Communication opportunities for the decade

As we look across the spectrum of new high-capacity satellite and terrestrial transmission systems, electronic switches, and arrays of terminal devices, we can foresee an unprecedented series of opportunities. Our great task is to grasp these opportunities innovatively and quickly and to apply them to create better and more abundant communications at lower effective cost for the future.

We can look forward to seeing and living in real time not merely in our immediate surroundings but around the world and beyond. We can be in touch anywhere and everywhere by means of electronic voice, record, and video communications. What could be more exciting for those who are privileged to share in the unprecedented communications opportunities and benefits of our time!

However, these achievements from the practical applications of technology will not come about automatically or by happenstance. There will be accelerating pressures for improved performance, at lower effective cost, within quickened time frames, and in an increasingly competitive environment. We in RCA no doubt can rise to challenges and thereby share in these opportunities that lie ahead for this decade.

Howard R. Hawkins
Executive Vice President, RCA Corp.,
Chairman and Chief Executive Officer,
RCA Global Communication, Inc.
New York, N.Y.

Our cover

... draws upon the talents of MSRD's Andy Whiting to capture the broad range of services provided throughout the world by RCA Global Communications, Inc. The style brings us back in time about 50 years — to a time when RCA was becoming established as an international communication carrier (see Quinn and Strebel, p. 38).

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Oct | Nov
1973

A technical journal published by
RCA Research and Engineering
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Bldg 204-2 (PY-4254)

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.

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

Contents

Emphasis — Global Communications

editorial input

expanding service for a growing world

On October 17, 1919, the Radio Corporation of America was incorporated as the first American company to handle international radio communications. At that time, the best known means of long distance wireless transmission was the Alexanderson high frequency alternator.

Things have certainly changed in 55 years. The Alexanderson alternator is now a museum piece, and RCA — in addition to pioneering in electronics and communications — has become a leader in many other businesses — from auto renting to space exploration. And through this period of change, perhaps most significant has been the revolution in international communications that has bridged national boundaries by allowing the peoples of the world to communicate their voices, pictures, and information to one another virtually without delay.

Today, RCA Global communications, Inc., continues to be at the forefront of this revolution by matching the needs of a rapidly advancing and growing society with new technology, equipment, and services.

Globcom maintains worldwide facilities to provide businessmen, government agencies, and the news media with a variety of services, including:

—Leased channels
—Overseas telegraph
—Phototransmission
—International telephone
—Marine telegraph
—Data transmission
—Intercontinental television
—Overseas news broadcasting
—Communications system and equipment leasing
—Communications network management

Globcom's subsidiary, RCA Alaska Communications, Inc.:

—Operates long-lines communications systems for Alaskan intra and interstate telephone service.
—Provides telex, private line, and data communications for Alaska.
—Handles television transmission via satellite for the entertainment and education of Alaska's citizens.

This year, RCA is investing about 40% of its capital expenditures in improving these services and initiating new ones.

The first half of this issue describes some of Globcom's more recent engineering activities. These papers should give the reader an insight into the type of work being done and into some of the programs being planned for the future.

Readers interested in more information on the engineering organization behind these programs should see "RCA Global Communications, Inc.: an engineering profile" by Ed Williamson in the June-July issue of the *RCA Engineer* (Vol. 19, No. 1).

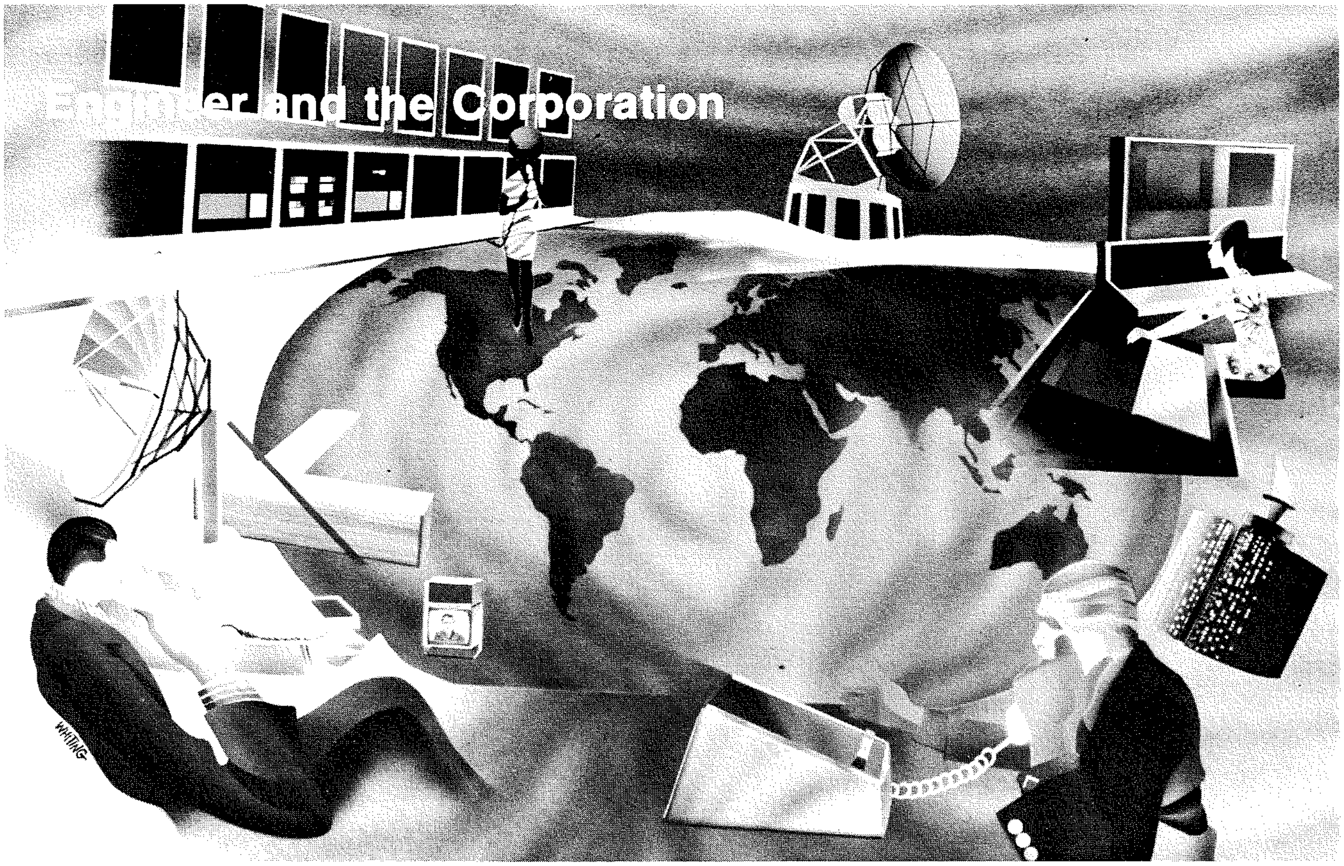
— J.C.P.

The next issue of the *RCA Engineer* will feature broadband communications. Some of the topics to be covered are:

Cable television systems
Cable television receivers
Consumer information systems
Color frame-freeze equipment
Wideband recording systems
Linear transistors amplifiers
UHF television exciter

Discussions of the following themes are planned for future issues:

Communications, command, control
RCA, Ltd., Canada
International activities
Consumer electronics
Product design
SelectaVision
Advanced communications
Electro-optics



Social implications of world communications

E. F. Murphy

International communications technology has conferred on man the revolutionary capacity to engineer his environment. The primary social impact of international communications is the central role it plays in creating a firm basis on which to found world peace. The traditional barriers separating diverse social segments cannot long withstand the vastly improved flow of information across oceans and continents. Other social aspects include the advancement of education, especially in underdeveloped areas lacking adequate schools, teachers and educative materials; the promotion of international trade; the extension of medical and health care services on a worldwide basis; the promotion of more effective international law enforcement; and long distance data exchanges aided by the interconnection of numerous branches of computers.

THE ERA of intercontinental electronic communications opened on August 16, 1858 when Cyrus Field, builder of the first transatlantic cable, transmitted the following message between New York and London: "Europe and America are united by telegraphy. Glory to God in the highest, on earth peace and good will towards men." Since that date, dramatic assaults on time and space have been mounted and have produced telephone, radio, television, and the communications satellite. Nonetheless, at present, world communications technology, as potent and promising a force as it is, is still in its infancy. The task of this paper is to explore the complex and far-reaching social implications of this force which has conferred on man revolutionary capacity to engineer his environment.

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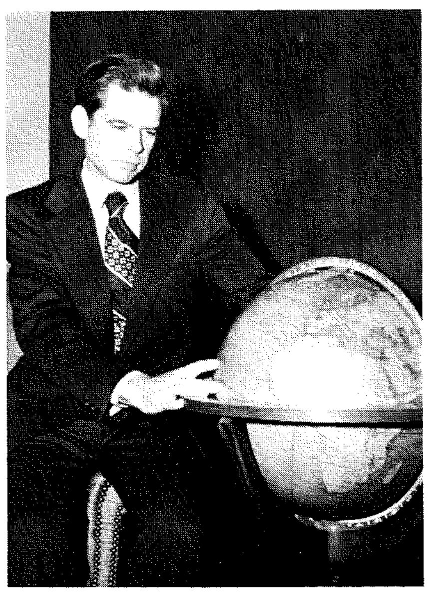
Eugene F. Murphy, Executive Vice President, Operations, RCA Global Communications, Inc., is responsible for worldwide satellite, cable and radio operations, Government leased channels, regulatory matters and operating arrangements, and administration of District operating offices. Mr. Murphy joined the Company as an attorney in 1964, after working as a litigation attorney and also serving with the Central Intelligence Agency. He was appointed Vice President and General Counsel in 1969 with responsibility for all legal matters affecting the Company's worldwide communications interests. He also played an important role in RCA's acquisition of the Alaska Communication System and is a director of RCA Alaska Communications, Inc.



Contribution to world peace

The most important social impact of world communications is the central role it plays in creating those conditions upon which world peace is based. For it is ideas that constitute the foundation on which the whole edifice of human social cooperation is constructed and sustained; and as pointed out in the Preamble to the Constitution of UNESCO: "ignorance of each others ways and lives has been a common cause throughout the history of mankind of that suspicion and mistrust between the peoples of the world through which their differences have all too often broken into war."

It is a characteristic feature of world communications that it expands the amount of information available to the world's peoples about each other and lays a foundation for a broader understanding that is inconsistent with chauvinistic and xenophobic sentiments.

Indeed, the media of intercontinental television transmission and the international press (which depends upon world telegraph, data and facsimile services to speed the collection and dissemination of news[1]) have conferred on peoples in distant lands an opportunity without precedent to communicate and collaborate. As the flow of data regarding diverse cultures, traditions, and religions increases, broad differences between social segments in different nations tend to decline.[2] Moreover, the shared experience of dramatic human ventures, such as the American lunar space exploration and President Nixon's visits to Peking and Moscow, materially contribute to building a genuine spirit of international community.[3] It is a fact, as David Sarnoff has written, that modern international communications have opened a "vista of unlimited range for linking the world in a common dialogue, with incalculable effects on the thinking, the understanding, and the culture of all mankind.... The day of the closed or remote society is coming to an end. No barriers of time or distance or ideology can long withstand the mounting flow of information and the vastly improved access to information across the oceans and continents. The awareness of knowledge is the first step to its acquisition, and the acquisition of knowledge is, in turn, fundamental to human advance in every sphere.

Advancement of education

International communications in general and satellite communications in particular have opened up solutions to the pressing problems of educating the illiterate masses in the world's underdeveloped areas. By transoceanic television broadcasts, the best teaching and the newest pedagogic methods can be shared, and the opportunity to learn can be universalized. Educators may reach students where-there are no schools, offer courses where local teachers are not equipped to teach them, and in fact, give every individual free access to all educational material needed for his personal training.

Other educative uses for satellite communication include the training of teachers and instructors in countries in which they will shortly be in severe need, the advancing of health, agricultural and vocational skills and the broadcast of programs of civic and cultural activities where reinforcement is necessary to contribute to national unification.[5].

Of course, the role open to international educational tv in more highly developed countries also merits fostering.

Promotion of international trade

The growth of international trade and the rise of the multinational corporation is traceable, in part, to world communications progress. Without the broad range of voice and video services available to industry, substantial inroads against economic isolationism could not be made. The free flow of goods and services across national borders, the most efficient utilization of capital, labor and natural resources, and the development of backward economic sectors are all supported by the communications function. International industrial activities would be sharply restricted without the capacity to quickly collect and analyze vital data, schedule intercontinental business conferences, and control operations spread over large areas.

Other social implications

The impact of modern world communications on medical and health care services is made evident by noting that expert medical diagosis, prognosis, and treatment are potentially available instantaneously on a worldwide basis wherever there is a communication link to qualified specialists. Several years ago open-heart surgery was televised live via satellite from the US to Switzerland, with Swiss doctors asking questions of the surgeon thousands of miles away while the operation was in progress. Furthermore, it is anticipated that a multitude of new uses will develop, e.g., a group of prominent internists have proposed the establishment of an international diagnostic communication center. This would mean that a patient's medical records, including such things as televised electrocardiograms, could be transmitted instantly via satellite to wherever consultants were situated.

Other areas of impact relate to more effective international law enforcement, the instantaneous transmission of weather forecasting data to distant agricultural communities and long distance data exchange aided by the interconnection of numerous banks of computers. It is possible to forsee a time when the great libraries of the world will be codified for electronic research and retrieval, providing the researcher with instant access to the particular information he is seeking.

As the foregoing has illustrated, world communications technology offers humanity unique opportunities to extend freedom of action and enhance knowledge. In fact, it approximates almost unlimited usefulness to man.

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1. See Ray, "Telecommunications and the Transmission of News", printed in *Communication in the Space Age* (UNESCO 1968).
2. Encyz, *International Communications*, p. 98 (UNESCO 1970).
3. See Schramm, "Some Possible Social Effects of Space Communications", printed in *Communications in The Space Age* (UNESCO 1968); Baram, "On the Impact of The New Communications Media Upon Social Values", 34 Law & Contemporary Problems 244 (1969).
4. D. Sarnoff, *Looking Ahead*, (McGraw-Hill 1968) p. 163, 168.
5. U.S. & India Agree on Experiment in Instructional TV", 61 State Department Bull. 334 (October 20, 1969).

Development of international leased-channel networks

P. B. Silverman | S. Schadoff

From inception to final implementation, the development of an international leased channel network represents a major challenge for RCA Global Communications, Inc. Contributing to the dimensions of this challenge are the complex operational, technical, logistic, and quite often political problems which demand viable solutions if a subscriber's leased channel requirements are to be accomodated. The analysis of RCA Globcom's response to this challenge demonstrates both the magnitude of the typical problems encountered and the methodology employed to solve them.

Saul Schadoff, Mgr, Commerical Leased Channels, RCA Global Communications, Inc. New York, NY, enlisted in the U.S. Army Signal Corps at the start of World War II while attending the City College of New York. He received an honorable discharge four years later after having served as a cryptographer in the War Department Signal Center in Washington and in the Pacific Theater of Operation. Since joining RCA in 1946, Mr. Schadoff has held a number of management assignments in Traffic Engineering, Operations, and Leased Facilities and Engineering. In his current position, he has world-wide product responsibility for RCA Globcom's Commercial Leased Channel Service. He has served as a member of the National Industry Advisory Committee (NIAC) to the FCC.

Paul B. Silverman, Mgr., Customer Projects, RCA Global Communications, Inc., New York, NY, received the BS in Physics from the City College of New York in 1969 and has completed all course requirements for the BEE. Presently attending Polytechnic Institute of Brooklyn. Mr. Silverman will receive the MS in Management Science within several months. Since joining RCA Globcom in 1968, he has been actively involved in all areas of leased channel operations including planning, engineering, and implementation of a number of major leased channel networks. In his current position, he has project engineering responsibility for major leased channel projects within the Commercial Leased Channel area. Mr. Silverman is a member of the IEEE—Communications Technology Group.

Authors Schadoff (left) and Silverman.

INTERNATIONAL communications is a most complex business—a business fraught with challenging technical, operational, and quite often political problems that must be solved if an international record carrier is to provide its subscribers with efficient, reliable, and cost-effective communication service throughout the world. And *service* is the key word—for international communications is first and foremost a service-oriented business that is in operation twenty-four hours a day, seven days a week, three hundred sixty five days a year. As we shall see, it is a formidable task for an international record carrier to develop an international communications circuit from inception through final implementation and acceptance. And it is an even greater challenge to maintain an international communications circuit which perhaps spans several continents, incorporates sophisticated multiplex equipment at remote locations and is subject to a host of operational anomalies that can immobilize it at any time.

Point-to-point example

To gain insight into some of the problems associated with both the development and operation of an international communmicaitons channel, let us analyze a typical example. Consider the point-to-point simultaneous voice/record circuit illustrated in Fig. 1 for XYZ Corporation.

Upon receiving an order to provide the service depicted in Fig. 1, RCA Globcom, in a joint effort with the respective overseas "correspondent" (such as the General Post Office in the United Kingdom or Radio Suisse in Switzerland) would make arrangements to reserve one international voice-grade circuit for the exclusive use of XYZ Corporation. The international circuit could be routed via either cable or satellite facilities and would be provided between the respective central office of each international carrier as indicated in Fig. 1. A suitable voice-grade facility with proper circuit conditioning would be provided by the local Bell System affiliate between XYZ Corporation's domestic location and RCA Globcom's central office. Similarly, overseas the respective local carrier

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would provide the necessary voice-grade circuit between XYZ Corporation's overseas location and the international carrier's central office. Both RCA Globcom and the overseas correspondent would provide appropriate equalizers and circuit conditioning equipment to smooth the transmission characteristic of the overall circuit thus enabling XYZ Corporation to utilize the circuit for the transmission of high speed data.

RCA Globcom, as prime contractor for the international circuit, would accept end-to-end responsibility for the service, from inception through the operational phase. Thus RCA Globcom would, on behalf of XYZ Corporation, attend meetings with both domestic and overseas carrier representatives, develop specifications for all required landlines and multiplex equipment and maintain overall project coordination of all activities needed to implement XYZ Corporation's international communications network.

Economic considerations

To justify the cost of a dedicated international circuit, it is almost mandatory that the international circuit and associated multiplex equipment interconnect into the subscriber's existing voice-switching system at each location and also gain access to the respective public networks. At this point in the planning phase, we encounter one of the major challenges in the design of an international communications circuit the integration of two voice-switching systems, often separated by thousands of miles and widely diversified technologies, to provide an international voice circuit that is operationally viable for XYZ Corporation's domestic and overseas locations. The specific mode of voice-circuit operation on the circuit, whether it is foreign exchange, manual ringdown, or a bi-directional dial repeating tieline, will depend upon XYZ Corporation's unique requirements and all applicable system constraints. A system constraint may be potential timing problems encountered when attempting to integrate a domestic Centrex-ESS operation with an overseas step-by-step system for a dialing application. Or a system constraint may be the inability of the manufacturer of the overseas switchboard to provide the necessary trunk circuitry to interconnect to the RCA Globcom multiplex equipment. Or a system constraint may be the overseas administration, for economic or political reasons, denying the subscriber access to the overseas public network from the dedicated international circuit. Working within the framework of the subscriber's operational requirements and all applicable system constraints, RCA Globcom will—after a series of meetings with both domestic and overseas carrier representatives—develop technical and operational specifications for both the domestic and overseas public network interconnects.

Another factor in the cost justification of the international circuit is the ability of XYZ Corporation to transmit high speed data on an alternate basis with the voice transmission. RCA Globcom recommends or provides at all locations whatever data transmission equipment is necessary to satisfy the subscriber's unique data transmission requirements. During the planning stages system interface and timing criteria are developed for all locations to insure overall system compatibility between the subscriber's domestic and overseas data terminal equipment. Due to the long propagation delays associated with international circuits (*i.e.*, nominal round trip delay—cable: 100 ms; satellite: 600 ms), it is necessary to investigate the impact of reduced system throughput and increased response time on the subscriber's existing data system operation. The system throughput and response time characteristics can be especially critical if the subscriber's data system utilizes an error detection and retransmission scheme and is configured for multi-point operation. As the prime contractor for the international circuit, RCA Globcom would attend meetings with the subscriber's data processing staff in addition to vendor representatives to insure that the proposed data system is both technically and operationally viable.

Multiplexing

Next in the planning phase we have the problem of multiplex equipment. RCA Globcom designed "Simultaneous Voice/Record" or "Speech-Plus" multiplex equipment will enable XYZ Corporation to utilize the international circuit for the transmission of several low speed teletype channels simultaneously with either voice or data signals. Each multiplex terminal must be custom-

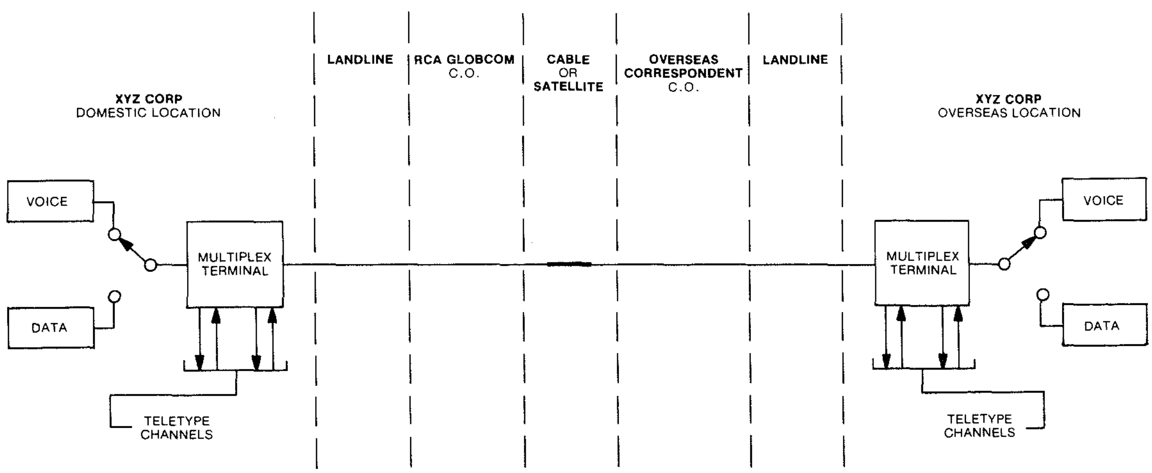

Fig. 1 — Point to point simultaneous voice/record circuit.

engineered to satisfy the unique "communications mix" required by a particular subscriber. For example, XYZ Corporation may require alternate voice and data transmission at 4800 bits/second with the simultaneous derivation of two 75 baud low-speed teletype channels whereas another subscriber may require the same alternate voice/data capability indicated; however only one simultaneous teletype channel operating at a speed of 134.5 bits/second may be necessary. Whatever the subscriber's unique reqtirements are—and quite often they involve complex variations of the basic SVR service offering including remote switching schemes and sophisticated monitoring systems—each multiplex terminal must be custom engineered during the planning phase to satisfy the unique requirements of a particular subscriber. Thus, for the XYZ Corporation requirement illustrated in Fig. 1, the speech-plus multiplex equipment provided would be engineered to support alternate voice/data transmission and the derivation of two seventy-five baud teletype channels.

Type approval

Another aspect of the planning phase related to the multiplex equipment is the problem of "type approval". Any telecommunications equipment that is to be utilized for interconnection into the public network of an overseas administration must receive formal "type approval" by the respective administration before it can be installed. Type-approval proceedings can be expensive, time-consuming processes which can considerably increase the lead time needed to implement an an international communications circuit. In addition, each time the multiplex equipment is modified, however slightly, it must usually be formally re-submitted for type approval. The rigidity of the type approval proceedings vary from country to country with some overseas administrations such as the Netherlands Postal & Telecommunications Services (PTT) merely requiring an independent testing laboratory to certify that the multiplex equipment meets the prescribed standards set forth by the PTT. The General Post Office (GPO) in the United Kingdom, however, requires that the multiplex terminal be shipped to their premises where it undergoes an extensive analysis by the GPO engineering staff. If modifications are required, and they usually are, the unit is returned and must be formally re-submitted for type approval once the required modifications are completed. The unforeseen delay incurred during type approval proceedings can quite often render the most carefully planned system installation schedule useless.

Implementation

Upon completion of the planning phase, the international speech plus circuit for XYZ Corporation can be implemented. Prior to the system cutover date, all landlines will have been installed. All multiplex equipment will have been fabricated, tested, and shipped to both the domestic and overseas locations. The necessary type approval will have been received from the overseas administrations. The international facility reserved for XYZ Corporation will have been tested and conditioned in accordance with the appropriate transmission specifications. Assuming the above tasks are accomplished, the system will be installed on the target date. RCA Globcom technicians will be at XYZ Corporation's domestic and overseas locations to insure proper circuit line-up on an end-to-end basis. Upon completion of the system installation, a short system debugging period will follow after which time the international circuit will be considered operational for XYZ Corporation.

Maintenance

For maintenance, the international leased channel (Fig. 1) is a major challenge. Contributing to the dimensions of this challenge are several interelated factors. First, there are public network interconnects at both the domestic and overseas location that are effectively beyond the control of the international record carrier since at no point do they interconnect to an RCA Globcom central office. To alleviate this problem, RCA Globcom has incorporated considerable diagnostic and monitoring aids within each "speech-plus" multiplex terminal to enable system failures to be rapidly isolated and corrected. A second maintenance problem relates to staffing considerations. Due to the widely scattered subscriber locations throughout the world, site selection and staffing analysis of the overseas maintenance centers are critical factors in the performance of the overall system maintenance effort. By carefully analyzing both the existing communication services and future growth trends, RCA Globcom optimizes the site selection of the overseas maintenance centers so as to provide minimum service response time to the greatest number of subscriber locations. Another challenge to the maintenance effort is the lack of qualified technical personnel at certain overseas locations. To effectively maintain the system indicated in Fig. 1, the overseas maintenance personnel must be trained in the areas of high-speed data transmission, voice-transmission techniques, teletype systems, and "speech-plus" multiplex technology. Domestically it is a difficult task to find maintenance personnel who are equipped with the diversity of skills indicated. Overseas, the problem is compounded considerably.

Conclusions

While the development of an international leased-channel network represents a major challenge for RCA Globcom, the demands in the future will undoubtedly be greater. To remain competitive in the leased channel area, creative new service offerings must be developed, each designed to satisfy a segment of the overall leased-channel market. Two prerequisites for successful market segmentation will be the ability to both identify future leased-channel markets and utilize technological advances to create viable new leased channel services. It is the writers' view that based upon these factors continued growth can best be achieved by pursuing a total marketing concept within the leased-channel area. This implies greater interaction between engineering and marketing groups coupled with increased use of market research and forecasting techniques to define potential market areas and future technological trends.

By pursuing a total marketing concept, RCA Globcom would be well equipped to adapt to the increasingly competitive and rapidly evolving leased channel market in the years ahead.

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1. Silverman, P.B. "International Communications—An Overview", presented at Western Electronic Show and Convention (WESCON), September 1972. (To be published in *Proceedings — WESCON '72*)

The quality of international leased channel service

G. Berman

RCA Globcom assumes an end-to-end responsibility for leased channel service, though it has direct control over only a small portion of the many links that are required to maintain service. A Quality Control Program of error detection and error correction has been established. The automated Leased Channel Reliability System is at the heart of the program. In operation less than three years, the program has resulted in improved reliability, cost savings, and a broader concept of service quality. The remaining goal of the program is error prevention.

LEASED CHANNEL TROUBLE TICKET DVTS-NY — RCA Global Communications

TIME/DATE REPORTED (TIME STAMP)

TICKET NO. ____ PREPARED BY (SINE) ____ SUPERVISOR SINE ____ TIME/DATE RESTORED ____

L/C NUMBER ____ CHANNEL ASSIGNMENT ____ SUB SINE ____ RCA SINE ____ SUB TICKET # ____

SUBSCRIBER'S NAME ____ CALL BACK NUMBER ____ TIME TO OMT ____ OT/OMT SINES ____

WAS TROUBLE AN OUTAGE? ____ IMPAIRMENT? ____ DISTURBANCE? ____ ELAPSED TIME ____ MINS

LOCATION CODE ____ REASON CODE ____ REFUND TIME ____ NO REFUND ____ APPROVAL SIGNATURE ____

(ENTER CODES FROM REFERENCE TABLES ON REVERSE SIDE)

ORIGIN OF TROUBLE OTHER THAN SUBSCRIBER ____ CALL BACK NUMBER TELEX/PHONE ____

TROUBLE REPORTED

TELEGRAPH	VOICE/DATA
☐ GARBLING IN/OUT	☐ LEVEL HI/LO
☐ OPEN IN/OUT	☐ NOISE/JITTER
☐ NO CONTACT	☐ HIGH ERROR RATE
☐ HUNG	☐ OUT OF SPEC
☐ SUBSCRIBER'S EQUIPMENT	☐ NO CONTACT
☐ OTHER (EXPLAIN)*	☐ WILL NOT PASS DATA
	☐ SUBSCRIBER'S EQUIPMENT
*EXPLAIN BELOW	☐ OTHER (EXPLAIN)*

ASSIGNMENT RECORD (1)
TIME ASSIGNED ____ SINE ____
TIME RETURNED ____ SUPVR SINE ____
COMPLETED ____ PENDING ____
TIME SUB INFORMED ____
TIME D/E CTO OR OTHER RCA CTO INFORMED ____

ASSIGNMENT RECORD (2)
TIME ASSIGNED ____ SINE ____
TIME RETURNED ____ SUPVR SINE ____
COMPLETED ____ PENDING ____
TIME SUB INFORMED ____
TIME D/E CTO OR OTHER RCA CTO INFORMED ____

ASSIGNMENT RECORD (3)
TIME ASSIGNED ____ SINE ____
TIME RETURNED ____ SUPVR SINE ____
COMPLETED ____ PENDING ____
TIME SUB INFORMED ____
TIME D/E CTO OR OTHER RCA CTO INFORMED ____

TIME/SINE	REMARKS: TECHNICIAN ACTIONS AND EXPLANATIONS (MANDATORY FOR CODES "07" OR "T")

921899/041015447 4/72

ATTACH ADDITIONAL TICKETS IF REQUIRED

Fig. 1a — Leased Channel Trouble Ticket form.

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In the simplest leased channel configuration, RCA Globcom provides its leased channel subscribers with a full-time, full-duplex communication channel capable of transmitting and receiving slow-speed telegraph signals between one domestic and one international location. In its more complex form, the leased channel is capable of simultaneously transmitting voice, facsimile, or high-speed data, as well as slow-speed telegraph signals. The leased channel also may be interconnected to computer switches, which interface with multi-level communication networks at either or both the domestic and distant end of the leased channel.

RCA Globcom has in most instances direct control over only a small portion of the many links and equipments that are required in establishing the leased channel service. Most of these links and equipments are provided by other communication carriers both domestically and abroad. Additionally, the subscriber may provide some of his own equipment.

The leased channel subscriber views quality in the overall performance of his service and is basically not interested in the quality of the various segments that are required even in the simplest leased channel configuration. Furthermore, he expects RCA Globcom to maintain the quality and respond promptly to his quality problems regardless of where they occur. One faulty link or piece of equipment, whether located in an RCA Globcom control room or in a remote part of the world, can interrupt or degrade the service on the entire leased channel.

Leased channel troubles

Once leased channel service has been inaugurated, there are three types of service troubles that the subscriber may experience. (A leased channel trouble is defined as any reported problem concerning the function of leased channel service.)

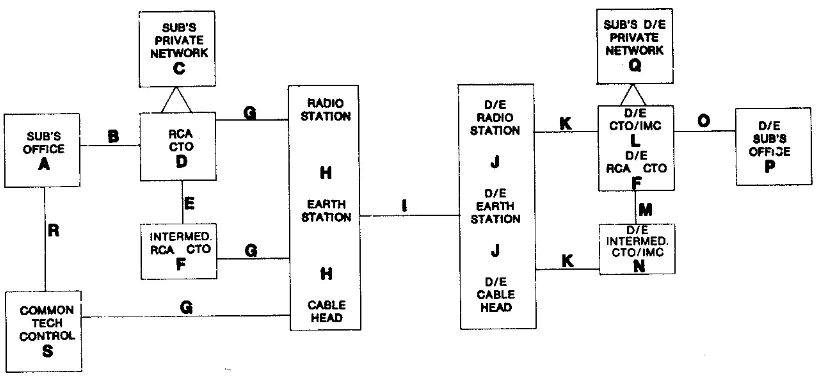
—An *outage* is a trouble that interrups leased channel service and prevents its usage.

—An *impairment* is a trouble that degrades but does not interrupt the usage of leased channel service.

—A *disturbance* is a trouble that either interrupts or degrades the usage of leased channel service, but is beyond RCA Globcom's assumption of end-to-end operational responsibility.

Generally an outage occurs when the leased channel subscriber is prevented

LEASED CHANNEL TROUBLE TICKET — CODE REFERENCE TABLES



LOCATION OF OUTAGE

CODE	DESCRIPTION
A	Subscriber's Office
B	Subscriber to CTO Line
C	Subscriber's Private Domestic Network
D	RCA CTO (Determined by Leased Channel Designator)
E	Landline between RCA CTOs
F	Intermediate RCA CTO or Distant End RCA CTO
G	RCA CTO or Common Tech Control To Bearer Facility Terminal
H	Bearer Facility Terminal (Earth Station, Cablehead or Radio Station)
I	Submarine Cable/Satellite/Radiopath

CODE	DESCRIPTION
J	Distant End Bearer Facility Terminal
K	D/E Bearer Facility Terminal to D/E IMC/CTO
L	D/E IMC/CTO (Use Code "F" for D/E RCA CTO)
M	Landline Between D/E IMCs/CTOs
N	D/E Intermediate IMC/CTO
O	D/E IMC/CTO To D/E Subscriber's Office
P	D/E Subscriber's Office
Q	D/E Subscriber's Private Network
R	Subscriber To Common Tech Control
S	Common Tech Control Facilities
T	Other — Please Explain

REASON FOR OUTAGE (RFO)

GENERAL

01	Power Failure
02	No Contact
03	Personnel, Format or Procedure Error
04	Aircon Trouble
05	Cleared While Checking
06	Undetermined
07	Other — Please Explain

CIRCUITRY

08	Carrier Failure
09	Submarine Cable Failure
10	Satellite Failure
11	Open Circuit
12	Grounded/Shorted Line/Foreign Battery
13	Propagation
14	MUX Rephase
15	Retuned HF XMTR/RCVR
16	QRM
17	Incorrect Level
18	Phase Jitter/Frequency Translation
19	Delay/Amplitude Response
20	Cross Talk/Foreign Tone
21	White/Impulse Noise
22	Circuit Release

EQUIPMENT

23	Teleprinter Equipment Trouble
24	Customer Supplied Equipment Trouble
25	SVR Equipment Trouble
26	Switching Equipment Trouble
27	Storage/Speed Conversion Equipment Trouble
28	MUX Equipment Failure FMVF/TDM/ARQ
29	HF XMTR/RCVR Trouble
30	Bad Amplifier/Bad Equalizer
31	Cords and Jacks/Mispatch
32	Equipment Trouble (Not Described in 23-31)

Fig. 1b — Reverse side of Trouble Ticket form, showing coding descriptions.

