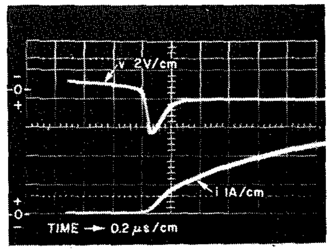

Fig. 11—Turn-on voltage drop in the commutating-switch diode.

gate-cathode junction by use of an internal ohmic connection between the cathode and one extremity of the gate. At this point, the cathode (N-type emitter) is shorted to the gate (P-type base); the technique is referred to by the descriptive term "shorted-emitter" construction. The shorted-emitter construction technique, in effect, provides a parallel resistance from gate to cathode over the length of the P-type base. Fig. 8 shows the equivalent circuit for the gate when this technique is employed. The use of the shorted-emitter technique makes it possible for the SCR's to block reapplied forward voltages at the high rates of rise inherent in the new deflection circuit. Fig. 9 shows the junction charging current in the commutating-switch SCR that results from the high rate of rise of reapplied forward voltage (dv/dt= 400 v/μs).

An RC network is connected in parallel with the SCR to help reduce the rate of rise of forward blocking voltage. For a simple RC network, the discharge current that flows when the SCR is turned on results in a fast rate of rise of ON-state current (di/dt) which may contribute substantially to turn-on losses in the SCR. In the design of such networks, therefore, a compromise must be effected between turn-on losses and dv/dt capability.

Characteristics of the switching diodes

Each of the two bilateral switches in the deflection circuit includes a diode in an inverse parallel connection with the SCR. In the design of these diodes, a careful compromise was required to achieve the optimum balance of turn-on losses, conduction voltage drop, reverse recovery, and blocking.

The circuit action in the deflection system is such that transitions from full current to full reverse blocking voltage occur in each diode. The diodes are designed to minimize the reverse-recovery current in order to prevent interference in signal circuits from the electromagnetic radiation generated during the cutoff of reverse-recovery current. This condition is achieved by use of gold-doping to control the lifetime of minority charge carriers. An abrupt decrease in the peak negative current may also be avoided with proper junction geometry. The reverse-recovery losses are less than 5% of the total losses in the diodes. Fig. 10 shows the reverse-recovery characteristics for the trace-switch diode. The reverse recovery of the diode initiates the flyback pulse.

Although the reduction of minority-carrier lifetime through the use of gold-doping facilities diode recovery, this technique adversely affects diode turn-on and the conduction voltage drop and, therefore, results in increased diode dissipation. Fig. 11 shows the turn-on voltage drop that results from the first current pulse in the commutating-switch diode. The gold-doping also increases the reverse-recovery blocking current (Fig. 12).

Although reverse blocking losses are normally small, appreciable conduction losses require the use of adequate heat sinks so that the junction temperature is maintained below the level at which thermally regenerative reverse-blocking losses can cause thermal runaway.

Arc protection

Arcing in the high-voltage system for the picture tube can produce high current surges that may be coupled through the high-voltage transformer into the deflection system.[2] The most severe effect is produced by arcing across the high-voltage rectifier tube. Such arcs can cause a damped train of oscillations at a 50-kHz resonant frequency to flow through the trace switch with peak currents up to 70A. The current surges produced in the commutating switch are considerably smaller.

Both the trace-switch SCR and diode can conduct the high magnitudes of surge current for the duration of which they are applied without harmful effect. Properly designed SCR's and diodes will remain in the low-dissipation ON state during any peak current. The surge capability of such devices is restricted primarily by relatively simple thermal limitations which are readily overcome by use of a pellet of the proper size, good ohmic contact systems, and adequate heat sinks .

The circuit used to protect the SCR deflection system from high-voltage

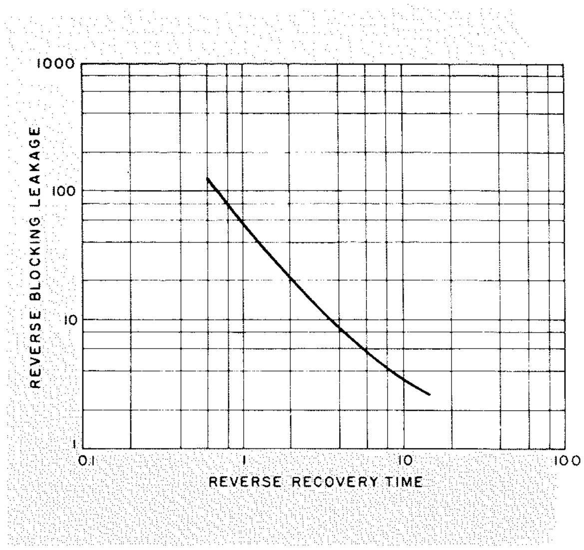

Fig. 12—Reverse blocking leakage as a function of reverse recovery time for the switching diodes.

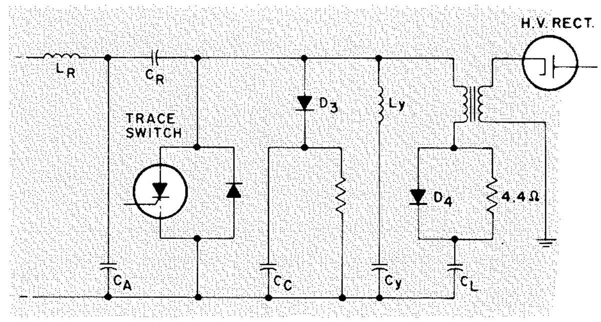

Fig. 13—Simplified schematic showing the arc-protection circuits for the SCR horizontal-deflection system.

arcing consists of a simple high-voltage clamp circuit (diode D_3 and associated components) connected in parallel with the trace switch as shown in Fig. 13. The clamp capacitor C_C is normally charged to the peak value of the flyback voltage. If an arc occurs while the trace-switch SCR is not conducting, the clamp diode conducts to limit the overvoltage on the SCR and diode to within the transient blocking-voltage rating of 600 volts. Diode D_4 and the resistor in parallel with this diode provide damping for the arcing currents.

Continuous arcing in the high-voltage rectifier results in failure of the SCR's to turn off which, in turn, causes the overcurrent protective devices for the receiver to operate. This action is considered desirable under this condition.

References

1. Dietz, W. F., "An SCR horizontal-deflection generator" RCA ENGINEER, *this issue*.
2. Wheatley, C. F., "Destructive Circuit Malfunctions and Corrective Techniques in Horizontal Deflection," *IEEE Trans. on Broadcast and TV Receivers* (Jul 1965).

An SCR horizontal deflection generator

W. F. Dietz

The basic principle of a new solid-state deflection system is described as it developed from previous known principles. The new circuit operates from the rectified line voltage and uses as switches silicon controlled rectifiers in combination with short-lifetime silicon rectifier diodes. The description of the basic circuit follows its adaptation into a color television receiver with its associated auxiliary circuitry.

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received the BSEE from Staatstechnicum Konstanz in Germany in 1948. After working for several other manufacturers of FM and TV receivers in Europe and the United States, he joined RCA in 1958. He was located at the David Sarnoff Research Laboratories until 1962, where he engaged in various advanced development projects. From 1962 to 1968, he was a design engineer in the RCA Consumer Electronics Division at Indianapolis, Ind., investigating various kinds of solid-state deflection circuits and other areas of color TV.

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THE APPROACHES taken to solid-state horizontal deflection in the past were based on the trace-driven deflection principle and the retrace-driven principle. The trace-driven principle is the most widely publicized and used because of its high efficiency and simplicity. The name reflects the operation; i.e., the sawtooth current to the yoke which deflects the beam is generated during the latter part of the trace interval by closing an active controlled switch which connects a constant voltage across the yoke (Fig. 1). To retrace the beam (i.e., to reverse the yoke current) the yoke inductance is made to oscillate with the retrace capacitor for one half-cycle. This oscillation is provided by opening of the active switch which is part of the bilateral switch connecting the yoke across the supply. After the current has reversed, the other part of the switch, which is polarity-controlled, closes and conducts the other part of the sawtooth.

Trace-driven horizontal-deflection circuits are being used with success in black-and-white TV receivers, but do not provide adequate performance in large-screen color receivers, as compared with tube-type deflection circuits. The limitation is that presently available high-voltage power transistors used as the active switch restrict this type of circuit to a voltage supply lower than the rectified line voltage.

With the advent of silicon controlled rectifiers (SCR's),[1] much work was done with the retrace-driven circuit, which operates from the rectified line voltage. The SCR used as a retrace switch conducts energy accumulated on the retrace capacitor into the yoke during retrace time. Briefly, the energy thus stored in the yoke is then conducted back to the DC power supply through a diode during trace, and produces a ramp of current. Because of the need for a transformer for the yoke and the losses in the diode which conducts the full peak-to-peak yoke current, these circuits are less efficient than trace-driven circuits.

The circuit described in this paper is a retrace-driven circuit which also operates from the rectified line, but circumvents the problem of the basic retrace circuit because a bilateral trace switch (SCR plus diode) is used instead of a single diode. The trace switch conducts the first half of the required yoke current into a trace capacitor and then with opposite polarity back into the yoke to complete the second part of trace. As a result of the bilateral switch and the use of a trace capacitor as a self-sustained voltage source for the yoke during trace, this circuit approaches the efficiency of a trace-driven circuit. The difference is in the losses caused by the commutating current required to turn off the trace SCR.

Operation of a two-SCR circuit

Fig. 2 shows a simplified circuit which uses two symmetrical switches, each consisting of a fast-turn-off SCR and a fast-turn-off rectifier. Waveforms for this circuit are shown in Fig. 3. The first switch, called the trace switch, conducts the sawtooth current of the yoke during the trace interval to and from the trace capacitor. The second switch conducts the commutating current which turns off the trace switch so that the yoke current can reverse, and then conducts energy from the retrace capacitor into the yoke. The commutating switch is closed by a trigger pulse from the oscillator before retrace, and opens shortly after retrace is completed. The input choke stores energy when the commutating switch is closed, and the choke current then charges the retrace capacitor C_r when the commutating switch is open and the trace switch is closed.

To explain the circuit under steady-state conditions, it is assumed that, since $\omega L_{cc} \gg 1/\omega C_r$, the current in the input choke L_{cc} is DC and small in comparison to the current in the commutating coil, L_c, and that the voltage across the trace capacitor has stabilized to a DC voltage. In addition, $L_{cc} \gg L_{yoke}$; since $L_{cc}=20$ mH, $L_y=500$ μH, and $L_c=50$ μH.

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The cycle is started during the second part of trace when the trigger pulse from the oscillator closes the commutating SCR, while the trace SCR is maintained closed and conducts the increasing yoke current. L_{cc} is then connected across the supply voltage, L_c across the charged retrace capacitor C_r, and the yoke across the trace capacitor C_t. While the current in the input choke L_{cc} increases slowly, the current in L_c increases rapidly and resonates sinusoidally with the retrace capacitor C_r through the closed trace switch. The yoke current i_y continues to increase more slowly, at a rate proportional to the voltage at the trace capacitor C_t. This current also flows through the trace switch, but in the opposite direction to the commutating current i_{cr}. When the rapidly increasing current in the commutating loop i_{cr} has reached a larger value than the yoke current i_y, the difference current between i_{cr} and i_y switches from the trace SCR to the trace diode at t_1 and reverse-biases the trace SCR for turn-off. After the current i_{cr} declines and $i_{cr} \leqq i_y$, the trace SCR is again forward-biased but, because it is in the blocking mode, the trace switch is open for retrace at t_2. (As shown in Fig. 3, the charge on C_r at t_2 is of opposite polarity from t_o, and can be used for energy transfer into the yoke.) With the commutating SCR still closed and the trace SCR open, the current in L_c and C_r is the same as the yoke current. The energy in the yoke charges C_r further negative until the stored energy of the yoke and the coil L_c is in C_r, combined with the energy which was stored in C_r at the start of retrace.

This combined energy, which is in the retrace capacitor at the middle of the retrace interval, then transfers into the yoke (and a relatively small part into L_c) to complete the reversal of the yoke current and at the same time restore the losses occurring in the yoke during the second part of retrace (t_3 to t_5). When the total voltage across C_r and L_c starts to ring negatively, the trace diode D_t conducts at t_5, the start of the trace period.

On the commutating side, the commutating switch S_c stays closed for a short period (t_5 to t_6) until the current in the commutating diode D_c becomes zero. During the period t_5 to t_6, C_r is charged positive by the current remaining in L_c at t_5. When S_c opens at t_6, the energy stored in L_{cc} (which is effectively a constant-current source for a given load) replaces the charge which C_r transferred into the yoke during retrace; this process continues until t_o, when S_c is closed again for retrace initiation.

On the yoke side, the energy stored in the yoke inductance during the second part of retrace charges the trace capacitor positively through the trace recovery diode D_t. During the first part of trace (t_5 to t_7), before the yoke current approaches zero (at t_7), a positive trigger pulse from a winding on L_{cc} is applied to the gate of the trace SCR so that it can conduct the second half of the sawtooth current, which is produced by the discharge of the trace capacitor into the yoke inductance. The size of the trace capacitor determines the amount of faceplate correction.

Fig. 4 shows a circuit similar to that of Fig. 2 except that an auxiliary capacitor is used between the two symmetrical switches. Waveforms for this circuit are shown in Fig. 5. After conduction, the SCR's in the circuit of Fig. 2 are reverse-biased for turn-off by conduction of the parallel diodes, and are then forward-biased again. When the diode turns off, the high rate of voltage rise on the SCR anode could turn on the device, especially in the case of the trace SCR, for which the total peak voltage is higher and the time allowed for turn-off is shorter than in the case of the commutating SCR. The undesired high dv/dt on the anode of the trace SCR can be reduced by use of an auxiliary capacitor from anode to cathode or, as shown in Fig. 4, from the other side of the retrace capacitor to ground. The auxiliary capacitor not only provides a lower rate of voltage rise for the trace SCR, but also improves inherent regulation when the retrace pulse across the trace switch is used for high-voltage generation.

In Fig. 4, the auxiliary capacitor C_a is in parallel with the retrace capacitor when the trace switch is closed, and forms a resonant circuit with the commutating coil L_c when the trace switch is open and the commutating switch is closed. The ringing of C_a with L_c can be, for example, for one or two cycles during retrace.

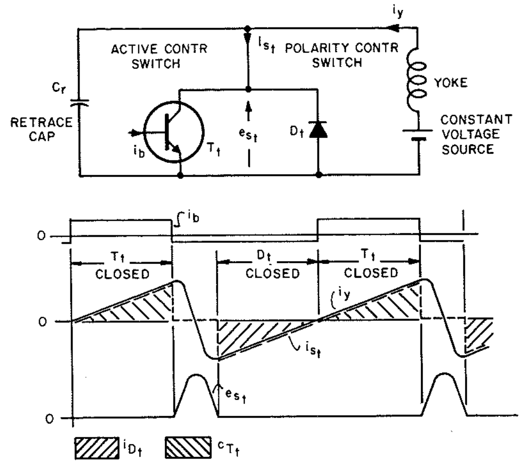

Fig. 1—Trace-driven principle.

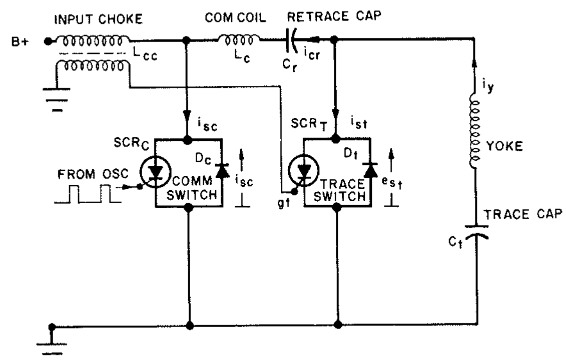

Fig. 2—Basic two-SCR circuit.

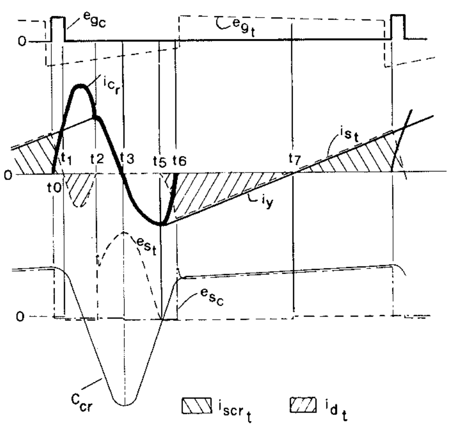
Fig. 3—Voltage and current waveforms for circuit of Fig. 2.

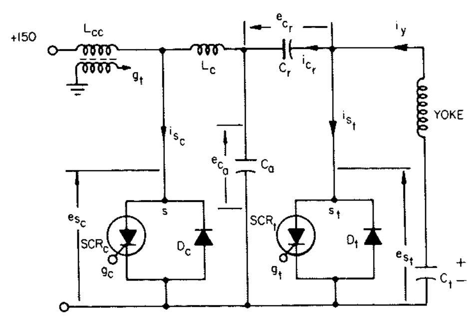

Fig. 4—Circuit of Fig. 2 with auxiliary capacitor added.

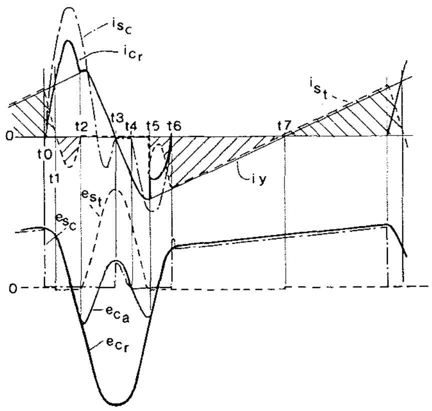

Fig. 5—Voltage and current waveforms for circuit of Fig. 4.

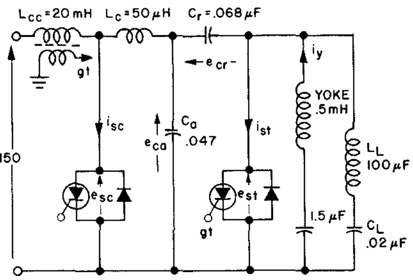

Fig. 6—Circuit of Fig. 4 with high-voltage transformer added.

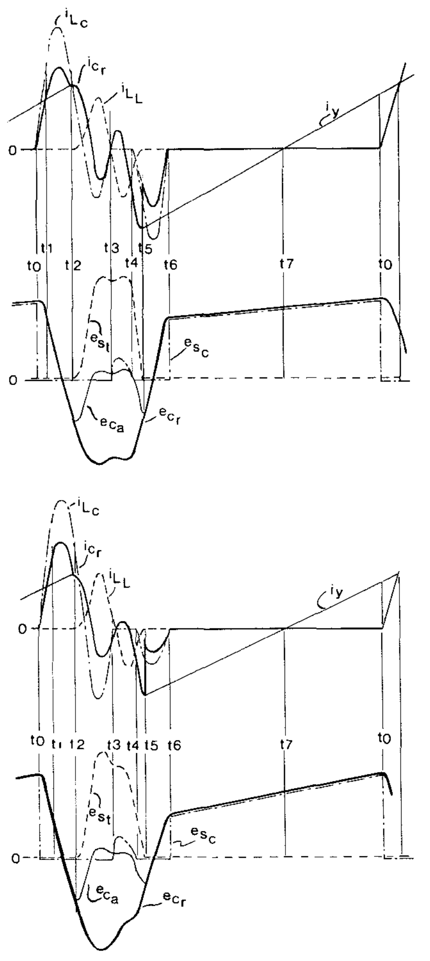

Fig. 7—Voltage and current waveforms for circuit of Fig. 6, with and without beam current.

Fig. 5 shows the voltage on C_r and on the trace switch with C_a ringing for one full cycle during the retrace interval. The retrace interval is terminated at t_5 when the voltage across the trace switch forward-biases the trace diode, i.e., when the retrace capacitor has discharged to the same negative voltage to which the auxiliary capacitor has been charged while ringing with the commutating coil.

Fig. 6 shows the circuit of Fig. 4 with a high-voltage transformer added. The high-voltage transformer introduces another tuned circuit which rings for three half-cycles during the retrace interval as a series tuned circuit in parallel with the trace switch. The third-harmonic ringing current is present in the retrace capacitor during retrace and affects the voltage waveforms on the trace switch as well as those on the auxiliary capacitor C_a, as shown in Fig. 7a. At optimum tuning of the circuit L_l and C_l, the current and voltage are zero when the trace switch opens, and are zero when the trace switch is closed again after the retrace interval.

Fig. 7b shows the same voltages and currents when beam current is drawn from the rectified high-voltage supply, i.e., when the high-voltage capacitor C_l is partly discharged during the middle of retrace. Because the current i_l is reduced during the second part of retrace, the energy returning from the series resonant circuit C_l and L_l and, in turn, the voltage on the retrace capacitor during the second part of retrace are also reduced. Consequently, the yoke current is reduced and the high voltage is decreased as a result of the inherent internal impedance of the high-voltage transformer. When the percentage change in yoke current is half of the percentage change of the high voltage, the picture size is constant regardless of beam-current changes.

The difference in the voltages on the retrace capacitor (which is the source for the yoke current and high voltage) at t_0 and t_6, with and without beam current, is a measure of the losses and the power consumed by the circuit in parallel with the trace switch, i.e., the yoke and the high-voltage supply. Because the charge returned to the retrace and auxiliary capacitors at the end of commutation (t_6) is smaller with beam current than without beam current, the current in L_{cc} (effectively DC under steady-state conditions) increases and charges C_r and C_a to a higher potential when their energy is transferred into the trace circuit. The maximum power taken from the system, however, is limited by the amount of energy which can be stored by the retrace and auxiliary capacitors. These capacitors are the link between the $B+$ supply and the load (i.e., the high-voltage transformer and what is in parallel with the trace switch) and are charged during the off-time of the commutating switch and discharged during the retrace time.

Complete horizontal-deflection and high-voltage circuit

Fig. 8 shows the complete circuit designed around the basic switching circuit. In the absence of the shunt regulator of a tube-type system, a new means had to be found to keep ultor (anode) and focus voltage constant or tracking with beam-current variations. The technique used regulates the input rather than forming a constant load as a shunt regulator does.

The regulator circuit shown in Fig. 9 is essentially a scan regulator which keeps the picture size constant with variations of the power supply and loading caused by beam current. It is a closed-loop system in which a voltage representative of the yoke current is compared with a reference voltage. The amplified error is then used to control the amount of charge on the retrace and auxiliary capacitors at the time t_0 when the energy transfer is initiated.

In this input-regulated system, the commutating circuit is tuned so that, with the regulator loop open, a change in high voltage caused by line-voltage or beam-current changes results in a proportional percentage change in yoke current. When the regulator loop is closed, the system keeps scan and high voltage constant not only with line-voltage variations but also with beam-current variations.

As shown in Fig. 9, the peak of the parabolic voltage on the trace capacitor due to the faceplate correction is compared with a zener. The error voltage turns on the transistor which, in combination with the recovery diode, produces a direct current in the control winding of the saturable reac-

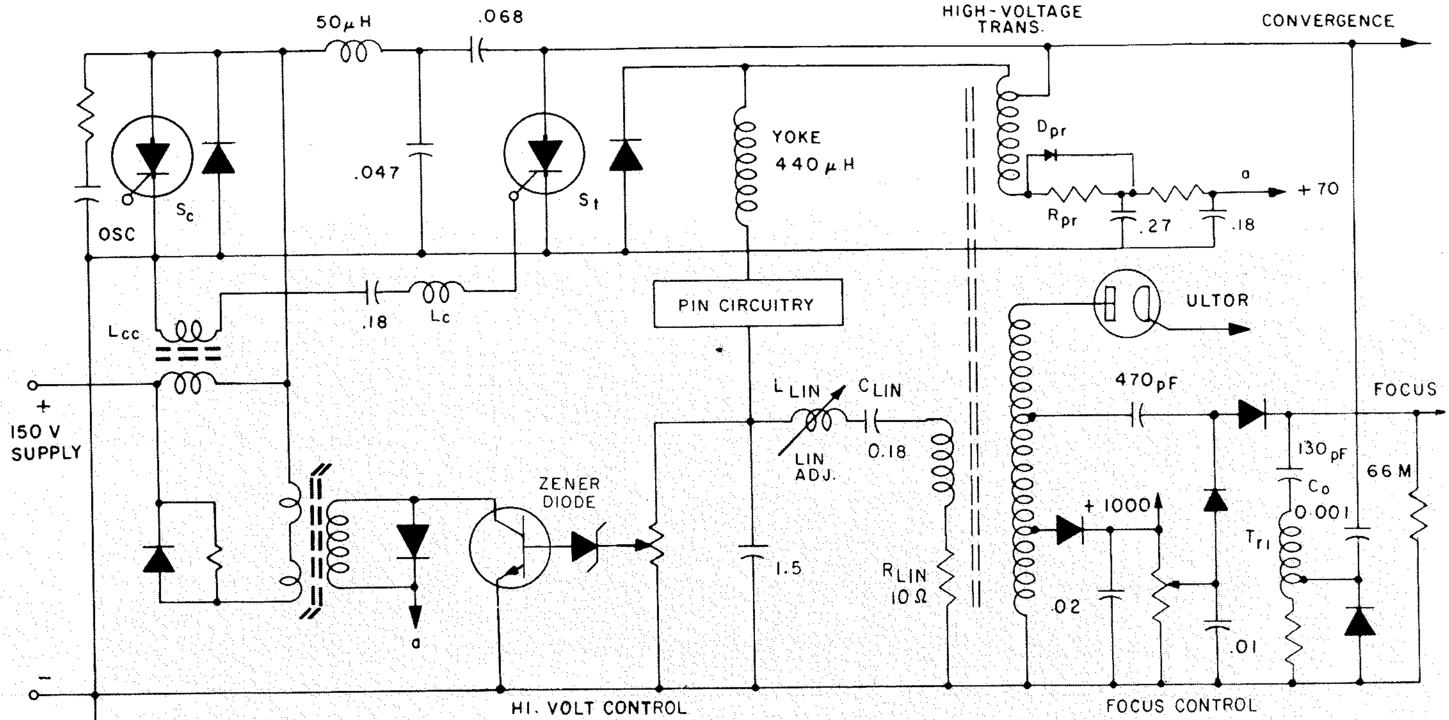

Fig. 8—Complete horizontal-deflection and high-voltage system.

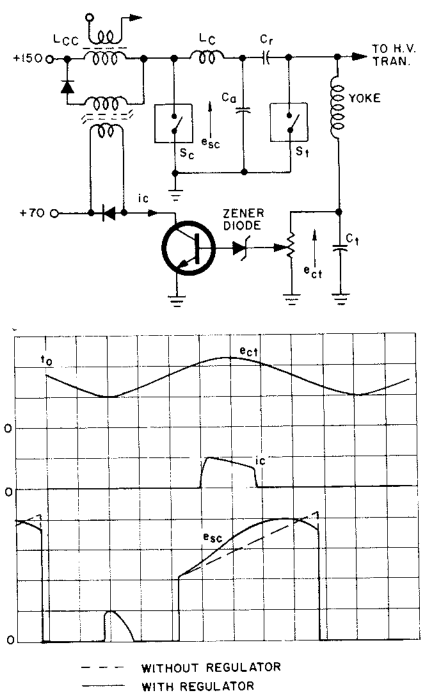

Fig. 9—Scan regulator (top) and scan-regulator waveforms.

tor. This current saturates the outer legs of the saturable reactor so that the total impedance of the saturable reactor and the input choke is reduced to the same order of magnitude as that of the retrace and auxiliary capacitors C_r and C_a. As shown, the capacitors are first charged and later discharged; thus, the charge on C_r and C_a is reduced when the energy transfer is initiated at t_o. The diode in series with the load winding prevents bilateral saturation of the core.