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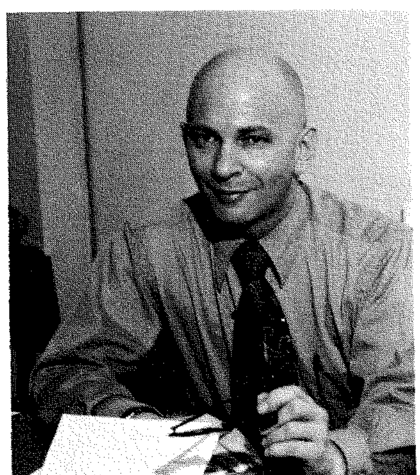


from transmitting and/or receiving between his domestic and overseas offices. For example, a submarine cable break that interrupts service is classified as an outage.

An impairment usually occurs when the subscriber can continue, or chooses to continue, to both transmit and receive despite the existence of trouble. If a subscriber reports that he is receiving an excessively high error rate but continues to use the leased channel and refuses immediate corrective action, the trouble is classified as an impairment.

Disturbances generally occur as a result of subscriber error or failure of subscriber-provided equipment. Subscriber-caused troubles include placing control switches in the incorrect position, using incorrect formats, or turning off power in their offices. The malfunction of the subscriber's computer is also classified as a disturbance.

Trouble detection and recording

Subscriber notification to an RCA Globcom control center is the primary source of discovering leased channel troubles. The subscriber is aware that certain types of troubles, given the present state of the art, are almost impossible or prohibitively costly to detect by other means. Control room detecting devices and notification by the domestic or distant-end communication carrier are other sources of discovering leased channel troubles. Sales or any other RCA Globcom function that has contact with the subscriber are also sources of discerning leased channel troubles. Once a trouble is reported, corrective maintenance is immediately instituted by control room personnel. At this juncture it is the prime responsibility of the control room to take corrective action designed to restore leased channel service as expeditiously as possible. The restoration of service may require the coordination of corrective action between two or more RCA Globcom operating districts. The responsibility for the coordination of the troubleshooting process among the various districts has been delineated in advance.

When a leased channel trouble is reported or detected, a Leased Channel Trouble Ticket is prepared. The Trouble Ticket (see Fig. 1) provides the necessary information needed by the technician to begin the troubleshooting process. The Trouble Ticket is also the basic source document for the Quality Control System.

The Trouble Ticket is used to record the complete history of the troubleshooting process. Each day in all operating districts the completed Trouble Tickets for the previous day are classified, codified, and then abstracted on the Leased Channel Outage Control Sheet.

For each Trouble Ticket there is a one-line entry on the Outage Control Sheet which provides the leased channel identification number, the time and date the trouble began; the time and date that service was restored, and by use of standarized codes, the reason for the trouble (32 possible categories), and the location of the trouble (20 possible categories).

The Outage Control Sheets are transmitted daily to Service Assurance at RCA Globcom's New York City headquarters. RCA Globcom districts with leased channel operating responsibilities are located in New York, San Francisco, Washington, D.C., Miami, Honolulu, Guam, San Juan, and Manila. When two or more districts work on the same trouble, separate Trouble Tickets are used in each. However, only the district with the designated responsibility for the leased channel reports the trouble to Service Assurance.

The current Quality Control Program is essentially one of error detection and error correction.. It is based on the measurement of leased channel operating performance, the comparison of the performance to a well-defined quality standard, the evaluation of the results of the comparison, and then the planning of corrective action on the basis of the evaluation. For error prevention, automated programs are planned.

Service assurance operations

RCA Globcom's Service Assurance section is responsible for evaluating the effectiveness of the quality control methods, certifying these methods as acceptable, and seeking improvements where they are not. Service Assurance also reports to management on how well the total quality function is being performed.

It is the responsibility of Service Assurance to summarize and analyze the trouble data. The results of the analysis are then compared to an established service quality standard. The results of the comparison are reported to various levels of management. Below-standard performance leads to the seeking of corrective action. Above-standard performance can lead to an upward adjustment in the quality standard or reflect a continued improvement in performance. The reliability of each leased channel is calculated and then compared to standard. Leased channel reliability is defined as the ratio of realized or actual circuit time to the total scheduled operating time, with this ratio then being expressed as a percentage.

The reliability standard for telegraph leased channels operating through New York control is 99.3% for a week. Since virtually all leased channels are scheduled to operate twenty-four hours a day, seven days a week, any outage or combination of outages totalling 75 minutes or more will cause a leased channel to fall below the reliability standard of 99.3%.

There are many benefits derived from quality measurement of leased channel performance. These benefits include the ability to know present performance and determine if improvement or deterioration is taking place; the detection of trouble trends and specific trouble areas; the highlighting, with a detailed analysis, of individual or groups of troublesome leased channels; a springboard for in-depth studies of types of equipment or geographical trouble spots; and the creation of management awareness to the performance of operations. These benefits are made possible by use of the Leased Channel Reliability System.

Leased channel reliability

The system is a series of automated statistical quality reports based on the data contained in the Leased Channel Outage Control Sheets. The Leased Channel Reliability System is designed to be responsive to the informational requirements of those managers concerned with the problems of leased channel reporting, channel reliability, and channel maintenance. The purpose of the system is to improve managerial control over leased channel operations by providing managers with timely and accurate information. A brief description of the individual reports will be useful in understanding the system.

1) The Master File Listing is a master list of all leased channels. The listing provides the activation and de-activation date of each channel, the type of channel (teletype, voice/data, etc.), the mode (radio, cable, satellite, etc.), the type of user (commercial, government, etc.), and the scheduled operating time. At the end of the listing is a summary of all changes in the list from the previous month. The Master File Listing is extremely important in both coordinating corrective action and trouble reporting to a system that now encompasses over 1000 channels that terminate in virtually every country in the world.

2) The Valid Transaction Listing is a complete listing of all outages that occurred during the month. It provides the same information contained on the daily Leased Channel Outage Control Sheets. However, it is organized by the individual leased channel. The listing provides the complete monthly outage history for each leased channel under one heading. The responsible managers no longer have to review or keep on file 30 separate daily reports in order to ascertain this important data.

3) The Reliability Recap is a summary of each leased channel's reliability performance for the month. The leased channel is identified by its number, type, mode, and class. The leased channel's reliability, total outage minutes, total number of outages, and the mean time to restore service are shown. Additionally the number of outages and the total outage minutes in each of the 32 Reason For Outage (RFO) classifications is shown. The Reliability Recap highlights those channels having poor reliability and indicates the specific problem areas. Used in conjunction with the Valid Transaction Listing, it provides the basic data required for corrective action planning.

4) The Grid-Point Analysis is prepared for each operating district. It is a graphic presentation of total outage minutes experienced by all of the district's leased channels by RFO and location. The Grid-Point Analysis provides an overview of the district's problem areas and pinpoints the types of problems and their locations that are affecting the performance of many leased channels. The percentage of total minutes to the district's total outage minutes is shown both for each RFO and each location and is a special feature of the analysis that immediately identifies the biggest problem areas.

5) The Systemwide Recap shows the system's and each district's reliability, total outage minutes, total number of outages, and the mean time to restore service. There are separate recaps for telegraph leased channels and voice/data leased channels as well as for all leased channels. The recap provides management with the overall quality picture of leased channel service.

The Leased Channel Reliability System's statistical reports are issued monthly, accompanied by an analysis which discusses specific problem areas, identifies trouble trends, compares performance to previous months, highlights specific subscriber problems, seeks corrective action, and reports on the results of corrective action taken. To obtain faster corrective action, there are daily reports on specific troubles and weekly reports that list all channels with below-standard performance.

Results of quality program

One of the major results of the quality program in the last two years was the discovery that only approximately one-half of the reported troubles result in outages. It has been traditional to record outage information for the purpose of determining if the subscriber would be allowed proportional credits for interruptions in his service.

Credits are given when an outage occurs in a location within RCA Globcom's assumption of end-to-end responsibility and not only in those locations where full operating control is maintained. Further investigation was undertaken on those troubles that did not result in an interruption of service or when the interruption was beyond the assumption of end-to-end responsibility.

After extensive analysis it was concluded that degraded service had a profound impact on service quality from the subscriber's point of view, an impact perhaps equal to that caused by interrupted service. It was also learned that the subscriber himself was causing many troubles and this too created a negative impact on his overall view of service quality. Subscriber error raised questions as to the ease with which the equipment configurations provided to the subscriber could be operated and as to the effectiveness of the operating manuals and instructions as well.

To make use of this new information the various types of troubles (outages, impairments, and disturbances) were defined, guidelines were distributed, and seminars were held for operating personnel.

The Leased Channel Trouble Ticket was re-designed and reporting of all leased channel troubles systemwide was begun in February 1972. To tie all of these elements of leased channel quality together the Untroubled Service concept was developed.

Untroubled service concept

Untroubled service is expressed as a percentage, and has the same relationship to all leased channel troubles including outages as the reliability percentage has to outages alone. The untroubled service percentage gives a measurement to the operating time when the subscriber is being provided "perfect" service, whereas reliability is only a measurement of uninterrupted service.

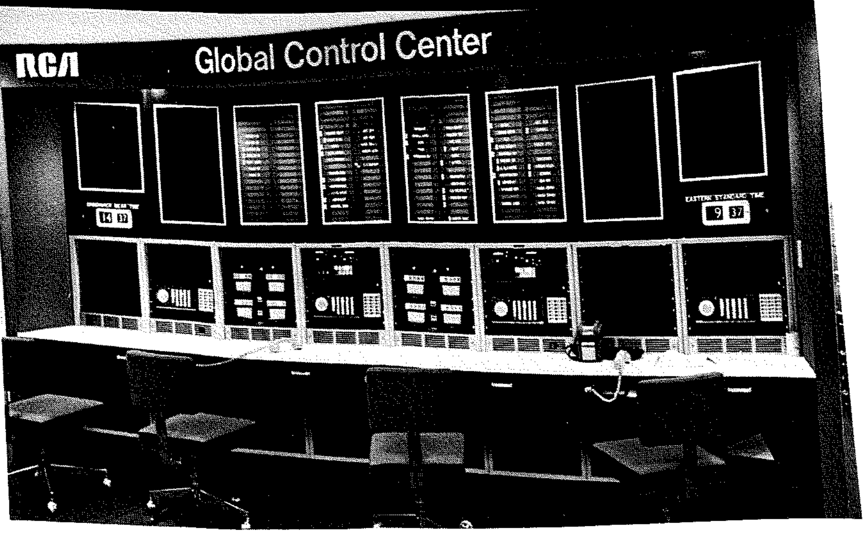
Since untroubled service provides a broader concept of leased channel quality, impairment and disturbance data is now being incorporated into all quality reports. All of the techniques that have been used to improve reliability are now in the process of being implemented to improve untroubled service.

Conclusion

Not all of the benefits of the quality program can be quantified; for example, quality information has been included in sales proposals to potential leased channel subscribers. This information has been instrumental in helping to obtain new leased channel business. The statistics show that there has been a continuing improvement in leased channel reliability in the last two years.

This improvement can in part be measured in dollars. Credits for interrupted leased channel service were reduced 34% in 1971 as compared to 1970, and 1972 credits were 12% less than in 1971. This improvement in quality represents a savings of over $200,000 in the last two years. Futhermore, there has been additional internal savings in that there have been fewer credits to process.

The Leased Channel Quality Program has been operating for the last three and one-half years at RCA Globcom. During this period there has been a concurrent improvement in quality, primarily because of improvements in error detection and error correction. The remaining object of the quality program is error prevention—error prevention based on planned corrective action geared specifically to the elimination of future recurrences of leased channel troubles.



DVTS control center

N.Kotsolios | E. Williamson

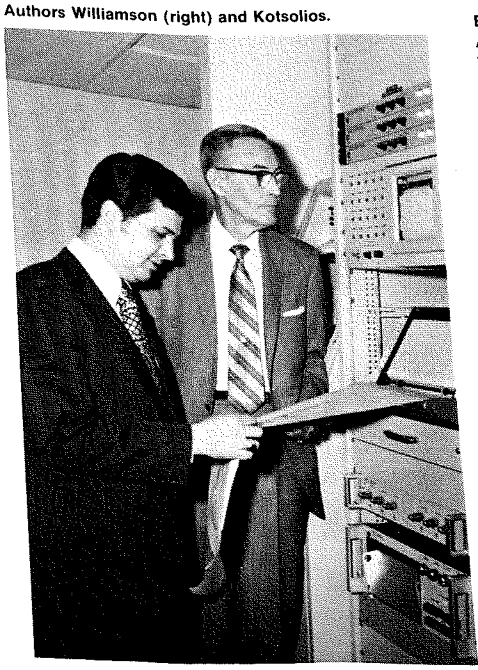
Installed at a cost of over one quarter of million dollars at RCA Global Communications, the new control center for data, voice, and television services (DVTS) insures rapid detection and correction of transmission difficulties. It is equipped with the latest test-control instruments and provides instant access to any subscriber circuits for a quick diagnosis of the circuit status. The center is equipped with an elaborate automatic alarm system which instantaneously detects circuit problems and a centralized command post to which subscribers can direct their queries.

A MODERN communications control center, promising to improve the quality of data, voice, and television service to present and future subscribers and to upgrade the reliability of such service, has been developed and constructed by RCA Global Communications, Inc. The center has been designed with the following objectives in mind:

1) Decrease response time to subscriber calls about service difficulties—such as outages, garbled transmission, voice impairments, and other troubles.
2) Reduce the time required for the restoral of circuits disrupted by equipment failure, system outages, or operating deficiencies.
3) Provide better and faster facilities for the routine inspection of circuits to detect unsuspected shortcomings and impending outages of circuits. This will permit the correction of such deficiencies, in many cases, and thus either prevent outages or shorten their duration.

These objectives have been accomplished by providing suitable equipment, arranged to make full use of the skills of the operating personnel. A brief description of these equipment arrangements follows.

Authors Williamson (right) and Kotsolios.



E.J. Williamson, Mgr. Leased Facilities & Engineering Administration, RCA Global Communications, Inc. New York, N.Y. received his formal education at Rutgers University. He joined RCA Global Communications, Inc. in 1937. Over the years, he has been engaged in the operation, installation and design of VLF, HF, UHF and microwave facilities and systems; power generation and distribution systems; and structural, architectural and mechanical aspects of physical facilities. Since 1959, he has been engaged in the design and development of equipment and systems used in control centres and in the transmission of signals over voice-grade channels in the microwave, HF, submarine cable and satellite media. He is registered as a Professional Engineer in the state of New Jersey and is a member of the National Society of Professional Engineers and of IEEE.

Notis Kotsolios, Leased Channel Engineering, RCA Globcom, New York, NY. received the BSEE from Polytechnic Institute of Brooklyn in 1965, the MSEE from N.Y.U. in 1966, and the DEE from Columbia University in 1968. He has been with RCA Global Communications since 1970. He is currently working in the department of Leased Channels and Transmission Engineering. His previous employment includes Western Union Corp. where he worked on Government low-speed and high-speed communication networks.

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Operating console

The console permits operators to respond quickly to subscribers' telephone calls; notify subscribers of the status of their circuits; instantly access any circuit at will by "touch tone" selection for first echelon diagnosis of circuit impairments; measure levels of discrete frequencies or composite signals; and correspond directly with the domestic and foreign International Maintenance Centers by telephone, telex, or talker printer. As shown in Fig. 1, the switching matrix will extend a subscriber's lines to the operating console for a quick level check or to the "in-service" test position for a more detailed analysis. Basically, it will permit the dialing-up of four pairs pe[r] line (XMT IN, XMT OUT, REC I[N], REC OUT); automatically, four DB[M] meters are switched on those pairs. T[he] four DBM meters function independe[nt]ly with automatic range selection. E[ach] meter includes a switchable filter whi[ch is] used when monitoring speech-plus-[...] or data-plus-TTY circuits. Filter i[nser]tion will block out the TTY wh[ich is] above the 2700-Hz cutoff.

The carrier test set and the dua[l] speaker can be inserted across the [...] operating the proper pus[h] switches. The carrier test set [...] measurements of various carr[ier] and frequency deviations o[f] channels by properly setting u[p con]trol knobs in its front panel [...] channels analyzed can be in [...] formats defined below:

No. of channels	*spacing*
24	120 Hz
12	240 Hz
6	480 Hz

A 300-Hz pilot tone can be analyzed also.

Status and alarm display panel

Visible to all personnel are lighted displays indicating the condition of each individual subscriber's circuit and the name of the subscriber. The displays indicate the status (in active use or being attended by operating personnel) plus any alarms indicating some malfunction. Another set of lighted displays gives indications or alarms of such common areas as power, continuity of cable or satellite trunks, AIRCON. The maximum subscriber capacity of the display panel is 250, which is the same as the capacity of the switching matrix.

Test position

In-service test position

This test position is equipped for more exact diagnosis of signal quality impairments such as individual levels, digital distortion, frequency-translational errors, noise, variations of level, error counts, signal dropouts, *etc*. Recording facilities and printers are available for long-term measuring and monitoring when found necessary. The in-service test position consists of instruments designed to be used independently or in conjunction with each other to analyze and test all types of teletype, data, and voice signals while the line under test remains in service. Generally speaking, all instruments are accessible through a central jack field. Since the input impedances of the test instruments used in the in-service test position average 10 to 15 kilohms, a system has been devised to permit bridging the line with any number of instruments. This is accomplished by a "bridging bus" consisting of a balanced input transformer coupled to a unity gain amplifier with a 100K input impedance. Its low impedance output is connected to 11 parallel jacks into each of which a test instrument can be connected. The frequency response is flat within its usable range of 300 to 3300 Hz.

To permit utilization of 600-ohm input equipment in a bridging mode without loading the line, a "dual gain amplifier" which features balanced high impedance (30K) input and a precise (600 ohm) balanced output is used. Its input may be connected directly to a line or the bridging bus.

Out-of-service test position

This test position is equipped primarily for the exact measuring of transmission characteristics of the various channels used by the subscribers. The facilities can be used also for testing and aligning circuits before initiating service or correcting transmission impairments occurring from time to time on established circuits.

Both types of test positions are interconnected to provide maximum flexibility and utilization.

Conclusion

By the use of such physical features as described above, it is now possible to organize specific job functions and operator's skills to improve the technical effectiveness of the personnel to permit them to perform their functions faster and with greater precision.

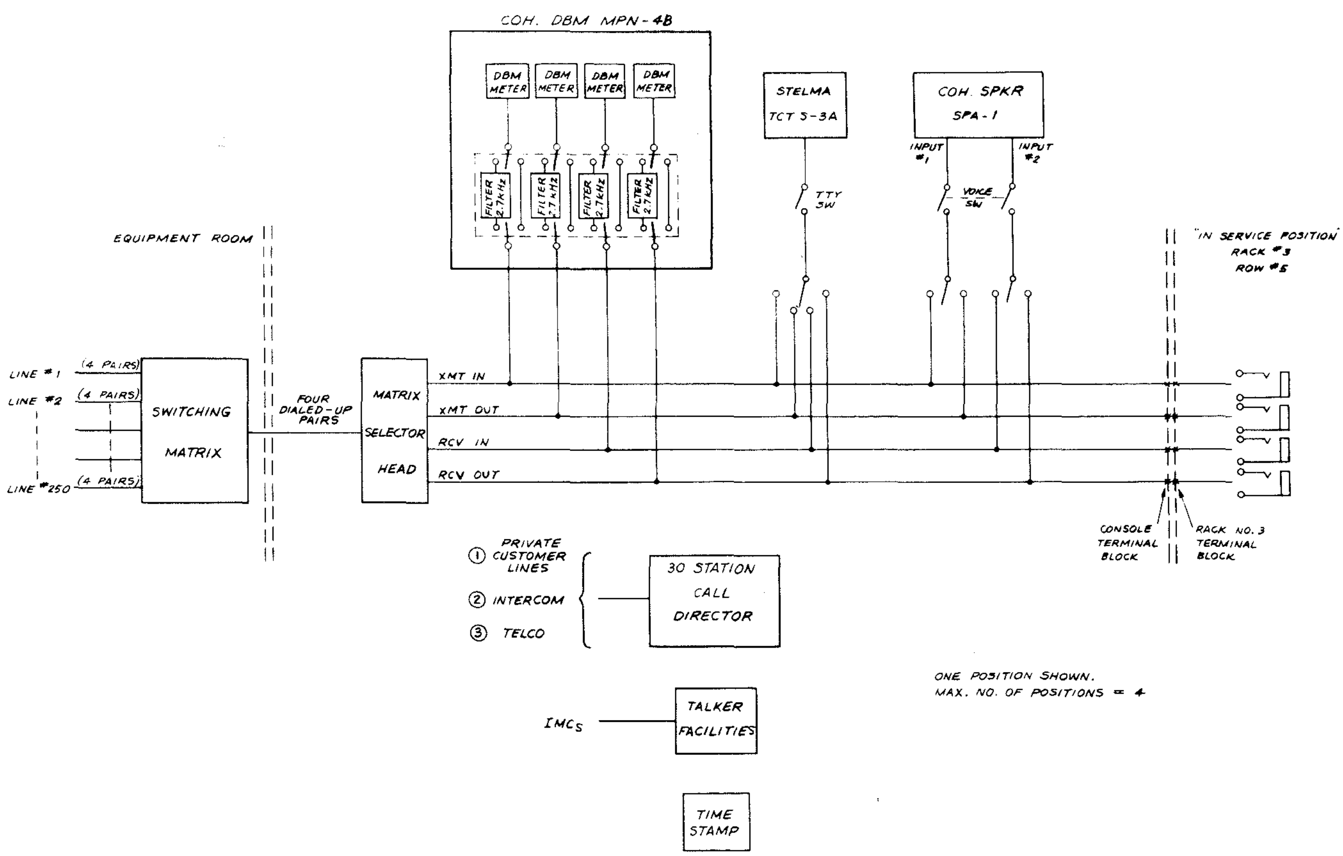


Fig. 1 — Flow diagram of the operating console.

RCA Globcom system diagnostics

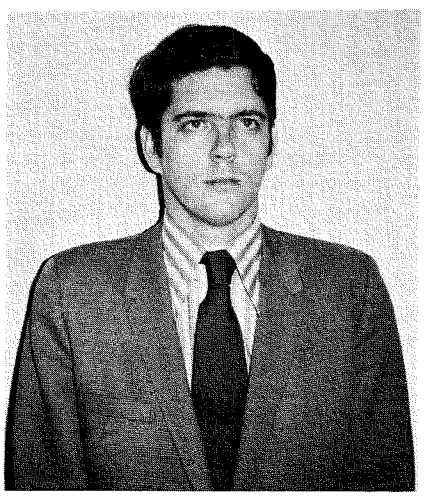
D. F. Segrue

To keep communication system integrity at a high level, diagnostic systems must be developed to enaable operating technicians to diagnose faults rapidly and accurately. However, such systems are subject to the constraints imposed by the domestic connecting common carriers and foreign administrations on RCA Globcom's control of communication systems. This article discusses the two types of diagnostic systems: OFF-line and ON-line.

THE ever increasing complexity of today's international communications systems, coupled with the limitations imposed throughout RCA Globcom's control over these systems by the domestic connecting common carriers and foreign administrations, presents to RCA Globcom a challenge to effectively meet the goals of high system integrity and minimum outage time while keeping maintenance costs at reasonable levels. It has become increasingly important, therefore, to develop diagnostic systems to faciliate meeting these goals.

To better understand how diagnostic systems can meet the stated objectives, the steps involved in problem diagnosis should be stated:

1) Recognizing the existence of the problem;
2) Locating the problem;
3) Determining causes; and
4) Determining feasible alternative solution.



Daniel F. Segrue, Engineering, RCA Globcom, New York, N.Y. received the BSEE and MSEE from the Polytechnic Institute of Brooklyn in 1967 and 1970, respectively. From 1968 to 1969 he was with Wheeler Laboratories, where his work was concerned with development of high power microwave feed horns and monopulse radar systems. From 1969 to 1970, he was with General Telephone and Electronics, where he was responsible for new designs of pushbutton phones. He joined RCA Global Communications in 1970, and is currently working on a Speech Bandwidth Reduction System and the design of special-purpose equipments for Leased-Channel subscribers.

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OFF-line diagnostics

There are two types of Diagnostic Systems: OFF-line and ON-line. The OFF-line diagnostic system is intended to provide routine periodic maintenance, through measurement of the transmission parameters of a communications system. The transmission parameters of importance are:

1) Amplitude response
2) Time delay distortion
3) RMS noise levels
4) Harmonic distortion
5) Phase jitter
6) Frequency offset
7) Impulse noise

Because the measurement of these parameters requires the use of a signal with bandwidth of 0.3 to 3 kHz, the communications system under test must be shut down for as long as is required to perform the measurements. Fig. 1 shows a typical OFF-line diagnostic system. This automated system measures the characteristics of voice-frequency (VF) channels within 5 minutes. When the communications system goes off line, the test signal source (TSS) transmits the code words and test signals needed by the data acquisition unit for parameter measurement (see Fig. 1). The test procedure is as follows:

1) The test signal source and signal analysis units are connected to the inbound and outbound sides respectively, of the line as soon as the channel is shut down.
2) The TSS transmits a code word (fm) to terminal A, acusing loop-back switch (S1) to put the system in loop-back (L) position.
3) Upon confirmation of loop-back, the system begins its test sequence — amplitude, time delay, frequency offset, harmonic distortion, phase jitter, frequency off-set and impulse noise measurements — on a loop-around basis.
4) The results of these measurements are stored and compared against bench marks previously established. If the measurements exceed these predetermined limits, a flag goes up, and the out-of-spec parameters are specified.
5) The TSS next transmits a code word causing loop-back switch (S1) to be set to T position, and causes the test signal generator (TSG) to transmit the signals required to perform the one-way test from terminal A to RCA Globcom's CTO.
6) The results of step 5) are compared to bench marks as in step 4); also, the measured amplitude and time delay data are subtracted from the respective data of step 4) and printed out on a teleprinter to give the one-way measurement from CTO to terminal A.
7) Under program control, the TSS and the signal analysis unit are then connected to the outbound- and inbound-line sides, respectively, and steps 2) thru 6) are repeated for S2 and terminal B.

On-line diagnostics

ON-line diagnostic systems provide RCA Globcom with the ability to monitor, without interruption of subscribers' service, system parameters where short-term time variations can dynamically affect system performance. Having the ability to monitor and relay the status of these parameters to the CTO provides RCA Globcom with the ability to quickly and accurately diagnose communication system problems, on an end-to-end basis, which can occur at any time. The parameters the ON-line system monitors are:

1) Line levels
2) Line breaks
3) Terminal equipment status
4) TTY distortion

The status of these conditions is reported via a binary fm telemetry signal to operating personnel at CTO. The status is displayed via a CRT monitor or hard-copy of a teleprinter. Fig. 2 shows an ON-line diagnostic system used in a point-to-point communications system. The system functions as follows: terminal A line control unit (LCU) carrier detects the telemetry signal transmitted from terminal B's LCU. At the CTO, each side of the line (inbound and outbound) is carrier detected and fm demodulated by line interface units. The demodulated signals are decoded and compared to the detected line levels so as to determine the status of the channel (inbound and outbound) and the terminal equipments. The status messages are displayed via a CRT or hard-copy printer (teleprinter).

Assume, for example, that "A-OUT" fails: the CTO outbound telemetry detector measures loss of carrier and the inbound detector measures a telemetry carrier. Also, the decoded code from B is "B-IN FAILED". Comparison of the data results in "A-OUT FAILED" being displayed on the CRT or printed out on the teleprinter.

Next, assume that "B-IN" fails. Both inbound and outbound telemetry carrier detectors measure proper levels. The decoded word from A is "A-IN NORMAL", while the decoded word from B is "B-IN FAILED". Comparison of the data results in "B-IN FAILED" being displayed.

In like manner, the status of the terminals is encoded in the telemetry signal, and status is displayed at the CTO.

Summary

OFF-line diagnostic systems find application, subject to the constraints of being shut down to allow for measurement, in communications systems in which channel transmission characteristics are important. Examples of such systems are: data, facsimile and videovoice.

ON-line systems find application in system where a narrow bandwidth (300 ± 15 Hz) can be allocated for the telemetry signal. Examples of typical applications are: alternate voice/data, FDM, and TDM systems. Because such ON-line systems function independently of the status of the associated communication system, they can be easily integrated as shown in Fig. 3 into complex communications networks to provide complete system diagnostic capabilities.

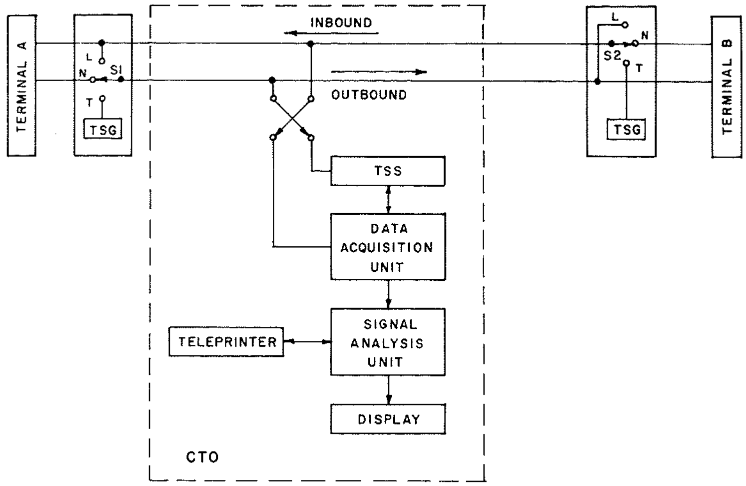

Fig. 1 — OFF-line diagnostic system.

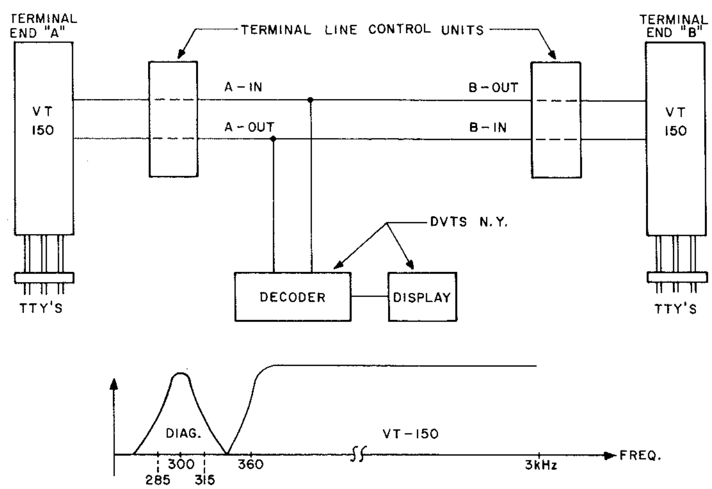

Fig. 2 — Off-line diagnostic system showing frequency allocations for telemery signal.

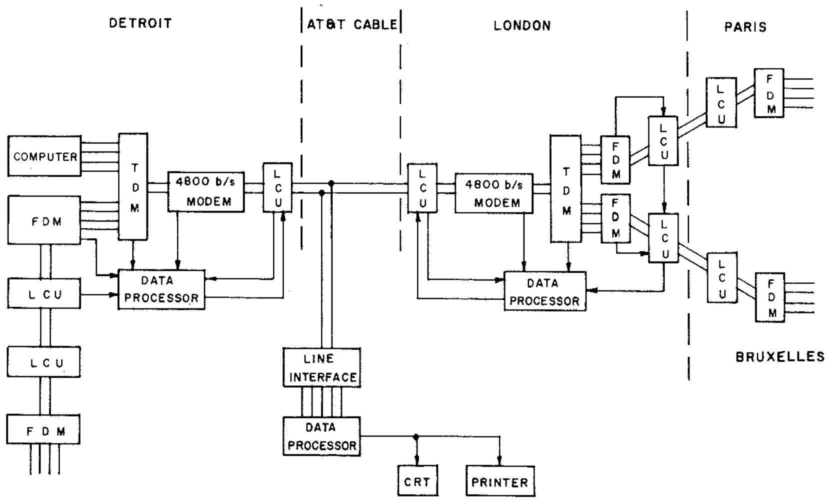

Fig. 3 — Use of an ON-line diagnostic system in a "complex" communications system.

Development and principles of cable restoration

J.C. Rogers

A break in an undersea cable or failure of the satellite communication system completely halts all communications using these facilities. The problem of restoring interrupted services quickly and effectively is a continuing requirement that is compounded and aided by the development of high capacity cables and satellites. The solution lies in providing alternate means to link the terminals of the failed media and in planning for its availability on short notice. Success has been achieved only when administrations and companies in the international communications industry pooled their resources. The innovative technology of the communications industry in the past two decades has generated an unprecedented growth in the market for these new services. With the increase in volume and quality of services came also the responsibility to insure continuity of the customer's service.

When high frequency radio was our primary method of transmitting and receiving overseas telegraph signals, equipment malfunction or failure was not considered a catastrophic event. A transmitter could be replaced, frequencies could be shifted, or transmission could simply be delayed until propagation improved. In most cases, no more than a few circuits were affected at one time and then only for a few hours. Even into the late 1950's important international communications could still be allowed leeway in delivery time.

Innovations in communications technology rapidly became the industry standard. Fifteen years ago, all of RCA's overseas services were by high frequency radio; today, radio accounts for less than five percent. The changing character of the communication media not only increased capacity and reliability, but so heightened the expectations of both carrier and user that service continuity must be maintained regardless of cost to the carrier. Today's customer in London who must access his computer in Kansas City 24 hours each day will not accept outages to his circuit, *whatever* the reason.

John Rogers, RCA Globcom, New York, NY, received the BA degree from Heidelberg College in 1963 and has done postgraduate work at Columbia University and Fordham University. Before joining RCA in September 1968, he held various positions in the communications field while serving in the US Navy. During the last year in the Navy he was Communication Officer of a Naval Communication Station in Vietnam. Since joining RCA he has worked in the Plant Operations Engineering Department on NASA communications and as Restoration Liaison Officer.