The focus voltage is obtained from a full-wave rectifier of the high-voltage transformer with a control at low DC potential. A tracking circuit keeps the ultor and focus voltages at a constant ratio. This circuit consists of a ringing network which gates the positive peak rectifier to the second part of the retrace interval, where the voltage is in relation to the ultor voltage regardless of the amount of beam current.

Summary

The retrace-driven horizontal-deflection circuit described makes use of devices which are presently available for production quantities at economical prices. The SCR's and diodes used have fast turn-off characteristics which have been used in the past in high-speed inverters, and operate in the circuit shown at voltages below 500 volts and RMS currents below 5 amperes. The system is capable of delivering more ultor power than was previously obtainable with tube-type or other solid-state deflection circuits. An additional feature is that this circuit can be used as a low-voltage supply for other circuits in the receiver.

Reference

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Holographic character generation system

D. Meyerhofer

The character-generation system described in this paper is capable of the high-quality reproduction demanded in printing yet can operate at the high speeds of contemporary photocomposers. The images are stored optically which leads to simplicity of operation and reduction in storage requirements. The novel feature of the system is that the characters are stored as diffuse holograms.

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studied Engineering Physics at Cornell and received his PhD degree in physics form MIT in 1957. While at MIT, he was awarded a Fellowship. His thesis was a study of the ferroelectric transitions in barium titanate. In March, 1958, he joined RCA Laboratories where he has studied various physical properties of semiconductors and insulators. In particular, he has measured galvanomagnetic effects in III-V compounds; investigated the band structure of degenerate germanium as deduced from the electrical properties of tunnel diode; and explored the transport of carriers through insulating layers by quantum mechanical tunnelling and the properties of evaporated thin films of silicon. Subsequently, he has been concerned with quantum electronic phenomena, specifically with the nature of the light emission from semiconductor diodes and lasers and its modification by piezoelectric tuning; with mixing of coherent light beams by electric field induced absorption; and with high power, high repetition rate Q-switched operation of the CO_2 laser. For two years, Dr. Meyerhofer was associated with the Graphic Systems Applied Research Laboratory and investigated electronic applications in the printing industry. This included the use of lasers for exposure of photosensitive printing plates and for direct machining of gravure cylinders; electronic halftone screening and holographic font storage. Dr. Meyerhofer is a member of Tau Beta Pi, Sigma Xi, the American Physical Society, the Optical Society of America, the American Association for the Advancement of Science, and the IEEE.

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In preparation of copy for printing or other kinds of hard copy production, photocomposition is becoming more important.[1] In this technique, a column or a page is composed by exposing the image of one letter at a time onto the appropriate spot on a photosensitive film. The developed film is then used as a master for preparing printing plates or making copies. Alternatively, imaging may take place directly onto photosensitive paper for single copies. The pictures of the alphanumeric characters that are to be imaged onto the film are stored either in one piece as optical patterns or in decomposed form as digital information. The use of optical patterns leads to simpler and cheaper systems which are, however, limited in speed and flexibility. Where digital storage is used, the characters are recreated on a cathode ray tube, usually by "writing" a number of closely spaced lines. This technique allows much higher speed operation and more flexibility in changing sizes and modifying images at increased cost.

The holographic character generation system combines some of the advantages of both the optical and the digital storage of characters. An outline of the system is shown in Fig. 1. A number of holograms, comprising one or more fonts of characters, are located on one plate. The desired one is selected by a mechanically deflected laser beam. The magnified real image of the character appears at a fixed location in space—on the faceplate of a camera tube. The image is read out and the signal processed to change size or shape of the letter which is then recreated on a small cathode ray tube. The letters are imaged onto the appropriate spot of the film either by moving the tube or by a lens system.

The timing of the system operation is determined by the storage characteristic of the camera tube. First, the laser is flashed on the desired hologram. This causes the real image to be stored on the camera tube faceplate. Subsequently, the image is scanned by the electron beam to produce the video signal. During the scanning or "read" period, the laser deflection system can move to its next position so that it is ready for the next laser "write" pulse at the end of the scan. This arrangement makes optimum use of the mechanical deflection which is inherently slow. Also, the "write" time can be made considerably shorter than the "read" time by using a laser with short, high intensity pulses.

Design goals

For the design of a prototype memory system, we considered, somewhat arbitrarily, the following parameter values as goals:

1) One font to consist of 256 characters stored on one plate;
2) Each character to have a resolution of 100 lines; and
3) Random access of the entire font at a speed of 200 frames/sec. or better.

Advantages of holographic storage

There is no fundamental difference between storing optical information in holographic or in pictorial form. It is therefore necessary to compare the two ways in detail to determine which is the more advantageous. The main disadvantage of holographic storage is the low optical efficiencies in readout (only of the order of 1% of the incident light is diffracted into the image). More powerful light sources are therefore required in the holographic system. Both types of plates require accurate photographic exposure in manufacture: the holograms because their density must be correct for uniform image reconstruction; the real pictures because of the high-contrast film used.

The advantages of diffuse holographic storage are the following:

1) The light beam addressing the hologram needs not to be positioned as accurately as that addressing a pictorial image nor does it need to be of uniform intensity or of exact size. A slight overlap into an adjacent hologram only increases the noise and does not immediately ruin the image.
2) To keep the size of the system reasonable, it is desirable to magnify the image when projecting it onto the photo pickup tube (magnification M). If the

location of the image on the tube must be of accuracy Δx, then the location accuracy of the hologram is also Δx, whereas that of the real object is $\Delta x/M$. This means that the pictorial object must be placed much more accurately when changing fonts.

3) The hologram does not require any lenses since they are "built into" the hologram. These lenses—one for each image in a real-space pictorial font—do not have to be expensive but they must be located accurately in the system, complicating its design and alignment.

4) The hologram has more resolution than a pictorial negative for the same size object because of holographic recording system can have a larger effective aperture than can economically be obtained with lenses. This means that a pictorial object must be larger than the holographic object making the addressing of the light beam more difficult. The size of the system will also be increased.

5) The hologram is very insensitive to scratches and other defects.

The system components

Laser

As described earlier, the laser must be pulsed so that the image may be flashed onto the pickup tube between vertical scans. The argon ion laser is particularly suited for this application because it will emit higher peak powers in pulsed operation than in cw operation in contrast to the *He-Ne* laser where the pulsed power is generally not more than the cw power. Argon ion lasers are now available that are compact, reliable, and long lived.

For the present experiment, a 100-mW cw *Ar* ion laser was adapted for pulsed operation. By pulsing it with 25-μs current pulses from a simple pulsing circuit, 10-μs light pulses were obtained. Typically, 100-mW peak power was used or 1 μJ of energy per pulse. The optical system with its 20 uncoated surfaces transmitted about 40% of the light and the holograms were about 1% efficient. This means that the photosensitive surface is exposed with 4 nJ per pulse. This proved to be about the amount required for the best operation of the tube. For some special tests at very small target potentials, higher energy pulses were used by lengthening the pulses.

Laser deflection system

The laser deflection system must be able to address each of the 16 x 16 holograms at random at a rate of the order of the frame rate (or at least 200 Hz). The simplest optical deflection system is based on mirrors and such a system was chosen. High speed galvanometers were used which had a deflection time constant of 0.3 ms. The galvanometer mirrors are very small (0.36 mm wide) but this causes no problem since the laser beam may be focused onto the mirrors.

Tests made on these galvanometers showed the response speed to be as specified. Their deflection is sufficiently linear and reproducible so that 16 different positions may be addressed with an accuracy of at least 25% of the position spacing (a more precise measurement was not performed). This is adequate to read out the holograms at full resolution without noticeable crosstalk.

To obtain independent x and y addressing, two galvanometers were used. The mechanical system was simplified by mounting the two galvanometers next to each other with their axes parallel in the same magnet block. This requires that the horizontal deflection produced by one galvanometer be converted into vertical deflection. It can be done with a corner reflector at a 45° angle. The optical system is shown in Fig. 2. The foci of all three lenses are located at the galvanometer mirrors so that beyond the lenses the beam is always collimated and parallel under deflection. To address the rectangular holograms more efficiently, the beam may be shaped by an appropriate aperture at the laser.

Holograms

The holograms were designed and fabricated by D. H. R. Vilkomerson and R. S. Mezrich. The specifications called for an array of 16 x 16 individual holograms on one plate, all of which are to play out with parallel laser light. All the real images are to appear in the same place on the photosensitive layer of the camera tube in an area of 12 x 16 mm. The holograms were designed to produce the optimum resolution by balancing the hologram size against the focal distance. The resulting arrangement for readout with the appropriate dimensions is shown in Fig. 3. The calculated minimum resolution for this arrangement is 375 TV lines for an analog character or 5500 digital bits with a redundancy of 1½. These values include a safety margin of 2x since, with present plates, the theoretical resolution cannot quite be achieved.

To demonstrate the resolution obtainable, a hologram was prepared using an array of dots such as would be used for digital storage. The dots were 50 μm diameter and spaced on 125 μm centers so that the entire frame had 100 x 130 dots. The video signal resulting from a single horizontal scan through a row of dots was photographed. It showed the pulse signals due to the dots to be clearly separated by regions of no signal.

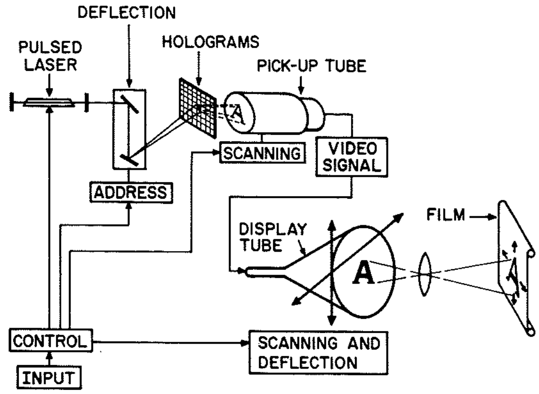


Fig. 1—Holographic storage photocomposition system.

Camera tube

The selection of the proper camera tube is critical for the success of the system. In particular, the signal produced by the tube in response to a certain optical signal should be independent of the previous history. If there has been on "write" pulse, there should be no signal from the subsequent scan. Since the tubes were not to be operated in the conventional manner, a number of different kinds of tubes were tested. The experiment was constructed to allow accurate, independent control of the various parameters. The target of the camera tube was illuminated with a spatially uniform stroboscopic light source. The light intensity was such that the tubes were operated just below the saturation level where the response is still linear. The light pulses were applied during the vertical retrace (this was found to be the region of optimum operation). The horizontal scanning frequency was 15.7 kHz, and the vertical frame rate was 210 Hz (not inter-

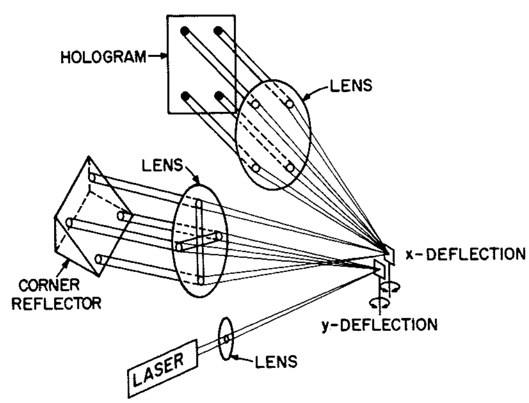


Fig. 2—Deflection system.

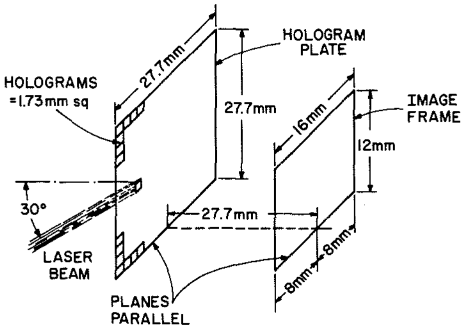


Fig. 3—Hologram memory design.

Pickup tube	Target height	Line spacing at TV rates (500 lines)	Experimental scanning height	Line spacing	Amplitude rise	Persistance ratio
	mm	μm	mm	μm		
Vidicon A	9	18	9	150	1.40	1.36
			4.5	75	1.23	2.00
Image orthicon	24	48	24	400	1.12	1.28
			3.6	60	1.20	8.30
Vidicon B	12	24	12	200	1.16	4.80
			6	100	1.10	4.85

Table I—Camera tube characteristics.

laced). This allowed 60 horizontal scan lines plus 15 more for the vertical retrace. The vertical scanning height could be changed to vary the spacing between horizontal lines. Two tests characterized a camera tube for our type of application:

1) The *amplitude rise* which is the ratio of the steady-state output signal (i.e., the signal when the light is flashed on before each scan) to the signal appearing after the first light flash (preceded by a long dark period). This quantity is related to the charge stored in the photosensitive layer itself rather than on the surface where it can be read out and to the transit time of the charge through the layer.

2) The *persistance ratio* which is the ratio of the signal read on the first scan after the light has been flashed for the last time to the signal read on the next following scan. It relates to the conventional term "lag," namely the fraction of the stored charge that is left behind after the target has been scanned once. This charge may be either on the target surface due to RC limitation of the scanning beam or in the interior of the layer due to conductive limitations.

The measured values of these quantities are shown in Table I for three different types of camera tubes together with the other parameter values. It can be seen that in most tests the horizontal line spacing was considerably larger than that used in a conventional TV raster. Since the electron beam was always well focused, this means that it then did not scan the entire area. There are regions between the lines where there is charge remaining. It is clear that vidicon B has the best response of the tubes tested, not only at conventional scan rates, but in particular as the line spacing is increased. In fact, its operation seems to be quite independent of the line spacing. The only tube which showed any better response was the image orthicon and only at conventional scan rates.

System performance

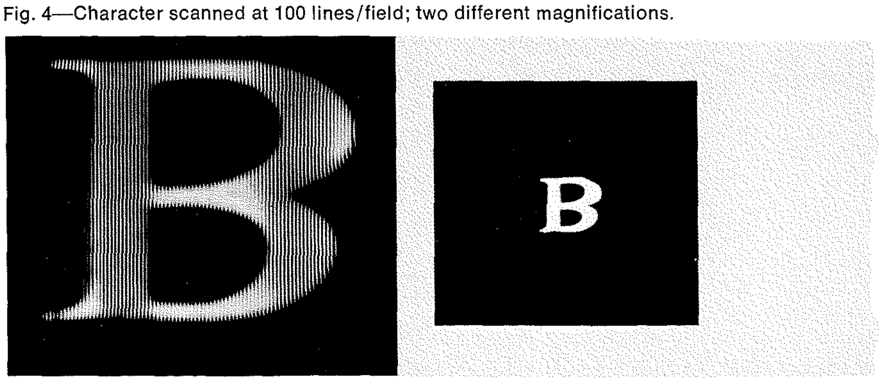
Using the components described above, a complete system (as shown in Fig. 1) was set up and tested. For the purposes of these tests, a special timing and control system provided both the synchronizing signals and the input information. In a practical system, the latter would, of course, be provided by paper tape or other such input. A 25-kHz clock signal was the basic timing mechanism which could be used for synchronizing the horizontal scan. The lengths of the "read" and "write" cycles could be adjusted from 0 to 5 ms in 40-μs units. Synchronizing signals were provided for each cycle. The input information was provided by two analog signals which drove the deflection galvanometers. Any one of the 256 hologram fields could thus be addressed. For dynamic testing, the input control system cycled repetitively through eight selectable addresses, changing to a different one for each "write" cycle.

A commercial camera was adapted to drive at the required rates. The horizontal scan could be varied from 15 to 30 kHz. A HP-214 pulser provided the necessary horizontal driving pulses. For most of the experiments, the horizontal sync output of the control system (25 kHz) was used to trigger the pulser. Then the horizontal scans were locked to the frame time and the same lines were always scanned on the photosensitive surface of the tube within the stability of the vertical deflection system. Alternatively the operation could be changed to a random horizontal scan by letting the pulser run free at the same 25-kHz rate or at some other rate. The vertical scan was provided by the sawtooth output of an oscilloscope which was displaying the "read" gate signal. The scan time was then equal to that signal and could be varied with it. This arrangement permitted testing over a wide range of the parameters such as number of scan lines and frame rate.

The experimental hologram plates had 16 of the 256 fields occupied, three in each corner and four at the center so that the most critical areas could be tested. In addition to 4 different letters, a test chart was put in one field of each of the groups. This allowed one to align the holograms with great precision, by addressing the various test charts in sequence and rotating the holograms until the real images of all the test charts superimposed exactly and were in focus at that same point. The holograms were fabricated with 514.5-mm $Ar+$ laser radiation and read out with the same frequency. Due to emulsion shrinkage, some slight distortion and non-overlap is to be expected but this could not be observed in practice. The exposure of the hologram plate in forming the holograms was determined by trial-and-error separately for each field. This led to variance in the image intensities which made the testing more difficult as shown below. It will be a relatively easy matter to improve this situation in the future by measuring the radiation at the photographic plate exactly and using its integral to control the exposure time.

The laser was synchronized to the "write-read" cycle by triggering a pulser at the beginning of the "write" gate to produce the laser current pulse. A "write" period of 320 μs was sufficient to form the pulse; and this value was generally used. The addressing signals for the galvanometers were changed during the "read" cycle when the laser was off.

Fig. 4—Character scanned at 100 lines/field; two different magnifications.



The video output from the camera was further amplified by a preamplifier—power amplifier combination to a peak voltage of 60 V so that it could drive the z axis to an x-y oscilloscope. The character could then be displayed by deflecting the x and y axes of the oscilloscope by sawtooth generators which were trigged at the same times as the vidicon deflection circuits. This has the advantage that the size of the displayed character may be changed at will without changing the number of scan lines per character. By varying the scan rate of the y-deflection generator, one or more characters could be displayed at the same time on the x-y oscilloscope. In particular, eight characters could be displayed at the same time in synchronism with the cyclical permutation of the addresses to simulate the way such an instrument would be used in practice. A clipping circuit was also included which allowed variable clipping of both top and bottom of the signal.

The operation of the entire system was investigated by varying the values of the parameters. The highest persistance ratio, or minimum lag, was observed at medium light levels and maximum camera tube target voltage of 80 V. Values as high as 10 were occasionally observed in the display of a character but about 4 was more common. These high values were only observed when the electronic focus was slightly different from its optimum value (e.g., 300 instead of 320 V on the focusing grid of the tube). No decrease in resolution was observed visually due to this change. Apparently, this small change caused a spreading of the beam to where it became of the order of the line spacing and did not leave any charge unscanned. This was confirmed qualitatively by the fact that, under these conditions, no difference in operation was observed between operating the horizontal scan synchronously and operating it free running. Under optimum focus conditions, the video signal became very noisy and the persistance ratio low and unsteady. This was found to be due to the vertical scan not being very steady and, in particular, having a 60-Hz component in its signal. This is not a fundamental limitation of this camera tube even if one desires to operate at optimum focus since, in the more stable test system used to select the camera tube, these instabilities were not observed. In that case, the persistance-ratio measurements were indeed made at optimum focus (Table I).

We now show examples of the output under the conditions discussed. The "read cycle" was adjusted to 4.0 ms with retrace taking place during the following "write" cycle. The horizontal scan was synchronized. This means that there are 100 horizontal lines of 40 μs per character. The character itself will have fewer lines as it does not take up the entire field. The frame time is then 4.32 ms and the frame rate 230 Hz. Note that what we have called the horizontal scan appears on the oscillographs as vertical lines. The vidicon is rotated 90° from the conventional position so the characters fill the faceplate more completely. The fast scan is in the vertical direction. Fig. 4 shows a character scanned at this rate. The two different images were made by varying both the horizontal and vertical deflection sensitivities of the display oscilloscope. The figure shows that for small images, the scan lines blend together to form a satisfactory picture. Even when the scan lines are reduced by a factor of two, the small image is almost unchanged.

Fig. 5 displays a readout of the first five of eight characters in a sequence. The first hologram is located on one corner of the hologram plate, the third one near the opposite corner and the second and fourth ones near the middle of the plate. The fifth through eighth frame are empty as the laser beam addresses a field that does not contain any hologram. This was done to demonstrate the lag or storage more clearly. For this display, the video signal was clipped. The video signal for the eight frames is shown in Fig. 6, both unclipped as it comes from the amplifier and clipped for the display of Fig. 5. This demonstrates the persistance ratio which is the ratio of the signal from frame 4 to that from frame 5, which should be empty. One can also observe that the various video signals are not of equal amplitude: the "A" is low and therefore not completely reproduced. This is due to uneven exposure in manufacturing the holograms, as discussed above.

Exposures were also made at considerably higher frame rates to test the speed of the addressing and readout system. Good exposures with similar clipping ratios were obtained at frame rates as high as 1000 Hz. Because of the limitation in the horizontal deflection rate, the fields consisted of only 25 scan lines at that speed with attendant reduced resolution. By increasing the scanning speed and the video bandwidth of the camera, satisfactory operation at the higher frame rates should be possible.

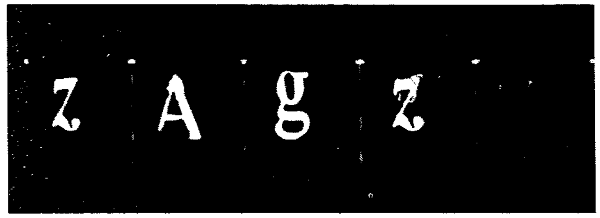


Fig. 5—Four different characters and four empty frames addressed in sequence at 230 Hz.

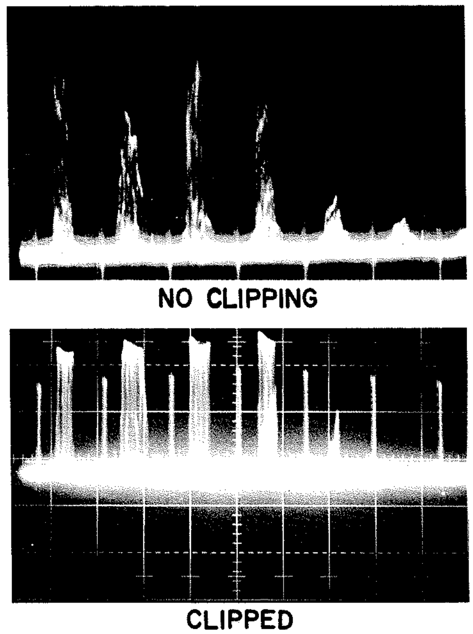


Fig. 6—Video output. Eight different frames are scanned at 230 Hz (same frames as in Fig. 5).

Acknowledgements

These experiments were performed in cooperation with P. J. Donald of the Electronic Printing Research Group, RCA Laboratories, who designed and built the galvanometer deflection system. D. H. R. Vilkomerson and R. S. Mezrich of the Data Processing Research Laboratory, RCA Laboratories, designed and produced the holograms. Finally, the testing of the pickup tubes was greatly assisted by A. D. Cope of the Conversion Devices Laboratory, Electronic Components. The help of all these colleagues is gratefully acknowledged.

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Modeling of system reliability and safety

B. Tiger

The safety analysis technique usually described in the literature is called fault-free analysis.[1] This technique consists of identifying hazards and then using logic symbols to identify respective combinations of component failures and errors which can cause each hazard. Although confronted with inadequate data and lack of comprehensive identification of all combinations of component failures and errors, this method has been used with apparent success on many complex systems. This paper describes system-state phase modeling (SSPM)—a more comprehensive and useful method than fault tree. The problem of identifying all the possible combinations of component failures and errors that can cause a hazard is still not fully resolved, but SSPM does provide a much more rigorous presentation and identification of the possibilities.

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received the AB from Brooklyn College with full majors in mathematics, statistics, and psychology. He received the MS from Stevens Institute of Technology with the major concentration in statistics and supporting courses in electrical engineering and programming. He has also done graduate work in electrical engineering, mathematics, and statistics at University of Connecticut and at Rutgers University. Mr. Tiger has developed and applied reliability, maintainability, safety, and effectiveness-prediction techniques; he has also developed design review procedures, test programs, experimental designs, tradeoffs, and overall product assurance programs. These efforts were performed on such programs as X-15, SAM-D, Apollo, VS(X) systems, Minuteman Control and Computer Systems, etc. Under a contract with Rome Air Development Center, he developed and conducted a test program which led to the identification of the underlying reliability characteristics of integrated circuits. These characteristics have resulted in a new and practical way for predicting integrated circuit reliability. Mr. Tiger has in the past seventeen years provided consultation, lectures, and papers on reliability, statistics, experimental designs, testing, safety and many other aspects of product assurance. He is past Chairman of IEEE Reliability Group—Philadelphia Section; Session Chairman of the Annual Reliability-Maintainability Conference; member of ASQC; Chairman Elect of the Northeast Chapter of the System Safety Society; and chairman of the Second Annual Seminar on Failure Analysis sponsored by the IEEE Philadelphia Section and Reliability Group Chapter.

A SYSTEM can satisfactorily accomplish its intended mission, or it may fail to do so. If it fails, there are two possible consequences:

1) There is no loss of life or property.
2) There is loss of life or property.

Success and failure are generally the subject of reliability; failure resulting in loss of life or property is the explicit domain of safety. Common to both reliability and safety analysis, however, is the need to identify the possible component failure modes, human errors, and erroneous signals and to determine their effect on the system.

In reliability analysis, it is usually fairly straightforward to identify the combinations of component failures and errors which still permit a successful mission. This is because the number of such system states is relatively limited. Safety analysis, however, requires identification and evaluation of virtually all failures and errors; a sort of identification of everything that can go wrong and then evaluating which of these events are hazardous. This is often very difficult to accomplish.

Partly because of this problem there has been less literature on safety measurement as compared to reliability prediction. Another problem is that of valid input data: component-failure probabilities, human-error probabilities and probabilities of signal errors resulting from induction or transients. Reliability prediction has been able to develop mainly on the basis of failure rates, but safety measurement requires full consideration of all of these additional types of inputs. Yet, only component-failures data has as yet been developed to any extent, and even here much that is available pertains only to overall component failure rate rather than probability of occurrence of each of the failure modes of a component.

Both of these problems are discussed in Ref. 2, which also describes the use of safety devices in terms of providing a lower bound on system safety. Such a device must have the property that a serious hazard can occur only if it has failed in a particular failure mode. For example, excessive electrical current cannot be going through the electrical lines in a home unless the fuses have failed short. Such devices provide a means for more rapid safety analysis because system safety is greater than the probability of its safety device not failing in a mode which make a serious accident possible. Canale expanded this concept to incorporate human and procedural controls.[3] That is, the accident cannot occur unless certain human errors occur or certain procedures are not followed.

It must be recognized that the concept of safety devices and controls is not a safety analysis technique. Application of controls or safety devices do reduce the scope of necessary analysis because the effort can concentrate on evaluating their loss of control and failure-mode probabilities rather than detailed study of all the failure modes and possible errors of the entire system. But the problem of how to do safety analysis remains, whether it is needed for the entire system or only its safety devices and controls.

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SSPM approach

The system-state phase modeling (SSPM) approach like fault tree, uses a logic format to identify each event or system state (i.e., a specific combination of component failures and errors). However, it is a "bottom-up" rather than a "top-down" approach. This means that, in SSPM, all the component-failure modes and possible errors are identified first and then their effect on the system is evaluated. Fault Tree, being "top-down", first identifies adverse effects and then uses a Boolean type of symbolism to represent only

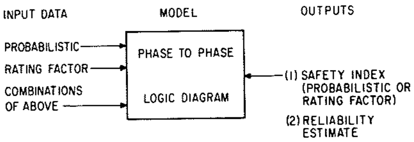

Fig. 1—Evaluating safety and reliability by analysis of the system states in their mission phases.

respective combinations of a component failures and errors which can result in each of the adverse effects.

Although more tedious, SSPM is a more rigorous analysis because system effects are not assumed and then traced back in terms of which failures and errors can cause them; they are identified *after* all the events which can happen to the system are identified and evaluated. There is, therefore, less possibility of SSPM missing a combination of component failures and errors which would result in a system hazard. Since all system events are identified in SSPM, safety is estimated by summing the probabilities of all the events (i.e. system states) which do not result in loss of life or property, and reliability is estimated by summing the probabilities of all the events in which the mission is satisfactorily accomplished.

In SSPM, each component failure and possible error is evaluated in terms of each phase of the mission in which the system is to be used. It is granted that sometimes safety analysis performed under a single set of assumed worst-case-usage conditions (instead of detailed phase-to-phase study) may be adequate. However, growing mission complexity (e.g., future space explorations) increases the need for detailed phase-to-phase study to reduce the possibility of overlooking any hazardous event. Also, continual assumption of worst-case conditions may prove to be excessively pessimistic in regard to future complex missions.

The SSPM approach consists of a phase-to-phase logic diagram which is a presentation of the possible system states at the end of each phase of the mission. The possible states at the end of any phase are conditional to the state of the system at the beginning of the phase and also depends on whether or not failed components can be replaced or repaired. Thus, SSPM accurately portrays such events.

In diagraming the possible system states, it is recommended that a certain type of switching network[4,5] be used rather than the logic symbols used in fault tree. A switch takes up less space than the symbols used in fault tree, and a switching network is readily understood by more engineers than a symbolic logic presentation. The recommended type of switching network is described below in terms of its specific properties which facilitate probabilistic analysis.

Such a switching network has certain properties which correspond to the basic rules of probabilities.

1) Each path in the network corresponds to a specific system state (or set of states). Therefore, multiplication of all the component and error probabilities in a path results in the probability of the system being in that particular state. Or more generally, each particular path represents a specific system state (or set of system states), and the joint probability distribution for all components and errors (as indicated by the path) is the probability of the system being in that state.
2) Since each path represents a different system state and the system states are mutually exclusive (i.e., a system can be in only one state at the end of each phase) the probability of being in any set of paths is simply the sum of the path probabilities.

Because of these two properties, this type of switching network obviates the need to write any algebraic or Boolean equations. The component and error probabilities can be recorded with each appropriate switch. Multiplication of these numerics yields the respective path probabilities. The probability of the system being in any one of a group of states is derived by simply adding the appropriate path probabilities. Groups of paths that are usually of interest include:

1) All system states in which the system satisfactorily accomplishes its mission (i.e., reliability).
2) All system states which do not result in loss of life or property (i.e. safety).

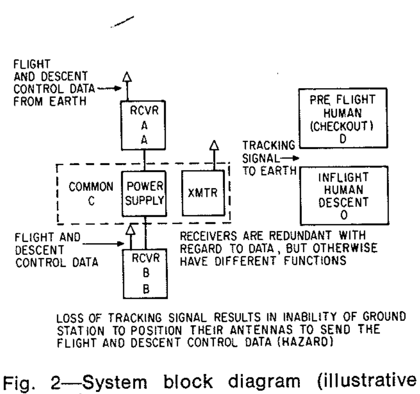

Fig. 2—System block diagram (illustrative example).

Recognizing that there is often a lack of fully validated input data, some rating indices or estimates may be needed for some or all of the components and errors considered in the model. This is why input data is shown as probabilistic, rating factor, or some combination in Fig. 1 which presents an overall view of SSPM. If all the input data are valid probabilties, then the outputs will, of course, be reliability and safety probability numerics. But, if rating indices must be used for inputs, then the resulting reliability and safety numerics can only claim to be rating indices rather than probabilities.

Example

The system described in Fig. 2 will be used to illustrate SSPM. A space mission consisting of three phases—power flight, orbit, descent—is considered.

The effectiveness of the pre-flight checkout will also be evaluated in the model, and used to establish a phase 0 (initial or base condition) for the system. The system consists of astronauts, transmitter, two receivers, and a common power supply. The transmitter is needed for the purpose of sending a tracking signal to earth. If this signal is not sent, the ground stations will not be able to position their antennas to send the flight- and descent-control data. Loss of this data during any phase of the mission is hazardous. The data can be received by either receiver, but otherwise the receivers are not redundant because they have different functions (e.g., mission success requires that receiver A receive voice while receiver B is receiving data). Thus, although they do not relate to safety, both are required for mission success.

The possibility of a human error, whether by an astronaut operator or an earth operator, during the descent phase will be included in the model.

The symbolism to be used is shown in Fig. 3. The number of needed symbols is reduced by noting that if either the power supply or the transmitter fail, the mission has failed and a hazardous situation exists. Since there is always the same effect on the system if either or both fail, they can be identified in the model by the same symbol (C). But it must be remembered that C represents the probability of both working while C represents the probability of either or both failing.

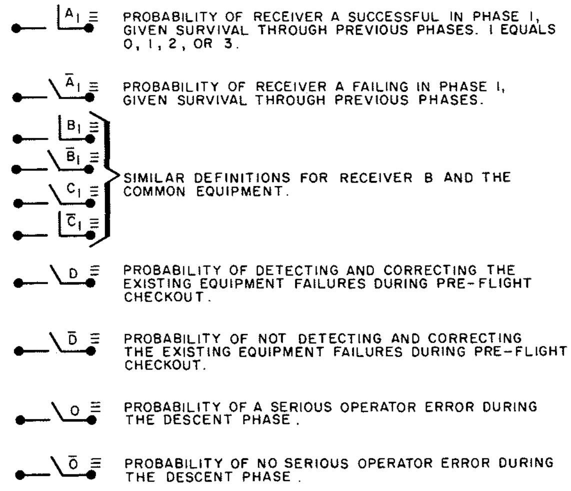

Fig. 3—Symbolism used in illustrative system state/phase model.

1. A success probability of 0.99 is assumed for each receiver and the combined power supply-transmitter in each phase. The probability of successful pre-flight checkout and of successful human operation during descent are also assumed to be 0.99.

2. It is assumed that maintenance cannot be performed during the mission. Possible operator error prior to descent is not considered.

3. Since each success probabilities is 0.99, the failure and human error probabilities are each 0.01.
   a. In performing calculations involving multiplication, the final result can have no more significant figures than the numbers with the fewest significant figures.
   b. In performing additions of numbers, the final result has no more significant figures after the decimal point than the numbers with fewest significant figures after the decimal point.

4. It is assumed that the equipments are independent of each other in regard to failure probability. However, to illustrate that conditional probabilities can be used in SSPM, 3 different subscripts are used in conjunction with operator error (O) in phase 3. They represent the fact that the probability of a serious operator error could differ depending on whether both receivers are good (O_1). Receiver A good and B failed (O_2), or receiver A failed and receiver B good (O_3).

Fig. 4a—Explanatory notes for illustrative system state/phase model.

Further explanation is provided in the Fig. 4. The SSPM is shown in Fig. 4a through 4e via a separate diagram for pre-flight checkout and each of the three mission phases.

Fig. 4b, shows that eight system states are possible at the end of preflight checkout, depending on what is failed and whether or not the failures are detected and corrected. State 1.0 indicates all equipments are good at the end of phase 0. State 2.0 indicates that receiver B is failed and has not been fixed, and so on for the other states. The notation used herein is such that the numeric to the left of the decimal point identifies the system state at the end of the phase indicated to the right of the decimal point.

The numbers on the right side of Fig. 4b are the path probabilities. Each is calculated by multiplying the numerics along the path. The probability of the system being in state 1.0 is calculated by summing the probabilities of all the state-1.0 paths. This results in a probability of 1.00 to 2 decimal places because of the rounding and rules for significant figures. A more meaningful way is to add up the path probabilities for the other states and subtract the resulting sum from unity. This yields:

$$P_{1.0}=1-0.0003=0.9997$$

Fig. 4c shows that states 4.0, 5.0, 6.0, 7.0 and 8.0 directly result in hazard during phase 1 (H_1). The notation used herein is such than an H inside a heavier circle denotes that the system has become unsafe (i.e. hazardous) in the phase indicated by the subscript of H.

If phase 1 is entered via state 1.0, then a hazard (H_1) can occur if C fails or if both receivers fail. The indicated paths are set up for the proper probabilistic calculations via the previously described rules of multiplication of probabilities along a path and addition among paths. If phase 1 is entered via state 2.0, then a hazard (H_1) can occur if C fails or if receiver A fails.

If phase 1 is entered via State 3.0, then a hazard (H_1) can occur if C fails or if receiver B fails. The other possible system states at the end of the phase are also indicated. The calculations show a 0.01 probability of H_1, a 0.97 probability of state 1.1 (i.e., the probability of all components good at the end of Phase 1), a 0.01 probability of state 2.1 (i.e., only receiver B failed), and a 0.01 probability of state 3.1 (only receiver A failed).

The modeling and calculations proceed similarly through phases 2 and 3. The results are:

Safety = 0.96
Reliability = 0.90

Note that mission success required that both receivers and the common components operate properly and that there be no serious operator error. The receivers were redundant in regard to safety.

Uses of SSPM

Mission and equipment analysis

The SSPM technique reveals the events which can cause system failure or accident. This can lead to system modifications to preclude them or lower their occurrence probabilities.

Safety indices and reliability estimates

Accurate probabilistic data is not essential for input data. Thus, if the occurrence probabilities of equipment failures, human errors and erroneous signals are not fully known, then estimates or qualitative ratings can be used instead as input data to the state-phase model. When ratings are used as inputs, then the resulting safety and reliability estimates (i.e., the numerical outputs of the model) are also ratings rather than probabilities. On the other hand, if the input data consists of accurate probability estimates, then the resulting safety and reliability estimates are also accurate probabilities.

Analysis of alternative system and mission profiles

If there are alternative system configurations and/or possible variations in mission conditions or objectives, then the state-phase modeling can be performed on each alternative in order to identify the safest alternative and the most reliable alternative.

Sensitivity analysis

Recognizing that there may be variability or lack of exactness in the input data and the assumptions regarding the system the system usage and mission conditions, it is advisable to determine their effect on the safety and reliability estimates, mission and equipment analysis, and the comparative analysis of alternatives.

Also, the modeling approach is readily computerized so that the multiplicity of numerical outputs, corresponding to all the input variations which would

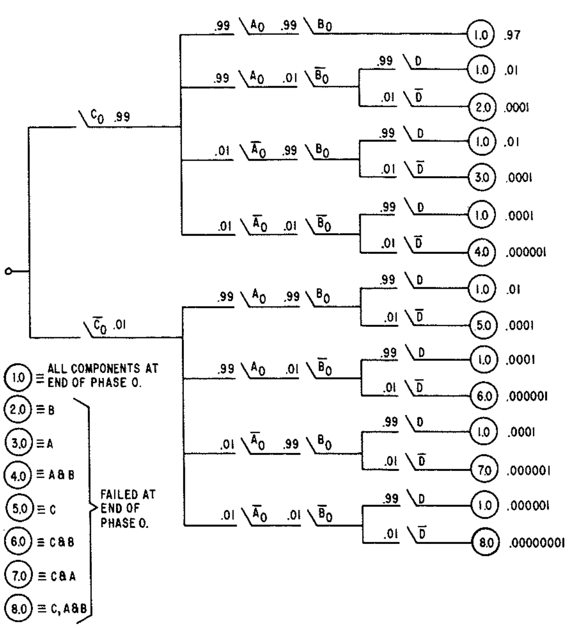

Fig. 4b—Pre-flight checkout (phase 0).

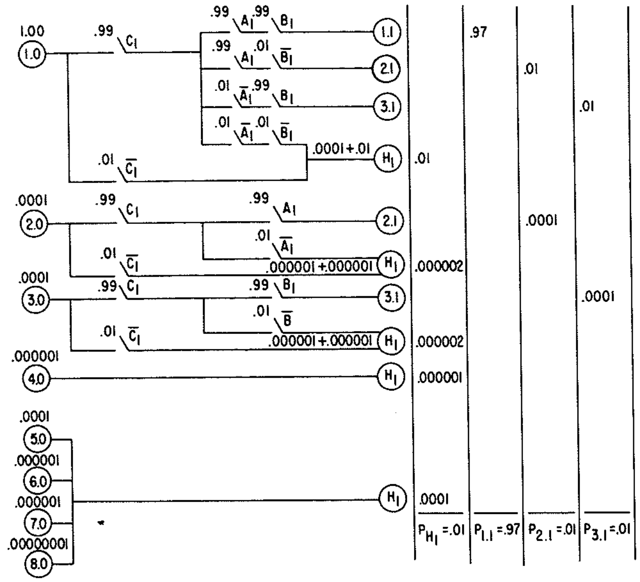

Fig. 4c—Powered flight (phase 1).

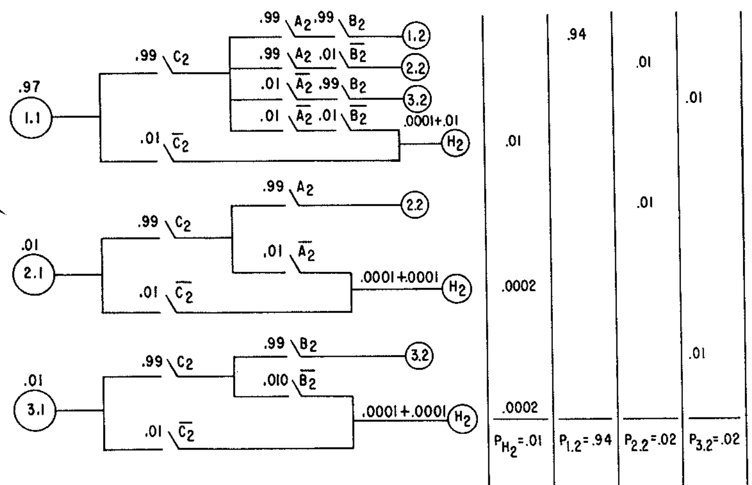

Fig. 4d—Orbit (phase 2).

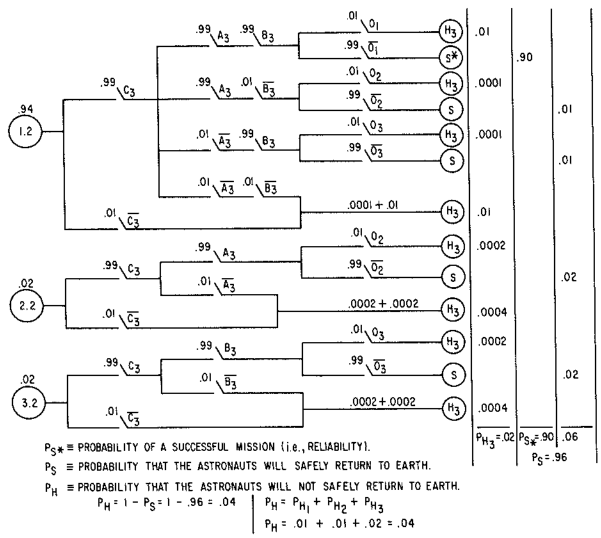

Fig. 4e—Descent (phase 3).

be encountered under the four uses described above, are quickly achieved.

There are many features to SSPM which make this method superior for these uses. These include:

1) a rigorous, comprehensive presentation of events in time frame is given;
2) The analysis can readily be checked for completeness of the identified states as well as correctness of calculations;
3) The method is applicable to logistics life-cycle phases and mission phases (functioning system);
4) Phase-to-phase differences in human element, erroneous signals, stress, error rates, and failure rates can be more thoroughly included.
5) Boolean algebra and symbolic logic are not needed to understand model.
6) It is more easily and economically programmed for a computer.
7) It provides safety engineering problem comprehension with rigorous mathematical analysis.
8) A complete history of events is carried through all phases of model because model paths are time continuous.
9) Success, reduced effectiveness, failed and hazard states are described at end of each phase and for the complete mission.
10) Unsafe failure modes of each component and their effects are described in a time frame and logical fashion.

Conclusions and recommendations

As systems continue to become more complex, space and other potentially hazardous missions become more frequent, and more and more nuclear weapons are manufactured and dispersed, the need for more comprehensive methods for safety analysis becomes critical. Also, this new method permits a more comprehensively developed system reliability estimate than the techniques currently described in the literature[4], although certain aspects of the logic diagraming used in SSPM have been previously described[4,5].

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A versatile controller for data communications

F. E. Brooks

This paper describes a data-communications device—the CCM (communications controller—multichannel, 70/668)—which can control 48 lines simultaneously. The need and total requirements for the CCM, in the context of a total communications system, is presented. The hardware, logic, and operation of the CCM is then described.

A DATA-COMMUNICATIONS DEVICE is rather unique because of the environment that surrounds it. The communications line which it must control is a limited bandwidth channel that passes through a great variety of hostile surroundings. Thus, the possibility of a transient communications error or an occasional total breakdown is relatively high. Furthermore, the line characteristics are set to service a great variety of users and to provide communications connections to any populated area of the world. For these reasons, the data communications controller must conform to the line requirements rather than dictate them.

Each communications line has its own peculiarities and characteristics and must be handled accordingly. These characteristics may be classified by data communications "system classes." A system class is defined by the following characteristics:

1) The communications terminal type;
2) The grade of communication line service (common carrier facility); and
3) The procedure used to establish communication and check the transfer of intelligence (channel coordination).

System classes are differentiated because of the following factors:

1) *Input/output media:* cards, paper tape, keyboard, printer, video display, computer data;
2) *Speed of data:* variable from 6 to 300 char/sec (sometimes higher).
3) *Costs of terminal equipment and communication line facility:* from a teletype printer to a large computer system.
4) *Security of data:* from advertising copy up to confidential financial or diplomatic information.
5) *Technological progress*

The CCM fits into a communications system as shown in Fig. 1.

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Since the great majority of communication lines are limited in speed, a CCM working with its associated processor can control 48 lines simultaneously (at least within the limits of communication line and terminal speeds). For each line, a communications buffer is required. The communications buffers are physically housed in the CCM logic rack. Some communication lines, by virtue of their length and speed are interfaced to the communication buffers with modem (modulator/demodulator) equipment or data sets. Specific modems may help to insure the line integrity, may provide the data clocking signals, or may provide the intelligence to denote when a remote terminal desires to transmit data. The CCM and communications buffers provide for the effective use of this modem-supplied knowledge with a minimum of processor and program interruption.

CCM's are capable of handling many (upwards of 40) different types (system classes) of communication lines. Up to 16 different system classes can be handled simultaneously by one CCM. Table I lists some of the communication terminal types and facilities which can be controlled by the CCM. The input/output media as well as the character speeds are listed for each type.

To control the multitude of different system classes, the CCM with its communications buffers performs certain general functions; the most important of which are the following:

1) Convert between bit-parallel characters for the computer and bit-serial characters for the communications lines;
2) Establish synchronization of data with the remote terminal;
3) Provide error detection;
4) Convert electrical signals to levels and meanings which are compatible with the various communications line interfaces;
5) Protect the computer system from total shutdown as a result of the failure of one communications terminal or line;
6) Provide a multiplexing capability for handling up to 48 communications lines;
7) Establish and terminate communication line connections.

Conspicuously absent from this list is a translate function. The CCM is not a code translator. Consistent, however, with the computer industry's desires for standardizing an USASCII (United States of America Standard Code for Information Interchange), the CCM does have the capability of translating between 8 bit USASCII line code and computer-utilized 9-bit extended ASCII.

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received the BSEE from Purdue University in 1949 and subsequently has taken graduate courses at the University of Pennsylvania. At Philco Corp. from 1949 to 1954 Mr. Brooks did design work on television home receivers. He joined the Component Parts Division of RCA in 1954 where he worked on television deflection components for wide-angle monochrome and color television. From 1957 to 1961 he was employed in the Home Instruments Division where he worked on television receiver design specializing in deflection components and circuits. In 1961 and 1962 Mr. Brooks was assigned to Lightning—an advanced development project for a tunnel diode computer. Since 1962, Mr. Brooks has been engaged in design of digital data communications equipment. Initially he worked on a series of communication buffers used for a product line with RCA's 301 and 3301 computers. He also worked on the Autodin Buffer which is used for connection of the 301 or 3301 into the Autodin network. In 1964, he became engineering group leader. He holds patents in the television and data communications field. The most recently completed project of his group was the design of the 70/668 CCM and a variety of associated buffers for use in the Spectra 70.

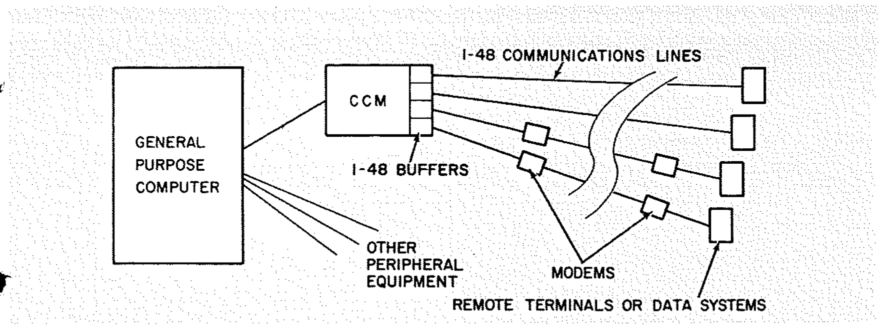

Fig. 1—Data communications system.

General CCM hardware

From a hardware standpoint, the CCM is quite analagous to a general purpose computer. It contains a core memory and uses status levels for the control of its operations. The memory contains 512 words which are each 18 bits in length (17 information plus 1 parity bit). The logic circuitry is basically RCA series-2 (diode-coupled transistor NAND). This circuitry contains discrete transistors and a mixture of discrete and deposited components. The logic is packaged on 535 plug-ins. These contain approximately 3000 transistors.

The CCM logic is mounted in a modified Spectra 70 peripheral equipment rack. Plug-ins are mounted in rows with 40 positions per row and 10 rows vertically per half rack. The logic occupies 14 rows, 10 in one half of the rack and four in the other. Space equivalent to three additional rows of plug-ins is occupied by the unit's power supply.

A major difference between the CCM rack and a standard Spectra 70 peripheral equipment rack is the addition of two swinging logic frames (areas C and D in Fig. 2). Each of these logic frames provides space for mounting plug-ins in 8 rows of 36 positions per row.

Communication buffers consist of logic additional to the CCM logic proper. The buffers are housed in the remaining logic rows on the front and rear of the CCM rack as shown in Fig. 2 (areas A, C, and D). One buffer is required for each communication line. At present, there exist seven different types of buffers. Buffer sizes range from 10 logic plug-ins up to 35. The average size is about 15 plug-ins. The series 2 logic circuits and plug-ins are used for buffers just as they are used in the CCM itself. No connectors are used in the CCM/buffer interface; they are wired in place. There are one, two, or three buffers per row depending on the buffer's physical size.

Memory organization

The CCM memory is divided into two sets of words. These are line-status words (LSW) and operational words (OW). Line-status words are organized in groups—one group for each communication line. Operational words are not used on a per line basis but rather are accessed upon transfer of special communication line control characters.

There are six line-status words in each group (called line-status words *A, B, C, D, E* and *F*). One group is used for one communication line. Thus, there are 48 groups or 288 LSW's total. These are used to store status and information on the communication lines as well as providing character buffering. Therefore, any change in line status requires modification of one or more LSW's. The CCM logic updates and works with these words in three hardware utility registers of 17 bits each. These registers are time-shared among the six LSW's for each line.

As an aid to understanding the use of LSW's, their principal functions for manipulating characters are shown below. These are functions which must be performed for every character transferred.

Character accumulation/distribution
Character parity control
Character synchronization
Block parity accumulation

Operational words are stored in pairs. There are a total of 64 pairs available in a CCM. They are used only when special control character functions must be performed. Operational words work with LSW's to perform these control character functions. Some of these functions are the following:

Termination of the operation,
Interruption of computer program,
Performance of block parity test,
Test for multi-character (up to 4) sequences,
Disconnect of communication line,
Acknowledging good data block (to sending terminal), and
Informing processor of good/bad message received.

Operational words are read from memory when a previously chosen special control character is transferred to the CCM from the processor or a communications line. The reading of an OW from CCM memory requires the particular decoding of three principal elements:

1) A control character (from line or processor),
2) A system class (from line-status words), and
3) Command status (from line-status words).

This action is fundamental to the CCM's ability to handle a multitude of different types of devices. The use of OW's is explained further in the discussion of system classes.

Scanning

The CCM utilizes two scanning operations to provide the multiplexing capability for handling 48 communications lines. The major scanning functions are the buffer scan and the processor scan. The buffer scan controls the bit buffers and provides functions associated with the communications line side of the CCM. The processor scan provides functions associated with the processor interface of the CCM. The buffer scan uses LSW, *A, B,* and *C* while the processor scan uses LSW *B, C, D, E,* and *F*.

The scanners operate by addressing one line at a time, performing functions required for that line and then advancing a logic counter to address the next line. The scanners time share the memory and the three main utility registers of the CCM. Timing considerations dictate that two buffer scans are performed; then one processor scan. Fig. 3 shows a typical scan sequence.

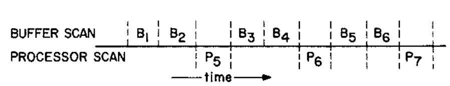

Fig. 3—Typical scan sequence (subscript denotes line number).

The two scanners select lines independently of each other. Therefore, they do not necessarily contain the same scan address at any given time.

The information flow is coordinated by virtue of the scanners time sharing the memory. One scan will access and update a set of LSW's. Then, at some later time, the other scanner will see the results when it accesses that same set of LSW's.