Cable development

Submarine cable technology saw its first major success during the 1850's when the first transatlantic cable was completed. This span, linking Newfoundland and Ireland, lasted less than 3 months but demonstrated the economic viability of the system. A decade later the first transatlantic cable to operate permanently was laid. The early cables were only a *simplex* operation—tranmission in one direction at a time—and the high level of distortion would only permit the transmission of telegraph signals. The first transatlantic cable capable of handling voice signals was not completed until 1956—ninety years later. Known as TAT-1, its initial capacity was 36 voice-grade channels but was later expanded to 48. TAT-2, with similar capacity, followed in 1959.

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Both of these cables used repeaters which could operate in only one direction, so two cables were necessary, one for each direction. After several years of intensive research into solving the problem of laying two-way repeaters in deep water, a new cable system was developed and laying was completed in 1961. Linking Canada to the United Kingdom, the so-called CANTAT cable had the capacity to carry 80 circuits.

The inauguration of TAT-3 in 1963 brought the first significant improvement in restoration capabilities. With its capacity of 138 voice grade channels, it could permit restoration of TAT-1 within a matter of hours.

Further improvements in transatlantic capabilities continued with TAT-4 and TAT-5 (see Fig. 1). Although elaborate *frogging plans* (prearranged patching assignments to create restoration groups) were required, circuits could now be restored on a group basis rather than by the lengthy channel-by-channel method.

Communicators soon learned to rely on diversified routing to maintain the traffic volume which quickly expanded to fill the new cables. But as capacity increased, so did voice-grade private leases to commercial subscribers. Whereas an individual telegraph circuit could be patched from one failed VFT system to an idle channel in another system as long as they both terminated in the same locations, this was not always possible with a 3-kHz channel; the carriers could not afford to retain idle channels of this bandwidth. A new approach to restoration was required.

In 1963, the Atlantic Mutual Aid Working Group (MAWG) met for the first time. This group was made up of the representatives of the foreign administrations and private American companies who were owners of TAT-1, TAT-2, and CANTAT. Plans for these cables were developed using the cables remaining in service to restore the failed cable.

Since then, three "Mutual Aid" type organizations have developed in the ocean regions in which RCA has sizeable interests. The Atlantic, Pacific, and Caribbean regions each operate separate and distinct plenary committees made up of cable owners, satellite companies and

TRANSATLANTIC CABLES	INAUGURATION DATE	CAPACITY	NO. OF FAILURES	AVERAGE DURATION
TAT-1 (UK)	1956	48	29*	4.7* DAYS
TAT-2 (FRANCE)	1959	48	30	6.4 DAYS
CANTAT (UK)	1961	80	17	9.8 DAYS
TAT-3 (UK)	1963	138	13	6.1 DAYS
TAT-4 (FRANCE)	1965	138	9	6.0 DAYS
TAT-5 (SPAIN)	1970	840	5	8.2 DAYS

* SINCE 1959

Fig. 1 — Transatlantic cable service.

MAJOR WESTERN PACIFIC CABLES	DATE CABLE INAUGURATED	CAPACITY	NO. OF* FAILURE	DURATION OF FAILURE
GUAM-HAWAII	1964	142	1**	5 DAYS
GUAM-JAPAN	1964	138	1	5 DAYS
GUAM-PHILIPPINES	1966	128	1	11 DAYS
GUAM-HONG KONG	1966	80	1	13 DAYS
GUAM-AUSTRALIA	1966	160	1	21 DAYS

* SINCE 1968
** SCHEDULED FOR REPAIRS

Fig. 2 — Transpacific cable service.

administrations, and the Manager for Intelsat. Each plenary committee has, in turn, created a working group which is charged with the drafting of restoration plans for each facility assigned by the plenary. Initially, only cable facilities were considered by the working party, but in recent years, Earth station and satellite restoration planning have been receiving increasing attention due to the enormous growth of satellite communications, and the belief that a cohesive group encompassing all the communication facilities and carriers is necessary for effective planning. For example, the present restoration plan for the Philippines-Taiwan Troposcatter System calls for the use of the Philippine and Taiwan Earth Stations via the Pacific Ocean region satellite. Reciprocally, this troposcatter system serves as partial back-up for both of the Philippine Earth stations and the Guam-Philippine cable.

During the mid nineteen-sixties several high capacity cables were laid in the Pacific and Caribbean regions (see Fig. 2). In 1964, the first transpacific cable link was established between the United States and Japan and the Philippines. This cable system was comprised of three links: Hawaii-Guam, Guam-Philippines, and Guam-Japan. Eventually, Guam was also linked to Hong Kong and Australia by submarine cables. Between 1960 and 1968, the Caribbean witnessed a virtual boom in new cable facilities as cable inaugurations averaged one a year during this period and for the first time a major submarine cable link was established between North America and South America.

Satellite development

In some cases, with only one cable linking two countries, it was impossible to devise substantial restoration plans. The development of the geostationary satellite was the ultimate key to providing an alternate route to cable failures (see Fig. 3). The first geostationary international communications satellite—Early Bird (Intelsat I) — was placed in commercial service in June 1965. Since then, thirteen communication satellites have been placed into commercial service and several more are in varying stages of construction. Each satellite series brought with it a greater ability to restore failed cable services. The spare capacity for restoration via Early Bird during 1966 was about 160 channels, adequate for all single- and some multiple-cable failures. The MAWG recognized the importance of this new capability and held meetings that year in Paris, London, Munich and New York to devise and test the technical and operational details of satellite restoration. The latest series, Intelsat IV, which has a capacity of 3000 to 9000 voice grade channels can handle its normal commercial traffic including television programs and still provide for restoration of the largest cables.

Restoration costs

Financial agreements in all the regional groups are based on the understanding that restoration costs are to be borne by the owners of the failed communication facilities. This originated as a means to differentiate the owners from the users who lease service; this agreement has continued to the present as an equitable form of allocating costs. The early transatlantic cables were constructed and owned by the American Telephone and Telegraph Company and their European partners. When one of the cables failed, the few channels leased by the record carriers were restored along with those of the owners, and charges were divided according to percentage of ownership. When Indefeasible Rights of Usership (IRU) became available to the record carriers in the mid-nineteen sixties this was considered a form of ownership for distribution of restoration costs.

Today, RCA has IRU or ownership in 24 cables world-wide with authorization to operate 414 voice-frequency channels. During the past three years, restoration costs have averaged $200,000 per year for all of these cables. More than 80% of this has gone to space segment usage charges.

Near end principle and backhaul charges

Most circuits to a foreign country involve joint ownership; thus costs to restore a failed submarine cable must be divided in a fair manner. The method commonly accepted in most areas is called the "near-end principle". Simply put, the owners of the failed terrestrial facility absorb the costs of the restoration facilities used nearest their respective terminals. If TAT-5 fails, the American owners pay COMSAT for space segment usage from the US Earth station to the satellite and the European owners pay the Spanish Administration for similar service on that side.

In some cases, a satellite Earth station or substitute cable is not located in the same country as the termination of the failed cable. When this occurs, services are routed to the nearest country that has a link to the failed cable terminal. Using such indirect facilities is called a "backhaul". Both the near-end principle and backhaul are illustrated in Fig. 4. Note that the cost of the backhaul is also equally divided.

In some cases, a mixture of cable and satellite routes provide the most effective back-up for a cable failure. Fig. 5 shows a TAT-3 restoration using TAT-5, satellite, and continental landlines to restore the

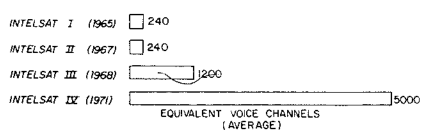

Fig. 3 — Satellite capacity.

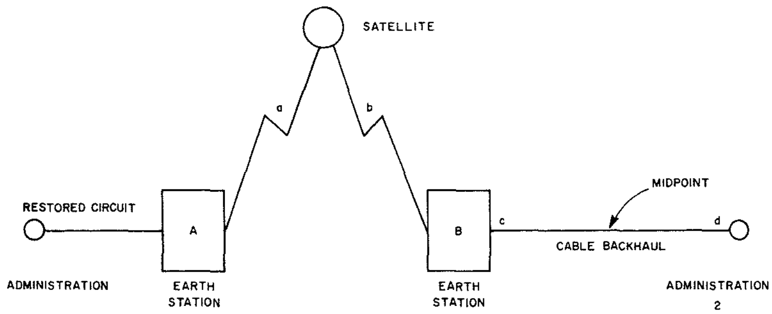

Fig. 4 — Near-end payment procedures. (Administration 1 pays for links A and C; Administration 2 pays for links B and D).

failed cable. This type of plan, which may take longer to activate, may be necessary when sufficient spare cable or satellite facilities are not available.

Testing of plans

In each region, cable restoration plans are scheduled for testing on a periodic basis, usually annually or biennially. The restoration route for each cable is established end-to-end and a complete test of all transmission characteristics is performed in both directions. Results of these tests are analyzed by the stations involved, and a full report is provided to all the members of the restoration group. Tests requiring use of a space segment may be performed without charge if there is no interference with scheduled operations and if no commercial service is routed over the links being tested.

Effect of alternate route on circuit quality

Transmission characteristics of two diverse routes are rarely identical. When services are transferred from one route to another, such as from a failed cable to satellite, transmission problems occasionally result for several reasons. Equalization for delay distortion may be required when the new route has a different number of intermediate points where the circuits must pass at voice frequency. The new route may be conditioned to lesser specifications or designed to operate at different transmission levels. Data circuits operating at high speeds are often slowed as much as 50% when shifted to a satellite route due to the greater loop time exhibited. This normally affects only those circuits using "transmit after acknowledgement" type error-correction systems. Finally, the alternate route may be maintained exclusively for restoration and may simply have gone out of specifications since its last use or test. However, these problems are usually a question of degree determined by the nature of the service provided. It is the exception rather than the norm to find a circuit that cannot function adequately when shifted to a predetermined restoration route.

Recent developments

Maintaining circuit availability without interruption, however slight, increases in importance as new developments in communications allow more frequent and faster interaction between nations separated by long distances. The use of centralized computer storage areas for real-time multinational operations demands 24-hour immediate access to accomodate the varied time zones of the using terminals. Airlines, stock exchange members and most large international corporations require one or more 3-kHz channels to handle their voluminous transfer of information between terminals. INTELSAT IV satellites, capable of rapidly restoring the largest cables, provide the back-up necessary to insure the users this continuity.

By far, the largest subscriber and perhaps the most sensitive to circuit outages is the US Government. Communications with NASA's manned spacecraft and orbiting scientific satellites must be continuous and exhibit the most stringent error-rate standards in the industry. The Defense Communications Agency and the State Department each have an extensive network of worldwide circuits which require protection equally important to NASA circuits.

To meet the increasing demands of these customers, many changes have occured in operational functions as well as plant areas. Where circuits were once turned down to install new equipment or to perform maintenance, 100% restoration is now planned long in advance to prevent such outages. Redundancy of important terrestrial routes, such as to a cablehead or Earth station is now a basic requirement. More important is the establishment of Restoration Control Offices by the restoration working groups to quickly reroute interrupted services to alternate facilities.

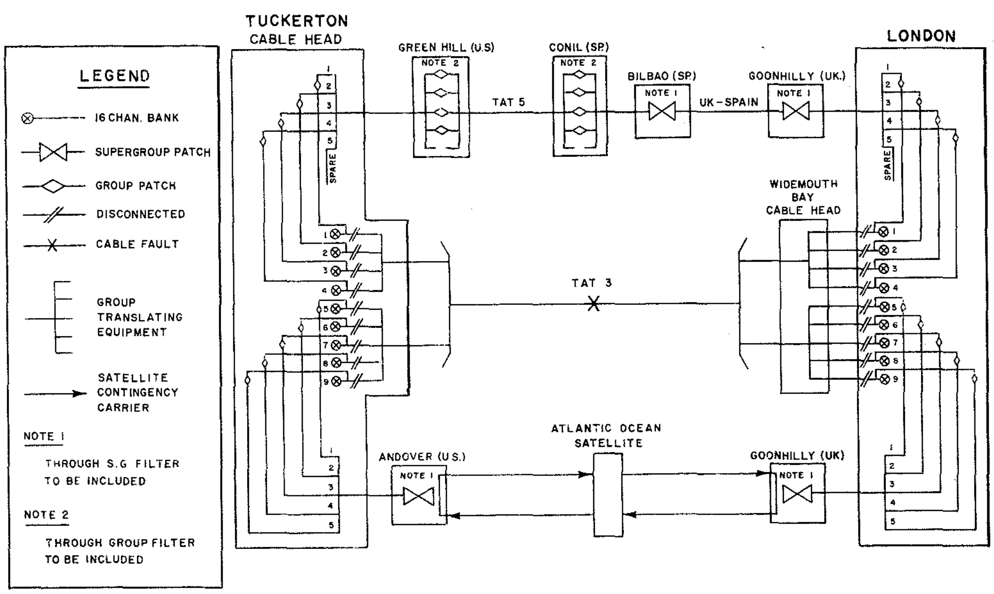

Fig. 5 — Example of a TAT-3 restoration plan.

An inexpensive earth terminal for tv reception in bush communities

A. W. Brook

The need for a capability to receive instructional and educational television in the bush communities of Alaska has prompted the design of an earth terminal which could receive transmissions from satellites designed to operate in a Domestic Communications Satellite System. The design is based upon currently available components, with particular emphasis on unattended operation and simple periodic maintenance. In Alaska, the concept of the service involves the use of one or two TV sets which are provided for viewing in a community center or school.

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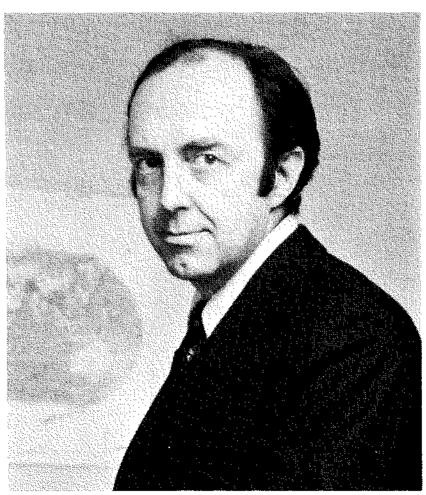

THE DESIGN of all communication systems is in some way influenced by the desire to provide the most service for the lowest cost possible. How much that desire influences the design of equipment is related to the quality of service to be offered and, in some part, to the number of users to be served by a particular piece of equipment. Thus, a telephone switching center serving many users may cost millions and be cost effective, while a handset serving one subscriber must only cost a few dollars. In a system designed to provide television service to a small, remote bush community in Alaska, the need for a low-cost receiver is compelling.

Despite the need for low costs, the seemingly contradictory requirement of good quality must be met. The quality of service to be provided need not be that required by a studio, but it must in no way inhibit the ability of the system to perform its task of complementing the normal program of education and bringing cultural benefits and life enrichment to the native communities.

The need for the service is real and immediate, so that solutions must be those which are available today. In addition, only modest quantities will be required so that designs which are monuments to engineering skill, but require the benefits of mass production for economy, are not suitable.

In the following paragraphs one solution for such a service is described which includes low cost of equipment, simple installation, unattended operation, and "fine" quality reception.

System design

In addition to low cost and ease of installation, maintenance, and operation, requirements which determine the electrical performance must be established. The most important of these is the transmission objective.

There are presently no specific transmission objectives for service to schools in terms of a recognized national standard. Systems in use today include high-resolution systems with more than 700 lines, the normal U.S. 525-line system, and also systems with fewer numbers of lines, say 120. By reducing the number of lines, the vertical resolution of the picture and the bandwidth required for the transmission of the signal are reduced. A reduction in the bandwidth from the normal TV signal is a desirable factor in minimizing the cost of the receiving earth terminal, but any change from the standard will result in some development cost penalties.

The advantages of using existing equipment lie in the compatibility of that equipment with the commercial TV systems. For this reason, a design is presented which uses the same video signal as that used for commercial service.

Three grades of service based upon the Television Allocations Study Organization (TASO) rating are examined, and it will be shown that, for a system using the standard commercial video signal format, a picture which is equivalent to better than "fine" is always achievable.[1]

A numerical example of how the performance has been derived is given and it is shown that a picture rated better than "fine" may be received using an uncooled parametric amplifier and a 15-foot parabolic reflector.

In the absence of other data then for service to schools, a TASO rating of "fine" has been chosen as the goal.

Satellite to low-cost receiver link

As a first step in establishing the design parameter of the low-cost receiver, an

Table I — Downlink power budget.

Satellite EIRP	32.0 *dB**
Dispersion loss	−196.5 dB**
Atmospheric absorption	0.0 dB***
Polarization loss	0.0 dB***
Ground antenna gain	G dB
Margin	−1.5 dB***
Signal power at earth	(G−166.5) dB
Receiving system noise temperature	T° Kelvin
Receiving system I.f. bandwidth	B Hertz
Receiving system noise (10 log KTB)	10 log KTB dBW
Downlink carrier-to-noise ratio	G-166 − 10 log KTB dB

*The assumption is made that the main antenna beam of a spacecraft has the characteristics described in Volume I, page 19, of "RCA Alascom/Globcom Application for a Domestic Communication Satellite System." The power at the 3-dB beam edge is then 32 dBW.

**The assumption is made that the slant range to Alaska is 24,800 miles and that transmissions will be made at 4 GHz. Hence from the expression $Ld = 36.6 + 20 \log f + 20 \log d$, $Ld =$ 196.5 dB.

***A margin of 1.5 dB has been included for rain and atmospheric absorption, and periodic polarization corrections are assumed.

expression for the carrier-to-noise (C/N) ratio of the link between the satellite and the low-cost receiver is developed from the downlink power budget as shown in Table I.

Video signal-to-noise ratio

Three expressions for the video signal-to-noise S/N ratio are developed below, based upon three different assumptions for the i.f. amplifier of the low-cost receiver.

The average sinewave signal-to-rms-noise ratio for a frequency modulated carrier is given by the expression:

$$\frac{S}{N} = \frac{3C(\Delta f)^2 \beta}{2N(fm)^3}$$

where C/N is the carrier-to-noise ratio of the received carrier, Δf is the peak deviation in MHz, fm is the top frequency of the baseband signal in MHz, and β is the bandwidth of the intermediate frequency amplifier.

Three cases are considered where the i.f. bandwidths are 36 MHz, 25 MHz, and 18 MHz and the top video frequency is 5.225 MHz. Using Carson's expression for bandwidth gives peak frequency deviations of 12.8 MHz, 7.3 MHz, and 3.8 MHz. Substituting for values of C/N derived from the downlink power budget, and expressing S/N in terms of peak signal-power-to-rms-noise power, we have:

$$S/N = (G\text{-}T) + 10.4 \ (\beta = 36 \text{ MHz})$$

$$S/N = (G\text{-}T) + 5.6 \ (\beta = 25 \text{ MHz})$$

$$S/N = (G\text{-}T) + 0.1 \ (\beta = 18 \text{ MHz})$$

It can be shown that the TASO values of S/N may be related to the International Radio Consultative Committee (CCIR) definition by the expression

CCIR, S/N = TASO, S/N + 0.6 dB.[2]

Finally, a noise improvement has been assumed from the use of pre-emphasis and de-emphasis network and a noise weighting network. AT&T claims a 14.0-dB improvement using their own networks[3] and in this work analysis 14.0 dB has been used.

CCIR, $S/N = (G\text{-}T) + 24.4 \ (\beta = 36 \text{ MHz})$

CCIR, $S/N = (G\text{-}T) + 19.6 \ (\beta = 25 \text{ MHz})$

CCIR, $S/N = (G\text{-}T) + 13.9 \ (\beta = 18 \text{ MHz})$

Table II gives the results of a series of calculations aimed at optimizing the link performance.

Table II — Data for optimizing link performance.

Picture quality, TASO	*Rating in dB, TASO*	*Equivalent CCIR, S/N*	*Earth terminal (G/T)** β=36 MHz	β=25 MHz	β=18 MHz
Excellent	45	45.6	21.2	26.0	31.7
Fine	34	34.6	10.2	15.0	20.7
Passable	28	28.6	9.0	9.0	14.7

*In order to exceed the fm threshold, assumed to be 10 dB, the G/T value must be 23.5, 21.9 and 20.5 dB, respectively, for values of β of 36, and 18 MHz.

From this data, it is apparent that the smallest earth terminal which will be capable of providing a signal of "fine" quality is one with a G/T of 20.7 dB and an i.f. bandwidth of 18 MHz. This illustrates that the system is margin limited rather than modulation limited. We may calculate the CCIR, S/N which will be obtained with an earth terminal with a 20.7 G/T ratio.

CCIR, $S/N = 20.7 + 13.9 = 34.6$ dB

This is a TASO Grade II rating, equivalent to a "fine" quality picture. A G/T of 20.7 may be obtained with an uncooled parametric amplifier and a 15-foot-diameter reflector operating at 55% efficiency.

Implementation

An unusual implementation described here is the result of trade-offs which considered the construction techniques

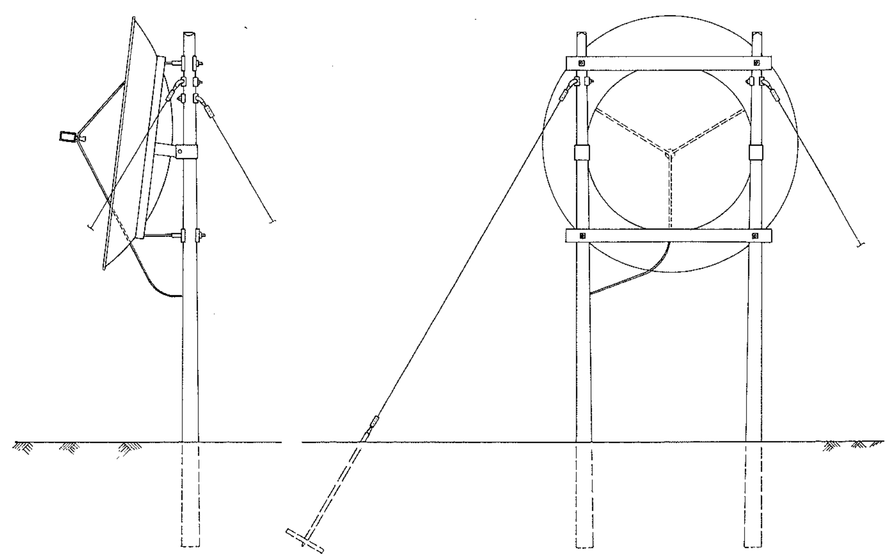

Fig. 1 — 15-foot bush tv antenna installation.

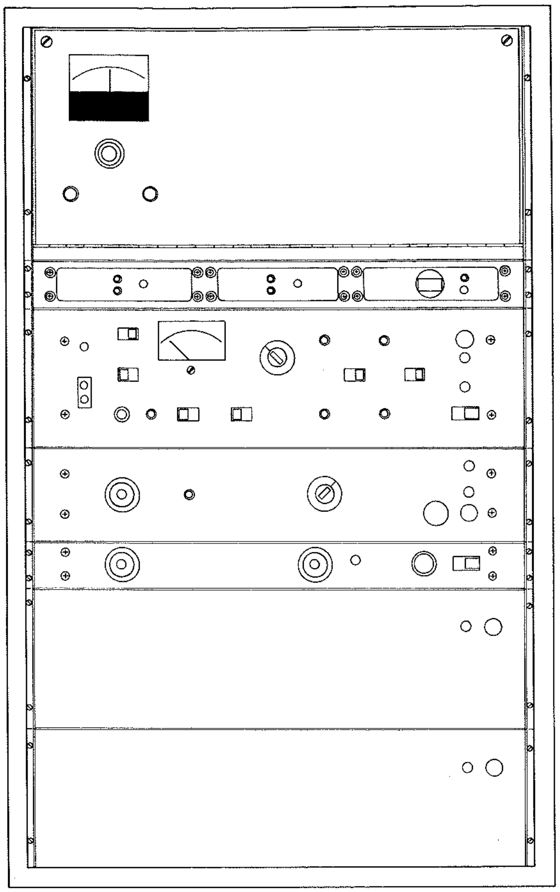

Fig. 2 — TV receiver and VSB modulator.

available in Alaska, the support facilities available at the sites, the Alaskan climate, and the look-angle to the proposed Domestic Satellite from such northerly latitudes.

The site requirements are quite modest. The antenna requires only that the line-of-sight to the spacecraft not be blocked and that the bottom rim of the dish be high enough to avoid physical interference with cars and people (for this reason, a height above-ground of 10 feet was selected for the bottom rim of the dish), and that the base to which the antenna is mounted be stiff enough to maintain the pointing of the antenna under the local wind conditions. The roof of a single-story building has often been proposed as being ideal for such an installation. However, an examination of several of the structures in the smaller villages in Alaska indicates that under the anticipated wind loads, the use of the roof as an adequate base should not be assumed. For this reason a base support structure, using a technique which has been successfully employed in Alaska, even in the permafrost regions, has been designed. The base employs two telephone poles which are permanently frozen into the ground using the technique of stripping and capping. The installation is illustrated in Fig. 1. In non-permafrost regions, the poles are placed in the ground in the normal manner, and guys are used to further increase the stability. The selection of telephone poles rather than concrete piers and a metal tower is due to the high cost of laying concrete in the arctic regions and the cost of maintenance on a metal tower.

The site support facilities are minimal, as the equipment not mounted on the antenna is able to operate up to 200 feet from the antenna and in any environment which is tolerable to humans. The equipment on the antenna contains its own environmental control in the form of heaters, which are required for stable operation of the parametric amplifiers and deicing of the feed horn window. The total prime power requirement is for 250 watts at 117 volts, 60 Hz. A regulator is built into the equipment to accommodate the large variations in line voltage which are anticipated. Fig. 2 illustrates the remotely located 4-GHz down-converter baseband demodulator, vestigial sideband modulator, and line amplifier.

The equipment requirements imposed by the Alaskan climate have been met with only a simple feed horn window heater. The antenna base is constructed of pressure creosoted pine and needs no other protection. The antenna reflector surface will, in some locations, be subject to ice buildup that will require periodic removal because of the danger of damage to the antenna from the additional weight. The performance is not expected to be appreciably decreased, however, provided the feed horn is kept free of ice. As the feed horn is integral with the parametric amplifier housing, the same heater serves to maintain the parametric amplifier's operating temperature and deice the feed. In most areas of Alaska, precipitation is low and during the winter period the winds are gusty and relatively high, conditions which tend to inhibit buildup of snow and ice on the antenna.

The prime focus feed configuration of the antenna system was chosen after consideration of the system noise temperature which could be achieved by both a prime focus feed and a Cassegrain optics configuration. The higher illumination efficiency achievable with the Cassegrain configuration was not fully realizable, due to the blockage by the sub-reflector of the small aperture antenna, and the sub-reflector increases the potential effect of ice build-up. The advantage normally enjoyed by the Cassegrain system when pointed vertically is not available when pointed at only seven degrees above the horizon. At that elevation, both systems experience the effects of the earth's temperature contribution to system temperature as a result of spillover. In terms of noise temperature, the performance of the two configurations was approximately equal. The prime focus feed configuration enjoys a considerable advantage in cost, however, both in manufacture and installation and lineup.

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Facsimile and its application in global communications

M. E. Logiadis

The need for the exchange of printed or graphic information around the globe has become increasingly more critical. The special problems associated with the transmission of fax over long-haul voice-grade circuits are discussed. In particular, speed, resolution and compatibility receive special attention, while the cost factor, based on traffic volume is analyzed in establishing criteria for comparison against other competitive units.

In the last few years, the electronic transmission of printed information and graphics over a 3kHz (0.3 to 3 kHz) circuit, began to attract the attention of the business community, which in turn induced the engineering profession to spend more time and effort in designing and developing facsimile devices which would meet their needs. At present, there are several manufacturers of facsimile terminals, and these terminals differ widely in price, copy quality and transmission speed.

Fax terminals that can operate over the dial-up telephone network have the greatest use so far because they offer great convenience to the user,who can dial any telephone set within their reach to establish connection with another compatible terminal. In addition, they perform relatively well in the poor signal-to-noise ratios and limited bandwidth of the switched telephone network. The low transmission speed of 4 to 6 minutes for a 8½x11″ document can be justified by the fact that regular telephone calls and equipment rentals are quite reasonable. The copy quality varies from manufacturer to manufacturer but most of them offer terminals with an average resolution of 80 lines per inch (LPI), which is satisfactory for black-and-white normal printed matter.

However, for long-haul circuits (over 2,000 miles), the line cost becomes an important parameter in determining if fax is viable, unless the traffic (pages per day) is very large. This suggests that the transmission speed should increase significantly for the fax to be competitive at an average resolution of 80 lines per inch. This resolution index would be sufficient for normal size print or graphics of corresponding size, but quite unsatisfactory for smaller-than-normal print size. The line characteristics of long-haul circuits (such as amplitude *vs* frequency, group delay and signal-to-noise ratio) are subject to sharp variations which can cause severe deterioration to the copy quality. We would, therefore, prefer fax machines with an average resolution of at least 100 LPI and one-page-per-minute speed.

Facsimile devices

Technically speaking, a facsimile device transforms printed or graphic information to electrical form, which can be transmitted over telephone lines or radio links of narrow or wide bandwidth, depending on the speed and resolution index of the device. In the receive-end, the inverse process is performed, *i.e.*, the electrical format is translated back into its original form of print or graphics on special or regular paper. Ideally, the end-product that is the received copy and the original document should be identical. However, this is almost impossible to achieve in practice, because of the noise and distortion introduced by the equipment and the transmission media. If the received copy has a degree of deterioration not exceeding 10% of the original with respect to the resolution index and shades of gray, we pretty much approach the ideal conditions.

Facsimile devices can be classified into two broad categories, according to the scanning techniques employed: mechanical scanning or electronic scanning.

In the mechanical method, the material for transmission is moving either on a flat bed or around a drum as it is being scanned line-by-line by a photosensitive device. In electronic scanning, an electronic beam is modulated by the black-and-white content of the material which remains stationary, as it is scanned from left to right and line by line. In both cases, the output is an electrical signal with a varying level which represents the white-to-black information of the original. The baseband of this signal is roughly 2 kHz and varies from device to device as a function of the scanning speed. The amplitude of this signal usually fluctuates between 0 and ±10 volts with the outer limits representing the black and white respectively.

Obviously, there is a strong dc component which is a problem when this baseband has to be sent over telephone circuits. To overcome this difficulty, analog modems are utilized to transform this baseband to a more suitable ac signal, which can be transmitted over these lines. Digital modems are sometimes used for transmission, after the base signal has been digitized through appropriate sampling. In general, this digital signal represents the black and white levels only, which in some cases, can be coded to remove redundant information and thus increase through-put significantly. To produce shades of gray, the digital signal is always coded, resulting in high data-transmission rates.

A high-speed digital modem up to 9600 b/s, must be employed to transform the digital signal to analog form, suitable for transmission over the 3-kHz line. However, this technique is quite expensive due to the high cost of the modem and additional charges for conditioned lines required by high-speed data. In systems utilizing high-speed modems to perform data transmission functions, this type of facsimile can be incorporated quite easily and inexpensively. Therefore, it is strongly recommended in such system configurations.

At this time, we would like to point out

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that digitized facsimile offers many advantages over the analog techniques, especially as far as transmission is concerned. This is because it can be integrated in high-speed data systems and intermixed with voice or low-speed/high-speed data. The all-digital communications network concept is recently gaining more acceptance by common carriers, which enhances the future of facsimile, since it would be possible to transmit at high speeds and resolution over a 3-kHz circuit.

Another interesting device utilizing electronic scanning by a regular television camera is Videovoice. This equipment developed by RCA Globcom and RCA Laboratories can transmit/receive a small document or a frame of a live object in 30 seconds. Optional equipment includes a large tv monitor, an electronic and/or a photographic hard-copy printer, and a tape recorder. The leasing cost is quite small, and it can operate over the dial-up telephone network.

Line cost vs traffic

In long-haul circuits, the line cost and traffic are very important parameters in determining if facsimile is economically viable, when compared with existing devices performing similar functions. In particular, it should be compared with a regular teleprinter of 100 words/minute. For leased-line subscribers, the costs involved are determined by the line, equipment, and manpower costs for a specific class of service.

Figs. 1 and 2 show the relationship between traffic (pages/day) and line cost (cents/minute) for a three-minute and one-minute facsimile transceiver, respectively. Both machines, it is assumed, are operating for 22 days a month and they lease at $80.00 and $160.00 a month, respectively.

Fig. 3 is a chart of the break-even zones of the costs involved for the one-minute and three-minute facsimile transceivers.

A long-haul 3-kHz line of approximately 3,000 miles, costs about $.25 per minute, which when added to the three-minute facsimile machine rental, results in $.85 per page if the daily traffic were 35 pages, and $1.15 per page if it were 12 pages (Fig. 1). On the other hand, if a one-minute facsimile terminal was available, for the same line cost of $.25 per minute, a daily volume of 10 pages would be required for the cost per page to be $.85, and 7 pages per day for a $1.15 per-page rate. The break-even traffic for the one-minute and three-minute units at a line cost of $.25 per minute, is 8 pages per day as shown in Fig. 3; that is, if the volume is greater than 8 pages per day, the one-minute machine has the cost advantage. When the facsimile transceivers are compared with a regular teleprinter at 100 words per minute, we also have to figure out the manpower cost for punching the paper tape for a 550-word full page.

The labor cost is approximately $1.75 or $.003 per word. (We assume the operator will need 17 minutes to punch the tape, 8 minutes to verify it, 10 minutes to correct the errors and 6 minutes to transmit it. Also that she is paid $2.35 per hour).

The line cost per word transmitted at 100 words per minute should be calculated on the basis of an effective teleprinter speed of about 85 words per minute. This is because teleprinter control functions, such as carriage return and line feed, reduce the message rate by 15%. Assuming $.25 per minute as the line charge, the transmission of a 550-word message will cost $1.60 or $.0029 per word. The total cost (manpower + line cost) is $.003 + $.0029 = $.0059 per word against $.0013 per word for the three-minute machine. (In this example, we assumed the rentals for the teleprinter and the facsimile transceiver are approximately the same).

The cost comparisons of the above example seem to favor fax for the specific application of transmitting a full-page of printed material.