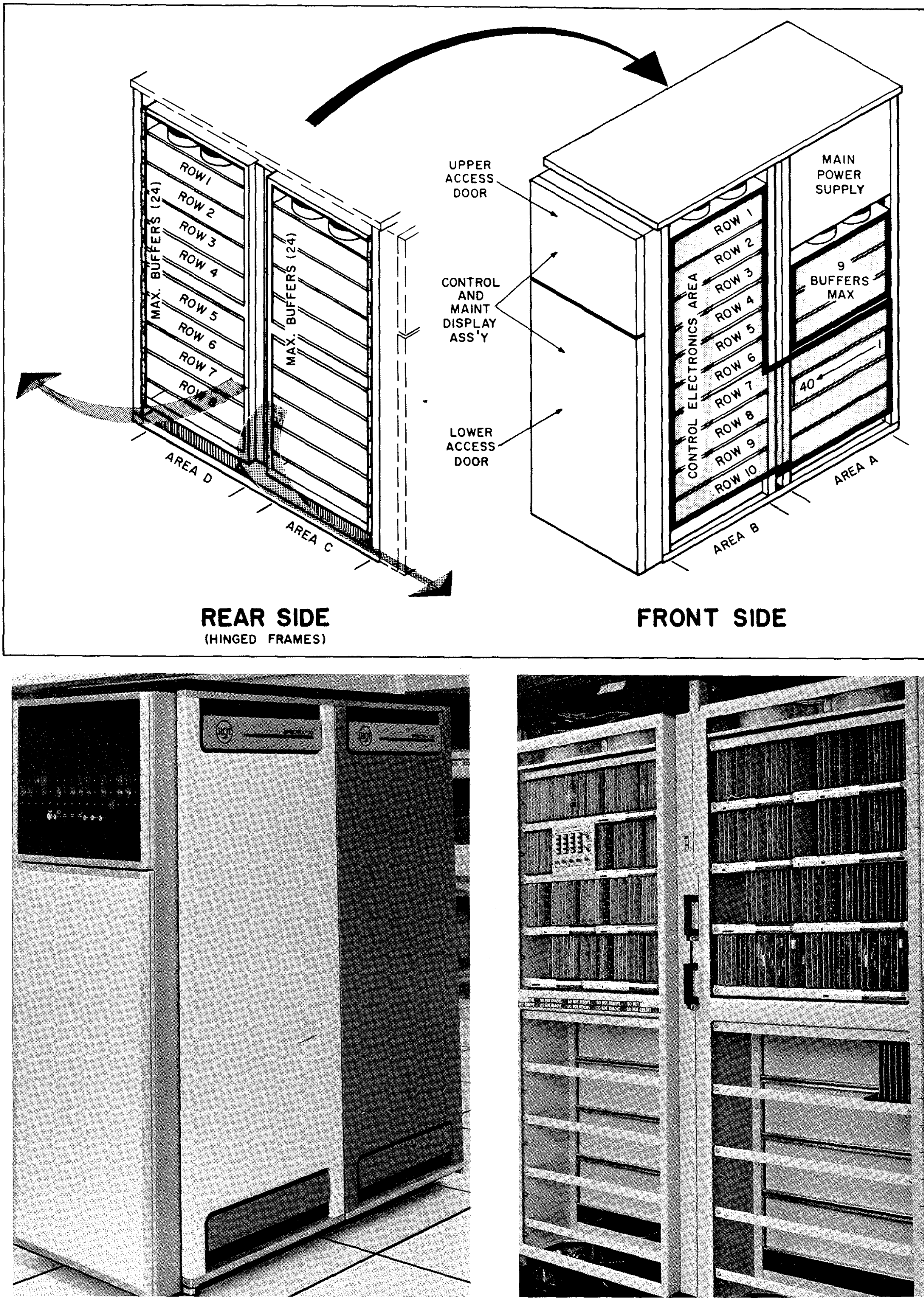

Fig. 2—Plan views of CCM (top); photo of the CCM rack (bottom left); photo of rack mounts (bottom right).

Table I—Terminals and facilities that can be controlled by the CCM.

Terminal	Facility	Media input	Media output	Speed (char/sec)
Teletype Models 20, 28,32	Polling Dial (Telex)	Key, Paper Tape	Printer, Paper Tape	5-10
Teletypes Models 33, 35, 37	Polling Pvt. Line Dial, TWX	Key, Paper Tape	Printer, Paper Tape	10-15
IBM 2741	Pvt. Line Dial	Key	Printer	14.8
RCA 6050 6077 70/752 VDT	Pvt. Line Dial	Key	Video Tube	10-120
RCA 70/750 VDS	Pvt. Polling	Key	Video Tube	250-300
IBM 1050	Polling Pvt. Line Dial	Key, Cards Paper Tape	Printer, Cards Tape	15
Friden 7311, 7312	Pvt. Line Dial	Card, Key	Printer	15
RCA 5925 CT	Pvt. Line Dial	Paper Tape, Key	Printer, Tape	15
AT&T Dataspeed II	Pvt. Line Dial	Paper Tape	Paper Tape	105
AT&T Dataspeed V	Pvt. Line Dial	Paper Tape	Paper Tape	72
RCA 70/510 VRU	Dial	Touchtone Dial	Voice (from VRU)	10
RCA EDGE	Pvt. Line	Badge, Card Manual Levers	Lamp (Verification only)	28
RCA 70/630 DGS	Pvt. Line	Badge, Card Manual Buttons	Lamp (Verification only)	120
IBM 1013	Pvt. Line Dial	Card	Card	250-300
IBM 7702	Pvt. Line Dial	Mag. Tape	Mag. Tape	250-300
RCA 70/740 DT	Pvt. Line	Card	Printer	250-300
Univac DCT 2000	Pvt. Line Dial	Card	Printer, Card	250-300
RCA 301, 3301 Spectra 70	Pvt. Line Dial	Computer	Computer	250-300
IBM 360	Pvt. Line Dial	Computer	Computer	250-300

Synchronization between communicating devices

The buffer scan and the communication buffers perform synchronization functions. To understand how these functions are performed, it is necessary to state the general requirements for communication line synchronization. The vast majority of communication lines operate in a bit-serial manner. Bits are transferred, one at a time, along the line and between the line and data processing equipment. In the CCM operation, the buffers perform bit recognition in receive and time-bit generation in transmit. The CCM accumulates bits into characters for receive operation and distributes characters into bits for transmit operation. The bit accumulation or distribution function is performed in LSW *A*. The complete character is stored in LSW *B*.

In order for two communicating terminals to become synchronized, the receiving device must first recognize bits and then the complete characters which the transmitting device is sending. Each device is controlled by a crystal master clock. Devices communicating with each other have the same clock frequencies so that they may remain in step once synchronization is established.

Synchronization may be established by either one of two basic operation techniques. These are commonly referred to as: 1) *asynchronous* operation, or 2) *synchronous* operation. In asynchronous operation, each bit-serial character has its data bits "framed" by a start and stop bit. Character synchronization is re-established with each character transferred by recognition of these framing bits. In synchronous operation, the transmission of each data block is preceded by a group of special synchronization characters. Synchronization is established by recognition of this character sequence and maintained throughout transfer of the block of data. The CCM can be programmed to handle both of these methods of synchronization.

Another related function performed by the CCM is that of rejecting spurious noise pulses which may appear as line data. This is a major problem because the CCM is frequently in the condition of waiting for a distant device to send data. During these sometimes prolonged periods, electrical noise often causes unwanted characters to spontaneously appear on the communication line. The CCM will transfer to its controlling computer only blocks of characters which are preceded by a specific start-of-message character.

System classes

The CCM's ability to handle different systems is vested in its use of a system class code for each line with which it communicates. Each time a line is serviced, the system class code is accessed. This code then controls the CCM's handling of the particular line. The system class provides for the performance of these functions that are used for all characters associated with a particular line; both data and control characters. The more complex operations performed on a communications line are governed by the reception or transmission of special control characters.

Action by control characters is implemented through operational words. As mentioned before, this is done primarily by combining control character code, system class, and command status. Where required, some additional conditions may also be included in this combination. This combination results in the generation of an ow address. When a combinational "hit" occurs, the ow in the proper memory address is read out. Action is then taken dependent on which bits in the ow are set. Operational words (ow) are accessed only when a "hit" occurs.

The combination function (decoding) is performed by a functionally large variable matrix. This matrix consists of a series of 64 multi-input diode gates. The decoding action of these gates is set up differently for each CCM application. The 64 diode gates correspond to the 64 ow pairs in the CCM memory.

Thus far, the accessing of ow's has been considered. The method and control of ow operations is necessary to complete this picture. The ow's are used in pairs and thus contain a total of 34 usable bits. Bits, when set, are used individually and in groups to indicate that a particular action is to be taken by the CCM. Bits set to "zero" will cause no action in the particular function of that bit or group of bits while those set to "one" will cause action to occur. The setting of the bits in the ow is determined when a particular CCM application is specified. The ow's are placed in the CCM memory on loading or 'bringing up' the CCM, and thus the ow's function just as a stored program in a processor. The ow configuration may, therefore, differ from CCM to CCM just as the ow decode matrices do.

This system class and decode action provides the basis for the CCM's flexibility. By utilizing system class on a per-line basis and ow's on a functional basis, the CCM can accommodate many varied applications.

CCM processor interface

The CCM logic which interfaces the controlling processor is required to perform many functions and to do them in a simultaneous manner. Since the CCM can control 48 lines, it must appear to the processor and program as 48 devices. This means that the major functions of command initiation, command termination, data transfer, and program interrupt must be interleaved for 48 addresses (or effective devices) over one multiplexor interface trunk.

These particular functions are controlled by the rules of the Spectra 70 I/O (input/output) standard interface. The rules of this interface were specified in detail prior to the design of the Spectra 70 processors and the CCM. It was, therefore, possible to carry on the design of the CCM in parallel with, and as a separate project from, the processors and yet have it successfully interface these processors upon design completion.

When performing command initiation, the CCM accepts a command from the processor, and stores that command and the address for it in logic until the processor scanner in the CCM matches this address. At that point, the command is transferred to the LSW *E*, for the appropriate line. Then at some later time it is transferred to the proper buffer by the buffer scanner. Program controlled commands to the CCM are READ, WRITE, AUTOCALL, DISCONNECT, HALT, SUPPRESS START-STOP and ACKNOWLEDGE.

Data transfer between the processor and the CCM is initiated by the SERVICE REQUEST signal from the CCM. Under control of the processor scanner, the data character is moved between this interface and LSW *B*. Here it can be accessed by the buffer scan. The buffer scan moves data between LSW *B* and LSW *A*. It is in LSW *A* where the bit accumulation/distribution is performed.

Command termination can be caused by the CCM or by the processor. Termination caused by CCM action is performed by operational word (resulting from a control character decode), or by a line fault or breakdown. Termination caused by the processor is under program control.

Program interrupt processing is done by the CCM upon receipt of a special command from the processor hardware. These interrupts result from the process of CCM caused termination or the action of I/O channel control in the processor. The CCM must store the results of the interrupt action for each line until the processor indicates by the WHO ARE YOU command that the program is ready to service the interrupt. Interrupts are stored in LSW *E*.

Communication message line

The standard interface is primarily a peripheral device interface and, as such, is limited in certain respects for use with a communications controller. To make the interface capable of passing more information, an extra line is created by logic in the CCM. That is, a CCM can actually appear, from an interface standpoint, as having up to 49 lines. Thus, there may be up to 48 communication device lines plus 1 control device line. This latter line is called the communications message (CM) line. During normal CCM operation a READ command must always be present for the CM line. This, of course, means that the central processor is in the position of being ready to accept data from this line at any time. Termination of this read will return the CCM to an idle mode (a mode in which no data or command for the communications lines will be serviced by the CCM). The data for this control line is generated by the CCM as two character messages. Each of these messages is actually a report on a condition which has occurred on one of the real communication lines.

The first character (or byte) of this message describes a communication condition which has occurred on one of the real communication lines. The second byte is the address for the line involved. Although this represents a two-byte data message from a hardware standpoint, the program uses this information to determine communication-line condition. In this manner, the peripheral interface is effectively broadened to be used as a communication interface.

The primary conditions indicated by the first character of the CM are the following:

Ring indicator — the program should answer an incoming call;
Transient line error—line noise;
Hard line error—line failure;
Line timeout — no line data has occurred for a period of seconds (in most cases 20 seconds);
Good message report—received message contains no detected errors (character parity, block parity, formatting, etc.);
Bad message report—received message contains detected errors; or
Control char/sequence recognized— specific control characters or sequences of control characters recognized.

CCM memory loading

An important function in the CCM operation is the initialization of its memory. This is, in effect, the programming of the CCM. All line status words (including those containing system classes) and operational words are inserted into the CCM memory by the loading operation. The entire memory is loaded before the communications system is activated by a read command to the CM line.

The loading operation is performed by having the processor issue a WRITE command to the CCM using the CM line address. This causes the CCM to accept data from the processor memory and store it in the CCM memory. In this operation, 1536 characters or bytes are transferred so as to fill the 512 CCM memory locations (each 18 bit memory location requires three bytes of computer data for loading).

Conclusions

The CCM was designed to provide the versatility required for data communications. Working with the appropriate buffer type, it can handle a wide spectrum of communications devices and systems. Thus, the need for a new equipment design for each application is eliminated.

Acknowledgment

The author expresses his appreciation to Mr. M. F. Kaminsky for valuable editorial and technical assistance.

Video phase equalizer

H. K. H. Yee

This paper describes the design of a new video phase equalizer which occupies only half the space of the previous model, uses standard printed-circuitry to reduce wiring costs; and provides improved performance. A computer program was used to optimize the design, and methods of simultaneously displaying the group delay and return loss were developed.

To compensate for envelope-delay distortions in a color television transmitter, RCA Ltd. developed the high-frequency phase equalizer MI-34026[3] and the low-frequency phase equalizer MI-34025[4,5] about 15 years ago. These equalizers were well-received on the market.

About January 1968, the Filter Group in RCA Ltd. was authorized to re-develop these equalizers. The objectives of the re-development were:

1) To reduce the size of the existing equalizers. The high-frequency phase equalizer measures 19 x 17½ x 10 inches and the low-frequency phase equalizer is 19 x 5¼ x 10 inches.
2) To package the new equalizers on standard broadcast modules.
3) If feasible, to modify the existing designs to meet the requirements of television broadcast stations.

Applications

The video phase equalizer (Fig. 1) consists of four different equalizer modules. These modules are 1) the receiver equalizer, 2) the notch equalizer, 3) the low-frequency equalizer, and 4) the high-frequency variable equalizer. These equalizers consist of only passive components and require no external power supply. Mechanically, these modules are standard RCA broadcast plug-in units which can be inserted easily into the standard frame MI-557300. Each module features toggle switches on the front panel to enable the user to select the desired curve and to switch the module in or out of the circuit.

The use of these phase equalizers (described below) in a color television transmitter will greatly improve edges and transitions and will provide better time correspondence between luminance and chrominance information.

Receiver equalizer

The average color television receiver by itself has appreciable delay distortion above 3 MHz. This distortion is corrected by the receiver equalizer in the color television transmitter. The delay characteristic of the new receiver equalizer meets FCC and D.O.T. specifications.

Notch equalizer

The delay characteristics of this equalizer are designed to equalize the delay distortion of a sound notch filter, such as a VHF filterplexer, MI-19179, or UHF filterplexer, MI-19086, in a color television transmitter.

Low-frequency equalizer

This equalizer will correct low-frequency delay distortions caused by a vestigial sideband filter.

High-frequency variable equalizer

This is used as a variable equalizer to mop-up high frequency delay distortions caused by the over or under compensation of the other two phase equalizers.

Delay specification modifications

Due to having much additional accumulated data from field measurements, the characteristics of some of the phase equalizers were modified to better compensate actual installations. An extensive study of actual measurements was made to determine the optimum equalizer characteristics and the Filter Group was informed of the following design guidelines:

1) The delay curve of the receiver equalizer in MI-34026 was to remain unchanged (Fig. 2).
2) An additional curve C was to be added to the existing curves A and B in the notch equalizer of MI-34026 (Fig. 3).
3) Curves 5 and 6 were to be added to the existing four curves in the low-frequency phase equalizer (Fig. 4).
4) The six curves in the variable equalizer of MI-34026 were to be completely re-designed (Fig. 5).

The preliminary delay specifications of the new curves were issued by the Broadcast Group. A computer program was written to optimize the design of the new equalizers and to obtain the best curve fitting to the preliminary delay specifications. The final delay specifications were a compromise between the laboratory measurements of the optimized designs and the original target specifications.

Envelope delay equalizer

The delay equalizer is a constant-resistance all-pass network. The poles and zeros of its transfer function are conjugate pairs with respect to the $j\omega$ axis (non-minimum phase). A delay equalizer in the lattice form is shown in Fig. 6. The series impedance, Z_a, the shunt impedance, Z_b, and the impedance level, R, are related by

$$Z_aZ_b=R^2 \qquad (1)$$

The envelope delay is given by[1]

$$\tau=\frac{db}{d\omega}=\left(\frac{2R}{R^2+X_a^2}\right)\left(\frac{dX_a}{d\omega}\right) \qquad (2)$$
$$=\left(\frac{2R}{R^2+X_b^2}\right)\left(\frac{dX_b}{d\omega}\right)$$

where b is the insertion phase; X_a is the imaginary part of Z_a, and X_b is the imaginary part of Z_b.

It is well-known that any higher-order delay equalizer can be realized by cascading only first and second order networks in series. In this design, only the second order network is used because its group delay characteristic is more versatile than that of the first order, and it can be reduced to the unbalanced form easily.

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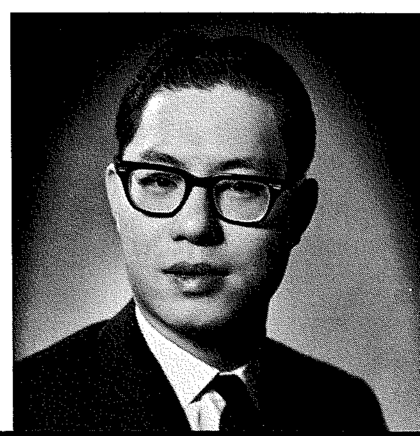

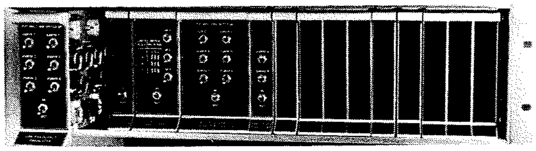

Fig. 1—Video phase equalizer

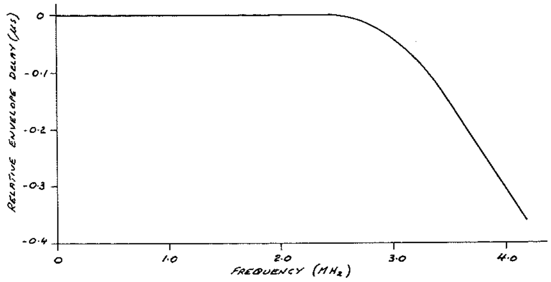

Fig. 2—Receiver equalizer delay curve (tolerance on curve is ±0.015 μs).

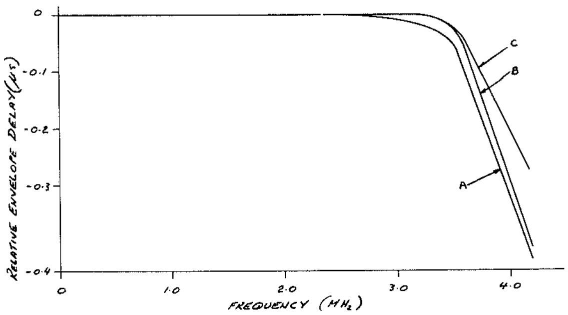

Fig. 3—Notch equalizer delay curves (tolerance on curves is ±0.015 μs).

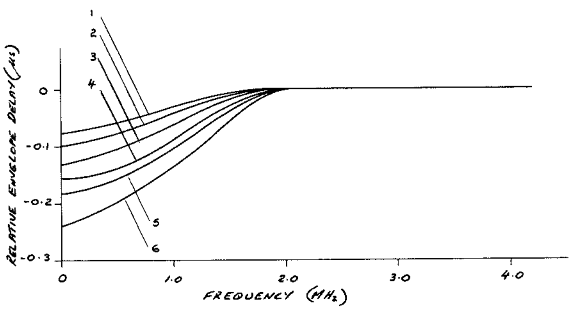

Fig. 4—Low-frequency equalizer delay curves (tolerance on curves is ±0.015 μs).

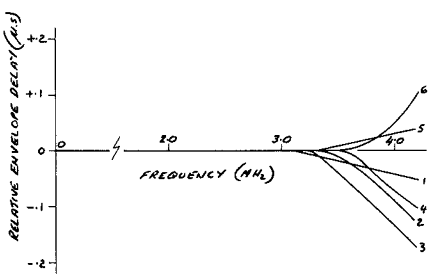

Fig. 5—High-frequency equalizer delay curves (tolerance on curves is ±0.015 μs).

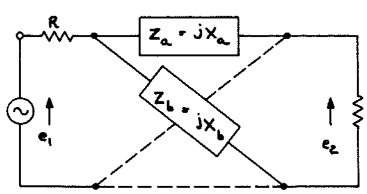

Fig. 6—Delay equalizer in the lattice form.

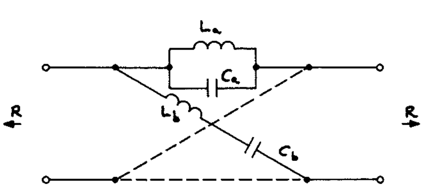

Fig. 7—Second-order delay equalizer in lattice form.

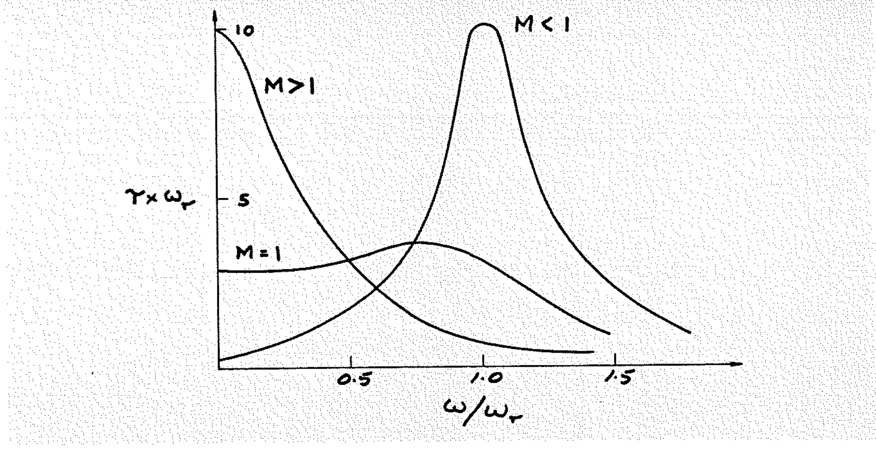

Fig. 8—Effects of varying M.

A second-order delay equalizer in the lattice form is given in Fig. 7. Its elements are related by

$$\omega_r L_a = \frac{1}{\omega_r C_a} = MR \quad (3)$$

$$\omega_r L_b = \frac{1}{\omega_r C_b} = \frac{R}{M} \quad (4)$$

and its normalized group delay

$$\tau \times \omega_r = \frac{2M[1+(\omega/\omega_r)^2]}{1-(2-M^2)(\omega/\omega_r)^2+(\omega/\omega_r)^4} \quad (5)$$

From Eq. 5, the group-delay characteristic of a second-order equalizer is determined by two parameters: the resonant frequency ω_r and the sharpness factor M. When $M<1$, the delay curve is parabolic in shape and peaks near ω_r. The sharper the peak, the smaller the factor M. When M is increasingly larger than unity, the delay curve peaks at zero frequency; the larger the factor M, the sharper the peak. The effect of varying M on the delay characteristic is shown in Fig. 8. To unbalance the lattice in Fig. 7, we can use Barlett's Bisection Theorem to obtain several equivalent circuits. To standardize our design, we use only two different configurations: Fig. 9 for $M<1$ and Fig. 10 for $M>1$.

Computer optimization

A computer program was written by the Filter Group to optimize the design of the new equalizers. The computer program reads in the specified group-delay characteristic and the number of delay sections to be used. The two parameters M and ω_r in each equalizer section are perturbed to reduce the RMS error in curve fitting according to the least-squares method. The iterative scheme basically consists of the following steps[2]:

1) From initial value M and ω_r, the initial group delay values at the sample frequencies are calculated.

2) Using Taylor series expansion, the deviation or error at each sample frequency is

$$\Delta\tau_j = \tau_{desired} - \tau_{computed} = \sum_{i=1}^{N} \frac{\partial\tau}{\partial M_i}\Delta M_i + \sum_{i=1}^{N} \frac{\partial\tau}{\partial\omega_{ri}}\Delta\omega_{ri} \quad (6)$$

where N is the number of equalizer sections and $\Delta\tau_j$ is the delay error at the j^{th} frequency point.

3) The partial derivatives $\partial\tau/\partial M_i$ and $\partial\tau/\partial\omega_{ri}$ are computed analytically or numerically and form the matrix $[A]$.

4) The delay errors $\Delta\tau_j$ form a vector $\mathbf{B}$.

5) ΔM_i *and* $\Delta\omega_{ri}$ are the unknowns in vector $\mathbf{X}$. They represent the amount the initial values of M_i and ω_r should be changed.

6) Basically, we have the following relationship

$$[A]\mathbf{X}=\mathbf{B} \quad (7)$$

7) The transpose of $[A]$ is first obtained. We perform matrix multiplication:

$$[A^T][A]\mathbf{X}=[A^T]\mathbf{B} \quad (8)$$

$$[C]\mathbf{X}=\mathbf{D} \quad (9)$$

and solve for the unknowns $\mathbf{X}$ as in simultaneous equations.

8) After ΔM_i and $\Delta\omega_{ri}$ are known, we correct our initial values by

$$M_{i+1}=M_i+\Delta M_i \quad (10)$$

$$\omega_{r\,i+1}=\omega_{r\,i}+\Delta\omega_{r\,i} \quad (11)$$

and go back to step 1).

9) The above procedure is repeated for a user-specified number of iterations.

Alignment procedure

Each group-delay curve in the phase equalizers consists of several group

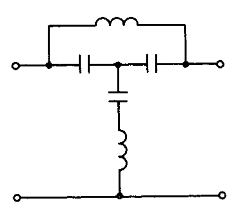

Fig. 9 — Bridged-T equivalent of lattice in Fig. 7 for $M \leq 1$.

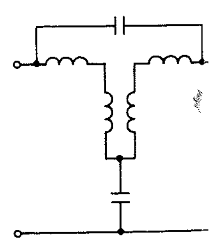

Fig. 10—Bridged equivalent of lattice Fig. 7 for $M \leq 1$.

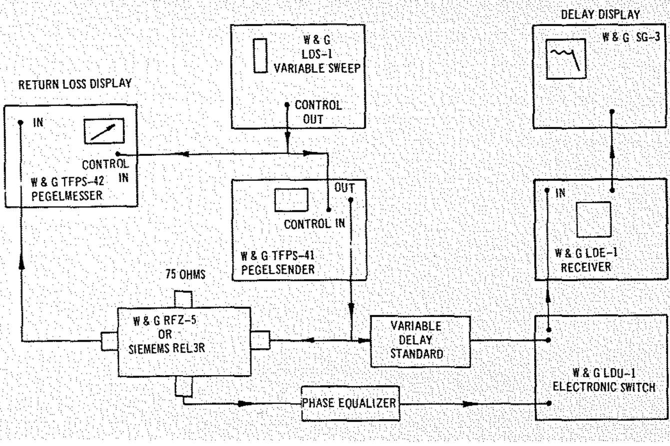

Fig. 11—Setup to obtain simultaneous displays of group delay and return loss.

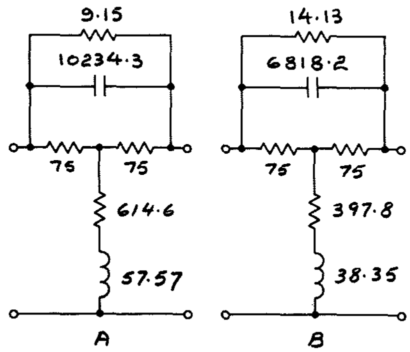

Fig. 12—Amplitude equalizers A and B (resistors in ohms; inductors in μH; capacitors in pF).

delay sections in cascade. These sections are in the form of Figs. 9 or 10. Each section is initially tuned for the best return loss before the overall cascade is touched up to meet the required group delay. To minimize impedance mismatching problems, a good return loss should be maintained at the input and output of each phase equalizer. To each the alignment procedure in production, a method to obtain the simultaneous displays of return loss and group delay of a network has been developed. This setup enables the user to tune the phase equalizer according to the specified group delay, while maintaining the return loss at a minimum. The schematic of this setup is shown in Fig. 11.

Amplitude equalization

Ideally, the phase equalizers should have no amplitude distortion, because they are all-pass networks. However, because of finite dissipations in the passive elements, some amplitude distortion does occur in practice.[5] When several delay sections are in cascade, the distortion in the amplitude response is approximately 0.4 dB in the receiver phase equalizer, 0.6 dB in the notch equalizer, 0.6 dB in the low-frequency equalizer, and 0.4 dB in the high-frequency equalizer. Two amplitude equalizers (A and B) of different slopes were designed to improve the amplitude response to ±0.5 dB from 0 to 4.2 MHz. These amplitude equalizers are bridged-T constant resistance networks and they have negligible delay distortion. Amplitude equalizer A is used to equalize any two curves in cascade and amplitude equalizer B to equalize any three curves in cascade. The use of amplitude equalizers A and B together should equalize any four delay curves in cascade. These two amplitude equalizers are shown in Fig. 12.

Component standardization and mechanical features

To ease production problems, all the components in the phase equalizers are standardized. For all the inductances, Siemens pot cores, B65651, (18mm dia x 11 mm) are used. All capacitances consist of silver mica fixed capacitors in parallel with ceramic trimmers. Only two types of trimmers are used: 5 to 50 pF and 11 to 110 pF. To make the stray elements uniform in component layout and to save the cost of interwiring components, several printed-circuit boards were designed to mount the components. To reduce the initial cost in developing these printed-circuit boards, great emphasis was placed on sharing the same board among different phase equalizers.

Mechanically, the equalizers were packaged in standard broadcast modules. These modules are plug-in units to the standard mounting frame MI-557300. Toggle switches for selecting the desired delay curve were mounted on the front panels of the modules. The use of toggle switches instead of rotary switches (as in the existing units) offers several advantages:

1) The toggles save space and simplify the mechanical layout of the components.
2) The toggles are cheaper to wire than the rotary switches.
3) The toggles allow different combinations of delay curves to add internally. For instance, the high-frequency variable equalizer has six different curves and the total number of different delay outputs is 63 ($\sum_{i=1}^{6} C_i^6 = 63$).

The mechanical features of the new phase equalizers are summarized in Table I.

Broadcast module	*Receiver*	*LF*	*Notch*	*HF*
Module width (inches)	0.92	1.84	1.84	2.76
No. of toggle switches	1	7	4	7
In-or-out switch	yes	yes	yes	yes
No. of printed-circuit boards	1	2	2	3
No. of group delay sections	4	9	7	10

Table I—Mechanical features of the phase equalizer modules.

Conclusions

The video phase equalizer occupies only half of the RCA standard mounting frame MI-557300. All the components in the equalizer are standardized and they are packaged on standard RCA broadcast modules.

In the development stage, a computer program was written to optimize the new designs and a method of displaying simultaneously the group delay and return loss was developed. This new method greatly eases the alignment procedure of the production units and is expected to reduce the production cost substantially.

The delay specifications of the receiver, notch, low-frequency, and high-frequency variable phase equalizer are presented in Figs. 2, 3, 4, and 5.

Acknowledgment

The author acknowledges the contributions made by A. D. R. Walker, F. Assmus and L. Giasson; and he is indebted to F. H. Holm and D. H. Macaulay for technical support and guidance in this project; to L. Slaven, Manager of Filter Group, for his direction and assistance in the preparation of this article; and to C. Cannon for typing the manuscript.

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Remote color genlock

R. J. Butler

A genlock system serves to produce synchronous TV signals at a predetermined junction. This paper describes two basic types of genlock—forward and feedback—and the inherent drawbacks of each. Also described is a new method of off-air color-locking for remote terminals.

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THE TELEVISION PROCESS is a sequential one, where each element of the picture is transferred from the camera to the receiver. The camera breaks down the geometric pattern of the picture into a time train of information, the receiver reassembles this information into the original geometric pattern. The receiver accomplishes this reconstruction by the use of the synchronizing pulses, transmitted as part of the video signal. Two types of sync signals are used which, in effect, generate time references for the X and Y coordinate location of any picture element. Elapsed time between similar sync signals represent the magnitude of the coefficients of these coordinates. There are 262½ scans in the horizontal direction for each scan in the vertical direction. At the end of each horizontal scan there is a horizontal sync pulse added to the video signal. At the end of each vertical scan a vertical sync pulse is added. Assuming a linear scan and accounting for retrace time, any element can be located in the horizontal plane by calculating the elapsed time from the last horizontal sync pulse. In a similar manner the Y, or vertical coordinate, of the same element is established by the elapsed time since the last vertical sync pulse.

The sync pulses keep the receiver in step with the camera. Two pictures scanned in the horizontal and vertical plane which do not accomplish scanning in exactly the same time will not be compatible simultaneously on the same viewing monitor. Two pictures which accomplish scanning in the same time, but which arrive at a common mixing junction with a time displacement between their individual sync pulses will not be compatible with each other. Time displacement is generally caused by unequal path delay between two signals which accomplish scanning in the same time.

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Let us define signals which accomplish scanning in the same time as signals having the same *time base*. Let us also define two signals which have the same *time base* and have no time displacement between their sync-pulses as *synchronous signals*.

Genlock is a system which produces synchronous signals at a predetermined junction. The first prerequisite of synchronous signals is that their *time bases* shall be the same. The time base of any color system is the color subcarrier frequency, defined by the NTSC as 3.58 MHz. The horizontal scanning rate H is derived from the subcarrier frequency by the following relationship:

$$(3.58/455) \times 2 = H$$

The vertical to horizontal relation can be stated as follows:

$$H \times 2/525 = V$$

Since the horizontal and vertical scanning rates are directly related to the subcarrier frequency, the first requirement of a genlock is satisfied when two pictures are generated from the same subcarrier frequency. The second requirement of a genlock is not as easily satisfied. Synchronous signals at a given junction requires a comparison to be made which feeds back corrective information to one or the other signals to cancel any time displacement between their respective sync pulses.

Forward genlock

The lower section of Fig. 1 illustrates a monochrome sync generator with a scanning genlock capability. The addition of the top sections provides the necessary functions to create in total a complete color sync generator. When operating as a color reference generator, the scanning oscillator is slaved to the subcarrier oscillator (i.e., the switch in the color position). If required to lock a remote color signal, burst recovery and AFC circuitry phase lock the master 3.58 to the incoming burst: the switch in the genlock position. The inplant (studio) sync generator is actually at the disposal of the incoming remote video signal. All internal time references are slaved to the synchronizing information incorporated with the remote signal.

The burst recovery unit gates out the 8 cycles of subcarrier which is originally supplied by the remote sync generator, compares it with local 3.58 and produces the necessary correction voltages, with the desired resultant phase lock of the local oscillator.

The sync recovery unit uses horizontal sync to lock the scanning master oscillator with a similar AFC technique. Vertical sync extracted from the remote signal is differentially compared with the vertical output of the 525 countdown, which produces a miscount until the vertical components are coincident.

Thus the two requirements of color genlock are satisfied by:

1) Establishing a common time base of 3.58 MHz; and

2) Phasing the local horizontal and vertical scanning to be time coincident with the incoming remote signals.

In Fig. 2 (not to scale), the remote and local video are mixed without a common time base. The entire remote picture, including its sync signals, are displaced with reference to the local signal. Note that Fig. 2 represents an instantaneous stop frame of the mixed signals. Actually the picture displacements will be continually in motion.

Fig. 3 shows a mixture of local and remote picture information where the time base is the same, but the signals are not in time coincidence. This second condition will remain steady state until a form of genlock renders the remote video into proper alignment with the local video.

Fig. 4 depicts how the reference sync generator is that of the remote station, and the time base is carried forward with the video signal to lock the studio generator. Any abnormal noise, microwave fades, or any discontinuity of the incoming remote signal disturbs all local cameras tied to the inplant (studio) sync generator. This is because the inplant sync generator has no time base of its own and is continually dependent upon the incoming sync signals, as part of the remote video. This dependency exists 100% of the air time, though the remote origination may contribute only 10% of the television program. This factor can be completely reversed by employing more sophisticated forms of genlocking, limiting remote failure probability to its 10% program contribution. It is evident that the control point must pass to the local station which should be the source of the time-base reference information.

Fig. 5 adds further evidence to the case against forward genlock. Forward genlock has an even more serious drawback when more than one remote is feeding the control studio. Note that the video sources at the control facility are genlocked to one or the other remote but not both at the same time. This means that either a non-synchronous switch will have to be accepted when remote 2 is switched to the program bus, or on-air genlocking must take place. Remembering that any true color signal must always possess fixed horizontal and vertical countdown relationships to the 3.58-MHz time base, suggests only one way to accomplish on-air genlock. Alteration of the local subcarrier frequency could eventually cause the local signals to become synchronous with the second remote. The process however might take as long as one hour. Faced with the long delays probable in accomplishing on-air synchronization of local signals with various remotes, forward genlock becomes very unattractive.

Feedback color genlock

Feedback color genlock provides a satisfactory means of integrating multiple remotes at a central control point. The difficulty in this procedure is that a 3.58-MHz reference must be provided to the remote stations. Two methods have been tested operationally, which obviate the need for an actual wideband line to provide this feedback.

Method I—atomic frequency standard

Separate and distant subcarrier oscillators with an atomic frequency standard as the 3.58-MHz generator will remain at precisely the same frequency over long periods. A correction feedback loop to provide this function, thus is not required and the first prerequisite of genlock is satisfied. The remaining requirement of horizontal and vertical phasing can be achieved by *talking in* the remote origination by local control.

This is operationally unattractive, whereas horizontal and vertical correction by the control point without involving the remote source is desirable. To avoid voice procedures, Audlok is permissible to serve as the medium for scanning phase correction, with a single operator at the control point making the necessary adjustments.

Audlock, as the name implies, uses an audio frequency to time lock distant sync generators. In the example shown in Fig. 6 two Audlock transmitters located at local control are connected by means of phone lines to two remote program sources. The horizontal line frequency of the local sync generator is processed by Audlok transmitters to produce a time-related audio tone of approximately 4000 Hz. Continuous phase shifters in series with the output of the Audlock transmitters make it possible to frequency modulate the 4000-Hz tone before it arrives at the Audlock receivers. Multiplication of the incoming tone by the Audlok receivers produces a 31.5-KHz signal used to lock the remote sync generators. Comparison of the two remote

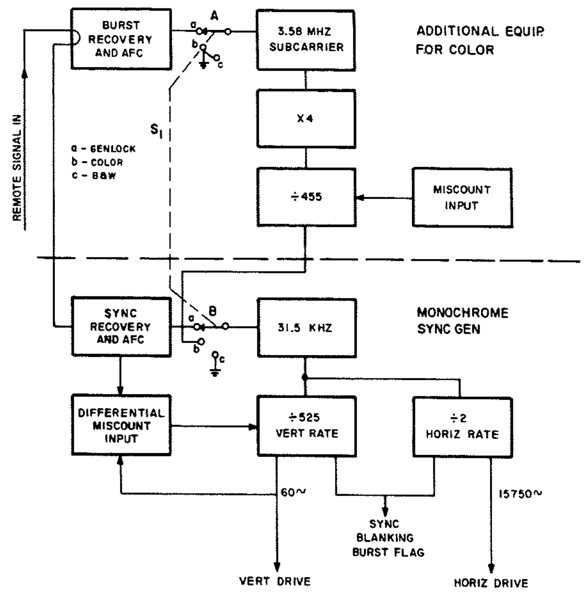

Fig. 1—Monochrome sync generator with scanning genlock capability.

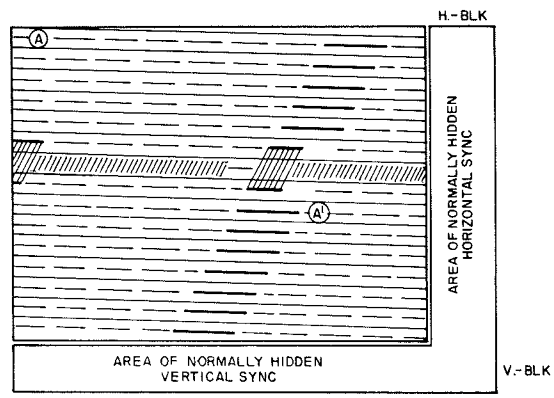

Fig. 2—Remote and local video mixed without a common time base *A* is the upper left hand corner of picture 1, and *A'* is the upper left hand corner of picture 2.

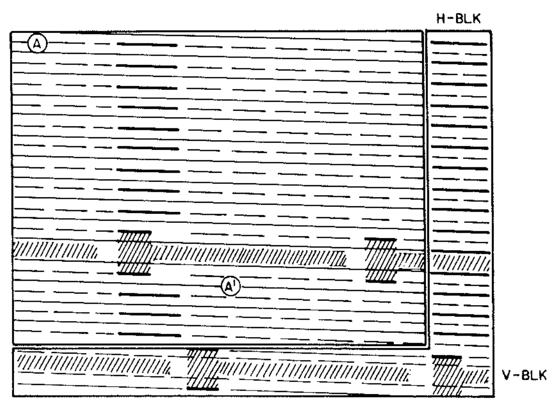

Fig. 3—Mixed video signals with a common time base but without time coincidence.

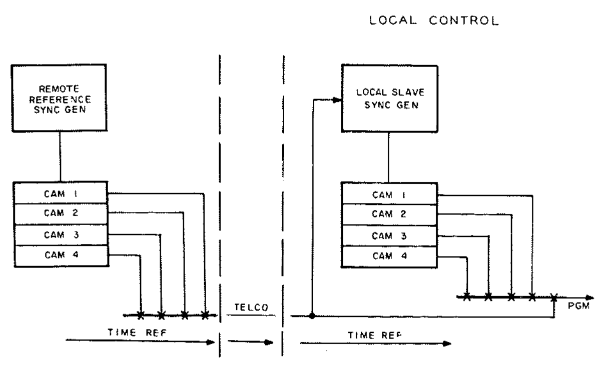

Fig. 4—Relationship between reference sync generator and local generator.

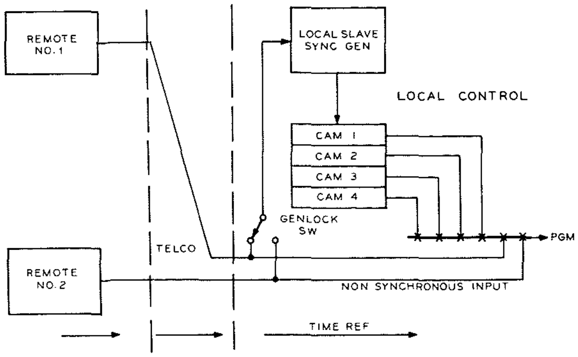

Fig. 5—Disadvantage of forward genlock.

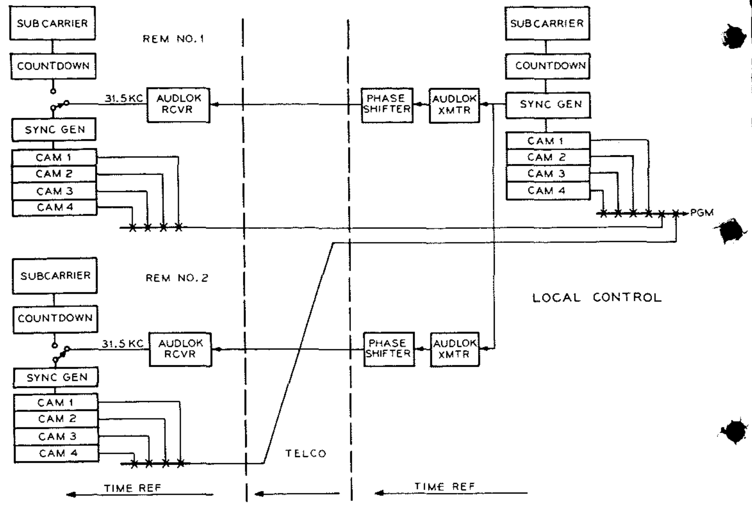

Fig. 6—Audlock transmitters connected via phone lines to remote program sources.

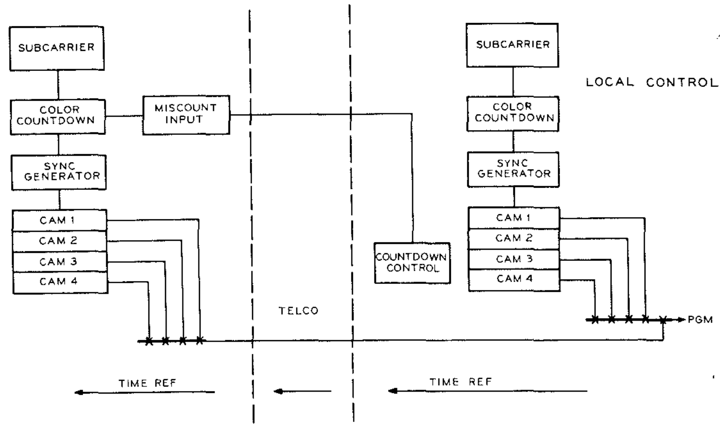

Fig. 7—Alternative to the system shown in Fig. 6. This arrangement requires feedback only when corrections are required.

video signals as they arrive at local control indicate whether the phase shifters should be used to produce synchronous conditions. One drawback of this method is the total dependence on the continuity of the Audlok phone lines. Any discontinuity of the 4000-Hz tone would result in loss of synchronization. Another system (Fig. 7) which can be utilized with accurate time-base standards has the advantage of only needing feedback when phase corrections are required. By allowing a miscount to occur between the subcarrier standard of the remote and its scanning master oscillator, a similar effect to Audlok can be achieved.

Resultant slipping of the scanning oscillator can advance or retard the horizontal and vertical sync until coincidence is reached at the mixing junction. To accomplish this we can employ a phone line between the comparator at the control point and the 455 divider at the remote. Upon completion of the phasing procedure all miscount input information is stopped and the scanning master oscillator is returned to the time base provided by the atomic standard.

Accuracy of the atomic standard at 3.58 MHz is within 0.002 Hz. In Fig. 8, the significance of the precision subcarrier standards is illustrated in terms of accumulated timing errors and subcarrier phase errors, as a function of frequency accuracy.

To correct the resultant subcarrier phase shift, a burst phase comparator at the control position is connected to a subcarrier phase shifter at the remote (associated with the atomic standard). The same narrow band line used in the miscount operation described above provides the physical path.

Method II—normal 3.58 MHz standard

A second method, the vertical interval color genlock system (VICG) can serve as an alternate replacing the atomic frequency standard and the physical connecting lines used for corrective purposes. The VICG is permissible under the FCC ruling which allows lines 18, 19 and 20 of the vertical blanking interval to be used for test control or cue signal transmission. It is possible then to place a 3.58 signal used for correction on one of these trace lines and thereby use the transmitter's air path in lieu of a phone cable, to a standard receiving monitor at the remote location. Not only does the transmitter and resultant RF energy adequately serve as an excellent quality wideband line, but the number of remotes permitted to genlock with a single control point is unlimited.

Off-air color-locking for remotes

NBC is experimenting with a new system of off-air color-locking of remotes located within reasonable distance of TV transmitters. Experiments to date have indicated its practicality and plans are being made for its use in the upcoming political conventions where many nearby remotes must be coordinated with central convention hall activities. It utilizes the wideband transmission path made available by local TV transmitters and takes advantage of presently standardized vertical interval reference signals. For that reason, it is referred to as vertical interval color genlock (VICG).

Test signals on trace lines 18 and 19 are now distributed along commercial network routes, and could be carried to the affiliate's transmitter. Fig. 9 depicts special control signals for insertion on lines 18 and 19 of both fields in lieu of present test signals.

Standard burst-recovery units separate the eight cycles of 3.58 MHz from the horizontal back porch to lock a remote oscillator. In the vertical interval system, approximately 180 cycles of subcarrier are extracted from either line 18 or 19 of each field to supply locking information.

Fig. 10 illustrates the method by which subcarrier is added and recovered

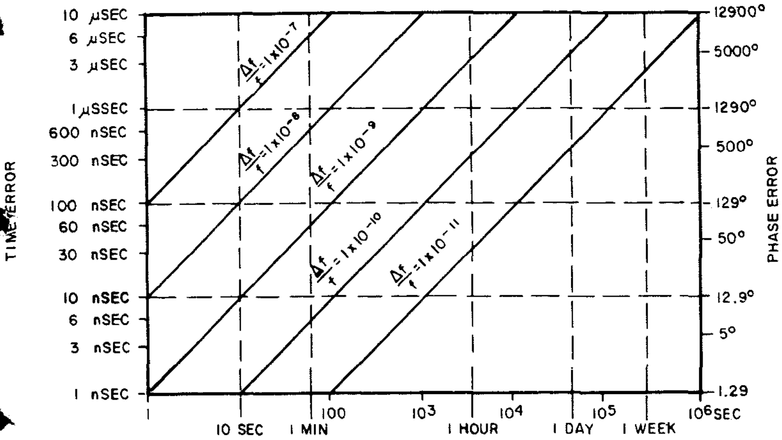

Fig. 8—Accumulated timing errors and subcarrier phase errors.

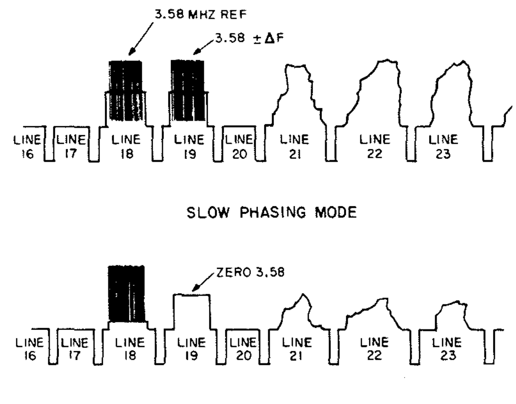

Fig. 9—Special control signals.

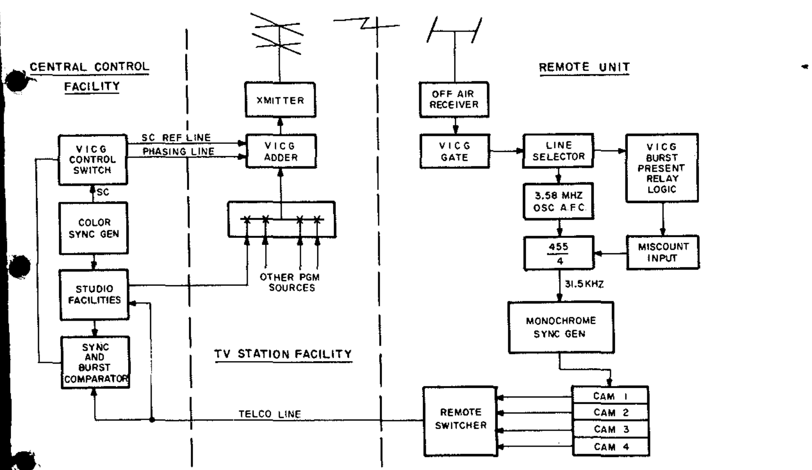

Fig. 10—Method of recovering the subcarrier from the vertical interval.

from the vertical interval. Remote signals arriving at the control facility are checked for sync comparison. If the error is small—less than a line—the VICG control switcher introduces an offset subcarrier in place of original references 3.58 MHz on what is called the vertical-interval phasing line. This signal is added to the video feeding the television transmitted. Within the range of the transmitter, the RF signal is received and demodulated, recovering both the picture signal and vertical interval control signals. A special VICG gate unit derives an appropriate control signal from the sync recovered from the off-air picture. Separation of the correct line in the vertical interval is accomplished in the line selector circuitry. Receiving the 180 cycles of subcarrier from the line selector, an AFC circuit integrates the information and applies it to shift the remote oscillator slightly off nominal frequency. Since the time base of the remote signal is now not equal to the control point, horizontal displacement will occur. The frequency offset (either higher or lower than nominal) will determine in which direction this displacement acts. At the precise time when the remote signal coincides with the locally generated pictures, the VICG switcher will reestablish reference subcarrier on the phasing line. Both local and remote points will remain locked in phase unless the vertical interval transmission is interrupted. Corrections of this type are very slow. If the offset is 1 cycle per second, it will take 3 minutes and 45 seconds to shift by one complete line.

The burst present relay logic associated with the line selector and miscount input circuits provide the means for fast correction for errors exceeding one line. If when comparison is made a large vertical error of the remote signal is detected, all subcarrier is removed from the transmitted phasing line. A burst sensing relay changes its state at the remote unit causing a miscount in the color countdown circuits. The direction this miscount takes with regard to vertical phase is arbitrary; reversal can be accomplished by returning burst to the phasing line and then removing it again. When proximity to coincidence is achieved, offset burst is returned to the vertical interval phasing line by the VICG switcher thereby allowing a slow approach to perfect synchronization. Upon coincidence, reference subcarrier is returned to the phasing line and all displacement stops.

The line selector at the remote point then is switched from phasing line to reference line. The transmission of two lines within the vertical interval is necessary in order to phase two or more remote locations. One remote after another is switched to the phasing line and then returned to a reference subcarrier which never changes.

The VICG system was first tested in October 1967 between the Brooklyn studios and the NBC Radio City plant. Results over a four-hour test period indicated a total 3.58-MHz phase drift of 20° with a short term instability of 10°. Much of the short term instability seems to come from crosstalk between the on-air signal and the vertical interval reference. Improvements in the vertical interval gate circuitry, it is believed, will reduce this error to two degrees.

Conclusions

Even if atomic frequency standards are increased in their stability, intermittent feedback will always be required for scan phasing. The two methods described have an inherent drawback which is that both the remote and control points must be equipped with specialized gear. Ultimately an all-electronic translator utilizing video memory will eliminate all requirements for color genlock.

Fluid thermal actuator

B. A. Shepherd | K. R. Johnson

This paper describes the design, development, and construction of a thermal actuator for use as the sensor and prime mover of a spacecraft active thermal control system for use on NASA's TIROS M meteorological satellite. The design was based on the thermal expansion characteristics of a confined fluid. The design philosophy and implementation are reviewed, and a series of design equations from which predicted performance curves can be derived is given. A comprehensive test program, developed and performed on a breadboard model and on flight-configured units of this actuator, is described; and the results are presented in relation to the specified design goals and the predicted characteristics of the device. The operating parameters of the actuator, as designed for the TIROS M satellite, are summarized, and the degree of flexibility of the basic design concept and its adaptation to other systems of spacecraft active thermal control is discussed.

IN THE DESIGN of any space vehicle, thermal control of the environment is of prime importance in maintaining the operational reliability of the on-board equipment. There are reliable passive techniques of control, such as control of surfaces, location of equipment, and orbit configurations; however, in many cases, they become burdensome and unpredictable, and an active thermal control system is required.

Typically, active thermal control systems vary the effective area of a radiative surface with a louver, or series of louvers, opening and closing in response to temperature. The thermal actuator described in this paper (Fig. 1) provides the sensing and prime motion in such a system. The actuator operates on the principle of controlled thermal expansion of a confined fluid; its output is linear motion as a function of the sensed temperature.

The need for an active thermal controller on NASA's TIROS M meteorological spacecraft stimulated the development of this thermal actuator, which culminated in an actuating device that senses the spacecraft temperature and controls a single 35x5-inch louver. Four of these systems in different locations on the spacecraft provide the required thermal environment.