However, there are other applications such as interactive real-time systems involving computers in which the teleprinter or a keyboard with CRT display are the only terminals which can be used effectively. In the above example, we considered that a 100-word teleprinter required a bandwidth equal to that of fax. Actually it requires a bandwidth of only 120 Hz at 75 baud,which with frequency division multiplexing, allows for up to 24 teleprinters to operate simultaneously on a 3-kHz circuit. Even with this heavy channel loading, facsimile proves to be less expensive, because of the manpower cost, teleprinter rentals and additional charges for the FDM equipment which more than offset the line-cost savings

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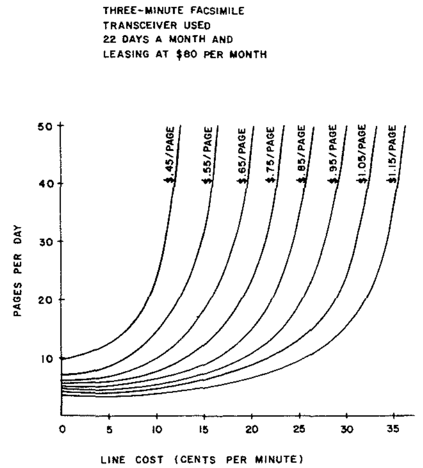


Fig. 1 — Traffic *vs.* **line cost ofr a three-minute facsimile transceiver.**

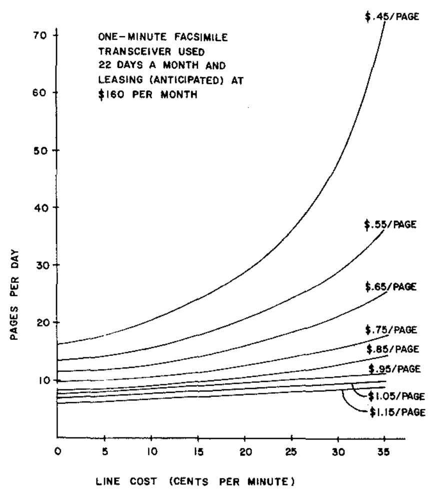


Fig. 2 — Traffic *vs.* **line cost for a one-minute facsimile transceiver.**

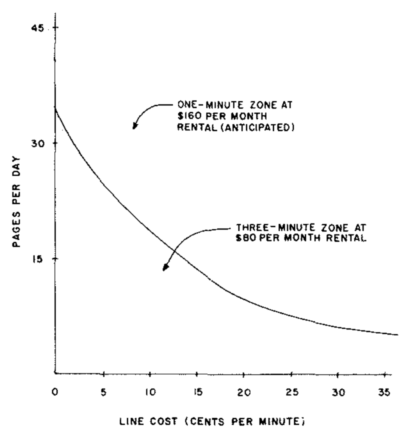


Fig. 3 — Break-even zones for one-minute and three-minute facsimile transceivers.

resulting from more efficient use of the 3-kHz circuit.

The optimum bandwidth utilization would be made if the fax were used in voice-plus-teleprinter systems, in which voice or data or fax and 3 to 4 teleprinters share a 3-kHz circuit on a frequency basis.

In this system configuration, the teleprinters perform their real-time functions, interacting with other teleprinters or computers and the fax moves documents, when voice or high-speed data is not sent over the line. Finally, the ultimate approach would be to time-division multiplex voice, low/high-speed data and fax for simultaneous transmission in an all-digital format, as it was mentioned earlier.

Compatibility requirements

In global communications, we frequently deal with countries in which fax equipment is manufactured. Naturally, our correspondents in these countries insist on using their machines in domestic and international communications. This becomes a serious problem when the fax terminals employed at each end of the link are incompatible.

At the present time, there are very few machines in the market compatible in some degree with models of other manufacturers. It is, therefore, high time that someone establishes universal minimum standards for the handshake, synchronization, speed and resolution requirements every machine should meet. This will enormously enhance the use of facsimile over global circuits and regular domestic dialing telephone networks.

In addition, it will greatly simplify their operation and maintenance to the mutual benefit of subscribers and common carriers.

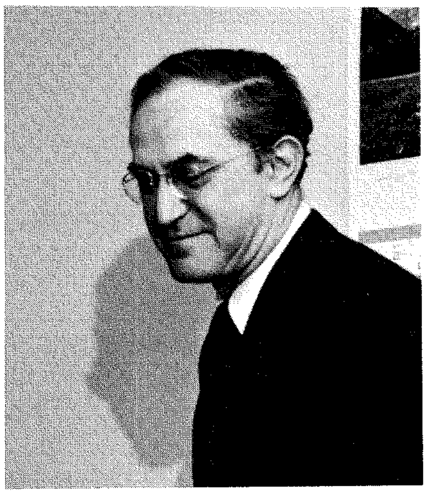
Conclusion

From the foregoing brief discussion, one can conclude that fax has the potential of becoming soon an important member of the family of communications equipment serving the business community. Eventually, when prices are reduced and transmission speed is increased significantly, the dream of electronic mail for the home will come true.

Faces and fax in a tv conference system

S. N. Friedman

The tv conference network described in this paper was developed for use within a proposed Corporate Microwave Network. If implemented, the system would provide state-of-the-art video technology to the Corporation's business community to help meet growing communications needs. The network provides for 1) a two-way live video channel for remote conferencing, 2) a camera-facsimile channel for electronic mail service, 3) a call director control and switching unit at each subscriber terminal, and 4) a distribution system to deliver the information to the end destination. Designed specifically for use on a private microwave system, it is also directly suited for use via domestic satellite systems and two-way cable tv. Planning has been based on the modular concept throughout to allow for expansion, added functions, and new and improved services. Full colôr capability is included in the video system but near-term transmission from most terminals will be monochrome, since the requirement is maintained throughout for very low cost terminals and for normal room lighting operations within the skill level of the average participating executive.



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TRACING the family tree of electronic communications takes us from telegraph, to telephone, to television. Although the first two have pretty much run their course, a great deal remains to be written before the television chapter is complete.

It is fairly evident that television's phenomenal rise to universal public acceptance has been as a one-way transmission medium — one which added sight to sound, but with the restriction that the participating individual be involved almost solely as a spectator. We are now, it appears, on the threshold of two-way television transmission systems, which is a necessary prerequisite to full-fledged membership in the communications society.

In addition to providing a new and far more powerful means of communicating, television can help alleviate the massive problems associated with the severe overloading of the voice media and of the postal service facilities. Furthermore, it may help stem the rapidly rising cost of communications-related travel, a very cost ineffective way of meeting limited objectives that could be accomplished much more economically with a good video communications system.

Television is, in truth, an invaluable tool which we may be about to tap closer to its full potential. And present-day technology does already encompass many solutions to the video-associated problems of our work-a-day world.

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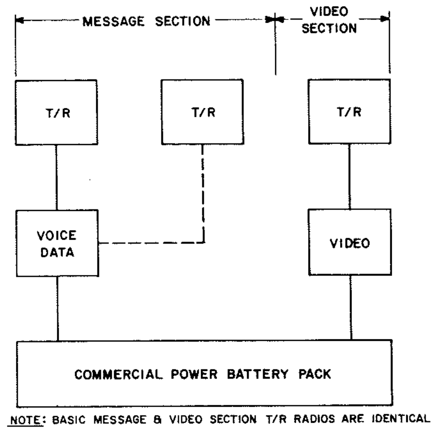

Fig. 1 — Proposed Corporate microwave system.

Television on a private microwave system

The proposed plan for private Corporate Microwave System provides for a microwave network serially interconnecting Corporate installations in a line-of-sight sequence. This facility will consist of two sections: a voice/data section for corporate telecommunications, and a video section with two-way, full duplex television capability (see Fig. 1). The system would be initiated as a private network operating in the industrial band, and its services would be provided for intracorporate use by the participating divisions and individual users at each location.

The incorporation of the tv channel represents a significant forward step in Corporate communications planning, and will provide a practical means for demonstrating business applications for broader utilization of electronics in communications. Remote visual conferencing will promote the development of new management and marketing techniques, procedures for cost savings in labor and administration, and for reduction in executive travel.

In addition to this Remote Conference Service, the Video Section of the Network will provide facilities for a broadband, camera-facsimile channel for internal electronic mail service multiplexed into the video baseband signal.

Provision of these services includes the design and implementation of the following at each of the locations:

1) Microwave radio system including antennas, *etc.*, as well as radio equipment;
2) Multiplex system for simultaneous operation of video, electronic mail, audio conferencing, local conferencing, and system control;
3) Distribution system for signals, of all services, to the individual terminals within each site;
4) Switching and control for the overall system and for each site; and
5) Terminal facilities for each subscriber. This includes the following types of facilities initially:
   - —Executive console tv conference terminal/mobile video cart.
   - —Remote tv confererence room facility.
   - —Electronic mail-room facility.

Modular design concepts are used in all instances to provide for simple expansion either for an increase in the number of subscribers or for the addition of new services or facilities.

It is important to note that, although the system will be implemented initially for intra-corporate use between New York and Camden, plans are being made for expansion of the network to Washington, DC, and for later commercialization and operation as a common carrier service. It has significant spin-off benefits in its potential application to the domestic satellite system and for the tie-in to other systems internationally. Also, it can serve as a showcase system and test-bed for CATV and 2-way video systems of the future.

Remote conference service

The remote conference service provides the complete facility for conferencing, tying in remote sites to the local live conference area. All of the aspects of the live video are preserved and as much of the "live" feeling as possible is transferred to the video presentation of the remote participants. As part of the basic service, executive console-type operation is provided, besides the conference room facilities. These consoles are small table-mounted units and are placed in selected executive offices, enabling face-to-face, full tv executive conferencing on an office-to-office, or office-to-conference room basis.

In addition to the executive console, a basic low-cost conference room facility is made available for installation at any location which has a requirement for full-fledged remote conferencing, with more extensive participation than provided for by the executive console. All terminals are designed on a modular basis to allow for expansion to a more elaborate system, if desired.

Executive console conference tv and mobile video cart

The real economy-minded implementation of the conference service is the small, mobile, tier-table console designed for executive office use. The basic operating equipment consist of 1) a monochrome camera and monitor for set-up and transmission, 2) a color tv monitor for receive display; and 3) a telephone-video call director set, enabling each executive participant to select the party or parties with whom he would like to confer and to exclude all others normally on the party-line system.

A terminal of this type is capable of very good quality monochrome transmission from all terminals, and the color receiving monitor provides full capability for receiving either monochrome or color from the other sites. A low-cost color video tape recorder supplements these equipments and allows for pre-recording for transmission, or recording of received video for record or replay.

Color conferencing

Since inexpensive color-tv-camera technology is still in the early stages, prices are still high and performance below acceptable levels in the equipment category of interest. Even the somewhat higher priced units currently available still require studio lighting and critical adjustment. Consequently, initial executive console implementation does not include color camera capability. However, color videotape recorders are available as optional devices and pre-recorded video can be transmitted over the system. Thus, the color receivers and recorders which are incorporated in the consoles allow for meaningful, full-color conferencing at those locations where a color video source is available; that is, either a studio or conference room, off-the-air video, or videotape.

Of course, since this is a completely compatible tv system, the user can utilize any standard tv equipment he may have available to augment the basic equipment supplied with the terminal.

Remote tv conference room facility

The modular concept allows a conference room to be equipped on a less or more elaborate basis (depending on individual needs and the associated means) and also to provide for expanding the services at an existing facility. The basic facility includes the following:

A conference table seating approximately six to eight people on one side, as participating conferees. A comparable number of seats suitably placed behind the first six can serve as a spectator-participator section.

Three cameras, with associated monitors for set-up and transmission, serve as follows:
- —One camera to take in the full scene, equipped with telephoto or zoom lens.
- —One camera, with standard lens, movable to focus on any one of the conferees, or on a lecturer position. (optional)
- —One camera with zoom lens for document, flip-chart, or viewgraph presentation. The cameras, in general, are fixed-adjusted to perform their specified functions. The fine adjustments and camera selection to meet the specific application conditions are centrally controlled, easily handled by the executive-operator.

Two large-screen color tv monitors for transmit-and-receive display are provided.

A large-screen video projector is a special recommended option. The relatively low-cost, high-performance monochrome video projector projects a clear, bright picture on any standard projection screen in widths from 2½ feet to as large as 10 feet, for either front or rear screen projection.

The projector incorporates many automatic features for ease of setup and operation, and has remote control capability so that the familiar contrast and brightness controls can be adjusted from the conference table. It is completely solid-state, modularized and used the RCA projection kinescope. Its room lighting requirements for comfortable viewing correspond to those of standard conference room devices such as viewgraph and slide projectors.

A conference telephone set is also provided. The unit contains three microphones, a speaker and the audio conference controls, in addition to the regular handset for private conversation.

In addition, all standard conference room facilities such as speaker lecterns, projectors, etc. can be accomodated and included in the video conferencing.

Video system

The basic requirement for the video system is to provide for two-way video

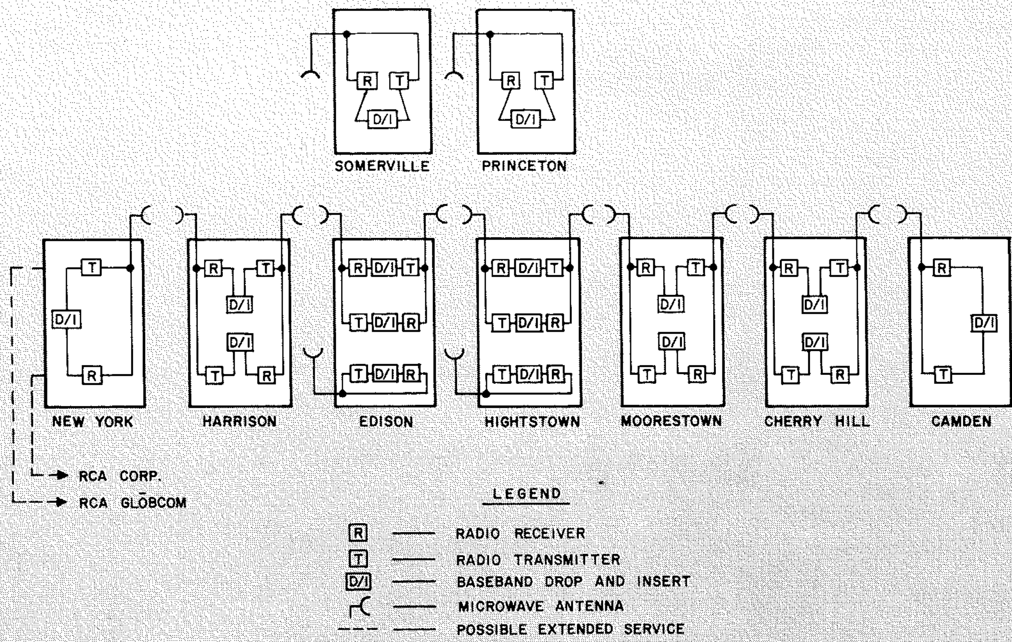

Fig. 2 — Video system rf interconnection.

communications between any two locations, selectable at any of the subscriber terminals from the ten locations which are interconnected by line-of-sight radio transmission paths. It is, at the same time, required that a video broadcast interconnection be feasible, so that any one of the ten locations can transmit to all of the other nine, which will simultaneously receive on a party-line basis.

The line-of-sight interconnection economically as well as technically dictates that the locations be serially connected. Further, all locations except those at the end points must be able to transmit in two directions and receive from two directions. In addition, each location must serve as a repeater station to pass the signals on to the adjacent location when not acting as a video drop or video insert point to the system. The requirement also exists for so-called spur sites, *i.e*, Somerville and Princeton, to access the main radio path with the capability of transmitting and receiving in either of two directions (or both for broadcast). The system configuration is shown in Fig. 2.

Video services and distribution

The plan is to provide simultaneous video service and electronic mail document service by multiplexing the two into an aggregate baseband along with voice, signal, and control channels. There will be a main video drop and an addressable electronic mail room at each site (Fig. 3).

The radio set and multiplexers will be centrally located at each site and distribution facilities provided to key points throughout the site for subscriber terminal connection, for remote conference service. Distribution facilities for electronic mail will similarly be distributed throughout the site so that small, low-cost mail pick-up devices can be situated directly at the subscriber offices. Initially, however, mail delivery will only be at the electronic mail room where the printer will be located.

Special features

The radio system implementation was designed to meet these requirements in such a way as to provide maximum benefits and minimum risk both from the near-term and long-range points of view, as follows:

1) The radio sets are identical with the message system equipments and are completely interchangeable with them. Thus, they contribute to economy in procurement and could, for example, be used for the message system expansion to Washington, should such an eventuality be deemed desireable.
2) Some circuits and features can be used in common with the message system, such as control, status and alarm circuits as well as maintenance provisions and procedures.
3) The system design provides an economical and flexible configuration for conferencing and called party selection without the need for a central control node or for special system operators, initially. However, it is adaptable to a centralized control system for later commercialization.
4) For the future, it allows for segmented operation of the system; that is, multiple independent conferences can be held on the system, as long as the connecting links for the separate conferences are non-overlapping. This could significantly increase system utilization with associated reduction in user costs.
5) A video intercom mode will be provided to tie-in to local closed-circuit video facilities at each location. This will extend the utilization of presently localized capabilities, such as Princeton colloquia and seminars, to all of the participating locations. That is, two locations interconnected on the microwave system on a point-to-point hook-up, can actually be broadcasting through-out each of the locations on a local video intercom network with widely distributed audiences.

Video system operation

In operation, a calling party accesses the loop by addressing the called party from a Call Director control set which is provid-

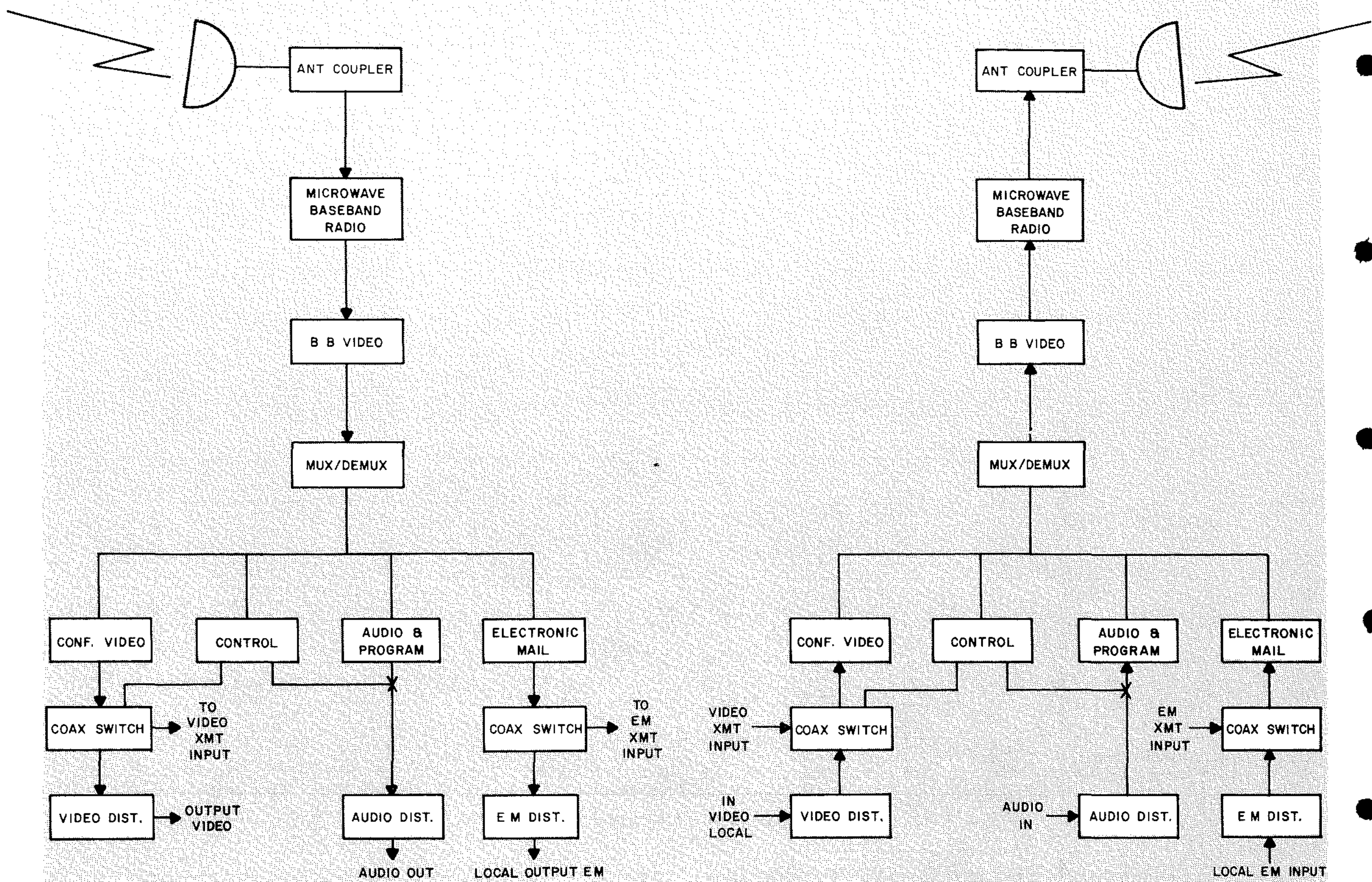

Fig. 3 — Typical site subsystem block diagram.

ed at each station (console or conference room). This action excludes all other parties from accessing the loop. Provisions are also made to allow one user to broadcast to all other stations on the network for conferencing purposes. In such instance, the person conducting the conference has sole access to the system, with all other parties viewing the procedures. Some *a priori* operational procedures will be established to allow each conferee access to the system for questions or contributions to the conference. This will also be on a broadcast basis so that everyone in the conference will see and hear the entire process.

Electronic mail service

In addition to the conferencing services, the video section of the microwave system provides sufficient bandwidth in the radio set to allow for the implementation of an electronic mail service, frequency division multiplexed into the baseband above the video. The system provides a fast-fax type service using a document-resolution camera and a very high speed, hard-copy printer to transmit and reproduce an 8½×11 inch document in less than 10 seconds.

This implementation of electronic mail — utilizing a high-resolution television camera as a pickup device, in conjunction with a receive hard-copy printer that relies on optical transfer of information at the receive terminal for printout — is technically complicated. This is true even when standard 4.5-MHz television bandwidth circuits are used for transmission, and becomes increasingly so as available bandwidth become narrower. This is due to several factors, some of which are the following:

1) Accepting the fact that document resolution requires in the order of 90 lines (45 line pairs) per inch, transmission of an 8½×11-inch document requires a "resolution" in the order of 1000 lines horizontally as well as vertically, roughly 4 times the resolution of a standard 525 line television frame. Thus, even with the standard television bandwidth, the frame rate would have to be decreased roughly by a factor of 4, to 7½ frames per second, to stay within a 4.5-MHz video signal bandwidth. If further, the bandwidth were to be reduced to approximately 1 MHz, then the vertical frame rate would have to be reduced still more to the order of one frame per second, corresponding approximately to a 1-kHz line rate.
2) Standard television devices, though they may have variable horizontal-scan-rate capability, are all pretty much restricted to line-locked vertical rates. Consequently, to

allow for the greatly reduced line and frame rates at these relatively narrow bandwidths, the camera and the monitor both should preferably be electronically rather than magnetically deflected.

3) A further complication is that it is undesirable both economically and technically to require special storage devices for the video at either the receive or transmit end of the circuit. Therefore, both the pick-up and the receiving subsystem, *i.e.*, monitor and the opto-electronic converter in the printer, must be able to operate at this slow line and frame rate, relying only on their own inherent storage capability, to avoid having to provide expensive external storage.

The system being developed for commercial implementation meets the requirements for minimal storage at bandwidths down to approximately 1 MHz. The addition of *x-y* deflection circuits, appropriate synchronization, and black-level clamp circuits, make for a novel and effective system.

For the near term, and to extend the electronic mail service to industrial applications, where narrower bandwidths in the order of 100 kHz are all that can be accommodated, other techniques are being prepared. A low cost laser flying-spot scanner used as a pick-up device in place of the camera, in conjunction with a fibre-optic thin-window tube at the receive terminal as an optical buffer and line-by-line printer is in the final development stages ready for product design.

Electronic mail room

Either of the above approaches meet the following basic requirements for the service:

1) Transmission time of one second and printout time of ten seconds or less for an 8½×11-inch document. The hard-copy printout has a facsimile-grade resolution.
2) Copy with five shades of gray or black-and-white can be transmitted and printed.
3) Since a good depth-of-field pickup system is used, the subject material can be three dimensional, and is not restricted to flat copy; enlargement or reduction is also possible.
4) Each terminal is full duplex and is capable of transmitting and receiving simultaneously; however, system limitations may restrict a terminal to half-duplex operation in certain system hookup configurations. It can also be used in loop-back mode as a copier, if desired.
5) A significant feature, also, is the system efficiency for transmitting a letter where a number of copies have to be sent to different installations as electronic mail; it is not necessary to run copies at the source mailing point and distribute them separately to their destinations. It is simply a matter of placing the copy in front of the camera at the mailing point and addressing the transmission to the individual receiving points. All addressed locations then receive copies simultaneously on their printers.

The cost-effectiveness of such a service can be high-lighted in various ways: *e.g.* a facility which has a heavy requirement for the transmission of documents and, which, by present fax devices, ties up a toll line all day long and finds it to be still inadequate. The substantial savings in costs both in tolls and in manpower which can be realized by the broadband approach are obvious in this case.

Needless to say, the increased efficiency made possible by "instant-mail" facilities can also be of value, even though an exact dollars-and-cents figure may be difficult to assess.

TV-fax capability

In addition to the very high resolution document transmission capability, facilities are included in the system for tv-band transmission of standard tv frames where the 525-line raster resolution is adequate. For these applications, a hard-copy printer with a 4×5-inch printout on a 5×6-inch sheet is available.

This implementation is economical in terms of initial equipment cost and is very inexpensive in cost per copy. Transmission time is one-half second per 525-line frame and printout time is 5 seconds or less for the complete process. As with the electronic mail equipment, the paper is inert, white, and has the qualities of bond paper. It will accept pen or pencil notes, has an indefinite shelf life, requires no fixers after printing, and is non-fading.

Since it is standard video transmission, any of the standard conference system cameras can be used; transmission can emanate from any of the conference system terminals via the tv conference circuit, and can be received at any hard-copy printer terminal. In fact, the printer unit is small enough to be incorporated as standard equipment in conference rooms and even in executive consoles.

Electronic mail circuit

For sending mail over the electronic mail circuit without the necessity for bringing the copy to the electronic mail-room, primary consideration is being given to low-cost, portable pick-up devices which are completely separable and independent of the receiver-printer unit. Applicable equipment would include high resolution vidicons with slow-scan capability, and the laser flying spot scanner previously mentioned. In addition, electronic teletypewriter terminals are being investigated. These compact units allow for composing and editing a letter, using the tv monitor as a composer-display, and then for transmitting directly from the keyboard-composer. Mating receiver-printers in the mail rooms can then provide the copy for transmission over the electronic mail system.

Later developments may provide for delivery from the mailroom to the destination via similar subscriber devices. This is more complex, however, since an office-compatible printer is required and this may be some time away.

The next stage

What has been described is the basic implementation of a network designed to provide the benefits of state-of-the-art video technology to the business community to help meet growing communications needs. The planning has been based on the modular concept throughout to allow for expansion, added functions, and new and improved services on the network. Although the initial configuration is directed towards limited coverage — intra-corporate use — it looks forward to increased coverage via an expanded microwave system, via the domestic satellite system, and over international circuits. It can also serve as a test bed and showcase system for the two-way cable-tv systems of the future.

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Computer analysis of radio frequency interference between earth stations and terrestrial microwave facilities

R. H. Tatowicz

One of the most difficult problems encountered in the design of a satellite communications Earth station is that of choosing a site that is relatively free of harmful interference. Since the transmit (5925 to 6425 MHz) and receive (3700 to 4200 MHz) bands used for satellite communications must be shared with terrestrial line-of-sight microwave facilities, all those microwave sites which interfere with the Earth station, and all those sites to which the Earth station causes interference, must be identified.

PHENOMENAL DEMANDS for high-quality voice, television, and data communications circuits have resulted in the first attempt to establish a commercial domestic satellite communications system in the United States.

In this type of communications system, information is transmitted from an Earth station, up to an orbiting satellite, then back down to another Earth station. The satellite is located in an equatorial orbit approximately 22,300 miles above the equator. In such an orbit, the period of rotation of the satellite around the Earth is the same as the period of rotation of the Earth about its spin axis. Thus, to an observer on the ground, the satellite appears to remain stationary in the sky.

Ground-segment interference

One of the most difficult and time-consuming tasks associated with the planning and design of a satellite communications Earth station is that of analyzing its competing environment of existing microwave installations for potential interference problems.

Specifically, the difficulty lies in the need to avoid mutual interference for all frequencies in the 3700 to 4200-MHz Earth-station receive band and the 5925 to 6425-MHz Earth-station transmit band (see Fig. 1). These same bands are currently allocated by the Federal Communications Commission to terrestrial radio services.

Because of the large number of terrestrial microwave installations existing in the United States, manual methods for analyzing radio frequency interference (RFI) problems are totally inadequate. Fortunately, a large portion of the work involved in an RFI study lends itself to computer analysis.

Radio frequency interference analysis

The Federal Communications Commission prescribes that for every proposed Earth station, an RFI analysis must be performed to demonstrate that all existing microwave facilities are free from harmful interference caused by the Earth-station-emitted rf power; and also that the existing microwave facilities will not cause harmful interference at the Earth station. To determine the receive power levels at the Earth station and the microwave facility, the following basic equation must be solved:

$$P_r(p) = P_t + G_t - L_b(p) + G_r, \qquad (1)$$

where $L_b(p)$ is the minimum permissible basic transmission loss not exceeded for p percent of the time, in dB; P_t (at 4 GHz) is the maximum available microwave rf power delivered to the antenna, in dBW; P_t (at 6 GHz) is the maximum available Earth station rf power density delivered to the antenna in dBW/4 kHz; G_t (at 4 GHz) is the component of gain of the transmit microwave antenna in the direction of the Earth station, in dB; G_t (at 6 GHz) is the component of gain of the Earth station antenna in the direction of the receive microwave antenna, in dB; G_r (at 4 GHz) is the component of gain of the Earth station antenna in the direction of the transmit microwave antenna, in dB; G_r (at 6 GHz) is the component of gain of the receive microwave antenna in the direction of the Earth station, in dB; $P_r(p)$ (at 4 GHz) is the received power at the Earth station not exceeded for more than p percent of the time, in dBW; and $P_r(p)$ (at 6 GHz) is the received power at the microwave facility not exceeded for more than p percent of the time, in dBW/4 kHz.

Before proceeding with a description of how the above terms are computed, two additional ideas must be introduced: that

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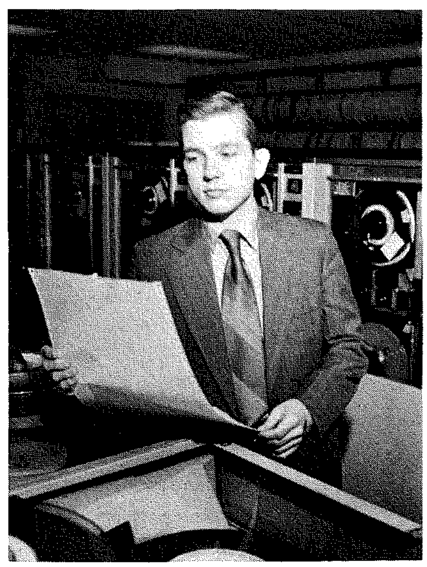

of satellite visibility arc, and that of horizon profile.

Since the Earth station will operate with a satellite in synchronous orbit, the corresponding azimuth and elevation angles to which the Earth station antenna will be restricted is termed the *satellite visibility arc*. Fig. 2 shows a plot of the satellite visibility arc for a hypothetical site, illustrating the satellite (and/or antenna) elevation as a function of azimuth. A single point on this arc represents a particular geostationary satellite position. The entire arc represents all possible geostationary satellite positions with which the Earth station is designed to operate.

The *horizon profile* of an Earth station may be defined by assuming the Earth station is located at the center of a polar coordinate system; then each point on the horizon may be expressed in terms of an elevation angle above the horizontal plane, and an azimuthal angle measured in a clockwise direction from the geographical north pole. This is illustrated in Fig. 3.

Basic transmission loss

The three major factors that influence the attenuation of a microwave signal over a path are:

1) The path distance
2) The progagation mechanism
3) The progagation geometry

These factors are interrelated as certain geometries favor certain propagation mechanisms. Since forward scatter, diffraction, and ducting modes are influenced to different degrees by path characteristics, it is necessary to postulate a path model that yields sufficiently low values of predicted basic transmission loss when compared with real paths. Several studies have been made which allow the derivation of a model path that takes all the discussed parameters into consideration.

Briefly, analysis of terrain profiles between Earth station sites and terrestrial microwave facilities reveal that over 90% of the paths have microwave antenna horizon elevation angles greater than −12 milliradians (*i.e.*, less negative than −12 milliradians, or positive). Also, single knife-edge diffraction paths are encountered frequently for path distances

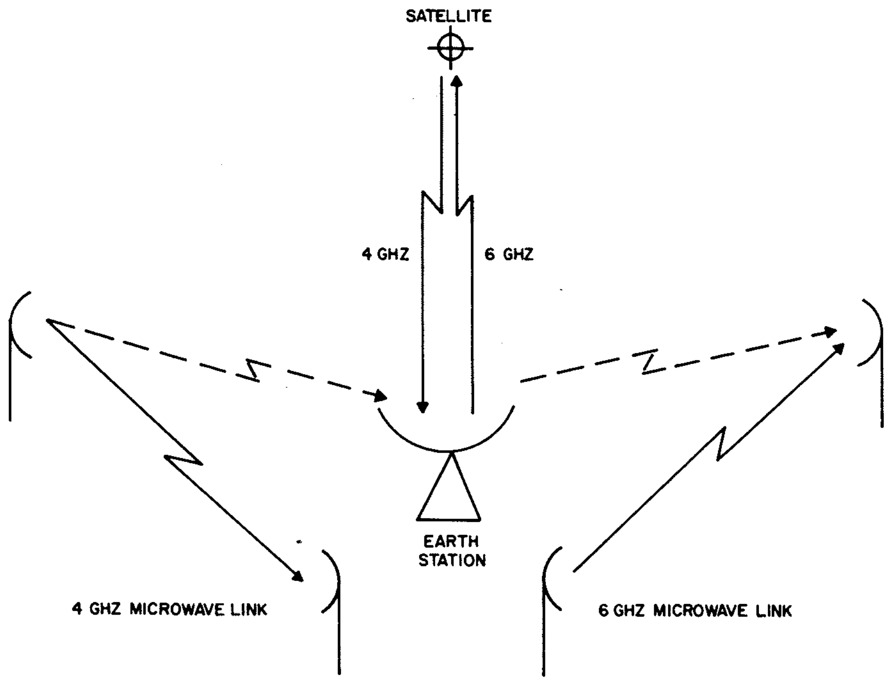

Fig. 1 — Terrestrial interference considerations.

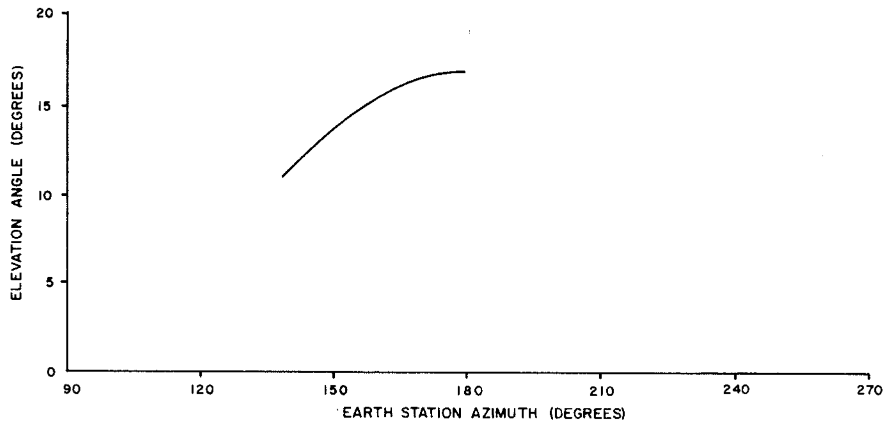

Fig. 2 — Satellite visibility arc.

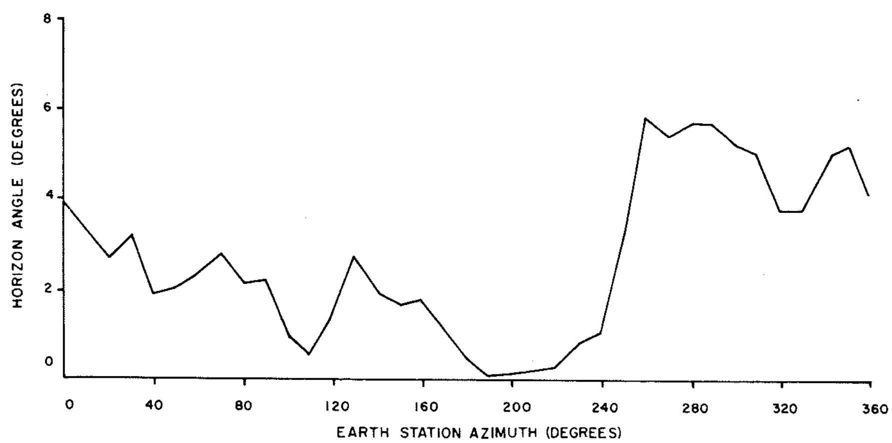

Fig. 3 — Horizon profile.

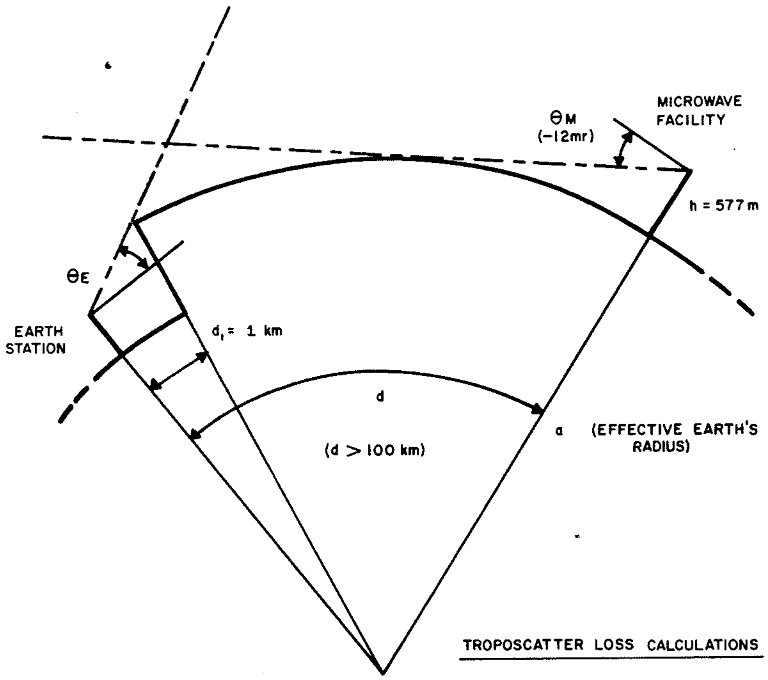

Fig. 4 — Model path geometry for troposcotter loss calculations.

less than 100 km, but rarely encountered for path distances greater than 100 km. These two observations allow the derivation of a path model suitable for calculation of basic transmission loss.

It has been found that for paths over 100 km in length, tropospheric scatter is the dominant mode of propagation. The transmission loss over such a path is essentially dependent upon the horizon elevation angle at the Earth station, θ_E, the horizon elevation at the microwave facility, θ_M, and on the path length, d. Since transmission loss must be determined without knowing the actual path characteristics, a conservative value of θ_M (equal to -12 milliradians) is assumed (see Fig. 4). The parameter θ_E, on the other hand, is obtained from the Earth station horizon profile described previously. For paths shorter than 100 km, single knife-edge diffraction is the dominant mode of propagation. For this type of path, the transmission loss is a function of θ_E, θ_M, d, and the distance to the obstacle from the Earth station. In this case a minimum value for θ_M is no longer admissible. Instead, a microwave antenna height of 577 meters is assumed. This antenna height corresponds to the previous tropospheric scatter case, where a maximum antenna height of 577 meters is required to assure a minimum microwave horizon elevation angle of −12 milliradians. Thus, the antenna height implied in the tropospheric scatter case is also used for paths less than 100 km. Finally, to obtain sufficiently low values of transmission loss, an obstacle distance of 1 km has been assumed (see Fig. 5).

All the parameters required for calculating transmission loss are now available. It is beyond the scope of this paper to describe the mathematical and empirical methods employed in calculating basic transmission loss. For this, the reader is referred to Ref. 1, where comprehensive methods for predicting transmission loss are presented.

Due to climatic variations, interfering signals are subject to level fluctuations with time, either within a given propagation mechanism or as a result of transitions between different propagation mechanisms. Consequently, interference criteria are customarily given as two values of maximum permissible received interfering power, associated with two percentages of time during which they may be exceeded.

The computer program to be discussed incorporates a routine which utilizes the previously described path model, and predicts path loss for 0.005% and 20% of the time.

Earth station horizon antenna gain

One of the parameters required to solve Eq. 1 is the Earth station antenna gain along the potential interfering path. Assuming the Earth station is located at the center of a polar coordinate system, then each point on the horizon may be expressed in terms of an elevation angle, θ_E, above the horizontal plane, and an azimuthal angle measured in a clockwise direction from the geographical north

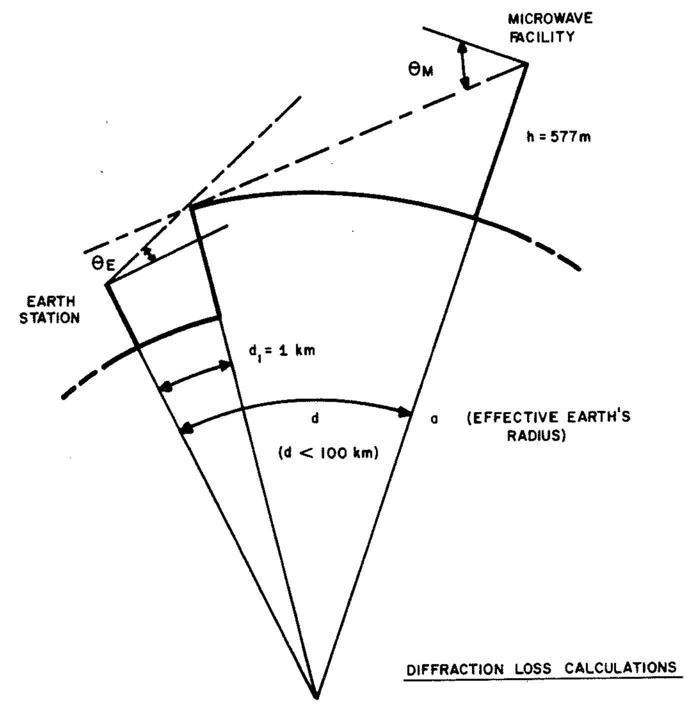

Fig. 5 — Model path geometry for diffraction loss calculations.

pole. In this coordinate system, each point on the physical horizon is separated by a certain angle from a given satellite position. Refering to Fig. 6, it can be seen that the separation angle from a given horizon point is different for each permissible satellite position. Among all possible separation angles there is a smallest one, which may be termed $\Delta\theta_{MIN}$. For each horizon point around the Earth station one such angle, $\Delta\theta_{MIN}$, can be found. A functional relationship between minimum separation angle $\Delta\theta_{MIN}$ and azimuth can thus be determined. In accordance with Report 391, CCIR XI, Oslo, 1966, the antenna gain of large apertures, at an angle $\Delta\theta$ off the main beam, can be approximated by the following equation:

$$G(\Delta\theta) = \begin{cases} 32\text{-}25 \log \Delta\theta \text{ dB.} & 1° \leq \Delta\theta \leq 48° \\ -10 \text{ dB} & 48° \leq \Delta\theta \leq 180° \end{cases}$$

Substituting the minimum separation angle, $\Delta\theta_{MIN}$, into this equation yields for each azimuthal angle a new function which gives maximum horizon antenna gain as a function of azimuth (See Fig. 7). This function may be directly used as G_t or G_r in Eq. 1.

Microwave antenna gain

Another parameter required to solve Eq. 1 is the microwave facility antenna gain along the potentially interfering path. Since, in many cases, the real antenna patterns are unknown, a worst-case antenna-gain envelope is assumed. The relevant microwave off-beam antenna gains for 4 GHz and 6 GHz are defined as follows:

For 4 GHz.

$$G(\Delta\theta) = \begin{cases} 40 \text{ dB.} & 0.5° \leq \Delta\theta \leq 0.9° \\ 39\text{-}25 \log\Delta\theta \text{ dB} & 0.9° \leq \Delta\theta \leq 23.0° \\ 5 \text{ dB.} & 23.0° \leq \Delta\theta \leq 110.0° \\ -7 \text{ dB.} & 110.0° \leq \Delta\theta \leq 180.0° \end{cases}$$

For 6 GHz.

$$G(\Delta\theta) = \begin{cases} 43 \text{ dB.} & 0.5° \leq \Delta\theta \leq 0.7° \\ 39\text{-}25 \log\Delta\theta \text{ dB.} & 0.7° \leq \Delta\theta \leq 36.0° \\ 0 \text{ dB} & 36.0° \leq \Delta\theta \leq 110.0° \\ -4 \text{ dB.} & 110.0° \leq \Delta\theta \leq 180.0° \end{cases}$$

Great circle distances and azimuths

In addition to the above, in order to implement a procedure by which microwave facilities may be cleared, the following parameters must be determined:

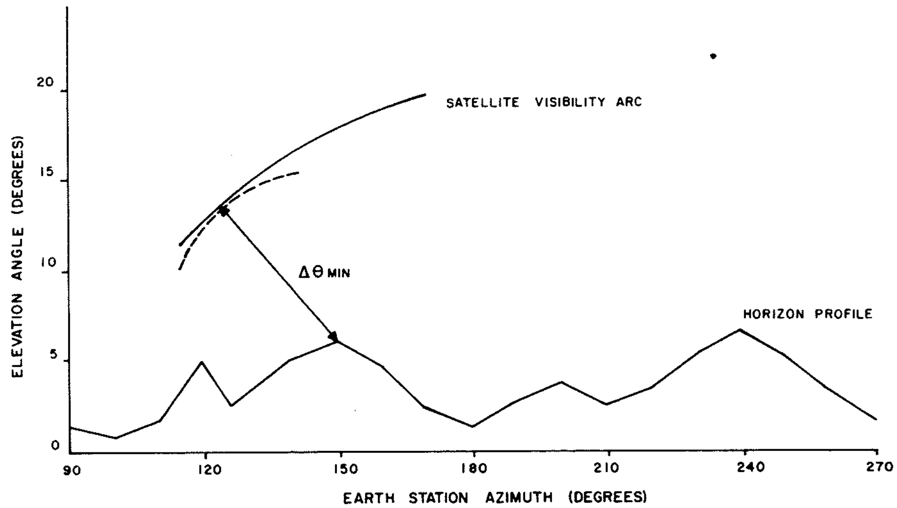

Fig. 6 — Minimum separation angle.

1) Azimuth at the Earth station toward the microwave facility; to permit computation of the Earth station horizon antenna gain.
2) Azimuthal difference at the microwave facility between its antenna main beam azimuth and the azimuth toward the Earth station; to permit computation of the actual component of microwave antenna gain in the direction of the earth station.
3) Distance between the Earth station and microwave facility.

The above three parameters can be calculated knowing the coordinates of the Earth station, the coordinates of the microwave facility under investigation, and the actual azimuth of the microwave antenna.

Data base organization

A program to perform the kind of analysis previously described requires a data base of enormous proportions. The data base used can be divided into two major areas:

1) Earth Station site data
2) Microwave facility site data

Earth station data base

The Earth station site data base is maintained on standard computer cards and is

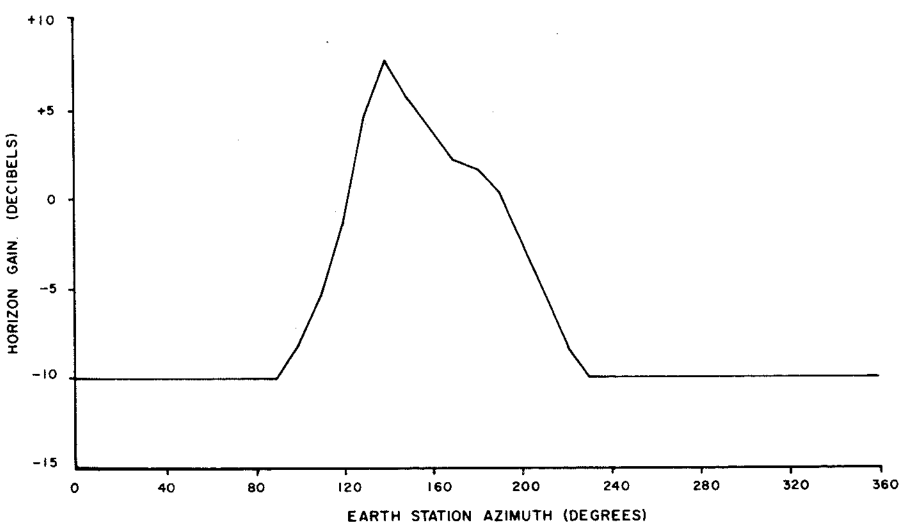

Fig. 7 — Horizon antenna gain profile.

SITE NAME BOONTON, NEW JERSEY

SITE COORDINATES 40 56 07 N 74 29 25 W

FREQUENCY BAND 3700-4200 MHZ

FREQ (MHZ)	MICROWAVE LATITUDE	MICROWAVE LONGITUDE	CALL SIGN	USER SYMBOL	DIST (KM)	LOSS .005% (DB)	LOSS 20% (DB)	ES-MW AZIMUTH (DEG)	MW-ES AZIMUTH (DEG)	ACT MW AZIMUTH (DEG)	DELTA AZIMUTH (DEG)	REC PWR .005% (DBW)	REC PWR 20% (DBW)
4190.0	40 36 21	74 33 37	KEA23	B	37.08	125.4	135.4	189.2	9.1	185.1	176.0	-127.4	-137.6
3710.0	40 36 21	74 33 37	KEA23	B	37.08	125.4	135.4	189.2	9.1	141.4	132.3	-127.4	-137.6
4110.0	40 36 21	74 33 37	KEA23	B	37.08	125.4	135.4	189.2	9.1	141.4	132.3	-127.4	-137.6
4130.0	40 36 21	74 33 37	KEA23	B	37.08	125.4	135.4	189.2	9.1	141.4	132.3	-127.4	-137.6
4190.0	40 36 21	74 33 37	KEA23	B	37.08	125.4	135.4	189.2	9.1	185.1	176.0	-127.4	-137.6
3730.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	270.3	73.2	-127.0	-137.5
3810.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	270.3	73.2	-127.0	-137.5
3890.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	270.3	73.2	-127.0	-137.5
4130.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	270.3	73.2	-127.0	-137.5
3730.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	54.1	70.7	-127.0	-137.5
3810.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	54.1	70.7	-127.0	-137.5
3890.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	54.1	70.7	-127.0	-137.5
4130.0	40 34 16	74 20 49	KEA76	B	42.23	137.0	147.5	163.4	343.4	54.1	70.7	-127.0	-137.5
3770.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
3850.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
3930.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
4010.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
4090.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
4170.0	40 6 24	74 28 50	KEB40	B	92.08	144.5	154.4	179.5	359.5	48.3	48.8	-134.5	-144.6
3750.0	41 18 14	74 40 25	KEE60	B	43.74	149.8	159.0	339.5	159.4	67.5	91.9	-139.8	-148.9
3830.0	41 18 14	74 40 25	KEE60	B	43.74	149.8	159.0	339.5	159.4	67.5	91.9	-139.9	-149.0
4170.0	40 44 4	74 10 42	KEG63	B	34.44	129.8	141.5	130.3	310.5	197.9	112.6	-131.8	-143.5
3750.0	40 29 39	74 26 37	KEM53	B	49.17	129.9	138.9	175.4	355.4	321.5	33.9	-119.9	-128.9
4150.0	40 29 39	74 26 37	KEM53	A	49.17	129.9	138.9	175.4	355.4	321.5	33.9	-119.9	-128.9
4170.0	40 29 39	74 26 37	KEM53	B	49.17	129.9	138.9	175.4	355.4	321.5	33.9	-119.9	-128.9

Fig. 8 — Typical printout of "Radio Frequency Interference" program.

updated as required. Each Earth station data set consists of 38 cards containing the following information:

1) Earth station site name
2) Earth station site coordinates (in degrees, minutes, and seconds)
3) Earth station site code identifier
4) Earth station horizon elevation as a function of azimuth (in azimuthal increments of 10°)
5) Earth station horizon antenna gain as a function of azimuth (in azimuthal increments of 10°).

Microwave facility data base

The microwave facility data base is maintained on reels of magnetic tape which contain a total of approximately 50,000 records. Each record contains information on a specific microwave link. The relevant microwave link parameters are:

1) Frequency of operation
2) User symbol
3) Transmitter coordinates (in degrees, minutes and seconds)
4) Transmit antenna azimuth
5) Transmitter call sign
6) Receiver coordinates (in degrees, minutes, and seconds)
7) Receive antenna azimuth
8) Receiver call sign

Program description

As presently written, the "Radio Frequency Interference" program can analyze a maximum of 40 Earth station sites simultaneously. Upon execution, it accepts as input the Earth station data set cards described previously and, after the last card has been inputed, reads the microwave facility data tapes. As each microwave link record is inputed, its operational frequency is examined to determine whether it lies in the 3700 to 4200 MHz or the 5925 to 6425 MHz frequency band.

If it lies in the 4-GHz (or 6-GHz) frequency band, the following occurs:

1) For the coordinates of each Earth station site, and the transmit (or receive) coordinates of the microwave link,

— the great circle distances are computed
— the microwave-to-Earth station azimuths are computed
— the Earth station-to-microwave azimuths are computed.

2) The microwave discrimination angles are computed (*i.e.*, the angular separation between the microwave-to-Earth station azimuth and the actual azimuth of the microwave antenna).
3) From the Earth station-to-microwave azimuths, the Earth station horizon gains are computed.
4) From the microwave discrimination angles, the component of gain in the direction of each Earth station is computed.
5) From the great circle distances and relevant Earth station elevation angles in the direction of the microwave site, the basic transmission losses for 0.005% and 20% of the time are computed.
7) If the computed receiver power levels exceed predefined limits, the appropriate data are outputed to a magnetic tape along with the appropriate Earth station code identifier.

Since the Earth station "horizon gain *vs.* azimuth" and "elevation *vs.* azimuth" data are initially read in as discrete values at azimuthal increments of 10°, interpolation is performed when required.

Upon termination of the "Radio Frequency Interference" program, a print routine program is utilized to scan the output tape, and produce a print-out of all the potentially interfering, or interfered with, microwave sites. The resultant print-out is organized according to frequency band of operation (4 or 6 GHz) and Earth station site. Fig. 8 illustrates one page of a typical print-out.

Conclusion

Since the computer results are based on worst case assumptions, the print-out represents potential, as opposed to actual interfering, or interfered with, microwave sites; and is, therefore, subject to further interference analysis. This analysis consists of the use of the actual antenna gain patterns instead of worst case gain envelopes, and actual transmit powers instead of maximum permissible transmit powers, when this information is available. If these methods fail to eliminate all of the sites, path profiles are constructed from contour maps, and detailed path loss calculations are made based on the actual geometry of the involved paths.

Although the computer has not completely eliminated the engineer in the evaluation process, it has succeeded in reducing to manageable proportions a job that was previously impossible to do by manual methods.

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Appendix

Great circle calculations (refer to Fig. A)

To determine the great circle distance and azimuths between two points on the Earth's surface, the following equations may be used:

$$\tan \tfrac{1}{2}(Y - X) = \cot \tfrac{1}{2} C \; \frac{\sin \tfrac{1}{2}(L_B - L_A)}{\cos \tfrac{1}{2}(L_B + L_A)}$$

$$\tan \tfrac{1}{2}(Y + X) = \cot \tfrac{1}{2} C \; \frac{\cos \tfrac{1}{2}(L_B - L_A)}{\sin \tfrac{1}{2}(L_B + L_A)}$$

$$X = \tfrac{1}{2}(Y + X) - \tfrac{1}{2}(Y - X)$$

$$Y = \tfrac{1}{2}(Y + X) + \tfrac{1}{2}(Y - X)$$

$$\tan \tfrac{1}{2} Z = \tan \tfrac{1}{2}(L_B - L_A) \; \frac{\sin \tfrac{1}{2}(Y + X)}{\sin \tfrac{1}{2}(Y - X)}$$

where L_A = latitude of point A; L_B = latitude of point B; C = difference in longitude between points A and B; and Z = great circle angle between points A and B.

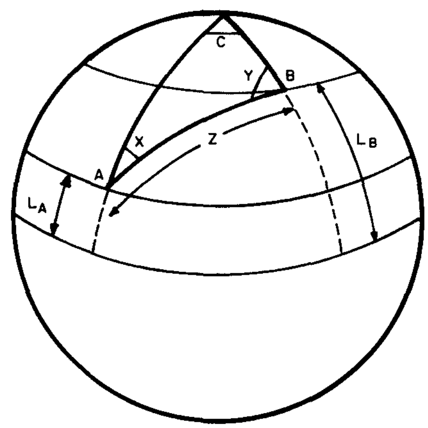

Fig. A — Great circle calculations.

Satellite elevation-angle calculations (refer to Fig. B)

To determine the elevation angle to the satellite from any point on the Earth's surface, the following equations may be used:

$$\tan \partial = \frac{\cos D\,[R/(-\,R + h)]}{\sin D}$$

$$\cos D = \cos|U| \cos|V|$$

where ∂ = satellite elevation angle; R = radius of the earth; h = satellite altitude; U = difference in latitude between the satellite location and the desired point on the Earth's surface; and V = difference in longitude between the satellite location and the desired point on the Earth's surface.

The satellite location is defined as that point on the Earth's surface directly beneath the satellite (*i.e.*, that point defined by the intersection of a straight line connecting the satellite and the Earth's center, with the Earth's surface).

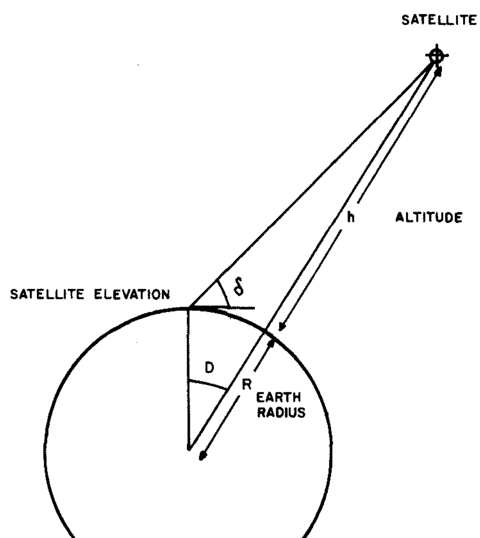

Fig. B — Satellite elevation-angle calculations.

Low-cost terminals for computer input and inquiry

A. Acampora

It is evident that there is a large number of potential users who are not presently interacting with computers because of the unavilability of low-cost terminals. One major step toward tapping this market is the use of the pushbutton telephone as a computer input and inquiry device. This paper examines current usés of the pushbutton telephone as a terminal device, shows the advantages and limitations of the telephone set, and discusses the addition of new features, such as a printer, display, and remote verification, which can significantly increase the telephone's utility.

MORE AND MORE, the business community is looking toward the computer as device for storing and processing vast amounts of information. Of primary interest in using a large-data-base computer system is the ability to interrogate and alter files on demand. A wide variety of special- and general-purpose terminals has been developed to interact with various computing systems. An example of a general-purpose terminal is the standard automatic typewriter. Examples of special purpose terminals include the CRT display devices utilized in stock quotation and airline schedule systems. Although the operation of these terminals is satisfactory, the rental (cost) is generally high.

It appears that a large number of potential users are not presently interacting with computers because low-cost terminals are not available. In the main, these users require occasional and/or intermittent access to a machine, and this limited use precludes the rental of purchase of expensive terminal devices. To appeal to this largely untapped market, many companies are directing considerable effort toward the development of low-cost terminal devices.

One major step in this direction is the use of the pushbutton telephone as a computer input and inquiry device. Information may be sent to a computer via the pushbutton pad that is normally used for signaling the switched network. Since this device is an ordinary telephone, audio response systems are utilized to transmit messages from the computer to the user. This is by far the lowest-cost, most-readily available terminal on the market today.

Alfonse Acampora, Video and Data Systems, RCA Global Communications, Inc. New York, N.Y., obtained the BEE (Magna Cum Laude) in 1957 and the MEE in 1959 from the Polytechnic Institute of Brooklyn. At that time, he joined the technical staff of the RCA Defense, Advanced Communications Laboratory in New York City. His participation at the facility included development of solid state FDM multiplex systems, multichannel data modems, digital phase-locked circuitry for high-speed transmission systems, and advanced demodulation techniques—particularly in the area of fm threshold extension. In 1968, Mr. Acampora joined the research staff of General Telephone and Electronics, in Bayside, New York. In 1970, Mr. Acampora rejoined RCA, at the RCA Global Communications facility, where he had project responsibility for the development of a system which led to a commercial Videovoice terminal currently being offered by RCA Global Communications. For his participation in this program, he received the David Sarnoff Outstanding Achievement Award. Acampora is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

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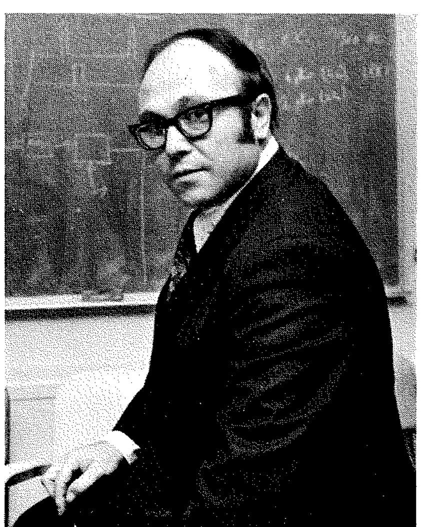
The telephone as a terminal device

Many banks are now using tone signaling for credit transactions. In the usual case, customers of the bank and stores in the area are issued precoded identification cards. A typical transaction involves a dial connection from a pushbutton telephone set to the bank's computer. The store number, salesman and purchaser identifications, and the amount of the transaction are fed to the computer via the button pad. The entire operation is completely automatic and no receipts are supplied. This system could be used for calculating salesmen's commissions as well as inventory control for the stores.



Touch-Tone data inquiry is also used for account balance verification at the banks themselves. Each teller's window is supplied with a pushbutton set. The teller is able to dial the bank's computer, punch in a customer's account number, and receive, via a voice answer-back system, the current balance of the customer's account.

In a typical bank in Chicago, 140 card-dialer telephones, in a closed network, are used to connect the main office to its branches and client suburban banks. The card dialer sets give the tellers an on-line connection to a computer system with an audio response unit. The teller has immediate access to the customer's files which are held on disc.

Several credit card authorization services presently utilize the pushbutton telephone as an input device. In these systems, the card holders' accounts are stored in a central computer file. The computer is accessed, from the telephone, and the account number is entered. Upn receipt of the account number, a check is performed validating the number. The file is searched and an audio answer-back system response on the status of the account is forwarded to the calling party. In one operating system, 64 English words are sufficient for all operations.

A new application of computer input and inquiry terminals has been developed for real estate multiple listings. A central computer file has on store volumes of information regarding houses in many locations. A realtor, after contacting the computer by telephone, will dial in via his pushbutton telephone information regarding the kind of house desired, *e.g.*, location, number of rooms, number of bathrooms, etc. The computer will search its files and return via audio response a message to the realtor indicating the page numbers in his multiple listing book that have houses fitting the desired description. Changes to these listings are numerous, and it is difficult to keep these books to to date at all times. Therefore, the audio response must also indicate all additions and corrections to the information contained in the multiple listing book. This can run, in some cases, to messages of 100 characters in length. Although this system can be quite effective, it also imposes some hardship on the user in cases where a large volume of information is returned.

Limitations of the telephone set

The preceding described some examples of various computer input and inquiry systems utilizing the pushbutton telephone as the basic input and output device. In many applications, the characteristics of the device are adequate in terms of the system requirements as well as user convenience. The most attractive feature, naturally, is the low-cost of the terminal. For some applications, however, this terminal is deficient in operation due to (1) lack of verification of input data and (2) basic limitations of the voice answer-back scheme.

In all the systems described, the user feeds information to a computer via his pushbutton pad and has no immediate knowledge as to whether the information is received correctly by the computer. In one-way systems the computer returns a tone signal to the user indicating that information has been received but gives no indication as to whether any errors (caused by the user or due to transmission) have occurred. Where voice answer-back systems are employed, the user knows that information has been received by the computer because he receives a response. So, although the user knows that he is getting some information into the computer, he generally has no knowledge—or does not know until his response is completed—as to whether the information he intended to enter was received correctly by the computer. In some applications, the potential error is not considered critical. These systems operate on the philosophy of a cross-check at a later stage of operation that would catch any input or transmission errors.

There are applications, however, where immediate verification of the correct receipt of the data by the computer is essential. For example, in a banking application where a depositor's account is debited or credited from such a terminal, it is most important that the user know, at the time the entry is made, whether the correct amount is being debited or credited. In such cases some form of verification must be supplied by the operating system to the user at the time the information is inputted into the system.

The items which are evident at this time are:

1) There is a large impending market for a low-cost alphanumeric terminal which would be primarily used for numeric entry.
2) Usage of the pushbutton telephone is presently filling this need. However, although the terminal is low cost, the full system requires voice answer-back which requires expensive equipment at the computer facility.
3) There is a large unfilled gap between the simple telephone and the more elaborate typewriter terminal.

Increasing telephone utility

Several additions to the ordinary pushbutton telephone would round out its usefulness as a computer input and inquiry device. The key to a low-cost alphanumeric terminal is a low-cost, reliable printing mechanism. Size, cost, and reliability are main factors used in judging the relative merits of various types of printers. Although a page printer format would be ideal, a strip printer would more likely to meet these requirements than any other form of printing device presently available. However, with the advent of large-scale integrated circuits, an alphanumeric display in the form perhaps of a "running sign" cannot be ignored.

Another feature which would be a requisite addition to the telephone is the need for verification of input data. Several forms of verification are suggested below, with the last being the most inclusive.

—*Acknowledgement of receipt of information.* After input information is transmitted to the computer, the receiving data set returns a tone to the transmitting set indicating that information has been received. This technique might be considered the least powerful form of verification since operation and transmission errors are not caught by this verification method.

—*Local verification.* In this mode of verification, the user inputs his information and sees the data either on a display or on a hard-copy before or during transmission of the message to the computer site. If an error is noted, a correction can be then made. This form of verification could be adapted to the pushbutton telephone, but only at great cost. The advantage of this form of verification is in that it eliminates input errors completely; however, it does not take into account transmission errors.

—*Remote verification.* In this mode of operation, the input information is transmitted to the computer and immediately retransmitted by the computer back to the terminal for display or printing. The user then verifies the accuracy of this information and signals the computer to either accept or reject the information. If the information is accepted, a transaction proceeds. If the information is rejected, the user may then re-enter the correct information.

It should be noted that, in actual operating systems, however, it would be sufficient to use remote verification only at those stages of the programs where significant difficulties could arise from the use of incorrect information. The previously quoted examples of deposits and withdrawals in a bank are such instances.

Conclusion

A low-cost alphanumeric computer terminal similar to that described in this paper could improve efficiency in those activities that now do not use a computer because their need is marginal.

The marketplace for such a low-cost terminal is vast—a few of the major applications are:

1) Banking
2) Real estate multiple listings
3) Credit card charge/authorization
4) Inventory control
5) Medical
6) Insurance
7) General information retrieval
   - Billing Information
   - Billing Information
   - Inventory
   - Accounts Receivable

RCA Global Communications, Inc. — a historical review

D.E. Quinn| J.F. Strebel

Any historical view of RCA Global Communications, Inc.,must include a review of the advances made in communications, since the Company started with the birth of modern international communications. RCA Globcom has grown with the state of the art, from the basic interantional service—the telegram—to present-day satellite communications. Today, in a globe-spanning network of over 2500 cable, satellite, and radio circuits, Globcom provides a complete spectrum of international voice/record services. Maintaining its place in the forefront of communications, the Company is ready to embark on ambitious new programs, including a proposal to build a domestic satellite system that holds the potential to revolutinize this country's communications.

TELECOMMUNICATIONS has grown faster in recent years than ever before in history. Even more accelerated growth is certain in the years ahead. Today, RCA Global Communications, Inc., a leader in the field of international communications, is in the forefront of this era of revolutionary change.