Design and Development

Constraints for TIROS M actuator

The thermal actuator designed for the TIROS M active thermal control system had to meet the following requirements:

1) Operating temperature range of 20 ±1.5°C;
2) Range selection from −10 to +10°C and up to +35 to +55°C;
3) Over-temperature relief, regardless of selected range, of +60°C degrees;
4) Minimum weight;
5) Reliable operation in space for 1 year (equivalent to 5000 cycles); and
6) Linearity of the driven louver stroke temperature gain within ±10% of full stroke for any point in the range.

The size of the controlling louver and the resultant bearing design dictated that the actuator have a relatively high force output compared with that of other actuators of a similar function. A further restriction prevented this device from consuming *any* of the available power from the solar array.

Preliminary study

A survey was made of existing actuating devices. The types of design investigated included:

1) Bimetallic springs,
2) On-off and proportional heater controls,
3) Stepper motors and solenoids, and
4) Gaseous expansion actuators.

None of these schemes could satisfy the TIROS M requirement of high force output without supplementary power drain on the spacecraft power supply. Therefore, it was decided to proceed with a design that had not previously been used for this purpose, one that utilized the controlled thermal expansion of a confined fluid. There were several advantages to this method:

1) Such a design would provide local temperature sensing at the actuator.

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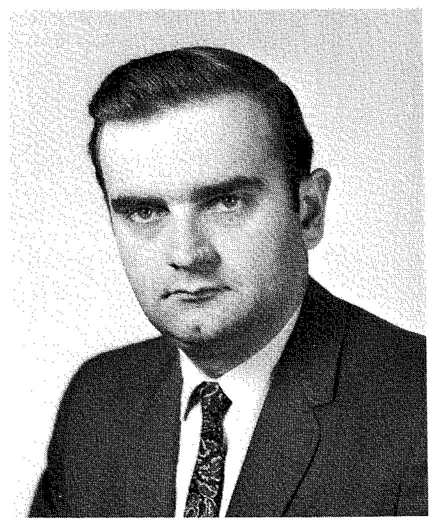
received the BSME from the Newark College of Engineering in 1960. From 1960 to 1962, he was an assistant instructor in the Department of Mechanical Engineering at that school and received the MSME in 1962. Prior to joining AED in 1964, Mr. Shepherd served as project engineer with the Bendix Corporation, working on the logic and electro-mechanical aspects of the OAO power supply control subsystem. During that period, he was also involved in the study and testing of a methanol-air fuel cell concept and worked on the design of automatic test equipment for missile safe/arm devices. He was a primary contributor in two patent disclosures in that field. As a member of the Spacecraft Design group at AED, Mr. Shepherd was involved in the mechanical design and testing of the TOS (ESSA) spacecraft, a review of the navigation satellite design, the mechanical design of the TIROS M active thermal control subsystem, and as a design and lead engineer on various classified programs. He is a licensed engineer in New Jersey and a member of NJSPE and NSPE, ASME, and Pi Tau Sigma.

* Since writing this paper, Mr. Shepherd has become associated with Garrett Corporation.



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received the BSME from Rutgers University in January 1967. He then joined RCA and participated in the design and development training program. In June 1967, he transferred to the Astro-Electronics Division as a member of the Spacecraft Design group. He participated in the ITOS (TIROS M) meteorological satellite program in the design and development of the active thermal controller of which the fluid thermal actuator is a portion. His work on ITOS also included the design of precision rotary mechanisms for the momentum wheel attitude control system. Most recently, he has been assigned as lead engineer on a classified program.

2) It would not require an external power source, and
3) A large force output could be extracted from the thermal energy imparted to the fluid due to temperature changes.

Fundamental design equations

The equation describing the volumetric characteristics of a compressible fluid at rest is derived as follows:

$$v=f(T,p,m)$$
$$dv=\frac{\partial v}{\partial T}dT+\frac{\partial v}{\partial P}dp+\frac{\partial v}{\partial m}dm \quad (1)$$

where v is volume, T is temperature, p is pressure, and m is mass. For a closed system, $dm=0$.

Then if we define thermal expansion coefficient β_T as

$$\beta_T=\frac{1}{v}\frac{\partial v}{\partial T}$$

and fluid bulk modulus β_p as

$$\beta_p=-v\frac{\partial p}{\partial v}$$

Eq. 1 becomes

$$dv=\beta_T\, v\, dT-\frac{v\, dp}{\beta_p} \quad (2)$$

Rearranging Eq. 2 and integrating

$$\Delta v=v_0\left[\exp\ \left(\beta_T\Delta T-\frac{\Delta p}{\beta p}\right)-1\right] \quad (3)$$

Let

$$x=\beta_T\Delta T-\frac{\Delta p}{\beta p}$$

Then from the Fourier expansion of e^x and Eq. 3,

$$v=v_0\left[\left(1+\frac{x}{1!}+\frac{x^2}{2!}+\cdots\frac{x^n}{n!}\right)-1\right] \quad (4)$$

By an order-of-magnitude analysis,

$$O(x)=10^{-2}$$
$$O(x^2)=10^{-4}$$

Therefore, the terms of $n=2$ and higher in Eq. 3 can be neglected, and the reduced form of the equation becomes

$$v=v_0\beta_T\Delta T-v_0\frac{\Delta p}{\beta p} \quad (5)$$

To implement this equation, it is necessary to select a fluid with predictable β_T and β_p, define pressure as a function of temperature, and provide a means of converting Δv into linear motion.

The thermal expansion and bulk modulus coefficients of most fluids are clearly defined and are available as a function of such other parameters as temperature and viscosity. However, silicone oil is used for this actuator primarily for its constancy of expansion coefficient with temperature, its low vapor pressure, and the expansion coefficient selectivity permitted over the range of available viscosities.

Conversion of volumetric expansion into linear stroke is conveniently accomplished with an expandable chamber—namely, a bellows of sufficient stroke and pressure capability. Using a bellows, the relationship between stroke and volumetric change required in Eq. 5 is given by the following:

$$\delta=\Delta v\ /\ A_M \quad (6)$$

where A_M is the mean area of the bellows. This design uses two bellows, one for the driving function and the other to provide adjustment of range and over-temperature relief. The inherent spring rates of these bellows provide the energy necessary for motion as the fluid contracts with decreasing temperature.

Each bellows operates in concert with a drive spring. These springs supplement the bellows spring rate and raise the force level of the system. The bellows/spring combinations are the sole determinants of the pressure buildup in the actuator.

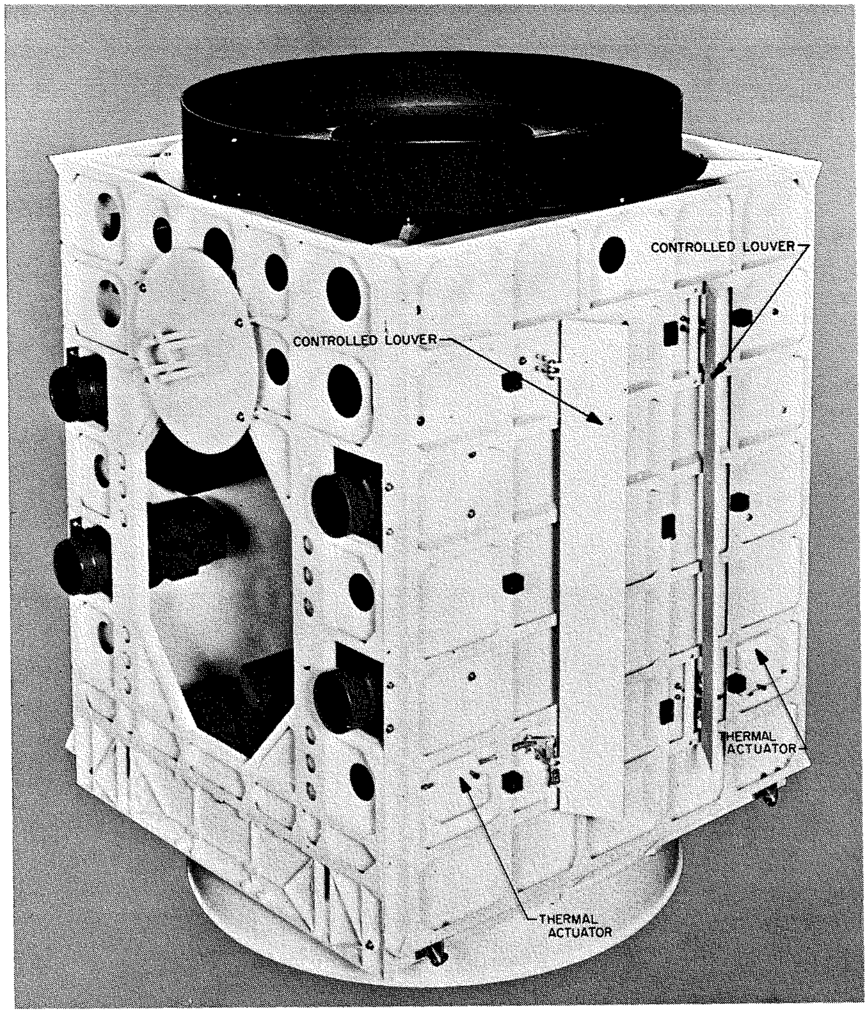

Fig. 1—Thermal actuators and controlled louvers on TIROS M.

Configuration and operational description

A cross section of the actuator is shown in Fig. 2. Basically, the actuator can be considered in two parts, referred to as the drive system and adjust/relief system. These two systems are hydraulically coupled to each other and to the reservoir. The fundamental components of the drive system are the drive bellows, drive spring, and drive piston.

The drive piston moves linearly on two piston-ring Teflon bearings. Not being rigidly attached to any fixed part, the piston is free to rotate; this provision allows linear adjustment of the external rod when it is locked on a shaft. The drive bellows is made of nickel and is accurately fabricated by electrodeposition for predictable spring rate, stroke, and pressure capability. To provide a usable stroke in a minimum package, the bellows is used in compression and extension, with the drive spring accomplishing the compression of the bellows.

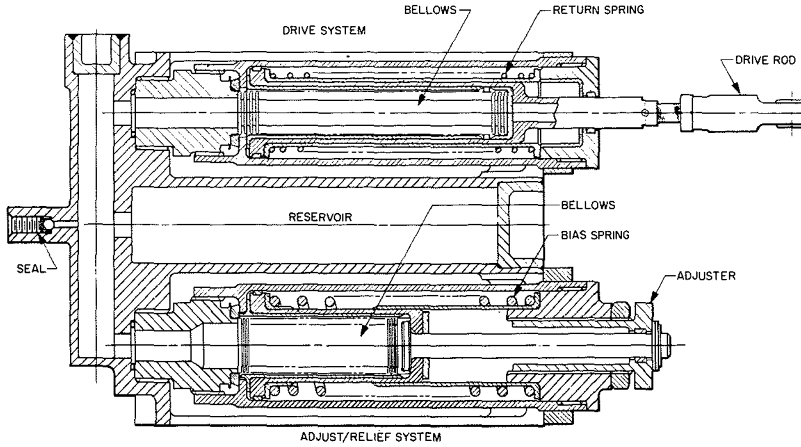

Fig. 2—Cross section of the thermal actuator.

As the fluid in the actuator expands with temperature, the drive bellows moves linearly to accommodate the expansion, working against the drive spring and moving the drive piston in an outward direction. In a cooling mode, with the fluid contracting, the drive spring provides the necessary force levels.

The drive spring is preloaded so that the minimum force level of the drive spring-drive bellows combination with the drive piston full in ($\delta = 0$) is not less than 4 lb. This available return force increases linearly as the drive spring is compressed with the piston moving out. The calculation of this force reflects the combined spring rates of the spring and bellows. Fig. 3 shows the relationship between drive position and available return force.

At first glance, it would seem that the available force in the outward direction during heating would be extremely large and limited only by any compressibility of the fluid. However, the force is limited to the threshold force or internal pressure at which the relief system picks up.

The adjust/relief system consists of a bellows, spring, and piston arrangement similar to the drive system and, also, an adjuster with a locking nut.

This combination of components performs the two supplementary functions of the thermal actuator: adjustment of the operating range and overtemperature relief. The spring and bellows spring rates of this system are sized to be compatible with the drive system. That is, the relief system is preloaded such that the minimum pressure required to move it is greater than the maximum pressure developed in the drive side. A typical pressure/temperature is shown in Fig. 4.

This adjust/relief system also incorporates the adjustment feature that permits the nominal 20°C temperature range to be selected anywhere between −10°C and +55°C. Adjustment in all cases means adusting to the temperature at the low end of the 20° range.

The ability to provide this adjustment can be explained as follows: With the unit filled with a known amount of fluid at a certain temperature, it is true from the thermodynamics of the closed system (Eq. 5) that there is a unique absolute volume of fluid associated with each and every temperature of the bracketed range. Therefore, by threading the adjusting nut, which simply expands or contracts the adust/relief bellows and changes the internal physical dimensions of the actuator, any specific temperature can be selected below which the fluid has not reached a sufficient volume to be effective. This represents the temperature at the low end of the desired 20°C range.

Design considerations and materials selection

Prevention of metal-to-metal contact of moving parts. In developing the actuator, there were a number of design considerations, selections, and philosophies that were felt to be pertinent to meeting the outlined goals. Most of these were motivated by the requirement to guarantee operation for 1 year in space. For example, the use of nonlubricated Teflon/steel bearings was dictated to avoid the evaporative and contaminating characteristic of viscous lubricants.

This philosophy was more applicable to the design of the moving louver section of the active thermal controller, but it is reflected in the design of the Teflon rings upon which the drive and adjust/relief pistons move. A related design philosophy is the use of nylon sleeves as guides for the springs and bellows. The design, in total, does not permit metal-to-metal contact of any moving parts.

Selection of bellows. The electrodeposited type of bellows was selected because it provided the best combination of available stroke, predictable spring rate, and wall homogeneity. Hydraulically formed bellows are stiffer and do not offer satisfactory available stroke per unit length. Welded bellows have a significant stroke advantage, but their noncontinuous construction does not provide the desired confidence against leakage.

In selecting a particular pair of bellows, the design procedure was iterative within the operating limits of the bellows and the defined paramaters for the actuator. With the temperature requirements of range, adjust, and relief, and with a reasonably selected stroke, the design approach was one of selecting the bellows/spring combination to reach a proper balance of the following parameters:

1) Available force of drive system.
2) Bias relationship of drive and adjust/relief systems.
3) Maximum allowable pressure of bellows.

Minimizing contaminants. With consideration of a design of this type, it was readily concluded that the ability to predict the operation of the device and, furthermore, to have confidence in the operation was highly dependent on the selection of the fluid, the amount of contaminants introduced, and the sealing quality of the chamber. It was previously mentioned that silicone oil was selected for its low vapor pressure, stability of expansion coefficient β_T, and range of expansion coefficients as a function of viscosity. Other fluids of higher β_T were considered, but they did not offer the flexibility of selecting within their specie a range of expansion coefficients. It is also true that many of these fluids were of magnitudes higher in vapor pressure, which could not be allowed because of the natural compressibility of gaseous vapors.

Because the operation of the device is fundamentally based on the small expansion capability of a confined fluid and because the effect of pressure buildup in the system is to subtract from this effect, it was highly undesirable to introduce compressible contaminants into the device. Of particular concern were traces of volatile components and entrained air in the fluid, air trapped in the bellows during filling, and air introduced during the final sealing procedure. Proper selection of fluid plus a vacuum de-aeration process negated the first concern of volatiles and entrained air.

The second concern of entrapped air during filling was felt to be minimized by a vacuum backfill technique wherein the fluid is introduced from a filling reservoir into the vacuum of the device. The problem of introducing air during the final seal was solved by use of the sealing mechanics shown in Fig. 2. The device may be sealed completely below the fluid level without the introduction of air.

Testing and Results

Testing of the actuator was done on a breadboard model identical to the flight model from the standpoint of operation and performance. Testing was carried out as a development program learning process with two objectives. The primary objective was to show that the actuator performed as designed and that the design goals, stated earlier, had been achieved. The secondary objective was an evaluation of the effect of certain unpredictable variables (mechanical compliance, entrapped air, and a variation in the fluid bulk modulus β_p) on the overall system performance.

All tests were performed in a temperature-controlled chamber. By the use of a potentiometer to monitor displacement and a temperature-compensated strain-type pressure transducer to check fluid pressure, the unit was evaluated over all temperature ranges. Freedom of range selection was demonstrated, as is shown on Fig. 4, which also shows the over-temperature relief capability to be in excess of the desired 60°C.

Initial tests in the program indicated that the operating range of the actuator was 24°C, instead of the predicted 20°C. It was further shown that the operation of the device was identical for any selected range. From consideration of the four parameters (ν_0, β_T, Δp, β_p) of Eq. 5 which affect the $\Delta\nu/\Delta T$

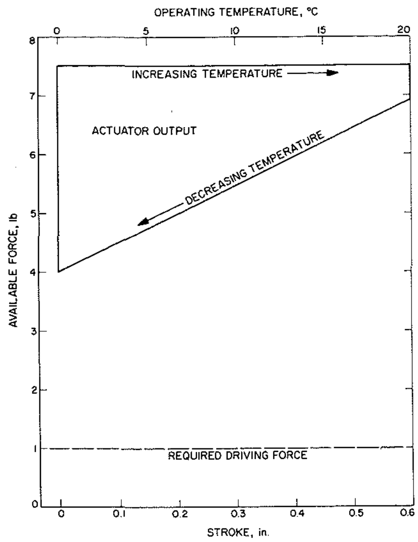

Fig. 3—Available force diagram.

relationship, it became evident that the value of the fluid bulk modulus β_p enjoyed our least confidence. Bulk moduli are typically published for high-pressure ranges, leaving low-pressure values to extrapolation and curve fitting.

Curve fitting from available manufacturer's data, however, resulted in an analytically determined compressibility that was one order of magnitude lower than that originally used. Furthermore, continued testing led to a conclusion that, in fact, we were dealing with other factors that were operating collectively to give us what we now term an equivalent bulk modulus (β_{pe}). Such factors as entrained volatile fluid components, inherent bellows compliance, and air entrapped during the filling operation could all interact in the equivalent system.

An analytical evaluation of the β_{pe} reflecting this interaction would at best be difficult because of the interrelated variables listed above. Thus, to substantiate our conclusion and evaluate the equivalent modulus, an empirical approach was undertaken in the form of an over-temperature pressure test. The results of this test are shown on Fig. 4. Above 62°C, a region where $\Delta\nu \approx 0$, the graph indicates a finite change in pressure as a function of a change in temperature. Analysis of this data by Eq. 5 gives $\beta_{pe} = 17 \times 10^3$ psi.

To compensate for a decrease in β_{pe}, which (according to Eq. 5) manifests itself as a reduction in gain, a new fluid with a higher β_T was selected. Subsequent testing showed the operating range to be 20±1.5°C with a linearity

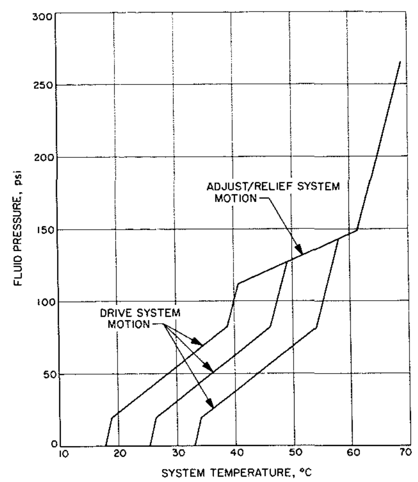

Fig. 4—Thermal actuator fluid pressure as a function of temperature.

of 2% maximum. With the operating range of 20°C, the over-temperature relief became 60°C, as predicted.

Conclusions

The tangible result of the developmental effort was the local-sensing thermal actuator with the following characteristics, which met the earlier established design constraints imposed by requirements for TIROS M:

1) Operating range provided was 20 ±1.5°C;
2) Range selection was from −10 to 10°C up to +35 to 55°C;
3) Over-temperature relief of 60°C was provided;
4) Stroke/temperature linearity was within ±2% of the full stroke;
5) Available force output was 4 to 7 lb.;
6) Weight was 2 lb.;
7) Reliability predicted was 0.995 for 1 year operation in space;
8) Minimum expected life is 10^7 cycles, based on bellows capability; and
9) Ability to change operating range by changing β_T was provided.

More fundamentally, the effort reduced to hardware and proved through test the reality of a thermally actuated device based on the principle of controlled fluid expansion. Such a device is particularly suited to applications where the consumption of electrical power is not permitted and, at the same time, predictable high force outputs are desirable.

Acknowledgment

The authors acknowledge the assistance of Mr. John H. Hayden, senior design specialist, for his invaluable contribution to the design of this fluid thermal actuator.

Value engineering—the profit is mutual

S. Robinson

This paper describes the planning and implementation of a value engineering program which is being conducted as a program requirement on a contract for development and production of the AN/PPS-9 (Figure 1) tactical radar for the U.S. Army Electronics Command (USAECOM). The major functional portions of the system consist of a battery operated radar set and scanning mechanism and a tripod.

BUYER AND SELLER teamwork for mutual profit is an important new ingredient in modern military procurement. The DoD defined the extra ingredient required in the Armed Services Procurement Regulation (ASPR) revision of 15 March 1962:

> ". . . Concern over the rising costs of weapons and military equipment has resulted in concerted and aggressive efforts to achieve cost reductions in procurement and has necessitated a complete re-evaluation of the policies governing the selection of contract types.
> The overall objective of assuring a fair and reasonable price is continued, but the contents of this Revision are directed toward this objective by providing maximum incentives for superior performance by the contractor through the exploitation of the profit motive."
> ". . . Profit, generally, is the basic motive of business enterprise. Both the Government and its defense contractors should be concerned with harnessing this motive to work for the truly effective and economical contract performance required in the interest of national defense. To this end, the parties should seek to negotiate and use the contract type best calculated to stimulate outstanding performance. The objective should be to insure that outstandingly effective and economical performance is met by high profits, mediocre performance by mediocre profits, and poor performance by low profits or losses. The proper application of these objectives on a contract by contract basis should normally result in range of profit rates."

The above established the philosophy for a whole new ball game in which both the buyer and seller would profit from improvements in system value. In essence, the new philosophy requires that both parties be acutely aware of the mutual profit to be gained

Fig. 1—AN/PPS-9 system.

by concerted action to simplify and reduce the cost of defense items.

Contractual incentives

This philosophy was implemented by increased emphasis on fixed price contracting to provide greater contractor cost responsibility. In addition, successive revisions were made to the ASPR on Value Engineering in order to provide increased profit incentive to contractors for Value Engineering Change Proposals (VECPs) to reduce cost.

The Value Engineering (VE) incentives appear in two forms. The first, and most commonly experienced at M&SRD is the "VE Incentive Clause." Basically, this clause states that the contractor may submit VECPs, and specifies his share of savings which result from those that are approved. No VE program is required.

The second type of VE incentive is the "VE Program Requirement Clause." This requires that a VE Program be conducted as a Statement of Work item, and its cost is funded by the contracting agency. The contractor's share of VECP savings is also specified, but is slightly lower than in the first case, in view of the customer's funding investment. It should be noted that VECPs and associated sharing of savings pertain only to situations where formal customer approval is required for changes in contract, specifications, or statement of work. When such is not required, the contractor is free, as in the past, to implement cost reduction changes within specification requirements, and retain all of the cost savings.

AN/PPS-9 incentives

The AN/PPS-9 VE program requirement and incentives were incorporated in the contract under the direction and guidance of the USAECOM value engineering agency, development value division (Fig. 2). This agency is implementing the policies of mutual profit motivation cited in the ASPR excerpt above. Their foresight is vindicated by the mutual benefits generated to date.

A VE Program Requirement of 1000 man-hours was specified in the subject contract, with the following incentives:

	% Sharing on approved VECPs	
	Cont.	*ECOM*
"Instant" contract (20 units)	25	75
Collateral savings	10	90
Government furnished material	25	75
Royalty on future acquisition	20	80

"Instant" contract

This is the contract in being at the present "instant." When a VECP is approved which reduces instant con-

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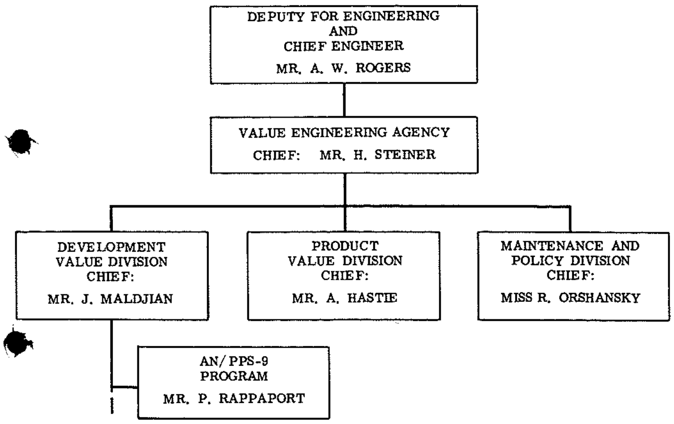

Fig. 2—USAECOM value engineering agency.

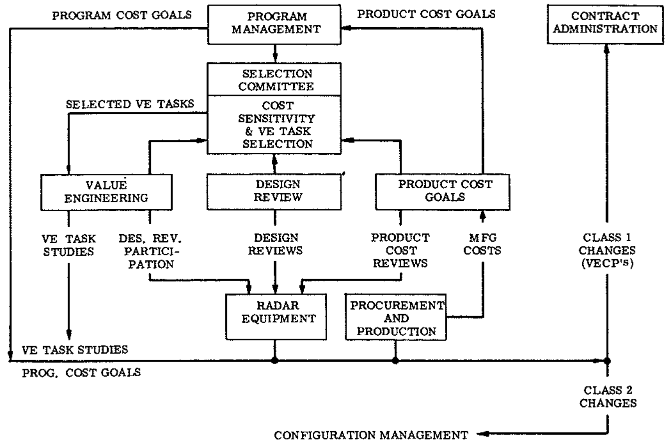

Fig. 3—Organization and interdisciplinary interfaces in the VE program.

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tract cost, the total target profit is increased by 25% of the saving and the price decreased by 75%. The instant contract cost may even be increased, so long as an ultimate net saving to the Government is indicated.

Collateral savings

When the VECP effects a net saving to the Government in areas such as operation, maintenance, logistic support, Government furnished property, the contractor receives 10% of the savings in a typical year of use.

Government furnished material

When the VECP effects a net saving in the cost of GFM under the instant contract, the contractor's price is increased by 25% of the net savings.

Royalty on future acquisition

For a period of 3 years after the instant contract, future purchases of items which utilize the VECP entitle the contractor to a 20% share of the savings, regardless of whether he gets the follow-on production award.

Program implementation

Organization and approach

Fig. 3 illustrates the organization and interdisciplinary interfaces in the VE program. Task selectivity is emphasized to concentrate VE effort on items of high value improvement potential.

A VE program must be tailored to the priorities and constraints of the contract and the nature of the system. Therefore, shortly after award of the subject contract, a series of system reviews were conducted with the project management to evaluate cost sensitivity and value improvement potential. In addition, a series of meetings was conducted for all program personnel and Engineering Department staff to brief them on the VE program requirements and significance of the VE incentives. The following VE program approach was developed:

1) Saving potential on the instant contract was limited because the instant contract quantity was small (20 units) and the delivery schedule tight and critical. It was necessary to press forward with existing design concepts to meet delivery requirements, making such changes as were feasible within this constraint.
2) A function cost analysis indicated that the scanning mechanism and tripod performed only secondary functions, yet contributed approximately 40% of the total cost (Fig. 4).