The satellite is a major contributor to the revolution in the communications industry. Likewise, trans-oceanic cable systems have vastly improved the quality of international telecommunications and the computer has provided effective, automatic, high-speed control for the great volume of modern communications traffic. Satellites, cable systems, and the computer have brought telecommunications forward in a quantum leap. But, like all technology, they are the result of a body of knowledge that literally began when the earliest man first waved to another a short distance away.

Since that moment, men have tried to find new ways to communicate with each other by sending signs, signals and sounds over longer distances. All telecommunications today are based on an endless chain of human developments. Progress was almost imperceptible, however, until the 19th Century. Then, European and American scientists initiated a steep curve of change that we are experiencing in modern communications.

The names of these men are part of our language today: Ampere, Baudot, Hertz, Faraday, Gauss, Kelvin are among those giants who contributed to the art of telecommunications.

International communications could be said to date from 1836, the year Samuel F. B. Morse invented the telegraph. He patented the invention and devised a new alphabet made up of dots and dashes, the forerunner of the Morse Code.

In following decades, Edison, Fleming, de Forest, Tesla and Bell brought the world ideas that greatly extended the range of electric communications. Bell invented the telephone, the prolific Edison discovered etheric force and patented the telephone transmitter. John Fleming invented the electronic valve detector; de Forest patented the phonofilm, putting sound on film; and Nikola Tesla designed the "Tesla Coil" which produced a current of very high frequency.

Wireless

In 1858, the first transatlantic cable was built to link the Old World with the New. And about the same time, electromagnetic waves were discovered that some day would free electric communications from wire, and enable signals to travel through space at the speed of light.

Then, in 1895, Guglielmo Marconi startled the world with his announcement that he had flashed and received signals by wireless. He began experimenting with messages across the English Channel and from British shores to ships at sea. Finally, in 1901, Marconi flashed the first signal across the Atlantic.

At the turn of the century, a galaxy of followers were coming into the field. Not content merely to send dots and dashes,

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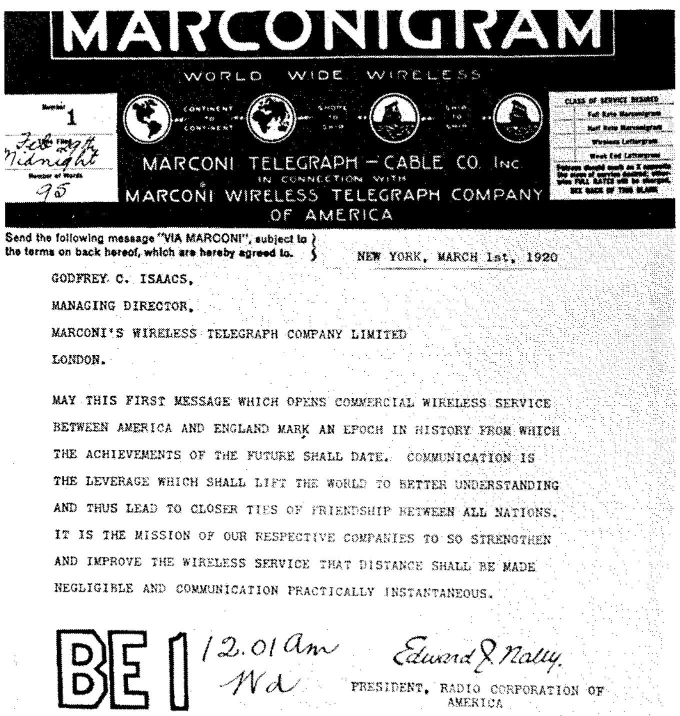
Quinn

Strebel

Joseph Strebel Adm., News and Information, RCA Globcom, New York, N.Y., received the BA from St. John's University, in June 1965. From 1966 to 1969 he served as a naval officer in a variety of duties aboard *USS Constellation* and as Navigator of *USS Pyro*. In 1969 he joined the editorial staff of *Electro-Procurement* Magazine, becoming Managing Editor in 1971. While there, he wrote semi-technical and marketing-oriented articles on the electronics industry. He joined Globcom in 1972.

Donald Quinn Manager, Public Affairs, RCA Globcom, New York, N.Y., received the BSS in English from Fordham University in 1958 and the MA in film and television writing from New York University in 1962. From 1959 to 1970, he was Manager, Marketing Administration, Radio Engineering Labs Division, Dynamics Corporation of America, with responsibility for compiling forecasts, reports and customer correspondence, market planning and all advertising and public relations. In 1970, he became Director, Marketing Services, Compat Corporation, with responsibility for marketing administration and public affairs. He joined Globcom in 1971 as Administrator, News and Information and became Manager, Public Affairs in 1972.

David Sarnoff, on duty as a wireless operator, was the first to receive news of the sinking of the *S.S. Titanic* in 1912. Thus began the link in the public mind between the communications field and the name of David Sarnoff. Mr. Sarnoff was Commercial Manager of RCA at the company's founding in 1919.



MARCONIGRAM

WORLD WIDE WIRELESS

CONTINENT TO CONTINENT — SHORE TO SHIP — SHIP TO SHIP

MARCONI TELEGRAPH – CABLE CO. Inc

IN CONNECTION WITH

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

Number 1

Feb 29th Midnight

Number of Words 95

CLASS OF SERVICE DESIRED

Full Rate Marconigram

Half Rate Marconigram

Wireless Lettergram

Week End Lettergram

Send the following message "VIA MARCONI", subject to the terms on back hereof, which are hereby agreed to.

NEW YORK, MARCH 1st, 1920

GODFREY C. ISAACS,

MANAGING DIRECTOR,

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED

LONDON.

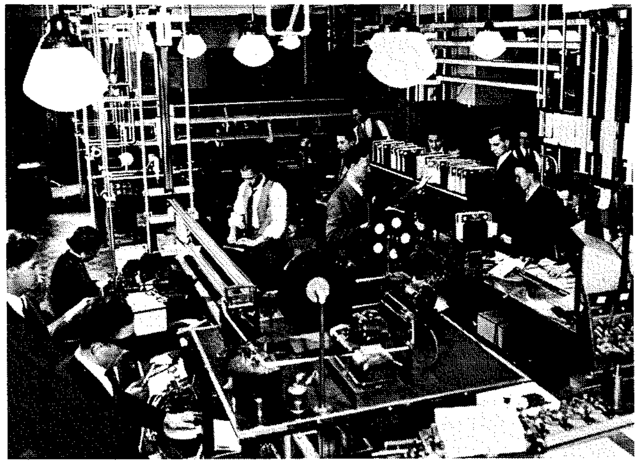
MAY THIS FIRST MESSAGE WHICH OPENS COMMERCIAL WIRELESS SERVICE BETWEEN AMERICA AND ENGLAND MARK AN EPOCH IN HISTORY FROM WHICH THE ACHIEVEMENTS OF THE FUTURE SHALL DATE. COMMUNICATION IS THE LEVERAGE WHICH SHALL LIFT THE WORLD TO BETTER UNDERSTANDING AND THUS LEAD TO CLOSER TIES OF FRIENDSHIP BETWEEN ALL NATIONS. IT IS THE MISSION OF OUR RESPECTIVE COMPANIES TO SO STRENGTHEN AND IMPROVE THE WIRELESS SERVICE THAT DISTANCE SHALL BE MADE NEGLIGIBLE AND COMMUNICATION PRACTICALLY INSTANTANEOUS.

BE 1 12.01 am Wd

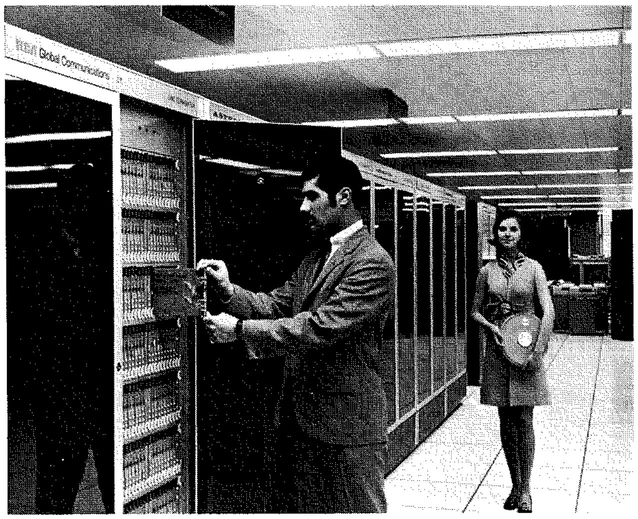
Edward J. Nally

PRESIDENT, RADIO CORPORATION OF AMERICA

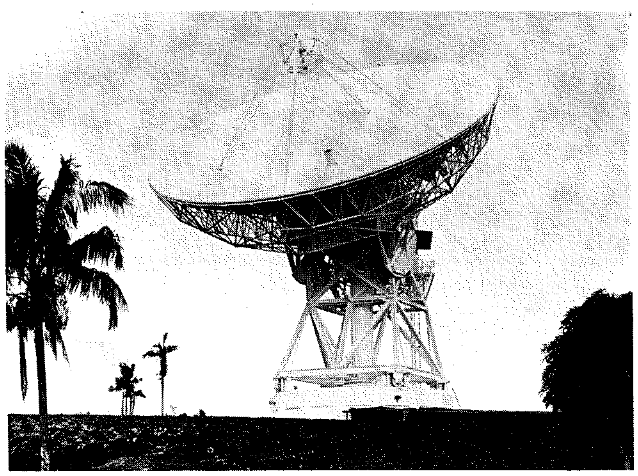
This radiogram, sent March 1, 1920, from New York to London, marked the inauguration by RCA of commercial long-distance radio communications between the US and foreign countries. The Radio Corporation of America was formed the previous year to insure that control of wireless telegraphy in the United States would be under the control of an American company.



Early RCA communicators processing international telegrams for transmission overseas. During its first year in business (1920) RCA handled seven million paid words. By the end of the company's first decade in business, volume had grown to over 40 million words as RCA extended its service to the Pacific as well as the Atlantic. The company also added new services, international voice broadcasts, facsimile and radiophoto, to its basic telegram service.



RCA Globcom today uses computers to control and process its international communications services. In addition to the Computer Telex Exchange, a portion of which is shown here, the company operates a Computer Telegram System and three AIRCON centers, employing 20 computers systemwide with more installations being added and planned.



Satellite communications now augment cable systems and radio transmission in RCA Globcom's worldwide network of more than 2500 communications channels. The company is operator of this satellite Earth station at Pulantat, Guam, and is a partial owner of the seven U.S. satellite earth stations, including the one in Cayey, Puerto Rico. Illustrative of RCA Globcom's leadership position in the field is the recent sale of communications satellite earth stations to the People's Republic of China.

Korn and others soon tried to send pictures through the air by wireless.

Ships everywhere were being equipped with wireless. The vital importance of radio to safety at sea was dramatically demonstrated on the night of April 14, 1912, when a young wireless operator on duty at the old Marconi Wireless Telegraph Company's station atop the Wanamaker's Department Store in New York, was the first to receive news of the sinking of *S.S. Titanic.* The operator's name was David Sarnoff. The world would hear his name with increasing frequency as radio extended its influence in the fields of broadcasting and television.

First world war

During World War I, a great transformation took place: radio found an electronic tongue; it learned to talk and to sing. New vacuum tubes were developed as keys to major advances in the development of radiotelephony and in harnessing the short waves which prior to the war had been considered beyond the range of usefulness.

The more powerful and efficient Alexanderson high frequency alternator was introduced to replace the spark transmitter which had played such an important part in the evolution of radio telegraphy. Radio emerged from World War I revolutionized. As a science and art, radio was on the threshold of a new era.

Control of international wireless

Because the Marconi companies and the Marconi inventions were to a large extent under British control, the United States faced the danger that this revolutionary method of wireless communications, with all its international implications, would be under foreign control.

Wireless telegraphy in the hands of the United States Government had given the nation an independent wartime communication service that spread across the hemispheres. But Congress declined to sanction the continuance, in peace, of such a government service. Restoration of the government stations to the Marconi Company meant possible control outside the country.

RCA formed

It was at this juncture, in 1919, that the Radio Corporation of America was formed, principally by the General Electric Company, as a result of suggestions by officials of the United States Navy, in order to provide an all-American communications company. On November 21, 1919, the business property of the Marconi Wireless Telegraph Company of America was acquired by the Radio Corporation of America. Then, General Electric turned over certain rights under its own radio patents to the new company which was to carry on the business of wireless communications as well as to develop new inventions and new radio apparatus.

On December 1, 1919, RCA began doing business. Owen D. Young was Chairman of the Board; Edward J. Nally, President; and David Sarnoff, Commercial Manager. Primarily, the purpose of RCA was to give the United States preeminence in radio communications. The aim was not only to send and receive messages on an international scale but also to improve and advance this new system of electric communication to conduct progressive research and to create and supply consumer goods — all with the purpose of serving Americans everywhere. Great possibilities for expansion of wireless service at sea as well as for communication between and within nations were foreseen.

Commercial long-distance radio communication between the United States and foreign countries was inaugurated by the Radio Corporation of America on March 1, 1920, when the first messages over RCA transatlantic circuits were sent between New York and London.

Before the end of 1920, service had been established with England, France, Norway, Hawaii, Japan and Germany. This was the forerunner of an expansion that was to make America a center of worldwide radio communications. Coincidentally, the efficiency of radio made possible the first reduction in international message rates in 38 years. Charges were reduced to five cents from as much as forty-eight cents a word.

Early developments

Radio engineers and contractors soon were busy building "Radio Central," RCA's main transmitting station on a 10-square-mile tract at Rocky Point, Long Island. The receiving station was located twenty-five miles away at Riverhead. When construction had been completed on November 5, 1921, President Warren G. Harding formally opened this great new center by sending a radiogram addressed "to all nations." This message from the White House was personally telegraphed by David Sarnoff and acknowledged by nineteen countries, four of which replied within fifteen seconds.

The Atlantic was shrinking. On July 6, 1924, a radiophoto of Charles Evan Hughes, then Secretary of State, was transmitted by RCA from New York to London, where it was radioed back across the Atlantic and recorded in New York. Later in the year, pictures of President Coolidge, the Prince of Wales, Stanley Baldwin and others were flashed from London to New York.

The first international voice broadcast which was transmitted from Chelmsford, England, was picked up by RCA at Belfast, Maine, relayed by shortwave to WJZ, RCA's broadcast station in New York, and there rebroadcast to the American audience.

Radio activity was not confined to the Atlantic. On May 7, 1925, facsimile messages, maps, and pictures were transmitted from New York to Honolulu, 5136 miles, by RCA radiophoto. The picturegram of a check was sent through the April air of 1926 via the RCA system from London to New York, where it was honored and cashed. On April 30th, RCA sent the first radiophoto across the Atlantic on a commercial basis; it was a picture of the Pilgrim Society dinner in London radioed to New York for publication in *The New York Times.*

RCA Communications, Inc., formed

Meanwhile, the growth of RCA in other areas as well as in point-to-point communications made it desirable to organize RCA Communications, Inc., as a separate, wholly-owned subsidiary. This was done in 1929. In 1932, the various companies having interests in RCA divested their stock and RCA became an independent corporation.

Success of the high-frequency alternators, rapid development of high-power transmitting tubes and the harnessing of short waves, had greatly expanded worldwide communications. In 1927, transoceanic traffic totaled approximately 38 million words; in 1920, it had been 7 million. In November, 1930, when an earthquake snapped 12 cables on the bed of the North Atlantic, radio efficiently and expeditiously handled all of the international transatlantic message traffic.

Second World War

When World War II broke out, RCA Communications' radio network was quickly modified to accommodate increased demands from the military, government agencies, and the press services. As the war progressed, RCA installed, staffed, and operated a number of long-distance short-wave stations which handled press and personal messages to and from servicemen overseas.

By 1944, RCA's international traffic reached 150 million paid words. But even that record was broken the following year when 250 million paid words were handled.

Post-war expansion

New operating techniques and methods developed during World War II were adopted by RCA Communications to modernize its international radio service. Pre-war transmission capacity was dramatically increased through the use of new multiplex equipment. Previously, each radio frequency could accommodate only a single radiotelegraph channel.

RCA opened a major automatic relay center at Tangier, Morocco, in 1946 to increase the reliability of its service. With the transmitting stations in New York, San Francisco and Manila, the Tangier relay gave RCA a belt-line of stations circling the globe. The RCA network was expanded further by the addition of many new direct circuits to countries in Europe, the Middle East, Africa and the Far East.

In 1948, RCA engineers, together with their counterparts from the Netherlands Postal and Telecommunications Services, developed automatic signal clearing equipment known as ARQ. This equipment greatly improved the accuracy of transmission by automatically rejecting distorted signals and requesting their retransmission from the overseas terminal until the signal is perfect.

Telex and leased channel service

ARQ-protected channels made possible the introduction of customer-to-customer services such as telex which provides two-way international teletypewriter conversations and leased channel service which places an overseas telegraph channel at the private disposal of the subscriber and his overseas correspondent. Both telex and leased channels require the very high degree of accuracy ARQ affords.

Leased channel service, which was inaugurated in 1948, increased from a single channel in that year to almost 900 leased channels in 1972. From 1950 to 1955, RCA was the only American international communications company that offered telex service to its private wire subscribers. The number of telex calls rose dramatically from 1500 calls the first year to 105,000 in 1955. In 1961, RCA handled nearly 750,000 calls, and by 1971, that figure jumped to more than 5½ million.

In 1955, RCA was the first to extend international telex service to Bell System teletypewriter subscribers, enabling them to make and receive overseas calls on their domestic TWX machines. Similarly, international telex service was extended to subscribers to the Western Union Telegraph Company domestic network in 1961.

Satellite data transmission

Early in 1962, the United States Weather Bureau asked RCA to join them in the transmission of facsimile and weather maps based in part on photographs taken by Tiros IV to meterological organizations throughout the world. These transmissions which provided detailed weather analysis were one of the first peaceful practical applications of America's space program.

RCA Communications was awarded a contract by NASA to provide a number of the teleprinter and voice channels required by "Project Mercury" for administrative and command purposes preceding the launching and during the orbiting of the first U.S. Astronaut.

These channels were used extensively on all of the subsequent Mercury orbital flights. RCA also provided a wide variety of communications links for the Gemini Project and performed the same important function in the highly successful moon landings of the Apollo Program.

Global expansion

The company, in 1960, in order to meet future needs, began to augment its radio

facilities by acquiring channels in the new coaxial cables to Europe, Puerto Rico and the Hawiian Islands and now provides service over radio, cable and satellite circuits. In 1964, RCA significantly added to its cable facilities in the Atlantic and acquired extensive facilities throughout the Pacific area.

This expansion of communications services throughout the world prompted the company to change its name to better reflect its activities. In 1968, RCA Communications adopted its present name, RCA Global Communications, Inc.

Today, RCA Globcom operates a global network comprised of more than 2500 radio, cable and satellite channels which provide message telegraph service between the United States and more than 200 overseas points; international telex service to and from 185 overseas points; and photo service with 68 foreign terminals. RCA provides international telephone service in the Pacific area and Alaska and provides two-way program transmission service for broadcasters with almost any point on the globe.

In addition, RCA maintains extensive facilities for communications with ocean-going vessels and ships plying U.S. inland waterways. The company also provides international leased channel service to all continents.

Along with gains in new customer-to-customer services, there has been a steady increase in the number of telegrams handled. In 1920, RCA's first year in business, the company handled 300,000 radiograms. In 1971, more than 11 million telegrams were handled.

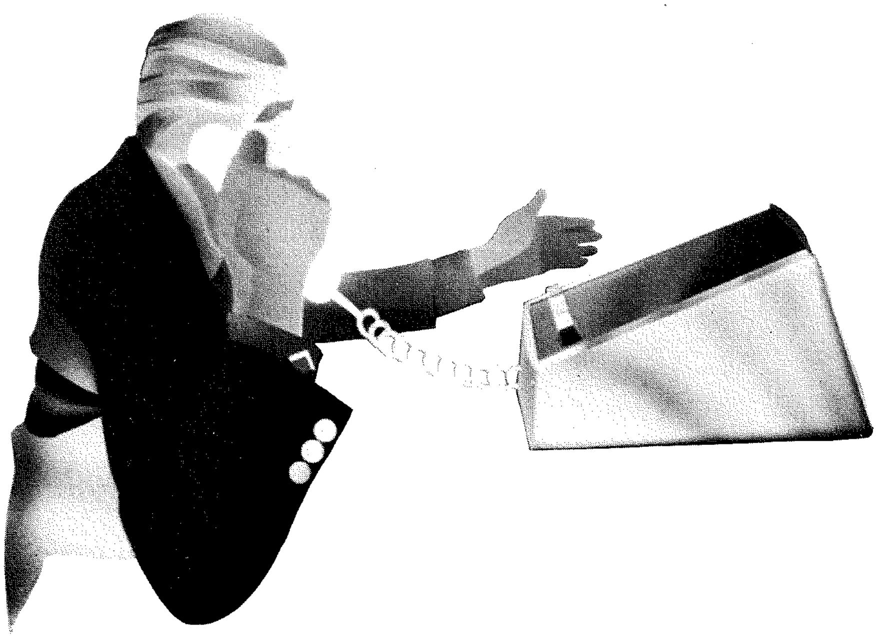
Datel

The growth of electronic data processing brought a corresponding demand for new systems of international communications capable of greater speed, flexibility and capacity. With this in mind, RCA introduced Datel service between the United States and United Kingdom late in 1962. This service permits subscribers to transmit data in any form (magnetic tape, punched cards or paper tape) overseas at speeds approximating 1200 bits/second. Datel is provided on a call-up basis (three-minute minimum charge) much like telex.

RCA provides Datel service to Australia, Belgium, Denmark, France, West Germany, Hawaii, Hong Kong, Italy, Japan, the Netherlands, Norway, Puerto Rico, Sweden, Switzerland and the United Kingdom. Plans call for the establishment of Datel service to other overseas points as the demand grows.

Alternate voice-data service

RCA Globcom also offers Alternate Voice-Data (AVD) circuits as part of its Leased Channel Service. AVD channels provide subscribers with both voice and data communications. Interpolated Voice/Record leased channel service allows data communication to take place without terminating voice communication. During breaths or pauses in voice conversation, bursts of high-speed data are silently transmitted across the circuit. When the circuit is not being used for voice communication, the flow of data accelerates. Both AVD and IVR leased channels also accommodate up to four standard speed teleprinter channels.



Computer telegram system

At the time it was introducing Datel, RCA also automated its overseas message handling system at its Central Telegraph Office in New York. International telegrams were electronically routed, processed and transmitted without operator attention in a Computer Telegram System.

At the heart of this Computer Telegram System is an array of electronic data processing equipment. This equipment automatically receives, audits, routes and transmits telegrams in microseconds. Similar operations formerly required minutes.

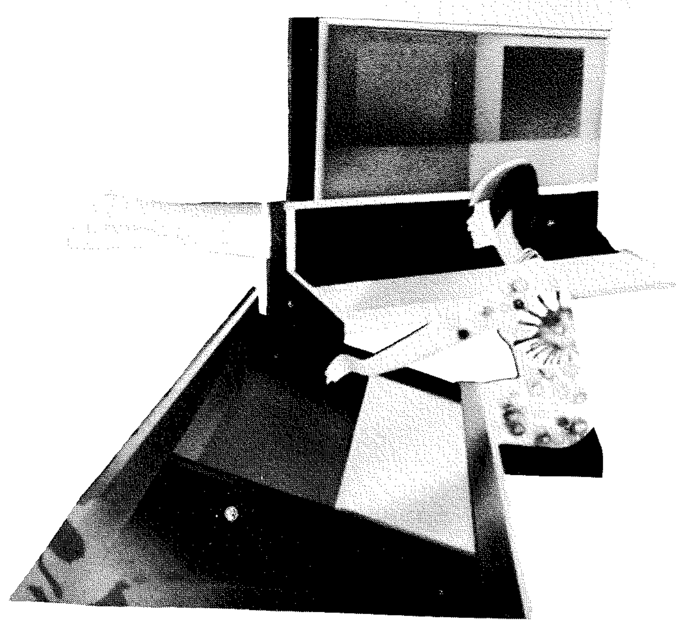
Computer telex exchange

RCA has also completed most of its program to automate its worldwide telex network. Subscribers once placed telex calls through operators at RCA's central office in New York. The operator then requested the overseas number from the telex operator at a similar terminal overseas. He, in turn, established the connection with the overseas subscriber. The process was reversed for calls from overseas to the United States.

Now subscribers in the United States direct dial overseas subscribers in over 50 points. The system utilizes area codes similar to those presently used for direct dialing long-distance telephone calls in the United States. A subscriber in New York, for example, can dial a subscriber in Frankfurt, West Germany, and establish a teletypewriter connection within seconds by merely employing the area code for Frankfurt — 841 — and dialing the subscriber's number immediately afterwards. The call is automatically switched through RCA Globcom's Computer Telex Exchange in New York and the telex exchange in Frankfurt without operator intervention at any point.

The Computer Telex Exchange also makes possible service enhancements such as RCA Globcom's Telextra, Camp-On and Uni-Code service. Telextra and Camp-On are options which subscribers may choose when telex circuits or the overseas teleprinter being called are busy. Subscribers may deposit their calls with the Telextra computer which will deliver the overseas call when circuits are free. Camp-On automatically keeps trying the busy number for several minutes or until the connection is made.

Uni-Code abbreviates the area code and telex number of a subscriber's most frequently called overseas correspondents to a single digit. When a subscriber dials the number, the RCA Globcom computer automatically extracts the complete number from its memory and makes the connection.



Expansion of overseas service

In 1972, the company filed with the FCC for authority to furnish direct overseas telegram and leased channel service from 18 additional cities in the United States.

The proposed system will improve service to international record communications users located outside the present operating centers of New York City, San Francisco and Washington, D.C., by providing relief from delays and congestion experienced in the network of the domestic carrier.

Under the proposal, three modern computerized switching exchanges, capable of handling up to 1000 telex subscribers, would be established in Chicago, Los Angeles and Houston. The central office in each metropolitan area would be equipped with time division multiplex facilities capable of subdividing a voice circuit into as many as 88 separate teleprinter channels.

Telex subscribers in all the proposed new operating centers would have the capability to use their teleprinters to file international telegrams as well.

In the here and now, RCA provides private two-way channels of communications, which operate at various speeds from 17 to 3000 words a minute, to meet the needs of large-volume customers. The radio "hot line" back-up circuit connecting Moscow and Washington which is provided by RCA is an example of this service.

RCA custom engineers these leased channels of communications to meet the specific needs of commercial and government users. Complicated, private domestic networks are linked directly by RCA leased channels with overseas offices and vice versa. A typical application is utilized by stock brokerage firms with offices abroad who use their private channels to interrogate computers in New York to obtain up-to-the-minute market information as well as to send and receive normal administrative traffic.

AIRCON

An entirely new concept in international information systems was born with the activation of RCA Globcom's computerized message switching service known as AIRCON. Unabbreviated, it is Automated Information and Reservation Computer Oriented Network.

AIRCON centers are maintained in New York City, San Francisco and Manila, in the Philippines, by RCA Globcom. These three AIRCON centers are the company's common-access computerized clearing houses that direct information flow and link widely separated offices of international and domestic organizations who subscribe to and are interconnected to these systems.

These centers are designed to carry essential message traffic for a wide range of industries, such as airlines, financial, petroleum, railroads, shipping and the like, who have particular needs for instant updating and exchange of information.

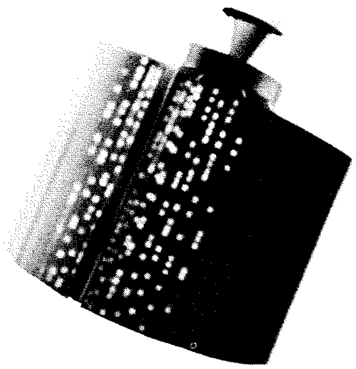
One of the most successful applications can be seen in the petroleum industry, which utilizes AIRCON switching networks to exchange refinery production data, tanker routes and schedules, crew assignments, cargo manifests and a great variety of vital administrative information between widely separated U.S. and overseas locations.

Satellite communications

As the need for communications services grew at phenomenal rates, satellite technology came upon the scene. Despite expansion into coaxial cables, the rising demand for international communications in business, diplomacy, medicine, law, newsgathering, and private affairs prompted the emergence of the communications satellite.

Today, in company with cable systems, communications satellites are providing the required facilities. By 1971, communications satellites were transmitting an average of 100 intercontinental television transmissions a month. Satellites were also relaying other information, such as voice and data, in vast quantity and with equal facility.

Satellites, while introducing a new era of international communications, also brought about the creation of Comsat. The United States Congress created the Communications Satellite Corporation,



known as Comsat, by the enactment of the Communications Act of 1962. As a private corporation, Comsat was first owned half by the public and half by the international communications carriers. (RCA Globcom owned 250,000 shares in Comsat's early days). Comsat is responsible for the development of communications satellites and is the United States' participant in the international consortium, known as Intelsat, operating the space system. At last count, Intelsat was made up of 83 countries in 1972. The Intelsat Consortium jointly owns the space segments and, under an interim agreement, Comsat acts as the manager.

Here in the United States, Comsat is primarily a "carrier's carrier." Its role is to provide satellite facilities to the authorized carriers for their use in serving the public.

Comsat, along with RCA and other international carriers, jointly own the ground stations located here in the continental United States, in Hawaii, Guam, and in Puerto Rico. The ground stations are necessary for the operation of a global satellite system.

Global communications coverage is now a reality with many earth stations and satellites successfully in operation.

As a U. S. international communications carrier, RCA Globcom owns a portion of 7 of the 8 existing U.S. satellite Earth stations located at Andover, Maine; Brewster, Washington; Pamulua, Hawaii; Etam, West Virginia; Jamesburg, California; Cayey, Puerto Rico; and Pulantat, Guam.

In addition, the company augmented the overall international satellite communications program by providing the first commercial satellite Earth station on the Southeast Asia mainland. The Earth station, located in Thailand, began commercial operation in May of 1967. This US-to-Thailand link utilized the Intelsat II satellite (Lani Bird) which operated in synchronous orbit 22,300 miles above the Pacific.

RCA Globcom's latest and most dramatic contribtuion to international satellite communicaitons was the Earth station at Shanghai, China, in February, 1972. The $2.9 million sale, which marked the first significant transaction to take place between an American company and the People's Republic of China under President Nixon's relaxed trade policy, also included microwave equipment and 20 units of RCA Globcom's Videovoice system.

The sale marked China's entry into modern communications, giving her the capability for direct communications with other countries of the world via satellite. The Shanghai station was installed in a record 30 days by RCA Globcom engineers and technicians, working in cooperation with personnel from the Chinese Telecommunications Bureaus. It began operation in time to provide television transmission of the President's departure from China.

The Shanghai Earth station had the initial capacity for 23 two-way voice bandwidth circuits and 12 two-way teleprinter channels to provide voice and record communications as well as video.

In August, 1972, RCA Globcom further enhanced China's communications capabilities with the sale of a permanent Earth station for Peking and the upgrading of the original facility at Shanghai. The latest Earth stations are equipped with antennas in the 98-foot-diameter range, giving the station the initial capability for simultaneous operation with four other Earth stations and the initial capacity for 60 voice-grade channels.

In the age of satellite communications, many breakthrough in electronic technology were achieved. Intercontinental television broadcasts have become an everyday reality. Computers talk to each other directly over wideband lines at high speeds.

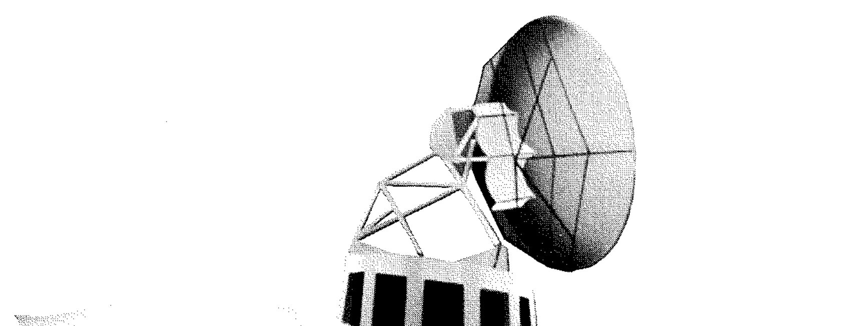
Alaska Communications System

In 1970, RCA Alaska Communications, Inc., was formed as a subsidiary of RCA Globcom to operate and dramatically improve the commercial network of the Alaska Communications Systems (ACS) which RCA purchased from the United States Air Force. As an Alaska-based and operated company, RCA Alascom is utilizing advanced long-lines communications systems and developing improved intrastate and interstate telephone service for Alaskans in cooperation with local telephone companies.

RCA Alascom also offers telex, private line and data communications services and makes television transmission service available via satellite to Alaska.

Domestic satellite system

RCA Globcom and RCA Alascom, early in 1971 filed applications with the FCC for authority to construct and operate a



multi-purpose domestic satellite system which would provide a wide range of communications services to the entire United States.

The proposed system is comprised of a space segment of three satellites in geostationary orbit with a fourth satellite in reserve on the ground. The earth segment would consist of eleven major earth stations located in major communications traffic centers throughout the United States. These earth staions would work in conjunction with the satellites. The system could also add smaller transmit-receive and receive-only stations. The system would become operational approximately 24 months after FCC approval of the application and the system would serve all 50 states and Puerto Rico.

RCA Globcom and RCA Alascom have received FCC authorization to provide domestic communications services through the Telesat Canada Satellite with Earth stations near New York City, Los Angeles, San Francisco, Jureau, and Anchorage. This service will continue until the full system, employing RCA-owned satellites, becomes operational.

Videovoice

Another recent development is RCA Globcom's Videovoice system mentioned earlier as part of the first contract with the People's Republic of China. Videovoice is a new video communiations service that permits people to see one another as they talk, and to exchange real-time views of equipment, charts, or other material.

The Videovoice system transmits still black-and-white pictures over the same circuit being used for voice conversation. The use of a narrow bandwidth circuit for video makes the service economically attractive.

The system is based on the premise that subscribers can benefit from the added dimension of real-time visual communications utilizing economical voice circuits. Domestically, Vidoevoice pictures may be transmitted over ordinary telephone lines, through existing switchboards with the addition of acoustic couplers. Internationally, voice-grade circuits are used.

Once two locations are equipped with Videovoice units, operation of the service is simple. A subscriber wishing to transmit visual information to an overseas location places a call, then trains the Videovoice tv camera on the subject to be transmitted.

If the subject is fixed, such as a chart, the subscriber merely pushes the transmit button. If the subject is live, such as individuals around a conference table, the sender pushes a freeze button to "snap" a picture, looks at a smaller monitor to see the picture, and then transmits it.

The Videovoice receiving unit at the distant terminal displays the picture on a tv screen until a new frame is transmitted. A discussion over the circuit can proceed while the picture is being viewed, although voice conversation must be discontinued during the brief video transmission period.

The picture can be displayed for several minutes, or a new picture can be transmitted each 30 seconds. There is virtually no limit to the uses of Videovoice.

The future

A system like Videovoice might at first appear to be a departure from the traditional business areas of RCA Globcom. It is not. Videovoice, together with the other sophiscated services the company offers, are part of RCA Globcom's committment to leadership in the field of communications. Part of that committment involves the development of services to fill new communications needs as well as the maintenance of traditional services.

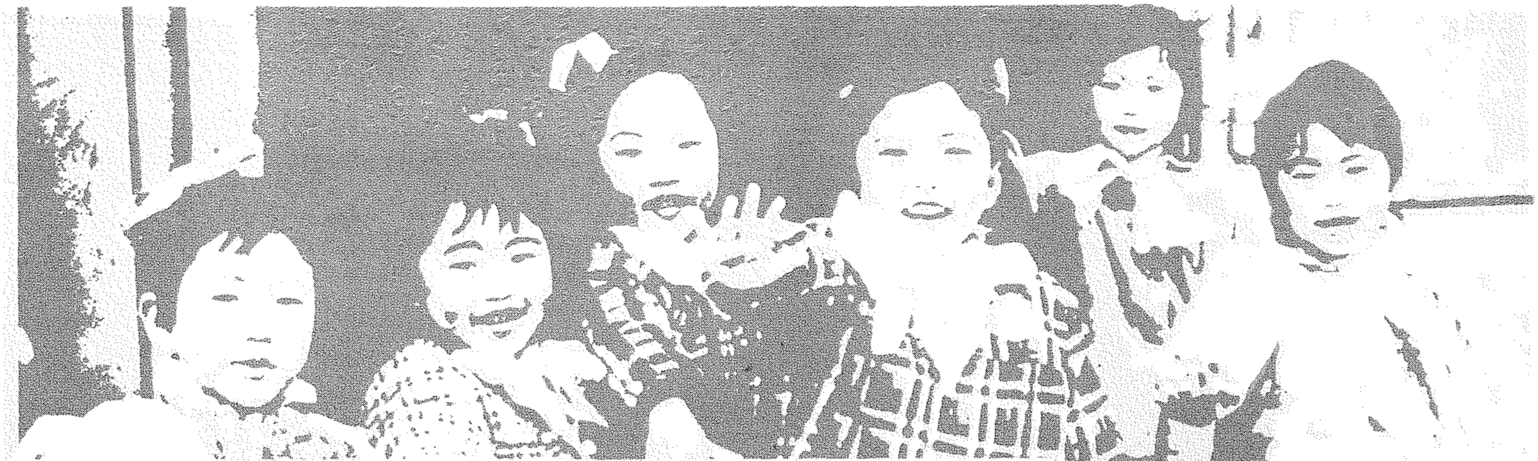
RCA Globcom is currently studying projects such as aeronautical and marine satellite systems. Digital transmission techniques are also being studied to insure that RCA's role of providing complete and efficient international communications services continues in the decades ahead.

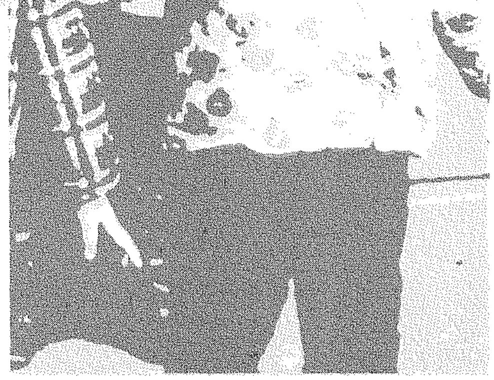
In this age of computers, the company is considering the expansion of its present Datel service into a high-speed, international data-exchange network. Such an expansion would provide computer-to-computer communications on a call-up basis.

This is the history, and also the future, of RCA Global Communications, Inc. For over a half century, RCA has provided the American people with among the most modern and efficient international communications facilities available in the world. With satellite links, and new systems for speedier and more economic communications, RCA Globcom expects to occupy its traditional leadership position in the years ahead — continuing in the fields of international record services and striking out boldly in the diversified world of communications.

Acknowledgment

Much of the historical material contained in this article has been adapted from a *Relay* magazine dated November-December 1967 and entitled "From Morse to Satellites" by George A. Shawy, Director, Videovoice and Leased Equipment, written when he was Manager, Public Affairs.





A China odyssey

Denis P. Dorsey | Robert S. Hopkins, Jr.

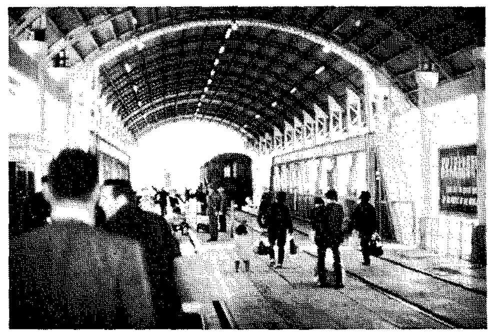
In 1972, Denis Dorsey and Robert Hopkins of the Communications Research Laboratory, RCA Laboratories, Princeton, New Jersey, traveled to China in connection with the RCA Videovoice system.[1] The following is an account of their trip.

Whoever wants to know a thing has no way of doing so except by coming into contact with it, that is, by living in its environment.
...Mao Tse Tung

In February, 1972, we embarked on on incredible journey to the People's Republic of China, truly the experience of a lifetime. For nearly twenty-five years, China's borders had been securely closed to Americans; then suddenly a few with specialized skills in telecommunications were invited to The People's Republic to prepare for President Nixon's historic visit. We were among those fortunate individuals.

On February 10, 1972, we boarded a Pan Am 747 jet in New York bound for Hong Kong via Los Angeles, Honolulu, Tokyo, Osaka, and Taipei. With only a few day's notice we were off on a journey that would take us half-way around the world to spend an undetermined amount of time in the communist country that had been an enigma to Americans for over two decades. The aura of adventure was augmented by the paucity of available information: no one, including the State Department and the American Consulate in Hong Kong, could tell us what to expect.

Our arms ached from all the immunization injections and our bodies were hopelessly jet-fatigued from flying nearly 12,000 miles over multi-changing time zones. Yet our arrival in Hong Kong still seemed a spectacular event. The breath-taking evening approach to Kai Pak International Airport clearly reveals Hong Kong as the gem of the Orient, where two worlds meet. Our instructions were to maintain daily communications with the RCA Globcom office in New York while awaiting contact by the Chinese. This lasted almost forty-eight hours until the Kowloon-based China Travel Agency provided our entry visas and instructed us to be on the early morning (February 14) train to the Lo-Wu checkpoint.



Leaving Lo-Wu by walking across the bridge.

Entering China at Lo-Wu.

Entering China

The Kowloon railroad station was teeming with thousands of Chinese returning to the mainland to celebrate the New Year, the Year of the Rat. We were beginning our Chinese adventure during the most festive week of their year. For nearly an hour, the crowded train wound through the New Territories before reaching Lo-Wu and the famous Anglo-Sino constructed bridge spanning the Pearl River. After a brief passport inspection ordeal by British and Gurka troops, we made that long walk across the Lo-Wu Bridge toward the ever-increasing volume of martial music. Moments later, there we stood, incredulous, in the People's Republic of China! For the first time since our trip began, we felt the overwhelming impact of its reality, actually standing in the land of Mao. Our emotions were a mixture of apprehension and anticipation. We had absolutely no idea how we would be received by the Chinese or when we would be permitted to return home; yet we were eager to begin experiencing this totally different culture.

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There was a formal welcome to the People's Republic by a female member of the army, following which we were escorted to a second-floor waiting room located in an official administration building. Within an hour our entry visas were approved, our luggage inspected, our passports turned over to military officials, permission granted to use our cameras and audio recorder, and our Hong Kong currency exchanged for Chinese Yuan and Jaio. After being served a magnificent multi-course luncheon, we were comfortably seated on the speeding Canton Express, watching Lo-Wu disappear from sight.

Evidently this train is one of the prized show pieces of the Republic. In marked contrast to the Hong Kong train, the Canton Express was immaculate. About a dozen Chinese soldiers shared our car, so we rarely left our seats. Yet a young girl constantly damp-mopped the floor, washed the windows, and dusted the empty seats. In between her cleaning rounds, she served traditional green tea in attractive Chinese mugs equipped with matching lids for steeping. There were even those old-fashioned white lace doilies on the back of each seat. Loudspeakers blaring martial music and quotations from Chairman Mao provided continuous entertainment.

Canton is several interesting hours by train from Lo-Wu. Shortly beyond the rugged border terrain, the countryside expands into broad plains. The landscape is laced with rice fields and dotted with small villages. Water buffalo, people working the endless fields, and others riding bicycles were common sights. We saw no mechanized farm equipment on the communes we passed, nor did we see a single paved road, just miles of apparently hand-tilled land.

When the People's Police were satisfied with our papers, we were taken to the Tung Fang Hotel. Then we spent the remainder of the day exploring Canton unescorted. Our first opportunity to mingle with the people of China occurred in a park across the street from our hotel. After paying the Chinese equivalent of one and a half cents, we entered the area and found it crowded with New Year celebrants. A group of about twenty curious youngsters quickly fell in step behind us. We were eager to make friends, but felt frustrated by the language barrier. Then we spotted a young boy about to have his picture taken by an elderly Chinese gentleman. Without the boy's realizing it, Denis moved in from behind and proudly posed with him for the photograph. This spontaneous act proved to be an ice-breaker. People, particularly children, appeared from all directions with cameras, anxious to take our pictures and to have us pose with them in group photographs. We enjoyed a period of warm non-verbal

We reached Canton by mid-afternoon and were promptly greeted by a gentleman associated with Shanghai Telecommunications, whose employees were to be our co-workers eventually. The automobile trip from the center-city railway station to a police station was a rare experience. The streets were so crowded with pedestrians and bicyclists that the car had to proceed at a crawl. Each time it stopped, masses of people dressed either in solid blue or gray surrounded the car with a sea of curious, staring faces. All of the buildings were drab sandstone structures, none more than four stories high. The city seemed completely devoid of color. Even all the bicycles were painted black. After we had traveled several miles, the people, bicycles, buildings, streets — all seemed to melt into a mass of gray.

Broad plains between Lo-Wu and Canton.

Dennis Dorsey with Chinese co-workers at telegraph office.

Tung Fang hotel at Canton.

This photo of authors Dorsey (far right) and Hopkins (center) was taken at Hungchiuo Airport at Shanghi, before returning to the U.S.

Robert S. Hopkins, Jr., Communications Research Laboratory, RCA Laboratories, Princeton, New Jersey, received the BSEE from Purdue University in 1964 and the MS from Rutgers University in 1967. In 1964 he joined RCA Laboratories and in 1966 was granted a Doctoral Study Award; he received the Ph.D. in 1970 from Rutgers. He was elected to Tau Beta Phi, Eta Kappa Nu, and Phi Eta Sigma. Prior to his involvement with RCA's Videovoice Project, he did mathematical analysis of high-frequency MOS transistors and electrostatic pick-up devices. In addition he has been associated with research projects involving the development of high density storage methods, laser photographic recording, and thin film technology. Dr. Hopkins was responsible for the development of the scan conversion electronics used with the existing Videovoice system and presently he is assigned to RCA's Palm Beach Division assisting in advance Videovoice techniques. He is a co-holder of three pending patents and this year was recipient of an RCA Laboratory Achievement Award.

Denis P. Dorsey, Communications Research Laboratory, RCA Laboratories, Princeton, New Jersey, received the BSEE from the University of Delaware in 1958 and the MSEE, with honors, in 1962 from Drexel Institute of Technology. He was elected to Eta Kappa Nu and Tau Beta Pi. In 1959 Mr. Dorsey joined the Astro-Electronics Division of RCA and was responsible for the design and development of several television camera systems as well as related studio and satellite ground-station equipment. While with AED, he contributed to the TOS and Nimbus HRIR satellite programs and was a member of the first TIROS project team. In 1966 Mr. Dorsey transferred to RCA Laboratories where he designed the video decoders for theHomefax facsimile receivers and the video encoders for the NBC Homefax transmitter. In addition, he coordinated the efforts of the Laboratories and NBC in field testing the Homefax system. Mr. Dorsey also developed an SRI single-vidicon color-encoding television camera that was used to produce holographic color video images. Recently he has designed several video storage units, test systems for the product divisions, video terminals, special television cameras, and frame-freeze units for the RCA Videovoice system. Mr. Dorsey has nineteen patents either granted or pending. This year he received an RCA Laboratories Achievement Award and a David Sarnoff Award for Outstanding Technical Achievement.

communication that was one of the highlights of our trip.

During this camera camaraderie with the Chinese, we had been moving deeper into the park. Therefore, we exited from a different gate, immediately finding ourselves in unfamiliar territory. Fortunately, before leaving the Tung Fang, a member of the hotel staff had given us a note in Chinese explaining that we were "American guests of the People's Republic and looking for the Tung Fang Hotel". Using this precious piece of paper and faintly recalling landmarks, we returned to the hotel by dusk. We spent the evening safely within the Tung Fang, sampling authentic Cantonese cooking in the huge dining room.

On to Shanghai

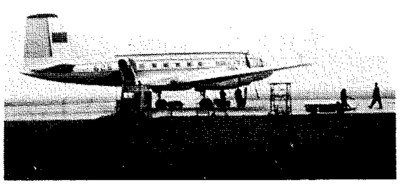
During breakfast at the airport the following morning (February 15), we inquired about the flight's departure time. We were informed the plane would leave as soon as we were ready, since we were its only passengers. We were, however, accompanied on the twin-engine, turbo-prop Ilyushin aircraft by six soldiers and a young girl who was also dressed in military garb. (There are no commercial passenger airlines in China; all planes are government controlled and operated.) Our khaki-clad personal hostess supplied us with a steady stream of candy, gum, and tangerines. Using hand signs, facial expressions, maps, pencil and paper, this delightful girl conveyed our flight schedule, landings, and estimated time of arrival in Shanghai. During this contrived conversation, we pointed out the area of the United States on our world map, prior to indicating our home states. We were surprised and impressed when she immediately corrected us by including Hawaii and Alaska in her gesture.

Our initial stop was Nanchang, hundreds of miles inland, where we stayed just long enough to realize how very cold Northern China seems in winter, especially when there is little relief from the chill in its unheated buildings. The second stop was beautiful Hangchow, where we enjoyed meeting and having lunch with a city official. He seemed genuinely pleased at our arrival and spent much time asking about our families, talking of our President's pending visit to Hangchow, and answering our questions. (This interchange was accomplished through an interpreter he had brought along.) One particularly astonishing fact emerged. Prior to the announcement of Mr. Nixon's trip, the city of Hangchow had no airport. It had been built for the brief one-day stopover of our President!

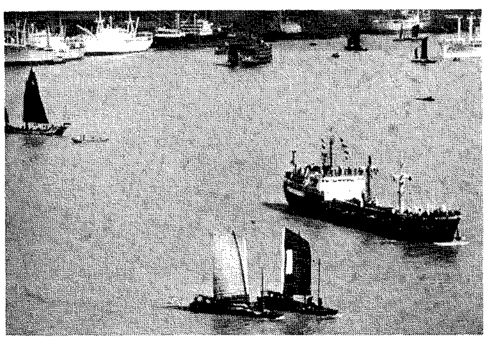
The final portion of our flight to Shanghai, the world's most populous city, lasted approximately an hour. When we stepped down from the plane at Hungchiao Airport, it felt as though we had landed in the Arctic. The strong, gusty wind easily penetrated our lined raincoats, making the 10° F temperature seem much lower. Fortunately, the Chinese Army quickly provided us with two of their fur-lined overcoats, which were to save us from freezing during our stay in Shanghai. We were met by Mr. Tin Win of RCA Global Communications and Mr. Liu, our official host, of Shanghai Telecommunications. Within minutes several gray sedans arrived to transport the four of us and the usual accompanying soldiers into the city.

Hungchiao Airport is about ten miles west of downtown Shanghai. As the motorcade traveled along Nanking Road, we noticed many giant red billboards proclaiming: "Long Live Chairman Mao!", "Long Live the Great Unity of the People of the World!", "Hold High the Great Banner of Mao Tse-Tung Thought!", *etc*. That Mao is omnipresent, dominating every aspect of Chinese life, was becoming increasingly obvious to us. We passed a former racecourse now converted into a People's park with its clubhouse serving as a library. We continued down Nanking Road toward the Whangpoo River, turned left on Chung Shan Road, left again on Peking Road, and stopped at a side entrance of the Hoping (Peace) Hotel.

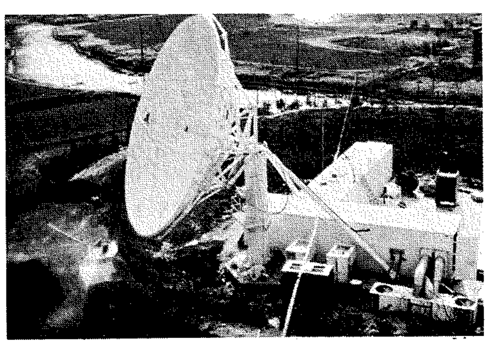
Hoping hotel at Shanghi.



Chinese airplane for flight from Canton to Shanghi.



Boats on Whangpoo river.



Earth station antenna for tv reception from satellite at Shanghi airport.

Initial impressions of Shanghai

This eleven-story building, which was our residence throughout our stay in Shanghai, had been the elegant Cathay Hotel, formerly famous for its gin gimlets and beef Stroganoff. The ornate front entrance had been completely sealed off, the old plush lobby furniture concealed in white sheet-like slipcovers, and the huge walls redecorated with Chairman Mao's thoughts and a giant tapestry of his birthplace, Yenan. The reception desk and small State store were staffed by men and women dressed identically in padded blue pants and jackets. Upstairs, the original thick red carpeting covers the corridors and the large, high-ceilinged rooms still contain the old heavy British furniture and bathroom fixtures. Many English-language engraved brass signs also remain, mute evidence of yesteryear.

We soon found that our freedom within the hotel was restricted to the lobby, lower mezzanine, and the seventh floor where our rooms were located. Other than the eleventh-floor dining room, the remainder of the Hoping Hotel was off-limits and remained somewhat of a mystery to us. Throughout our semi-confinement, every hour on the hour the huge clock atop the Customs House (a few blocks away) chimed the national anthem "The East is

Red", a gift and constant reminder of the Red Guard.

Several aspects of those first days in China were to characterize our entire stay. The most significant of these to us was how thoroughly the Chinese had arranged each detail of our lives. Looking back, we realize that almost every hour had been planned for us. Our regimented schedule included designated times for working, resting, eating, tea-breaks, cultural events, and social functions. On our various outings, we were transported in one of the few Chinese cars, all dull gray Shanghai-built sedans for official use only. Being an uncommon sight and driven with the horn constantly blaring, an automobile always attracts attention in China. As May-Quas (Americans) traveling in this manner, our conspicuousness was intensified.

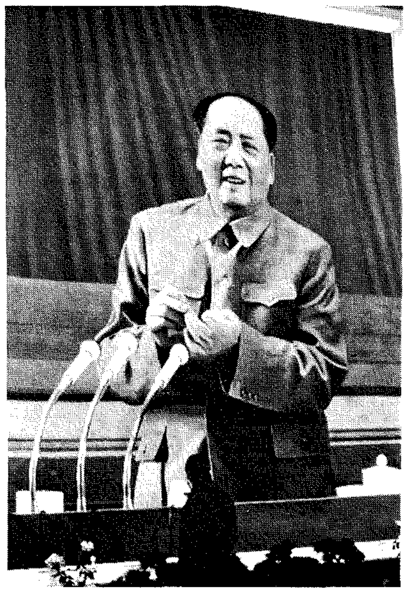
Because most of Shanghai's immense population had never seen a Caucasian, let alone an American, the crowds we drew in Southern China were minor compared to the throngs we attracted in downtown Shanghai. We could not leave the hotel without several hundred curious Chinese engulfing us. Hotel personnel and the People's Police tried to alleviate this situation, but finally suggested that it would be in our best interest if we did not leave the hotel unescorted until local residents became used to seeing us.

Chinese culture, then Videovoice

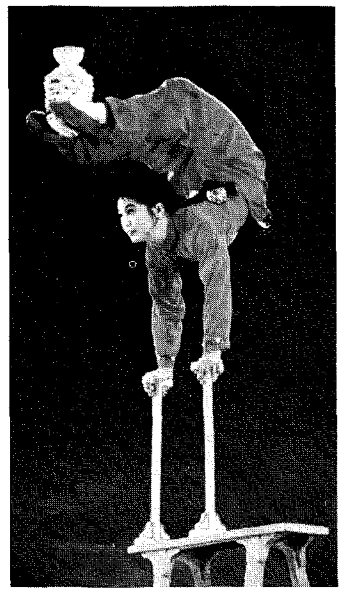
On our first three evenings in Shanghai, we were entertained by a revolutionary opera, a table-tennis exhibition, and an acrobatic performance. As we entered the great opera theater in the Nanshih District, we were thrilled to receive a standing ovation from hundreds of Chinese patrons and members of the performing company. The colorful production of "The White-Haired Girl" featured patriotic songs and acrobatic dances. At the table-tennis exhibition in Kiangwan Gymnasium, boys and girls ranging in age from eight to sixteen clearly demonstrated why the Chinese are considered the best ping-pong players in the world. In the acrobatic show, which is their version of our circus, dozens of young performers delighted us with their agility and versatility. This proved to be one of our most pleasant evenings; for the first time we saw large groups of Chinese thoroughly enjoying themselves.

Other than this initial sampling of Shanghai's nightlife, the next two weeks were devoted almost exclusively to work. On February 16 we returned to Hungchaio Airport and gathered all the Videovoice equipment that had been temporarily stored at the satellite earth-station.

"White-Haired Girl" opera.



Mao tapestry at Shanghi Industrial Exhibit.



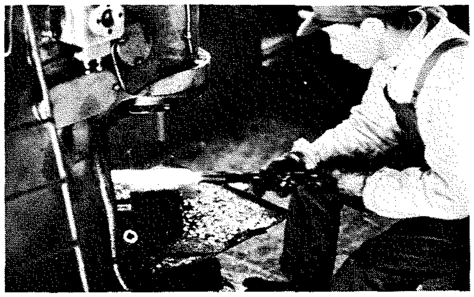
Chinese circus acrobat.

Several soldiers helped us load a truck dispatched especially to transport our gear from the airport to the Shanghai telegraph office. As it turned out, the telegraph office was actually part of the Hoping Hotel. From our working area in the telegraph center, we could see our rooms on the sixth floor through a strategically located air-well. We tested this observation by placing familiar objects on the window sills of our rooms. Yet each morning our Chinese co-workers politely escorted us out of one hotel entrance, down Nanking Road, then back again through another hotel entrance to our work area.

Since we were working, sleeping, and eating in the same building, we were rather confined to the Hoping Hotel, where, incidentally, only the bedrooms were heated. We spent most of the time arranging Videovoice transmission schedules between San Francisco and Shanghai, transmitting and receiving Videovoice signals, and instructing members of Shanghai Telecommunications in the operation and maintenance of Videovoice. All this was accomplished through our ever-present interpreter, Mr. Chen. A piece of equipment that fascinated the Chinese was our oscilloscope-mounted Polaroid camera. During one of our rare absences, they "shot-up" all twelve rolls of our Polaroid film, then asked if we would use our influence to obtain additional film from the earth-station.

Fortunately, there were a few lighter moments that helped us endure the long work schedule.

Resettlement village day-care center at Shanghi.



A forge at the Ma-Lu commune.

House at Ma-Lu commune.

Day-care center at resettlement village.

Women workers at Ma-Lu commune.

Reed weaving at the Ma-Lu commune.

Because our co-workers' Chinese names were so difficult to remember, we gave each a common American name (Charlie, Tom, Howard, Jack, Paul, *etc.*) and taught them the pronunciations. They enjoyed this immensely and soon were calling each other by their new names. On several occasions we were invited to midnight "snacks" where we joined some of our co-workers in strictly non-political, non-technical conversations. Surprisingly, none of our Chinese friends had ever been outside the city of Shanghai and were anxious to hear our impressions of Southern China. During one of these sessions, we were presented with personal gifts for every member of our families; this was a very moving moment for both of us. (Later we gave each co-worker a fountain pen.) On another evening we were given a special showing (in the hotel) of one of the most popular films in China, *The Red Lantern*.

We often spent our rest periods at the eleventh-floor dining room windows, observing the crowded streets of downtown Shanghai and the fascinating traffic on the busy Whangpoo River. At any time of the day, there were thousands of people filling Chung Shan and Nanking Roads. We saw row upon row of two and three-story buildings of English architecture. There were no new buildings nor any construction sites visible. There are no bridges across the Whangpoo River that divides Shanghai, so innumerable sampans and junks accomplish all the transportation between the east and west sections of the city. In addition, since the east bank of the Whangpoo is too shallow for freighters and tankers, they must dock on the west bank and have all their east-bound goods ferried across on sampans and junks. We saw no gulls gracing Shanghai's harbor nor any smaller birds among the trees along the streets below. Apparently, the Red Guard's extermination of Shanghai's flying friends had been complete. The only noticeable feature of the sky above the city was the persistent reddish smog caused by its growing industry.

Toward the end of this two-week period, the Chinese indicated their approval of our progress and the performance of Videovoice by rewarding us with Mao buttons, monogrammed blue work-jackets, and a series of sight-seeing expeditions. We visited a resettlement village, the Ma-Lu Commune, the Children's Palace, the Shanghai Industrial Exhibition, Shanghai's First Department Store, the Shanghai General Hospital, and the Friendship Store. Most of these interesting places were also toured by President and Mrs. Nixon.

Living conditions

The resettlement village is an apartment complex in an urban renewal area on the southwest edge of the city. Each family's unheated apartment consists of two rooms that function as livingroom-bedroom combinations, a toilet closet, and access to a communal kitchen used by three other families. Their two private rooms are sparsely furnished with necessities — beds, bureaus, tables, and chairs. The kitchen contains a charcoal-burning "pot-bellied" stove and a table with a bucket of water on it which serves as the sink. Although these living conditions are not comparable to American standards, they represent a giant step forward to most of the occupants. These quarters are adequate and they offer additional advantages. The rent is approximately five dollars a month. Each apartment complex is integrated with medical clinics, schools, day-care centers, grocery stores, and light industrial shops that supply most of the needs of the occupants.

The Ma-Lu Commune, situated about twenty-five miles northeast of Shanghai, is a totally self-sufficient, highly-mechanized, agricultural community of 16,000 Chinese. Farming is supplemented by industry producing everything from clothing, shoes, and baskets to tools, farm equipment, and diesel engines) in fulfilling the inhabitants' basic needs and providing employment. There are also primary and secondary schools, a small hospital, and a power generating station. Since state-regulated commune production quotas exceed the colony's own requirements, the surplus is purchased by the government and distributed in the cities. We learned that a bit of capitalism is also present. Ma-Lu families are encouraged to engage in free enterprise by growing their own vegetables in small plots adjacent to their homes and selling them for personal profit in Shanghai.

The commune's row-type stucco dwellings, although also an advance for many, contain fewer improvements than the apartments of the resettlement village. The Ma-Lu resident lives in an unheated, unfurnished, three-room shelter with dirt floors. In the "kitchen", and "bathroom", cement blocks are arranged to form a "stove", "toilet", and "bathtub", for which water must be carried from the central well. (Using that concrete bathroom in winter must be quite an experience!) The bedroom contains one bed, a dresser, and the ubiquitous picture of Chairman Mao. (Considering the average Chinese family includes two children, two adults, and a grandparent, I wondered where they all slept — at 20° F maybe they had a good idea.) The grandmother, who was proudly showing us through her home, took great delight in demonstrating the miracle of one small second-floor lightbulb. She concentrated on the flickering bulb for a moment and exclaimed, "Chairman Mao has made this all possible!" She inquired (through the interpreter) if we were "fortunate enough to have a bulb in America."

The Children's Palace

The Children's Palace, on Yenan Road in the Chingan District, is a specialized school for selected young people, ages five through fourteen. Talented children with politically active parents are chosen from various schools throughout greater Shanghai, given concentrated training in their particular areas, and often returned to their home schools to impart these skills to others. These youngsters were impressive even at our arrival. As we approached the large complex of buildings, all of the children playing in a nearby courtyard abruptly stopped their various activities and collectively applauded our presence. (This is a customary childhood gesture of respect for adults who are then expected to indicate their approval by returning the applause. We enjoyed this refreshing ritual on several occasions, often with a single Chinese child encountered on the street.)

Inside the Palace we witnessed extraordinary performances of acrobatics, table-tennis, ballet, choral and operatic singing, string-band orchestration, and rifle marksmanship. We watched children demonstrate with undistractable concentration their cultural skills and crafts, including acupuncture, moxibustion,* chemistry, physics, electronics, industrial machinery operation, boat building, sewing, painting, basket and tapestry weaving. Before leaving this remarkable institution (the epitome of pragmatic education), the Little Red Soldiers of China staged a musical program for us that included to our delight such old American favorites as "Billy-Boy", "Turkey-in-the-Straw", and "The Virginia Reel". There were also catchy Chinese numbers entitled "I See Chairman Mao in My Dreams" and "I Play Table-Tennis For the Revolution".

Shanghai Industrial Exhibition and a department store

The Shanghai Industrial Exhibition, also on Yenan Road, encompasses several massive buildings housing attractive displays of Chinese manufactured goods and works of art. There must be a sampling of everything China produces, including large machinery, video recorders, colorful textiles, musical instruments, and even children's toys. We were most impressed by the arts and crafts, especially the magnificent jade and ivory carvings and the immense intricate tapestries. Unfortunately, most of the wares on exhibit are exported and not enjoyed by the people of China. The Chinese seem to have the necessary technology, but are apparently still lacking the large-scale production facilities to make these desirable products cheaply enough for the masses.

Our shopping spree at Shanghai's First Department Store revealed much about Chinese daily life. Mao dominates all five floors of this huge building; entire counters display posters, paintings, linens, tapestries, and busts of the Chairman, as well as all of his published thoughts. Chinese youngsters eagerly purchase pictures of their favorite opera stars and popular revolutionary music. The practical clothing for children is colorful, but the drab adult apparel is strictly functional. The liquor department offers Chinese red and white wines, brandies, Peking and Shanghai Beer, and bottles of fiery 140-proof Mou-Tai rice whiskey. The variety of general housewares would challenge any American department store. However, we saw very little actually being bought from the large

Acupuncture practice at the Children's palace.

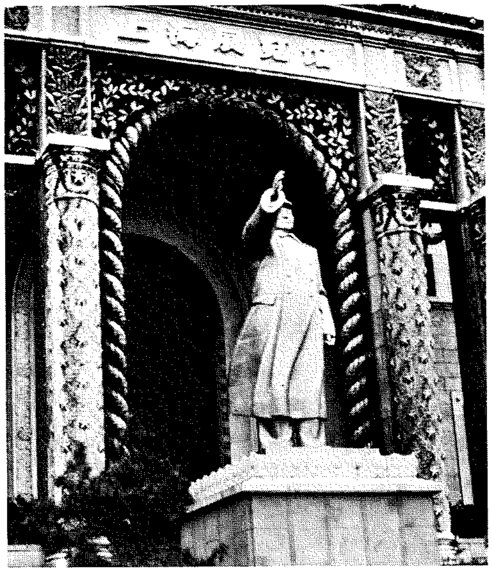
Children's palace.

Chorus at the Children's palace.

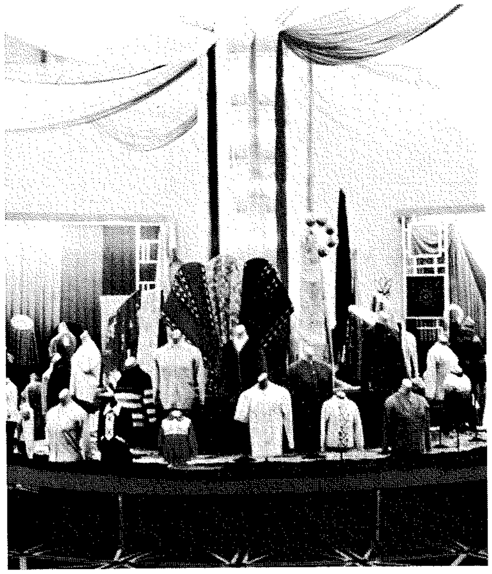
Singer at the Children's palace.

String band at the Children's palace.

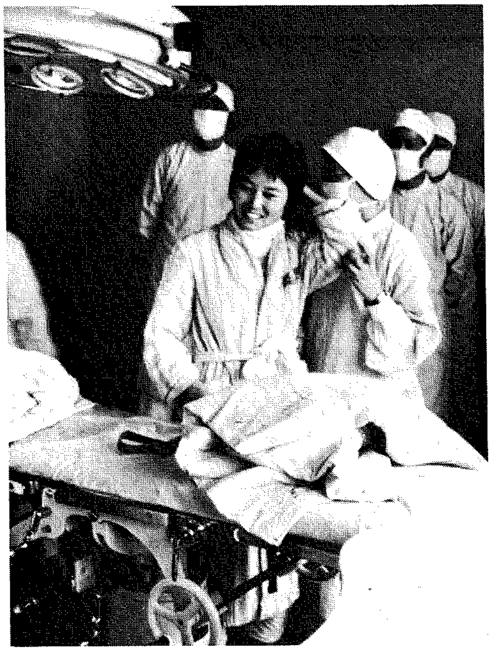
*A method of treating various ailments by burning herbs in a bottle, creating a vacuum, and then applying the container's open end directly on an infection.



Mao statue in front of Shanghi Industrial Exhibit.



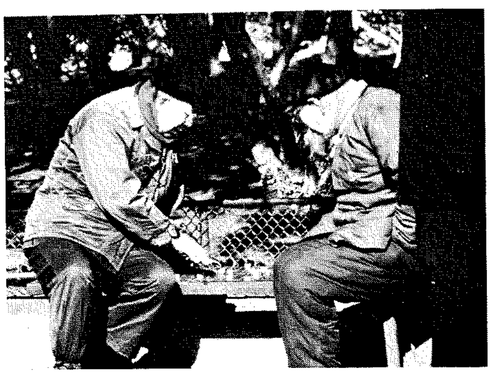
Chinese products on display at Shanghi Industrial Exhibit.