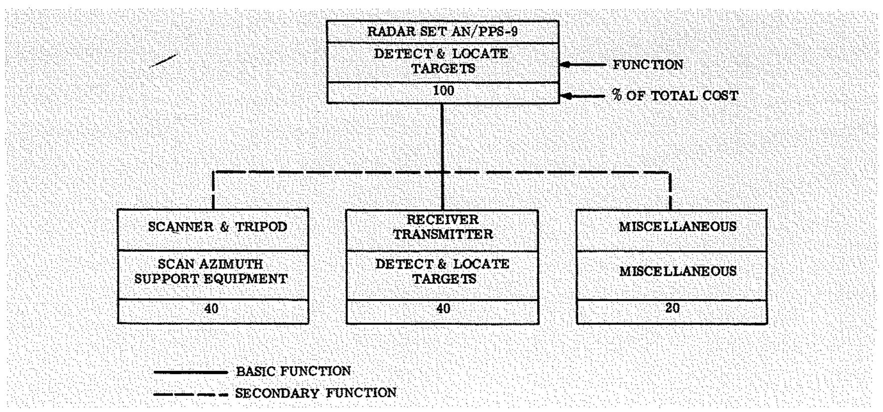


Fig. 4—Function/cost breakdown.

3) The contract specified that the scanning mechanism and tripod were to be manufactured in accordance with an already existing design. However, the scanner mechanism was most sensitive to value improvement because its cost, weight and power consumption were disproportionate to its secondary function. Moreover, the manufacturing cost of the existing tripod design was inordinately high compared to similar state of the art equipment. The scanner and tripod were therefore prime subjects for VECPs.

4) Future production potential was high. The greatest value improvement potential for the Government and contractor lay in changes applicable to future acquisition. A preliminary estimate of this potential revealed that it was indeed potent. For example, estimated savings on the scanner unit alone for various arbitrary future acquisition quantities showed the following:

No. of units	*Saving to govt. (M$)*	*Royalties (M$)*	*sales needed (M$) to match royalty profit*
1000	1	2	4
5000	5	1	20
10000	10	2	40

Assuming a 5% profit, the right hand column indicates the amount of new business the contractor must do to earn the equivalent of the corresponding royalty profit; or putting it another way, the earned royalty on 10,000 production units is equivalent to landing a $40,000,000 contract. Actually it is better than that because: a) The royalty is earned by the contractor whose VECP was approved, even if follow-on production incorporating the VECP is awarded to another company, and b) The royalty is obtained directly, whereas $40,000,000 of new business involves extensive capital investment and risk and by no means an assurance of 5% profit.

5) Low weight and low battery drain were prime performance factors. Approval of VECPs would be enhanced by devising lower cost alternates which also decreased weight and power usage.

6) The most significant value improvement potential for the receiver-transmitter lay in the application of advanced integrated circuit and microstrip techniques.

VE effort

Since VE payoff potential decreases rapidly as design progresses, the major portion of VE effort was scheduled during the first half of the program (before final drawing release) as shown in Fig. 5. The VE efforts were conducted via initial formal meetings of the designated task groups to evaluate functional alternatives, costs, and constraints. This set the direction of subsequent effort for continuous interaction of team members in context

VE EFFORT	J	J	A	S	O	N		TEAM LEADERS	MAN HOURS
SYSTEM REVIEW	10	10			FINAL DWG RELEASE △				20
SCANNER & TRIPOD	30	65	85	40	30				250
TRANSMITTER & DRIVER		35	75	75	35				220
DIGITAL BOARDS AND DC/DC CONVERTER			50	75	65				190
DECODER AUDIO AMP AND VIDEO			50	75	45				170
MISCELLANEOUS AND FAB AND TEST			15	10	5	20	----*		150
MAN HOURS	40	110	275	275	180	20	100		1000

* 20 MAN HOURS PER MONTH FOR 5 MONTHS

Fig. 5—VE task schedule.

INHERENT VE CHANGE
VALUE ENGINEERING PROPOSAL

Project No.
Proposal No.
Section

Part No.	Name	Qty. per Device	Function Verb	Noun	Date
ES-F-25901	Angular Control Assembly		Scan	Azimuth	8/9/68

PRESENT (show sketches)

Design incorporates unnecessarily tight tolerances in numerous parts.

PROPOSED (show sketches)

Changes have been made to 148 drawings to relax unnecessarily tight tolerances. In addition, some parts have been modified to reduce weight.

NON-RECURRING COSTS (est.)	Hrs.	$
Design	80.	1384.
Drafting	67.	793.
Evaluation		
Model Shop		
Publicat'ns		
Tech Lab		
Tooling		
Misc.		
Total		2177.

	Direct Material	Direct Labor	Variable Portions of Burden	Total Variable Cost Per Piece
Present Cost	2867.	--	--	2867.
Proposed Cost (est.)	2717.	--	--	2717.

Net Savings:
1. Difference Var. Cost, Proposed vs. Present: 150.
2. Total No. Pieces 20.
3. Total Gross Savings (1x2) +3000.
4. Less: Non-recur. Costs -2177.
5. Net Savings + 823.

Proposed By:

Fig. 6—Typical VE change proposal.

	Previous Design	*New Design*
Cost (relative)	100	52
Power consumption (relative)	100	10
Weight (relative)	100	67
No. of moving parts (actual)	60	8
Total no. of parts (actual)	140	75
RFI	Switch transients during scan reversal	No switch transients during scan reversal
Versatility	Only 2 scan sectors	Choice of any scan sector up to ±2500 mils
Environmental	Non Submersible	Submersible
Convenience	Controls move during scan	Controls stationery during scan

Table I—Comparison of new and old scanner designs.

with current design, manufacturing, and procurement efforts. The VE effort was therefore not abstracted from, but integral with the program effort.

Typical changes

In USAECOM nomenclature, an "inherent VE change" is one that reduces cost without impairing essential characteristics but does not require a change order to the contract. Fig. 6 exemplifies one of several such changes implemented to simplify the existing scanner design. This unit scans either of two selectable azimuth sectors at a slow uniform angular rate. Scan drive is accomplished by a battery operated electric motor and worm gear drive. Scan reversal is via switches which reverse drive motor rotation at the scan limits.

In parallel with the above effort, a new design concept for the scanner mechanism was developed by R. Schirmer of MSRD which achieves improved function at 52% of the previous cost. This was submitted as a VECP for development and delivery of several additional units under the current contract in accordance with the new design. This VECP has been approved by the customer.

An interesting sidelight of this VECP is that it was initially submitted as a so-called "preliminary VECP" (i.e. one which describes general concept and approach but does not have detailed technical and cost backup). This was done because:

- It was felt that some aspects of the design might be patentable.
- Incorporation of customer needs in the new design required immediate technical discussions with the customer.
- Further time was required to generate detailed design, test, and cost information needed for a formal VECP.

Although the Armed Services Procurement Regulation makes no provision for a "preliminary VECP" it appears to serve a useful "going on record" function. This requires close rapport with the customer: the contractor recognizes that the VECP must be rejected for lack of sufficient detail, whereas both parties acknowledge that it will be re-submitted when the detail is available.

The prime feature of the new scanner design is a mechanism which permits the motor to run continuously in one direction while oscillating the scanner head back and forth over the scanning sector. This mechanism eliminates the need for electrical switches to control the turn-around of the scan, thereby increasing the reliability and maintenance life of the equipment. In addition, running the motor continuously in one direction eliminates the turn-around transient current build up which, in the previous design, increased the current drain at turn-around time approximately 50%, up to almost one-half ampere. Continuous rotation of the motor in one direction also allows use of a motor of lower power rating. This, combined with the elimination of the turn-around transient reduces the power drain on the battery pack.

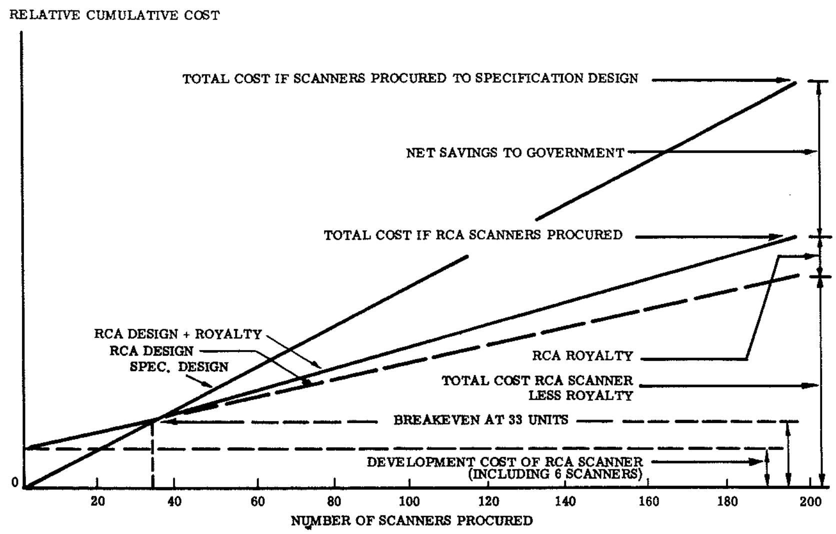


Fig. 7—Acquisition cost savings, break-even point, and royalty factors for scanner VECP.

The summary in Table I shows that the new scanner design truly enhances value by both improving function *and* lowering cost.

The cost savings indicated above for the scanner VECP pertain only to acquisition costs. When a VECP is approved, these costs form the basis for computing government/contractor sharing of savings on the instant contract and for determining royalties on future acquisition. Fig. 7 illustrates the future acquisition cost savings, break-even point, and royalty factors which would be associated with this VECP for an assumed quantity of 200 units. Note that royalty payments begin after the break-even point.

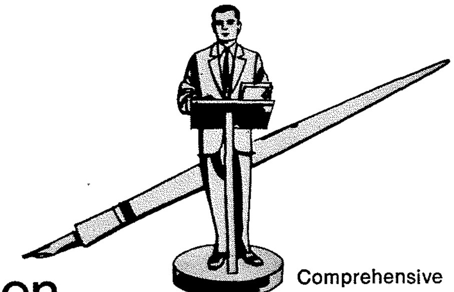
In this case, collateral savings to the Government in operational cost would also accrue. The amount of this saving in a typical year of use is determined by the Government, and 10% of this amount is awarded to the contractor. In submitting a VECP, a contractor is required to include his estimate of such collateral savings. This is desirable from the contractor's point of view and should be as comprehensive as feasible, since it establishes a basis for future negotiations. The collateral saving estimate for the new scanner design included the following categories of saving in operational cost: battery usage, limit switch wearout, motor brush wearout, random motor failures, scheduled maintenance, spares administrative costs.

Conclusions

At present, work is continuing along the lines indicated in the description of the program approach. During the entire program, we have had active and vigorous support and assistance from the USAECOM VE agency. This support has covered both general contractual policy and matters of detail implementation and has been of great value in assuring efficient program direction responsive to customer needs.

Our experience to date indicates:

1) Strengthening of the new contracting environment: buyer/seller cooperation for mutual benefit.
2) A realistic VE program must be tailored to the specific technical and contractual context.
3) A VECP is essentially similar to a proposal for new business. It must be developed and sold as such by the whole program organization.
4) Close and continuous customer rapport is essential to assure that VE effort is consistent with specific customer needs.
5) Strong and sincere Government support for VE incentives. It works—and the Government means business!



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AERONOMIC DATA INTERPRETATION from High Speed Vehicles Under Nonfree Molecular Conditions—G. K. Bienkowski, R. G. Groshans, S. M. Siskind (AED, Pr) Golden Anniversary Meeting of the American Geophysical Union, Washington, D.C.; 4/21-25/69

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MANAGEMENT

ACCEPTANCE SPEECH—G. H. Heilmeier (Labs., Pr) Eta Kappa Nu Award Banquet; 3/24/69

BASIC SCIENCE, Meaning of — Dr. J. Vollmer (AT, Cam) Franklin Institute, Phila., Pa.; 1/18/69

OPPORTUNITIES in Industry—E. B. Galton (ASD, Burl) Lasell Jr. College, Newton, Mass., Panel on Careers of the Seventies; 3/31/69

PLANNING PROCESS, The Use of Models in the—H. N. Garber (Labs., Pr) TIMS Meeting, New York City; 3/27/69

R&D PROJECTS, Evaluating and Selecting—A. S. Robinson (MSR, Mrstn) AMA Headquarters, Research Project Mgmt., Orientation Sem. #7221-07, New York; 4/9-11/69

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PLANNING PROCESS, The Use of Models in the—H. N. Garber (Labs., Pr) TIMS Meeting, New York City; 3/27/69

MECHANICAL DEVICES

ERECTABLE STRUCTURES and Meshes for Space Applications—H. J. Sheetz, III (AED, Pr) Society of Aerospace and Process Material Engineers, Los Angeles, Calif.; 4/29-5/1/69

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ACOUSTICAL PHONONS, Optical Detection of—E. S. Sabisky (Labs., Pr) American Physical Society Meeting, Philadelphia, Pa.; 3/23/69

ENERGY LEVELS of Ce^{2+} in CaF_2—R. C. Alig, Z. J. Kiss, D. S. McClure (Labs., Pr) American Physical Society Meeting, Philadelphia, Pa.; 3/24/69

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SEMICONDUCTING FERROMAGNETIC Spinels — P. J. Wojtowicz (Labs., Pr) INTERMAG Conference, Amsterdam, Netherlands; 4/15-18/69

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RADAR

CONDUCTING SPHERES as Calibration Targets for Nanosecond—Pulse Radars—S. Sherman (MSR, Mrstn) Sheraton Park Hotel, Washington, D.C., Spring Meeting, Int'ld Scientific Radio Union; 4/22/69

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COMMERCIAL STEREO DISC, Performance Characteristics of the—J. M. Eargle (Rec., Indpls) Audio Engineering Society Convention, Hollywood, Calif.; 4/69

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TELEVISION BROADCASTING

VHF TV TRANSMITTER, of Advanced Design, A Completely New—H. E. Small (CESD, MdwLds) NAB Conf., Washington, D. C.; 3/25/69

TELEVISION EQUIPMENT

COLOR PICTURE REPRODUCTION Using a High Resolution Television System—C. E. Smith, J. A. D'Arcy, E. A. Enfiejian (AED, Pr) 105th SMPTE Technical Conf., Miami Beach, Fla.; 4/20-25/69

IMAGE ENHANCEMENT—D. B. Gennery (MTP, Cocoa Beach, Fla) Master of Science in Physics at Florida Institute of Technology, *Thesis;* 4/69

LOW-LIGHT-LEVEL TELEVISION—S. S. Kolodkin, R. J. Gildea (ASD, Burl) TV Show, KCET-TV, Los Angeles, Calif.; 3/27/69

PHOTO DIELECTRIC Tape Camera Systems—J. A. D'Arcy (AED, Pr) NRR Company, Naval Air Development Center, Johnsville, Pa.; 3/25/69

TV CAMERA SYSTEM Used in the Apollo Command Module—M. H. Mesner (AED, Pr) 105th SMPTE Technical Conf., Miami Beach, Fla.; 4/20-25/69

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CAMERA TUBE DEVELOPMENTS, New RCA—R. E. Simon (EC, Lanc) Workshop at Marshall Space Flight Center, Huntsville, Alabama; 4/30/69

GRIDDED TUBES, High-Power 1968—T. E. Yingst (EC, Lanc) IEEE Convention, New York City; 3/24-27/69

IMAGE INTENSIFIER Tubes, Resolution Limitations of Electromagnetically Focused—I. P. Csorba (EC, Lanc) *RCA Review;* 3/69

IMAGE ISOCON and Related Developments for Astronomical Space Telescopes—A. D. Cope (EC, Lanc) Workshop on Optical Telescope Technology, Huntsville, Alabama; 4/29-5/1/69

PHOTOMULTIPLIER TUBE Technology, Recent Advances in—W. D. Lindley (EC, Lanc) Brookhaven National Laboratories, Upton, L. I. New York; 4/16/69

PHOTOMULTIPLIER Tube Capabilities, Present—W. D. Lindley (EG, Lanc) State University of New York, Stoneybrook, N.Y.; 4/17/69

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SILICON VIDICON TARGET with Electronically Variable Light Sensitivity and Spectral Response—S. R. Hofstein (Labs., Pr) IEEE Transactions on Electron Devices; 12/68

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CHEMISTRY in High Vacuum—J. J. Moscony (EC, Lanc) St. Joseph's College Seminar, Philadelphia, Pa.; 4/29/69

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Subject listed opposite each author's name indicates where complete citation to his paper may be found in the subject index. An author may have more than one paper for each subject category.

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Patents Granted

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As reported by RCA Domestic Patents, Princeton

LABORATORIES

Bidirectional IGFET With Symmetrical Linear Resistance With Specific Substrate Voltage Control — R. E. Werner (Labs., Pr) U. S. Pat. 3,441,748

Electrophotographic Method—R. G. Olden (Labs., Pr) U. S. Pat. 3,442,645

Torsional Light Deflector—W. H. Barkow (Labs., Pr) U.S. Pat. 3,436,139

Water Cooled Contractor for Anode in Carbon Arc Mechanism—R. E. Enstrom, W. F. Schact (Labs., Pr) U.S. Pat. 3,428,-847 (Assigned to U.S. Government)

Solid State Image Pickup Device Utilizing Insulated Gate Field Effect Transistors—H. Borkan (Labs., Pr) U.S. Pat. 3,435,138

Insulated Gate Field Effect Transistor—S. T. Hofstein (Labs., Pr) U.S. Pat. 3,434,021

Ring Counters Employing Threshold Gates—R. O. Winder (Labs., Pr) U.S. Pat. 3,434,058

Magnetic Memory Employing Stress Wave—L. S. Onyshkevych (Labs., Pr) U.S. Pat. 3,434,119

Wire Handling Apparatus—H. D. G. Scheffer (Labs., Pr) U.S. Pat. 3,438,403

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Method of Preparing Luminescent Materials—Z. J. Kiss (Labs., Pr) U. S. Pat. 3,438,881

Logic Circuits Employing Field-Effect Transistors—J. J. Gibson (Labs., Pr) U.S. Pat. 3,439,185

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Parity Circuits Employing Threshold Gates—R. O. Winder (Labs., Pr) U.S. Pat. 3,439,328

Black Level Setting Circuit for Color Subcarrier Modulator—P. Haferl (Labs., Zurich) U.S. Pat. 3,437,745

Driver-Sense Circuit Arrangement—A. K. Rapp (Labs., Pr) U.S. Pat. 3,440,444

Electro-Optical Memory—L. J. French (Labs., Pr) U.S. Pat. 3,440,620

Stress-Wave Thin-Film Memory—H. Weinstein (Labs., Pr) U.S. Pat. 3,440,625

Beat Frequency Holograms—H. J. Gerritsen (Labs., Pr) U.S. Pat. 3,444,316

Character Generator—M. Artzt, M. M. Sowiak (Labs., Pr) U.S. Pat. 3,444,319

Signal Translating Circuit Providing Signal-Controlled Time Delay—E. C. Fox (Labs., Pr) U.S. Pat. 3,444,396

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Threshold Control for Sync Separator Noise Protection Circuit and for AGC Stage—E. E. Janson, L. P. Thomas (HI, Indpls) U.S. Pat. 3,441,669

Stabilization of Television Deflection Circuits—J. A. McDonald, P. C. Wilmarth (HI, Indpl) U.S. Pat. 3,441,790

Deflection Circuit with Bidirectional Trace and Retrace Switches—J. B. Beck (HI, Indpls) U.S. Pat. 3,441,791

Inter-stage Coupling Circuit for Neutralizing Internal Feedback in Transistor Amplifiers—K. Siwko (HI, Indpls) U.S. Pat. 3,441,865

Hue Adjust Circuit for a Color Television Receiver—J. A. Konkel, F. A. Joy (HI, Indpls) U. S. Pat. 3,436, 470

Blanking Circuits for Television Receivers—T. A. Zimmerman, T. W. Burrus (HI, Indpls U.S. Pat. 3,436,475

Electron Beam Deflection and Low Voltage Supply Circuit—G. L. Grundmann (HI, Indpls) U.S. Pat. 3,436,591

Metallic Connection and the Method of Making Same—R. S. Degenkolb, W. H. Liederbach (HI, Indpls) U.S. Pat. 3,434,877

Convergence Apparatus for Nullifying Unwanted Induced Deflection Currents—G. K. Sendelweck (HI; Indpls) U.S. Pat. 3,435,276

Time Switch Controlled Energizing Circuit for Automatic Degaussing Apparatus—R. R. Norley (HI, Indpls) U.S. Pat. 3,433,993

Stabilization of Television Deflection Circuits—J. A. McDonald (HI, Indpls) U.S. Pat. 3,434,000

Phonograph with Circuit Board Mounted on the Motorboard Beneath the Turntable—J. A. Tourtellot (HI, Indpls) U.S. Pat. 3,444,333

Automatic Frequency Control Apparatus especially Suitable for Integrated Circuit Fabrication—J. Avins (HI, Som) U.S. Pat. 3,444,477

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Tape Reel or Similar Article—C. E. Bush (Rec., Indpls) U.S. Pat. D213,699

Endless Loop Tape Cartridge—S. W. Liddle, C. E. Bush (Rec., Indpls) U.S. Pat. 3,443,767

Endless Tape Cartridge—S. W. Liddle, C. G. Hawkins (Rec., Indpls) U.S. Pat. 3,443,768

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Field-Effect Oscillator Circuit with Frequency Control—O. P. Hart (EC, Som) U.S. Pat. 3,436,681

Vapor Depositing Infrasensitive Antimony Tritelluride—S. V. Forgue (EC, Pr) U.S. Pat. 3,424,610; Assigned to U.S. Government

Photosensitive Cathodes—R. G. Stoudenhiemer, D. L. Thoman (EC, Lanc) U.S. Pat. 3,434,876

In-line, High Temperature, High Vacuum Closure—A. Basiulis (EC, Lanc) U.S. Pat. 3,428,773; Assigned to U.S. Government

Television Deflection system including AFC Circuit with Regenerative Phase Detector—C. F. Wheatley (EC, Som) U.S. Pat. 3,441,673

Thermoelectric Device having a Graphite Member Between Thermoelement and Refractory Hot Strap—A. G. F. Dingwall, D. K. Wilde (EC, Hr) U.S. Pat. 3,442,718

Superconducting Ribbon—E. R. Schrader (EC, Hr) U.S. Pat. 3,443,021

Color Cathode Ray Tube with Radiation-Emitting Strip-Like Indexing Areas having Serrated Edges—R. D. Thompson (EC, Lanc) U.S. Pat. 3,443,139

PN-Junction Semiconductor with Polycrystalline Layer on One Region—B. R. Czorny, E. F. Cave (EC, Som) U.S. Pat. 3,443,175

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High Frequency, High Power Transistor having Overlay Electrode—D. R. Carley (EC, Som) U.S. Pat. 3,434,019

Cryoelectric Memory System—R. A. Gange (EC, Pr) U.S. Pat. 3,434,121

Sense Amplifier for Magnetic Memory—R. A. Williams (EC, Natick) U.S. Pat. 3,434,123

Insulated-Gate Field-Effect Transistor with Critical Bulk Characteristics for Use as an Oscillator Component—A. Blicher (EC, Som) U.S. Pat. 3,439,236

Method of Fabricating Semiconductor Devices—A. G. F. Dingwall (EC, Som) U. S. Pat. 3,437,533

INFORMATION SYSTEMS DIVISION

Circuit for Distinguishing Interrupt Signal from other Signals—R. A. Rodner (ISD, W. Palm Beach) U.S. Pat. 3,435,129

Self-Synchronizing Readout with Low Frequency Compensation—G. W. Jacoby (ISD, Cam) U.S. Pat. 3,441,921

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Packaging of Electrical Equipment—R. Taynton (ISD, W. Palm Beach) N.S. Pat. 3,434,014

Computer System Employing Elementary Operation Memory—R. H. Yen (ISD, Cam) U.S. Pat. 3,434,112

Write Verification for a Recording System—E. C. James (ISD, W. Palm Beach) U.S. Pat. 3,434,156

Card Processing Apparatus—M. F. Kaminsky, G. Spector (ISD, Cam) U.S. Pat. 3,440,409

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Digital Television Data Compression System—G. P. Richards (AED, Pr) U.S. Pat. 3,435,134

Ladder Network Filters Having a Negative Resistance to Compensate for Lossy Reactive Components in the Filter—T. G. Marshall (AED, Pr) U.S. Pat. 3,439,291

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AEROSPACE SYSTEMS DIVISION

Multiapertured Magnetic Memory Element—A Sherman, W. A. McNamara (ASD, Cam) U.S. Pat. 3,432,824; Assigned to the U.S. Government

Temperature Controlled Circuit Boards—C. E. Goltsos, A Amato (ASD, Burl) U.S. Pat. 3,440, 407

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Antenna for a Radio or Television Set—J. D. Callaghan (P&A, Deptford) U.S. Pat. D213,968

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Compensated Generalized Savart Plate—J. L. Dailey (MSR, Mrstn) U.S. Pat. 3,429,635; Assigned to U.S. Government

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Frequency and Phase Error Detection means for Synchronization Systems—H. Ball, D. N. McLaughlin (CESD, Burbank) U.S. Pat. 3,441,342

Electronic Splicing Control System—M. B. Finkelstein (CESD, Cam) U.S. Pat. 3,441,666

Professional Meetings

Dates and Deadlines

Be sure deadlines are met—consult your Technical Publications Administrator or your Editorial Representative for the lead time necessary to obtain RCA approvals (and government approvals, if applicable). Remember, abstracts and manuscripts must be so approved BEFORE sending them to the meeting committee.

Calls For Papers

SEPT. 8-12, 1969: ***Int'l Man-Machine Systems Symposium,** St. John's College, Cambridge, England. **Deadline info: 6/15/69 (papers) to:** W. T. Singleton, Applied Psychology Dept., Univ. of Aston in Birmingham, Birmingham 4, England.

SEPT. 16-19, 1969: **Solid State Devices Conf.,** Univ. of Exeter, Exeter, Devon, England. **Deadline info: 6/27/69 (syn) to:** P. C. Newman, Allen Clark Res. Ctr., Caswell, Towcester, Northamptonshire, England.

SEPT. 21-26, 1969: ***Intersociety Energy Conversion Engrg. Conf.,** Statler Hilton Hotel, Washington, D.C. **Deadline info:** T. G. Kirkland, U.S. Army R & D Ctr., Fort Belvoir, Va.

OCT. 27-29, 1969: ***Electronic & Aerospace Systems Conv. (EASCON),** Sheraton Park Hotel, Washington, D.C. **Deadline info: 6/2/69 (abst), 6/30/69 (papers) to:** H. P. Gates, Jr., P.O. 2347, Falls Church, Va. 22042.

OCT. 29-31, 1969: **Nuclear Science Symposium,** Sheraton Palace Hotel, San Francisco, Calif. **Deadline info: 6/15/69 (A & S) to:** J. F. Osborn, G.E. Co., 175 Curtner Ave., M/C 650, San Jose, Calif. 95125.

OCT. 29-31, 1969: ***Photographic Processing,** Society of Photographic Scientists and Engineers, Twin Bridges Marriott Motel in Washington, D.C. in Washington, D.C. **Deadline info: 7/1/69 (abst), 8/15/69 (sum) to:** Clifford B. Krumm, Photographic Processing Branch, Wright Patterson AFB, 1975 Shaftesbury Road, Dayton, Ohio 45406.

NOV. 5-7, 1969: **Northeast Electronics Research & Engineering Mtg (NEREM),** Sheraton Boston Hotel, War Mem. Aud., Boston, Mass. **Deadline info: 5/31/69 (abst) to:** C. J. Peters, Sylvania Elec. Pdts., 40 Sylvan Rd., Waltham, Mass. 02154.

NOV. 18-21, 1969: **Conf on Magnetism and Magnetic Materials,** Benjamin Franklin Hotel, Phila., Penna. **Deadline info: 8/11/69 (abst) to:** J. D. Blades, Franklin Inst. Res. Labs., Phila., Penna. 19103.

DEC. 8-10, 1969: **Int'l Symposium on Circuit Theory,** Mark Hopkins Hotel, San Francisco, Calif. **Deadline info: 7/1/69 (papers) to:** R. A. Rohrer, Fairchild Semiconductors, 4001 Junipero Serra Blvd., Palo Alto, Calif. 94304.

DEC. 15-18, 1969: **AGU/AIAA Exploration of the Planets Mars and Venus,** Jack Tar Hotel, San Francisco, Calif. **Deadline info: (abstract) to:** Headquarters, American Geophysical Union, 2100 Pennsylvania, N.W., Washington, D.C. 20037.

JAN. 19-21, 1970: **AIAA 8th Aerospace Sciences Meeting,** Statler-Hilton Hotel, New York, New York. **Deadline info: (abst), 8/18/69; 12/8/69 (papers to:** Robert A. Gross, School of Engineering and Applied Science, Columbia University, New York, N.Y. 10027.

JAN. 25-30, 1970: **Winter Power Mtg.,** Statler Hilton Hotel, New York, N.Y. **Deadline info: 9/15/69 (papers) to:** IEEE Hdqs., Tech. Conf. Svcs., 345 E. 47th St., New York, N.Y. 10017.

FEB. 4-6, 1970: **AIAA Advancd Space Transportation Meeting,** Cocoa Beach, Fla. **Deadline info: 9/4/69 (abst); 10/15/69 (ms) to:** Alfred C. Draper, Air Force Flight Dynamics Lab. (FDM), Wright-Patterson Air Force Base, Ohio 45433.

MARCH 2-4, 1970: **AIAA Earth Resources Observation and Information Systems Meeting,** Annapolis, Md. **Deadline info: (abst) 8/1/69 to:** George Barna, Astro Electronics Division, RCA Corporation, P.O. Box 800, Princeton, N.J. 08540.

MARCH 16-18, 1970: **AIAA Visual and Motion Simulation Technology Conference,** Cape Canaveral, Fla. **Deadline info: 7/21/69 (abst) to:** John P. Smith, NASA Flight Research Center, P.O. Box 273, Edwards, Calif. 93523.

APRIL 6-8, 1970: **AIAA 3rd Communications Satellite Systems Conference,** International Hotel, Los Angeles, Calif. **Deadline info: 2/2/1970 (papers) to:** Nathaniel E. Feldman, The Rand Corporation, 1700 Main Street, Santa Monica, Calif. 90406.

MAY 19-21, 1970: ***Signal Processing Methods for Radio Telephony,** London, England. **Deadline info: 8/25/69 (syn); 12/29/69 (ms) to:** IEE, Savoy Place, London, W. C. 2 England.

Engineering News and Highlights

H. W. Leverenz elected fellow of American Institute of Chemists

Humbolt W. Leverenz was recently elected a fellow of the American Institute of Chemists. Mr. Leverenz is presently Staff Vice President, Patents and Licensing and Chairman of the Educational Aid Committee. Mr. Leverenz received the BA in Chemistry from Stanford University in 1930. He also studied at University of Munster, Germany, and Harvard University Graduate School of Business Administration. He joined RCA in 1931 as a chemico-physicist. In 1938 he moved to Harrison, and in 1942 assumed supervision of research on electronically active solids at RCA Laboratories. In 1954 he was named Director, Physical and Chemical Research Laboratory. In 1961 he was appointed Associate Director of RCA Laboratories, a post he held for five years, when he became a Staff Vice President in 1966. Mr. Leverenz is a Fellow of the American Physical Society, the Optical Society of America, the Institute of Electrical and Electronics Engineers, and the American Association for the Advancement of Science. He is a member of the American Chemical Society, the Swiss Physical Society, Sigma Xi, and Phi Lambda Upsilon. He has been issued 67 patents for his inventions, and is the author of the book, "An Introduction to Luminescence of Solids," plus many technical and educational articles.

ASD Engineering sets pattern for growth

In a recent realignment, **Fred Krantz,** Chief Engineer of Aerospace System Division, emphasized that there was a need for clear organizational responsibilities and tight coupling of engineering technology and product plans with ASD's marketing effort. The overall effect is to give a unity of purpose to the Engineering Department and to provide a strong systems capability that matches market trends, improves our hardware sales potential, stabilizes ASD's workload, and provides potential for future growth.

The major portion of the organizational realignment consists of the establishment of one section devoted to Advanced Programs Analysis under **Paul Seeley.** This section would provide a skill center for systems analysis, synthesis, and simulation; support for new engineering development programs; an interface with the DEP advanced programs and planning activity, and recommendation of technology growth plans.

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The *RCA Review* is published quarterly. Copies are available in all RCA libraries. Subscription rates are as follows (rates are discounted 20% for RCA employees):

	DOMESTIC	FOREIGN
1-year	$4.00	$4.40
2-year	7.00	7.80
3-year	9.00	10.20

Degrees granted

F. J. Woelfle, Global Communications	BS, City College of New York, 1/69
R. Blosser, Labs., Pr.	PhD, Princeton University, 6/69
J. A. Castellano, Labs., Pr.	PhD, Polytechnic Institute of Brooklyn, 6/69
R. V. D'Aiello, Labs., Pr.	PhD, Polytechnic Institute of Brooklyn, 6/69
E. C. Ross, Labs., Pr.	PhD, Princeton University, 6/69
R. E. Smiley, Labs., Pr.	J.D, Temple University, 5/69
D. L. Staebler, Labs., Pr.	PhD, Princeton University, 9/69
W. P. Stollar, Labs., Pr.	PhD, Rutgers University, 9/69
D. H. R. Vilkomerson, Labs., Pr.	PhD, Columbia University, 6/69
J. Gerber, Labs., Pr.	MA, City University of New York, 2/69
W. Frifel, Labs., Pr.	MS, Polytechnic Institute of Brooklyn, 6/69
B. Miller, Labs., Pr.	MS, Drexel Institute of Technology, 6/69
A. Stoller, Labs., Pr.	MS, Rutgers University, 6/69
V. Christiano, Labs., Pr.	BS, Polytechnic Institute of Brooklyn, 6/69
R. Evans, Labs., Pr.	BS, Rider College, 6/69
M. Markulec, Labs., Pr.	BS, Newark College of Engineering, 6/69
R. Mazzochi, Labs., Pr.	BS, Drexel Institute of Technology, 6/69
J. Paczkowski, Labs., Pr.	BS, Polytechnic Institute of Brooklyn, 6/69

Professional activities

Central Engineering

Jerome W. Kaufman, Metallurgical Engineer, Central Engineering, has been re-elected to a two-year term as Treasurer of the Philadelphia Chapter, American Society for Metals.

Mr. Kaufman is the RCA Sustaining Member Representative in the American Society for Metals. In addition, Mr. Kaufman is on the Liberty Bell Committee for the 1969 Materials Engineering Exposition and Congress, which will be at the Civic Center in Philadelphia on October 13-16, 1969.

The American Ordnance Association Bronze Medallion was recently awarded to **W. W. Thomas,** Manager Documentation Programs, Central Engineering. Mr. Thomas has for over ten years been actively working with the Defense Department and the individual services, toward improved documentation practices. This work has included Chairmanship of both the AOA Engineering Documentation Section and the AOA Technical Documentation Division.

Mr. Thomas was also awarded the first Life Membership in the Delaware Valley Chapter of the Society of Reproduction Engineers, on April 16th.

Missile Test Project

Serving as charter members of a newly-formed oceanography advisory committee for Brevard Junior College (Cocoa, Florida) are **Dr. L. E. Mertens,** Chief Scientist, and **William N. Beall,** Engineer, with the RCA Missile Test Project. They are helping to organize an oceanography program at the college.

Commercial Electronic Systems Division

Charles E. Perry, Microwave Dept., has been initiated into Alpha Sigma Lambda, a National Honorary Fraternity for Evening School Students. Mr. Perry is currently taking courses at the Drexel Evening College.

Astro Electronics Division

J. E. Keigler and **R. F. Buntschuh** have been appointed members of Air Traffic Control Advisory Committee of Dept. of Transportation, USA.

Electronic Components

J. M. Forman, Industrial Tube Division, Lancaster Plant, presided as an Electronics Judge at a State contest held in Harrisburg, Pa. on 4/17/69. The contest was sponsored by the Vocational Industrial Clubs of America (VICA). The winners of the State contest become eligible to compete in the VICA National contest to be held in Memphis, Tenn.

Staff announcements

Electronic Components

E. M. Troy, Manager, Engineering Services, Solid State and Receiving Tube Division, has appointed **M. J. Sarullo** as Manager, Engineering Standards.

Information Systems

F. Edelman, Director, Operations Research, Management Information Systems, has announced the organization of Operation Research as follows: **P. Berger,** Manager, Business Systems and General Software Development; **H. N. Garber,** Manager, Advanced Technical and Administrative Programs; **S. Skillman,** Manager, Functional Systems and Time Sharing Applications.

J. R. Bradburn, Executive Vice President, Information Systems, has appointed **S. P. Marcy** as Division Vice President and General Manager, Memory Products Division.

Astro-Electronics Division

C. S. Constantino, Division Vice President and General Manager, has appointed **W. P. Manger,** Chief Engineer, Engineering Department.

Commercial Electronic Systems Division

B. Kreuzer, Vice President and General Manager, has announced the organization of the Commercial Electronic Systems Division as follows: **N. R. Amberg,** Manager, Industrial and Automation Systems Dept.; **T. J. Barlow,** Manager, Production Department; **G. W. Bricker,** Manager, Professional Electronic Systems Dept.; **W. T. Collins,** Manager, Operations Plans; **E. J. Dudley,** Administrator, News and Information; **W. R. Fitzpatrick,** Manager, Personnel; **J. F. Groark,** Controller, Finance; **E. J. Hart,** Manager, Commercial Communications Systems Dept.; **A. F. Inglis,** Division Vice President, Broadcast Systems Dept.; **A. Mason,** Chief Engineer; **A. M. Miller,** Division Vice President, Systems Programs; **J. P. Taylor,** Division Vice President, Marketing Programs; **J. W. Tyler,** Managing Director, RCA Limited Australia; **J. P. Ulasewicz,** Division Vice President Commercial Electronic Systems International Sales Department.

Laboratories

W. M. Webster, Staff Vice President, Laboratories, has appointed **J. A. Rajchman** as Staff Vice President, Information Sciences.

T. O. Stanley, Staff Vice President, Systems Research has announced the organization of Systems Research as follows: **N. L. Gordon,** Director, Systems Programming Research Laboratory; **G. B. Herzog,** Director, Digital Systems Research Laboratory; **D. S. McCoy,** Director, Consumer Electronics Research Laboratory; **L. S. Nergaard,** Director, Microwave Research Laboratory; **K. H. Powers,** Director, Communications Research Laboratory.

J. A. Rajchman, Staff Vice President, Information Sciences, has appointed **R. D. Lohman** as Head, Information Sciences Systems.

K. H. Powers, Director, Communications Research, has announced the organization of Communications Research Laboratory as follows: **J. R. Holshouser,** Head, Command and Control Research; **C. B. Oakley,** Head, Consumer Communications Systems Research; **D. A. Ross,** Head, Electronic Printing Research; **H. Staras,** Head, Radio Physics Research.

G. B. Herzog, Director, Digital Systems Research Laboratory, has announced the organization of Digital Systems Research Laboratory as follows: **W. A. Rosenberg,** Head, Integrated Circuit Technology Center; **J. R. Burns,** Head, Semiconductor Device Applications Research; **B. J. Lechner,** Head Peripheral Equipment Research; **R. Shahbender,** Head, Digital Devices Research.

D. S. McCoy, Director, Consumer Electronics, Research Laboratory, has announced the organization of the Consumer Electronics Research Laboratory as follows: **J. J. Brandinger,** Head, Systems Analysis and Display Research; **W. J. Hannan,** Head, Electro-optic Systems Research; **G. H. Heilmeier,** Head, Device Concepts Research; **W. D. Houghton,** Head, Consumer Information Systems Research; **E. O. Keizer,** Head, Video Systems Research.

N. L. Gordon, Director, Systems Programming, Research Laboratory, has announced the organization of Systems Programming Research Laboratory as follows: **L. J. Berton,** Head, Computer Center; **M. H. Lewin,** Head, Systems Architecture Research.

James Hillier, Executive Vice President, Research Engineering, has appointed **A. R. Trudel** as Staff Engineer, Product Engineering.

RCA Staff

Robert W. Sarnoff, President, has announced the following changes in executive responsibilities to be as follows: **A. L. Conrad** will become Executive Vice President, Services. In addition to his responsibility for Education Systems, Mr. Conrad will be responsible for the RCA Service Company, RCA Global Communications, Inc., the Hertz Corporation, and Parts and Accessories; **C. M. Odorizzi** will continue on the staff of the President as an Executive Vice President, and will perform special assignments for the President.

Electromagnetic and Aviation Systems Division

S. Sternberg, Division Vice President, has appointed **W. R. Jackson** as Product Line Manager of Electronic Warfare Systems.

Missile and Surface Radar Division

Richard J. Hall has been appointed as Manager of the RCA Micro-Circuit Department, Moorestown, N.J.

Promotions

to engineering leader and manager

As reported by your Personnel Activity during the past two months. Location and new supervisor appear in parentheses.

Electromagnetic and Aviation Systems Division

N. G. Hempling: from Prn. Mbr. Engrg. Staff to Ldr., Engrg. Staff (A. P. Kuzniar, Van Nuys)

DEP Staff-Defense Engineering

E. P. McGrogan, Jr.: from Engineer to Ldr., Design & Development Engineer (M. B. Herscher, Camden)

DEP Astro-Electronics Division

H. Perkel: from Ldr. Engr. to Manager, Specialty Engrg. (W. Manger, Princeton)

Information Systems Division

C. R. Faix: from Class "A" Eng. to Ldr., Des. & Dev. Engrg. (J. K. Mulligan, Camden)

P. K. Hsieh: from Class "AA" Eng. to Ldr., Des. & Dev. Engrg. (S. E. Basara, Camden)

J. L. Lindinger: from Class "AA" Eng. to Ldr., Des. & Dev. Engrg. (J. K. Mulligan)

RCA Service Company

C. E. Harris: from Engr. to Ldr., Engineers (E. J. Lauden, Cocoa, Florida)

E. T. Osler: from Engr. to Mgr., Switching Systems (T. J. Barry, Springfield, Va.)

R. E. Ray: from Engr. to Ldr., Engineers (C. L. Basney, Kwajalien)

W. W. Straus: from I&M Engr. to Ldr., Systems Service Engineers (H. Chadderton, Camden)

F. L. Waterfield: from Ship Instrument. Engr. to Mgr., Navigation and Data Handling-Shipboard (P. G. Vise, Cocoa, Florida)

RCA Global Communications, Inc.

R. Wickman: from Mgr. Computer Tech. Oper. to Ldr. (L. Cifuentes. New York)

G. Shapiro: from Design Engr. to Ldr. (S. N. Friedman, New York)

Licensed engineers

W. H. Liederbach, Home Instruments. Indianapolis, PE-13256; Indiana.

D. H. Rudd, RCA Service Company, PE-4654; New Mexico.

J. D. Sellers, RCA Service Company, PE-28903; Texas.

Awards

Aerospace Systems Division

Paul F. Minghella, Senior Member, Automatic Test Equipment Engineering, was selected as December Engineer of the Month for his contribution to the LCSS Program. His selection recognizes his creativity and outstanding design in improving the optical system performance in the LCSS.

Lionel Arlan, Senior Project Member, Electro-Optics and Controls Engineering, was selected as January Engineer of the Month for his contributions to the Development of the Low Level Television (LLLTV) for the TRIM A-6 aircraft.

The team of **B. T. Boyle, G. B. Curran, E. J. Gregg, F. T. Kelley, R. E. Thomas, M. M. Wienshienk, B. M. Carner, A. F. Dirsa, R. J. Geehan, J. M. Goode, J. R. Roberts, J. Salvato, W. Clark, M. A. Haven,** and **J. B. McElroy,** from Data Processing Engineering, was selected for a team award for its superior performance in carrying out the ADA programming and in-plant hardware demonstrations.

The team of **M. D. Brazet, J. W. Curry, Jr., G. L. Desautels, C. N. Hill, E. C. Shephard,** and **J. M. Welsh** from Radar Engineering was selected for a team award for the month of February. The team was selected for its outstanding performance in the successful completion of the LM/RR/T tracking tests during the Apollo 7 flight.

Missile and Surface Radar Division

George Stevens of section 689 was recently the recipient of the Technical Excellence Award for 1968. Mr. Stevens was cited for his original analysis and contributions advancing the state of the art in radar technology, in target acceleration processing, and in automatic target detection in land clutter.

C. E. Salmon of section 688 and **Dr. S. Shucker** of section 682 were cited for the Technical Excellence of their performance during the fourth quarter of 1968. Mr. Salmon was cited for contributions to the field of specialized electrochemical finishing techniques, resulting in significant enhancement of several current M&SR products. Dr. Shucker was cited for outstanding achievement in analysis and synthesis of ballistics, data processing, and system accuracy algorithms which enabled RCA's proposed AN/TPQ-27 system to meet special accuracy specifications within stringent weight and size contraints.

Missile Test Project

The RCA Missile Test Project Trinidad Complex was rated the top station in the Air Defense Command's listing for 1968. Communications Center personnel at the facility earned the honor by making the fewest operating errors of the 20 stations in the ADC tracking network. The 47th Communications Group at Ent Air Force Base, Colorado will present the tracking station with an award in recognition of the outstanding work.

Engineers at Electronic Components receive 1968 Engineering Achievement Awards

Harrison, N.J.

Three engineers of the Harrison, N.J. plant of RCA Electronic Components have received 1968 Engineering Achievement Awards.

Reinhard Schlaefli, an Associate Engineer in Product Development for the RCA Industrial Tube Division was cited for "outstanding contributions to microwave device design engineering". **Thomas P. Garrison,** an Engineer in Product Development was cited for a team award for "outstanding engineering team achievement in a solid-state microwave subsystem". (The other member of the team was **Donald E. Nelson,** Member Technical Staff for RCA Laboratories in Princeton, N.J.) **James Bamford,** an Engineer in Manufacturing for the RCA Solid State and Receiving Tube Division, was cited for "noteworthy engineering contributions to process techniques and parts design for receiving tubes."

Somerville, N.J.

Four engineers of the Somerville, N.J. plant of RCA Electronic Components have received 1968 Engineering Achievement Awards.

Louis Striednig, an Engineer in the RCA Solid State and Receiving Tube Division was cited for "noteworthy contributions to the design of receiving tube high frequency amplifiers."

A five-man engineering team consisting of three employees from the Somerville plant were cited for "outstanding team performance in silicon power transistor engineering": **Lawrence J. Gallace,** an Associate Engineer in the RCA Solid State and Receiving Tube Division; **Seymour S. Silverstein,** a Senior Engineer in the RCA Solid State and Receiving Tube Division; and John S. Vara, an Associate Engineer in the RCA Solid State and Receiving Tube Division. (The two other members of the team **G. V. Morris** and **J. F. Murray, Jr.** are employed at the RCA plant in Mountaintop, Pa.)

Lancaster, Pa.

Six engineers of the Lancaster, Pa. plant of RCA Electronic Components have received 1968 Engineering Achievement Awards.

Frank C. Fryburg, an Engineer in the Quality and Reliability Assurance Engineering Activity of the RCA Television Picture Tube Division was cited for "engineering excellence in the development of picture tube test and process control techniques."

A team award was presented to two engineers of the RCA Television Picture Tube Division for "valuable engineering contributions to the development of improved color tube phosphors"; the engineers are: **Joseph S. Martin,** Engineer in Product Development, and **Theodore A. Saulnier,** Senior Engineer in Product Development.

A team award was also presented to three engineers of the RCA Industrial Tube Division for "significant engineering contributions to a novel conversion tube": **Arthur (Pat) F. McDonie,** Engineering Leader, Manufacturing; **Frederick R. Hughes,** Engineer in Product Development; and **Thomas T. Lewis,** Associate Engineer in Product Development.

Marion, Ind.

Ting-Yang Wang of the RCA Marion Plant has received a 1968 Engineering Achievement Award of RCA Electronic Components. Mr. Wang was cited for "noteworthy engineering achievement in the mechanical improvement of picture tubes". Mr. Wang is an Engineer in the manufacturing Activity of the plant.

Scranton, Pa.

Three engineers at the RCA Electronic Components plant in Scranton, Pa., have received 1968 Engineering Achievement Awards. The engineers were selected for "significant engineering contributions to the manufacturing process of color television picture tubes". All three men are employed by the RCA Television Picture Tube Division. They are: **Edward A. Gronka,** an Associate Engineer in Equipment Development; **Donald F. Gumpert,** an Engineer in Product Development; and **Charles R. Moyer,** Associate Engineer in Manufacturing.

Dallas, Texas

James H. Owens of the RCA Sales Office in Dallas, Texas has received a 1968 Engineering Achievement Award from RCA Electronic Components. Mr. Owens was cited for "outstanding contributions to color television receiver field engineering". Mr. Owens is a Field Engineer for RCA Distributor Products.

Princeton, N.J.

Donald E. Nelson of the RCA Laboratories in Princeton, N.J., has received a 1968 Engineering Achievement Award from RCA Electronic Components. Mr. Nelson was cited for a team award for "outstanding engineering team achievement in a solid-state microwave subsystem". (The other member of the team was **T. P. Garrison** who is employed at the RCA plant in Harrison, N.J.)

Mountaintop, Pa.

Two engineers of the RCA Electronic Components plant at Mountaintop, Pa. have received 1968 Engineering Achievement Awards. The engineers were selected for a team award for "outstanding team performance in silicon power transistor engineering". The Mountaintop award winners, all employed by the RCA Solid State and Receiving Tube Division, are: **Gilbert V. Morris,** an Engineering Leader in Manufacturing and **Joseph F. Murray, Jr.,** an Associate Engineer in Manufacturing. (Other members of the team included **L. Gallace, S. Silverstein** and **J. S. Vara** of the RCA plant in Somerville, N.J.)

The Editorial Representative in your group is the one you should contact in scheduling technical papers and announcements of your professional activities.

Defense Electronic Products	
Aerospace Systems Division	**D. B. DOBSON*** Engineering, Burlington, Mass.
Electromagnetic and Aviation Systems Division	**R. J. ELLIS*** Engineering, Van Nuys, Calif. **J. McDONOUGH** Engineering, West Los Angeles, Calif.
Astro-Electronics Division	**I. M. SEIDEMAN*** Engineering, Princeton, N.J. **S. WEISBERGER** Advanced Development and Research, Princeton, N.J.
Missile & Surface Radar Division	**T. G. GREENE*** Engineering, Moorestown, N.J.
Defense Communications Systems Division	**A. LIGUORI*** Engineering, Camden, N.J. **M. P. ROSENTHAL** Defense Advanced Communication Laboratory, West Windsor, N.J.
Defense Engineering	**M. G. PIETZ*** Advanced Technology, Camden, N.J. **M. R. SHERMAN** Defense Microelectronics, Somerville, N.J. **E. J. PODELL** Systems Engineering, Evaluation, and Research, Moorestown, N.J. **J. E. FRIEDMAN** Advanced Technology, Camden, N.J. **J. L. KRAGER** Central Engineering, Camden, N.J.
Commercial Electronics Systems Division	**D. R. PRATT*** Chairman, Editorial Board, Camden, N.J. **N. C. COLBY** Mobile Communications Engineering, Meadow Lands, Pa. **C. E. HITTLE** Professional Electronic Systems, Burbank, Calif. **R. N. HURST** Studio, Recording, & Scientic Equip. Engineering, Camden, N.J. **K. C. SHAVER** Microwave Engineering, Camden, N.J. **R. E. WINN** Broadcast Transmitter & Antenna Eng., Gibbsboro, N.J.
Industrial and Automation Systems	**H. COLESTOCK** Engineering, Plymouth, Mich.
Information Systems Division	**M. F. KAMINSKY*** Engineering, Camden, N.J. **M. MOFFA** Engineering, Camden, N.J. **S. B. PONDER** Palm Beach Engineering, West Palm Beach, Fla. **R. J. McLAUGHLIN** Engineering, Marlboro, Mass.
Magnetic Products Division	**A. G. EVANS** Record Eng., Indianapolis, Ind.
Memory Products Division	**G. R. KORNFELD** Engineering, Needham, Mass.
Graphic Systems Division	**J. GOLD*** Engineering, Dayton, N.J.
Laboratories	**C. W. SALL*** Research, Princeton, N.J.
Electronic Components	**C. A. MEYER*** Chairman, Editorial Board, Harrison, N.J.
Solid State and Receiving Tube Division	**M. B. ALEXANDER** Solid State Power Device Engrg., Somerville, N.J. **R. W. MAY** Commercial Receiving Tube and Semiconductor Engineering, Somerville, N.J. **I. H. KALISH** Solid State Signal Device Engrg., Somerville, N.J. **J. KOFF** Receiving Tube Operations, Woodbridge, N.J. **K. LOOFBURROW** Semiconductor and Conversion Tube Operations, Mountaintop, Pa. **R. J. MASON** Receiving Tube Operations, Cincinnati, Ohio **J. D. YOUNG** Semiconductor Operations, Findlay, Ohio
Television Picture Tube Division	**J. H. LIPSCOMBE** Television Picture Tube Operations, Marion, Ind. **E. K. MADENFORD** Television Picture Tube Operations, Lancaster, Pa.
Industrial Tube Division	**J. M. FORMAN** Industrial Tube Operations, Lancaster, Pa. **H. J. WOLKSTEIN** Microwave Tube Operations, Harrison, N.J.
Technical Programs	**D. H. WAMSLEY** Engineering, Harrison, N.J.
Consumer Electronics Division	**C. HOYT*** Chairman, Editorial Board, Indianapolis, Ind. **D. J. CARLSON** Advanced Devel., Indianapolis, Ind. **R. C. GRAHAM** Radio "Victrola" Product Eng., Indianapolis, Ind. **P. G. McCABE** TV Product Eng., Indianapolis, Ind. **J. OSMAN** Electromech. Product Eng., Indianapolis, Ind. **L. R. WOLTER** TV Product Eng., Indianapolis, Ind. **R. F. SHELTON** Resident Eng., Bloomington, Ind.
RCA Service Company	**B. AARONT** EDP Service Dept., Cherry Hill, N.J. **W. W. COOK** Consumer Products Service Dept., Cherry Hill, N.J. **D. HALL** Govt. Service Dept., Cherry Hill, N.J. **M. G. GANDER*** Consumer Product Administration, Cherry Hill, N.J. **K. HAYWOOD** Tech. Products, Adm. & Tech. Support, Cherry Hill, N.J. **W. R. MACK** Missile Test Project, Cape Kennedy, Fla.
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*** Technical Publication Administrators listed above are responsible for review and approval of papers and presentations.**