Acupuncture — young woman after thyroid operation.

Acupuncture — woman with broken leg during operation.

Acupuncture patient drinking orange juice immediately after removal of stomach tumor.



Checkers game in Whang Poo Park — Shanghi.

Cyclist on Chung Shan Road.

displays of attractive consumer goods. Although the Chinese-made Shanghai solid-state radio was a selling item, most products are rather expensive for the people. Even the necessary bicycle costs an average Chinese two month's salary. In comparison to shopping at home, we found the purchasing procedure pleasantly facilitated. We simply handed our wallets to the extremely courteous and completely trustworthy clerks, who withdrew the proper amount of Yuan, inserted the correct change and appropriate receipts, and insisted upon delivering our neatly wrapped packages to our hotel rooms!

Acupuncture at Shanghai General Hospital

We were invited to the Shanghai General Hospital to witness acupuncture anesthesia in major surgery. Although acupuncture has been practiced in China for centuries in the treatment of a wide variety of ailments, it was not until 1958 that the Chinese began keeping detailed medical records of cases involving acupuncture. They are now making very effective use of this accumulated data. We were present at three very serious operations for which acupuncture was the only anesthesia: the resetting of a badly fractured leg and the removal of stomach and thyroid tumors. In each instance, just prior to surgery we were introduced to the patients and physicians, provided with small step-stools to facilitate viewing and photographing the operations, and alloted a clear area at the patient's head to tape-record an interview during the actual surgery.

The first patient was a fifty-three-year-old woman who had completely severed her left femur near the pelvis in a bicycle accident. With three electrically stimulated acupuncture needles in her face and two stationary needles in her spine, one of the two attending surgeons made an incision approximately twelve-inches long down the pelvic area along the outside of the femur. Then they exposed the fractured area, removed splintered bone fragments, filed and smoothed the femur, and carefully bored a clean half-inch diagonal hole through the femur and into the pelvic bone. One of the doctors then drove a foot-long acupuncture needle into the woman's side for additional anesthesia, placed a narrow guide pin into the diagonal hole, and finally hammered a thick setting-pin through the femur and into the pelvis. The woman was sutured and asked to manipulate her leg from her hip to her toes. Evidently the surgeons were pleased with her performance, for they removed the acupuncture needles, and graciously thanked her for being an excellent patient. She was talking, smiling, and waving to us as she was wheeled from the operating room.

In an adjoining operating room, a pretty twenty-eight-year-old girl was prepared for the removal of a thyroid tumor. Two small acupuncture needles were inserted into her wrists and gently rotated by the attending nurses. A surgeon cut her throat from ear-to-ear and carefully spread open the incision. Within thirty minutes a "golfball" sized tumor had been removed from the girl's thyroid gland. As soon as the surgery was completed, the girl sat up, put on a bathrobe and slippers, and thanked us for viewing her operation. She then walked unassisted back to an unheated recovery room. (Only the operating rooms are heated at this hospital.)

As we entered the third surgical room, the doctors acknowledged our presence and immediately opened a fifty-year-old man's torso from just below the rib-cage to the navel. He had just three small acupuncture needles for anesthesia, two facial, one spinal. All of his small intestines and stomach were placed on the man's chest. The surgeons rotated the stomach exposing a tremendous tumor, which was easily removed with surgical clamps, scissors, and scalpels. The stomach and intestines were placed back in the abdominal cavity and the fellow was sutured neatly together again. Within minutes after undergoing this serious operation, this gentleman was in a sitting position, talking to us and drinking orange juice!

For nearly four hours, we watched and photographed these operations, recorded conversations with the patients during their surgery, and conversed with the doctors and nurses through interpreters. The surgeons even interrupted the operations several times so that Bob could attain a better vantage point for close-up photography. All three patients were completely conscious throughout, exhibiting no pain, physiological shock, discomfort, or anxiety. The lady with the broken leg even ate several tangerines during her operation. We asked our skilled hosts the simple obvious question, "How and why does this incredible acupuncture anesthesia work?" Their very polite, collective response was, "We are not really sure."

Final impressions and farewell

On our final day in Shanghai, we left the Hoping Hotel unescorted and strolled along Chung Shan Road, which runs parallel to the Whangpoo River. At the entrance to Whangpoo Park there was a gigantic colorful billboard mural with a Chinese inscription urging the people to unite and work hard to ensure a bumper harvest for the coming year. Inside the park skilled slow-motion shadow-boxers and ballet dancers were practising the ancient art of tai-chi-chuan, an exercise designed to maintain physical and mental fitness. The best of the performers drew great crowds of people. We walked the full length of Whangpoo Park to the Soochow Creek, saw the Shanghai Mansion building, and then retraced our steps to the Friendship Store compound. This entire area was formerly known as the Bund.

The Friendship Store occupies the former site of the British Consulate of Shanghai and is maintained exclusively for foreign visitors. The smallest of the three buildings within the compound serves as a seamen's mission. Another contains jewelry, china, and other valuable antiques acquired from the elite upper-class during the revolution. All of these items were for sale at very reasonable prices. In the largest building, various Chinese manufactured goods were sold.

We slowly returned to the Hoping Hotel, taking long last looks at Shanghai. We had been notified we were to leave the next morning. That evening we were honored guests at a gala farewell banquet planned by our Chinese friends. Absolutely everything had been elegantly arranged. The multi-course feast featured all of the finest Shanghanese meats and seafood and every dish was toasted with wine or Mou-Tai. Spontaneous speeches of gratitude, friendship, and understanding were readily exchanged between Americans and Chinese as this memorable party lasted well into the night.

On the following morning (March 5) we exchanged final good-byes with our Chinese friends at Hungchiao Airport. Our luggage bulging with prized gifts and souvenirs, we boarded a four-engine military aircraft filled with Chinese soldiers and flew non-stop to Canton. By noon we had returned to the Tung Fang Hotel, bold, confident travelers of China.

We set out immediately to once again explore Canton. As before, we attracted a huge crowd of curious people who followed closely behind us. As we progressed the number grew to possibly five-hundred people. Becoming concerned over the size of the group, we entered a food market in an effort to escape. This was not a successful maneuver, for when we left the market, not only did most of the shoppers come along, but our original followers were waiting outside! However, their mood had changed from remote curiosity to overt friendliness. Suddenly they wanted to shake our hands, pat us on our backs, walk shoulder-to-shoulder, and happily exclaim "May-Qua!" They even responded to our English phrases with gay laughter and child-like hand clapping.

Exhausted, we left this playful throng outside the gates of a "pay" park. Recuperating inside, we heard someone say, "Beautiful day, isn't it? A Chinese gentleman, perhaps seventy-five years old, sitting on a park bench, had just uttered the first distinct English we had heard in Southern China. He was fascinating. He had not spoken a word of English for nearly thirty years and yet he talked with us for almost half an hour, using perfect English. We still shake our heads in utter disbelief whenever we recall that incident.

The train ride from Canton back to Lo-Wu was a duplicate of our entrance to China. However, we thoroughly photographed the picturesque countryside on the way back. At Lo-Wu we passed through Chinese customs simply by telling the officials what we were taking from China. There was no baggage inspection, none of the usual long forms in triplicate, and no long lines. As we were leaving the land of Mao, walking across the Lo-Wu bridge, an armed Chinese soldier said to each of us in English, "I hope you enjoyed your stay in the People's Republic of China. Goodbye".

Our actual China odyssey had ended, but we were to relive it through private thought, casual conversation, and public presentation over and over again. We had come "to know" much about China "by living in its environment". We had also gained a new perspective on our own country and way-of-life. Unquestionably, we prefer our sitaution. However, there are some decided advantages to their system: the prevailing atmosphere of honesty, the complete absence of crime, the courtesy and respect of youth for their elders, the avoidance of waste, and the appreciation of small comforts. There are few of what we consider personal joys in China, but self-sacrifice for the overall progress of their society has improved life for the masses. In so many respects, our two contrasting countries occupy opposite ends of an imaginary continuum. Yet in spite of these vast differences, our mutual humanity is finally emerging. This inherent rapport has always been the only real basis of hope for mankind.

Acknowledgment

We wish to thank Meg Dorsey who organized most of our material, viewed hundreds of slides on China, listened for hours to audio recordings, and applied her literary skills to the rewriting of this entire report.

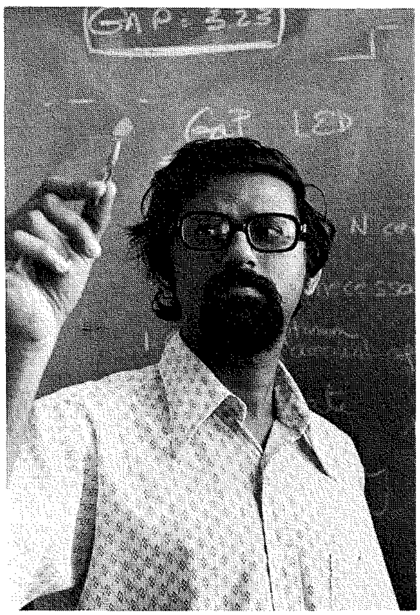
Reference

1. The RCA Videovoice system was discussed in the RCA Engineer by S.N. Friedman (Vol. 17, No. 20 and should be the subject of a future issue.

Environment, energy and the need for new technology

Dr. Vikram Dalal

What is the crisis in energy? To many scientists, the crisis is but a temporary phenomenon, which will be resolved soon by the availability of cheap and abundant nuclear power. Many nonscientists think of it only in terms of power brownouts or gas shortages. It has also become a fashion to blame the environmentalists for the energy crisis. It is the purpose of this article to point out that the energy problem is far more complex than power-plant location or the trans-Alaska oil pipeline. The energy problem exists not only on the supply side, but far more importantly, on the demand side. This article also argues that some of the technological solutions popular today may not be desirable in the long run, and that new technological initiatives are necessary, along with certain changes in demand, to achieve a stable energy society.



Dr. Vikram L. Dalal, Materials Research Laboratory, RCA Laboratories, Princeton, N.J., received his BEE in 1964 from the University of Bombay, and MA, MSE and PhD from Princeton Universtiy in 1966, 1967 and 1969, respectively. At Princeton University, he did research on high electric field effects in semiconductors. He spent a summer at Bell Telephone Laboratories in 1967, working on avalanche phenomena. He joined RCA Laboratories in 1969, and has worked in the field of infrared photodetectors, photoemission phenomena, high electric field effects, semiconductors, avalanche diodes, liquid phase epitaxy of III-V compounds, and MOS devices. He is the author of eight technical articles in the field of semiconductor physics. Dr. Dalal is a member of the IEEE and the American Physical Society.

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"*My name is Ozymandias, King of Kings*
Look at my works, ye mighty, and despair"
Nothing beside remains.

Shelley[1]

Scarcely anyone today is unaware of the environmental crisis. A significant portion of the environmental degradation is caused by man's use (or abuse) of energy. Our energy-intensive society accounts almost totally for our air pollution problems, a significant proportion of water pollution problems, and most of the local thermal pollution problems. In addition, there is the vast land pollution caused by our use of energy — ranging from strip-mining and highway building to the hollowing out of mountain-tops for pumped-storage installations. It is a little ironic that this vast use of energy, which has brought about such problems (along with benefits, of course), has itself caused a severe energy supply problem. In a simple society, this would lead to a closed circle, eliminating the effects by eliminating the source. But in our complex society, energy is one of the most basic resources, and our affluence seems to be intimately tied to energy consumption. This is shown in Fig. 1, where we plot per-capita GNP *vs.* energy consumption for several countries of the world.[2] The more affluent countries have a higher per-capita consumption of energy than poorer ones. (This, of course, does not necessarily imply that all energy use is beneficial, or even that a higher per-capita gross-national-product (GNP) necessarily means better life. This is discussed later.)

Energy trends in the U.S.

For specificity, we shall restrict the detailed discussion only to the US. Most of the discussion is easily adapted for the more developed countries of the word, and the discussion on technologies can be suitably adapted to most countries of the world.

It is instructive to start by studying the energy use pattern in the US in 1970. The use of energy for various purposes is shown in Table I.[2]

Efficiency of energy cycle: 50.6%

The first two columns in Table I are the resource input, and the last two for useful work performed, the "work" being space-heating or lighting or production of *Al* or whatever. It is clear from Table I that two of the primary sectors of the budget, transportation and electric power generation, are responsible for the relative inefficiency of the energy cycle. Also, note that electricity accounts for only 15% of useful work performed, and yet is the component of energy we worry about most. This is because electric power generation has been increasing at 7%/yr (doubling every 10 years), whereas the energy budget has been increasing about 3.2%/yr.[3] Some estimates, notably by the American Petroleum Institute, claim that the energy budget will increase at 4.1%/yr in the coming decade. We

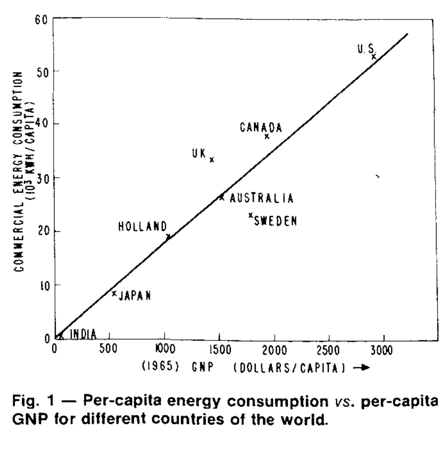

Fig. 1 — **Per-capita energy consumption *vs.* per-capita GNP for different countries of the world.**

Table I — Use of energy in the US (1970).

	(10^{12} *kWh*)	% *of total*	*Useful work* 10^{12} *kWh*	% *of total*
1. Energy resource for electric power	5.0	26.4	i) Household 0.85 ii) Industry 0.67	15.8
2. Nonelectric energy direct to household & commercial	3.8	20.0	2.85	29.7
3. Transportation	4.8	25.2	1.21	12.5
4. Energy direct to industrial use	5.4	28.4	4.03	42.0
Energy:	19.0	100.0	9.61	100.0
5. Nonenergy use of fuel resource	1.23		1.23	
Total fuel resource:	20.23			

Table III — Comparison of emissions of coal-plant and gas-advanced-power-cycle (1000-MW plant).

	Coal	*Gas-APC*
1. *SO*	29 kg/tonne	8.1 to 0.68 kg/t
2. NO_x	44 kg/t	4.5 kg/t
3. Particulates*	9.5 kg/t	0.0
4. Efficiency	0.40	0.49

*With precipitators

Table II — Total US fuel resources — 1970 (10^{12} kWh).

	Total† estimated	*Total used up to* 1970	*Proven reserves††*	*Annual use*
Coal	10,300	180	1350	3.9
Oil	320	160	65.0	7.0
Gas	383	120	80.0	7.1
Shale oil	4,500	—	450.0	—
Uranium*	168,500	—		0.06

*Includes U^{238}
†Estimated from geology of the US
††Estimated from actual drilling.

shall examine the effects of these trends in the following sections.

Energy resources

One of the most important consequences of the growth in energy demand is the depletion of natural resources. Table II shows the total estimated fuel resources of the US in 10^{12} kWh.[4,5]

It is clear that we are rapidly depleting the two presently most-useful resources, oil and gas. In each case, we are operating on a 10-year margin (proved resources/annual use). This ratio has been getting poorer over the last decade, and would be worse had it not been for the large Alaskan discovery. Even the Alaskan discovery (a total of 30 to 40 billion barrels of oil or 50 to 60×10^{12} kWh) would last only 10 years at the present consumption rate. Crude oil and natural gas will be depleted by the end of this century. Already, about 15% of the oil used in the US in imported.[3]

Coal and shale oil

The only longer-term fossil fuel resources are coal and shale oil. Each has its own peculiar environmental problems. Much is known about the tragedy of coal strip-mining in this country. What is not generally recognized is that oil shale development may be comparable to strip-mining. Oil shale is found mainly in the Green River Valley region of Colorado, Wyoming, and Utah. To extract oil, the shale has to be crushed. The oil-contents of the rock ranges from 40 to 250 litres/tonne.[4] This gives an idea of the tremendous rock overburden that will be produced in the process of extracting shale oil. Wherever this overburden is stored, it must be *permanently* shielded from percolating ground-water and surface runoffs to prevent serious water pollution problems.[6] Oil shale development may also significantly increase the already high salinity levels of the Colorado River, thus creating further problems for Mexico.[6]

It is becoming clear that in view of the shortage of gas and oil, coal will continue to be used for many decades. Unfortunately, coal is not a particularly good fuel to use because of the problems associated with SO_2 and particulates. The current solution to these problems lies in not locating the coal-powered plants in metropolitan regions, but instead locating them at places like Four Corners, New Mexico, to feed Los Angeles. This is hardly a long term solution.

Coal gasification

There is one technology which holds great promise for the use of coal. This is coal gasification. Among the advantages are the removal of sulfur at the gasification stage, the almost complete absence of particulates in the synthetic gas produced, the possibility of using gas in an advanced power cycle to achieve efficiencies of 50%, and a significant reduciton of NO_x.[7] This is shown in Table III.[7]

These advantages are sufficiently strong incentives for us to pursue gasification vigorously. It is encouraging to note that coal can be converted to low-energy-density (2 to 3 kWh/m^3) gas with about 90% efficiency. The efficiency for pipeline quality gas (8.5 kWh/m^3) is around 70% today, but it will probably increase to 80% in the near future.

Nuclear alternative

In view of Table II, it is not surprising that nuclear (fission) energy has begun to play an important role in our energy picture. Thus, Westinghouse has predicted that nuclear energy will account for over half of the electric generation by 1990.[8]. Fig. 2 shows their estimates for fuel use for power.[8]

However, the simple fission cycle, which uses U^{235}, cannot feed our increasing energy needs. This is because low-cost U^{235} resources are scarce. One estimate is that, using simple fission, we shall use up all our low cost (< $25//kg) *U* resources within 30 years.[5] This is why the breeder technology becomes so important, because it will generate fissionable Pu^{239} from U^{238}. The breeding technology that is currently popular is liquid-metal-fast-breeder reactor (LMFBR).

It is at this stage that need for a new technology becomes apparent. We have put all our hopes in the success of LMFBR, to the almost total neglect of other breeding alternatives. Leaving aside the nontrivial questions such as safety and liquid-metal technology, there is one potentially severe environmental problem. This involves plutonium. *Pu* is one of the most toxic substances known to man. A 1-μg load of *Pu* is considered toxic to man.[9] It is estimated that by the year 2000, there will be 1.4×10^5 kg, or 1.4×10^{14} toxic doses, of *Pu* stored in the US.[10] The implications of an accidental release of even a small fraction of stored *Pu* are obvious.

In view of the above, we should also consider the breeding technologies involving conversion of Th^{232} to U^{233} Among these are gas-cooled breeder and molten-salt breeder.

Fusion

Much has been written about fusion in the recent past, and no additional information can be usefully imparted at this stage. Nevertheless, it is important to point out that fusion, while not pollution-free (it will have neutron-irradiation and thermal-pollution problems) is far superior to LMFBR radiologically and from a safety viewpoint. Fusion technology is probably the most important energy project in the world today, and it is heartening to see the AEC taking more interest in funding fusion.

One of the great advantages of fusion is

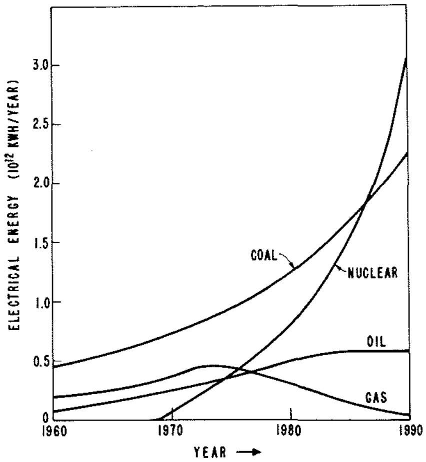

Fig. 2 — Projected electric-power production in the US by fuel category.

that because of the inherent safety of confined plasma against catastrophic accident, it can be located in the center of the load area, thereby making possible the utilization of the low-grade waste heat for residential and industrial purposes, thus achieving a lower overall energy consumption.

Solar energy

Now we shall turn to the one source of energy that has been sadly neglected in the past, and which is virtually inexhaustible. This is solar energy.

On a sunny day, typical solar insolation reaching the Earth is 1 kW/m^2 at the equator. For the US, over a year, assuming cosine of 0.8, 220 10-hr days, this averages to 1800 kWh/m^2. With an area of 9.1×10^6 km^2, the total insolation over the US is 1.6×10^{16} kWh/yr. This is about 800 times the total energy consumption.

Let us consider the different solar energy alternatives.

Photosynthetic fuels

Green plants convert solar energy into chemical energy with an efficiency of about 1%.[11] It is possible to use highly efficient grass or fast-growing crops as energy producing biomass. In the central US, the yearly average crop production is 7.2 kg/m^2.[11] Using 4.7 kWh/kg,[11] as average energy production from organic matter, we get 34 kWh/(m^2-year), or an efficiency of ~ 2%. Therefore, to satisfy the US energy needs in 1970, we would need 5.6×10^5 km^2. or about 6% of the US land area. A similar estimate can be made for forests. For comparison, the farm area of the US is 4.6×10^6 km^2, the area under crops is 1.2×10^6 km^2 and the forest area is 2.1×10^6 km^2.[3] Thus, the land area required for solar energy plantations is large.

If fast-growing algae, with efficiencies of 10% can be economically developed, a substantial fraction of the energy needs can be met this way. Of course, biomass would not be used directly — it would have to be converted into methane first.

Energy from organic waste

The claim is often made that organic waste could provide all the natural gas needs of the US.[12] The US has 115 million cattle, each producing about 1.5×10^3 kg of dry organic waste per year.[12] The solid waste generated by US society comes to 10^3 kg/capita/yr. Out of this about half is combustible matter. Thus, we get a total of 2.7×10^{11} kg/yr organic waste. One kilogram of dry organic waste generates 0.35 m^3 of methane,[12] with a heat value of 8.4 kWh/m^3. Thus, the total energy produced would be 1.75×10^{12} kWh/year, or about 25% of the natural gas usage in 1970. Of course, not all of this can be collected. Nevertheless, the amount of fuel literally being wasted is significant, and is more than the total fuel used for non-energy purposes (1.2×10^{12} kWh/year).

Solar cells

In view of the large solar insolation, any scheme that converts solar energy directly into electrical energy is extremely attractive. As is well known, *Si* solar cells with an efficiency of 10% are available today. Unfortunately, they are high in cost $30,000/kW. If we can reduce the cost down to $1000/kW, as seems likely with *CdS* cells, they would be highly competitive. Since the southwestern US has an average sunny weather for about 300 to 330 days in a year,[13] we have a yearly average insolation of 2×10^3 kWh/m^2 per year,. Thus, the entire energy needs of the US can be supplied by an area of 10^5 km^2 (10% efficiency) or about 6% of the area in the Southwest. One of the greatest advantages of the solar cells is that the energy rejected is distributed, and hence there is no local thermal pollution problem.

Solar heat-power cycle

In this scheme,[13] solar heat is concentrated on a steel tube containing liquid metal. The steel-pipe is suitably coated to minimize infrared radiation loss. The liquid-metal goes through a thermal storage medium and a secondary fluid produces steam, which runs a steam turbine. An overall efficiency of 30% is claimed. This reduces the energy area down to 3.3×10^4 km^2. The great virtue of this scheme is that it requires no major technological breakthroughs, and a small pilot project can be immediately started.

It is appropriate to consider energy-storage schemes for solar energy. One of the best energy-storage medium is hydrogen.[14] Both the solar-cells and the heat-power schemes can generate H_2 on site. The heat-engine cycle can be easily adapted to a dual-fuel system, burning H_2 to produce steam when not enough solar energy is incident. With the solar cells, such a scheme would require additional turbine-generator facilities, an economic penalty. Another, and possibly superior, way of generating electricity would be the development of economical fuel cells, which would be powered by H_2.[15] This allows a higher efficiency secondary generation (70%) as opposed to at best 50% for H_2-steam cycle. What is more, the same solid-state inverters that would be required for solar-cell power-conversion can be used for the fuel-cell output conversion into ac. Both these schemes are superior to pumped-storage, which would require prohibitively large water volumes and suitable land masses.[16]

Two of the greatest advantages of the solar-heat cycle are the relatively high efficiency (20-30%) and the low cost. Cost estimates as low as \$600 to 1000/kW have been made.[13,35] These costs make this scheme extremely competitive with the present-day generating schemes. (see section on costs).

Solar power from synchronous satellites

This scheme uses a synchronous solar satellite in orbit around the earth, collecting solar energy, then converting it into microwaves, transmitting it to earth and finally back into electrical energy.[17] It is claimed that such a scheme is 15 times better than collectors on earth.[17] Let us consider the true relative efficiencies of space as opposed to terrestrial solar power. This is shown in Table IV.

Table IV — Comparison of terrestrial and space solar arrays.

	Space	*Terrestrial*	*Relative* η ($\eta_{terr} = 1$)
Insolation (kW/m^2)	1.4	1.1	1.25
Clear days	365	300	1.21
Cosine of incidence	1.0	0.75	1.33
Duration of radiation (h)	22.8	8.0	2.85
Efficiency of generation	0.1	0.3*	0.33
Eff. of microwave genr.[18]	0.6	1.0	0.6
Eff. of transmission[19]	0.8	0.95	0.84
Eff. of rectification[19]	0.7	1.0	0.70
Net efficiency of I wrt II:	0.65	1.0 (base)	

*Using thermal conversion

Thus, far from being superior, the satellite scheme is energy-deficient. We have assumed realistic *Si* solar cells, *Si* avalanche TRAPATT diodes and *Si* Schottky barrier detectors. It may not be feasible to put up magnetrons in orbit,[19] because of weight and lifetime problems.

This is not to say that a satellite scheme is without merit. It may be suitable for northern Europe. An economical breakthrough in solar-cell arrays and microwave generation would help, but the cost limitations are severe, and are not likely to be overcome. One great advantage of any terrestial scheme is that it can be arranged so that there is no change in the heat balance of the earth — an important point as will be made clear in a later section.

Solar space-heating and water-heaters

Since most of the energy used in homes is for heating and cooling, it is more efficient to convert solar heat energy into useful heat directly.

A typical single-family house in the northeastern US needs about 3.5×10^4 kWh/year for heating.[20] (In southern California, this figure is only about 10^4 kWh/year.)[21] Assuming a roof area of 100 m^2, this comes to about 18% of the solar input (3 to 4% in the Southwest). Therefore, it should be clearly feasible to supply at least half of the heat energy by solar space-heaters. Many varieties are available ranging from flat-panel to cylindrical-lens roof units. These are all expensive at present, but comparatively will not be as the price of fuel increases.[22] Since these units operate by heating water, those houses that have hot-water radiant heating are ideally suited for solar-heating.

A water-heater uses about 4000 kWh/year.[21] Hence, it is possible, even for extreme northern climates, to supply most of this energy by solar heat.

This technology is almost self-evident and was at one time popular in the Southeast. It is unfortunate that we have chosen to ignore this technology because of the availability of "cheap" fossil-fuel resources, fuels that have been cheap because most environmental considerations have been considered "externalities" — of no concern to the fuel producer.

Energy for transportation

About 25% of our energy input goes into transportation, with an output efficiency of only 25%, the poorest among the energy sector. The automobile accounts for about ⅔ of this energy usage. The output/input efficiency of the automobile is only about 20%. When the efficiency of fuel production and transportation is taken into account, this figure drops further to 15%.[23] Yet, the automobile is the single largest polluter of the urban environment. The presently proposed techniques for reducing pollution from the automobile involve using lower thermal efficienceis to reduce NO_x pollution, thereby further reducing efficiency. What is more, the automobile technology of today is unsuited to urban driving needs — it simply does not perform either efficiently or cleanly in an urban driving cycle.

In view of the above, it is unfortunate that new technological initiatives have not been favored in automotive technology. Among these are electric cars[24] and fuel-cell-powered automobiles.[25]

Let us concentrate on the relative efficiencies of the two systems compared with that of internal combustion engines. This comparison is shown in Table V.[23,26] This table necessarily has uncertainties in estimates, especially for fuel-cells. However, the overall picture is clear. Electric cars and fuel-cell-powered vehicles would be far more efficient than those with the internal combustion

Table V — Comparison of overall effeciencies of automotive propulsion

	Present car	*Elec. car**	*Fuel-cell car**
1. Fuel production	0.96	0.9	0.9
2. Refining/power genr.	0.87	0.5†	0.9
3. Transport of fuel	0.97	0.93	0.97
4. Eff. of batteries or power fuel cells	1.0	0.9	0.60
5. Eff. of motor	0.25	0.9	0.9
6. Eff. of transmission/ controls	0.85	0.95	0.95
7. Eff. of wheels, *etc.*	0.9	0.9	0.9
	0.15	0.29	0.36
8. Eff. reduction due to urban cycle	0.8	0.9††	0.9
	0.12	0.26	0.324

*Using methane produced from coal as fuel
†Advanced power cycle
(advanced gas turbine cycle powered from coal-gas)
††Included regenerative braking

Table VI — Typical efficiencies of energy utilization

1. Elec. Generation	Fission (water reactors)	0.33
	Best coal	0.40
	Breeder	0.4
	*HTGR-fission	0.4
	Fusion	0.5?
	Advanced-cycle gas turbine	0.4-0.5
	Solar cells	0.1-.15
	Solar-heat-cycle	0.3
2. Household Utilization	Electric heat	1.0
	Heat pump	2.0 +
	Air conditioning	2.0 +
	Gas	0.80
	Oil	0.70

*High-Temperature-Gas-Cooled Reactor

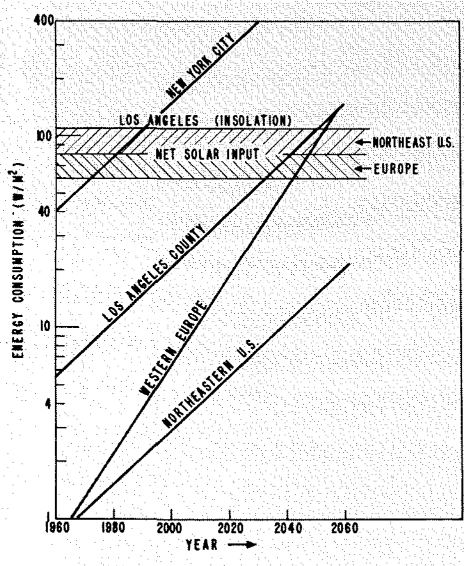

Fig. 3 — Comparison of exponentially increasing energy consumption with the *net* solar irradiation. Plots are for different regions of the industrialized world.

engine. The implications of such a technological development for the environment are obvious. The substantial reduction in overall air pollution have been discussed by Mr. Salihi of EPA.[24] It is also worth noting that the life expectancy of the propulsion system would be considerably better for an electric car. [A typical peaking-type (intermittent duty) electric generator runs for 60,000 to 100,000 hours.[27] As opposed to this, a typical internal combustion engine runs only for 5000 hours.] This, of course, can significantly reduce solid-waste production. The reduction is noise pollution is also substantial.

In view of these considerations, substantial research needs to be done on electric cars, particularly in developing reliable, high-energy batteries.[28] A hybrid cycle, employing an internal combustion engine for cruising, coupled with an electric battery (or flywheeel) for urban driving and acceleration would be a short-term solution.

Efficiency of energy utilization

This is an appropriate moment to discuss efficiencies of energy systems. Typical efficiencies are shown in Table VI.

Thus, it is clear that electric resistance heat is far less efficient than the direct use of fossil-fuels for heating. An efficient heat-pump should be utilized with electric-heat installations. This step is not being used.

Cost of energy

One of the characteristics of the energy crisis is the preoccupation with keeping the price of energy artifically down by ignoring many environmental factors. Environmentally preferable schemes are rejected because they may add a few percent to energy cost. This, of course, violates one of the cardinal rules of economics — "there is no such thing as a free lunch." Strip-mining may be an "externality" for TVA, but it is very much an internal factor for the people of Appalachia or the ranchers in Montana. In any event, the myth of cheap energy is disappearing very fast because of the scarcity of resources and the escalating construction costs (16%/year for 1969 and 1970)[29] and high interest rates.

It is worth examining the costs of energy in some detail. This is shown in Table VII. The data for this table have been collected from current literature and are representative for the northeastern US. The capital rate charged is 13.85%.[30] It is clear from the data that most electric energy costs are in the range of 10 to 12 mills/kWh and are not going to reduce. The days when "electric energy was cheap" (8 mills/kWh) are long past, and are not going to come back, no matter what the advocates of breeder reactors claim.[32] It is also clear that the costs of environmental improvements are very small compared to the other costs, particularly distribution costs.

Energy: the demand problem

So far we have concentrated on the supply problem. However, it is the demand that is fueling the supply and environmental crises.

Let us look at energy in terms of its ultimate output-heat. As we saw earlier, the energy output of the US is about 0.13% of the total insolation received (or about 0.2% of the solar energy retained). Thus, at present, the *average* energy output is not significant. But *local* thermal outputs are already large and it is worth comparing them to *net* insolation. This is shown in Table VIII.[46]

Thus, it is clear that the local thermal outputs are already significant compared to insolation in areas such as Los Angeles basin and New York. There is little doubt that the microclimate of New York would be severely affected by this large thermal output if it were not for the cooling effect of the prevailing winds. But these cooling effects cannot be relied upon forever, because of the simple fact that the surrounding regions are also becoming significant thermal polluters. It is very revealing to study the effects of exponential energy growth on heat outputs over the next 50 to 100 years. This is shown in Fig. 3, for several countries. The energy consumption per m^2 is plotted on the vertical axis (on log scale) and the year on the horizontal axis. The growth rate for Europe is 5.5%/yr and for US, 3.3%/yr.[(46)]

This figure clearly reveals the problem of exponential energy growth. We may have severe climate modifications over large portions of the industrialized world when thermal outputs become a significant fraction of the net solar insolation, as they will by 2020.

Note that this is only one effect of the exponential growth in energy demand. Among other effects that are important, but about which not much is known, are the effects of increasing turbidity, CO_2 levels, *etc.*

There is one other development that has already caused severe problems. This is the need for heat dissipation from power plants. It is estimated that by 2000 AD, the total amount of water required for cooling power plants will be equal to the *total* fresh-water runoff in the contiguous US.[47]

Of course, not all water would be so used. But the introduction of cooling towers has created another severe problem — water loss by evaporation (0.75 gallon/kWh generated). It is estimated that if all the power plants that are proposed for the Delaware basin (N.J.-Pa.-Del.) for the years 1970 through 1986 are built, the Delaware River simply would not be able to supply the water loss without causing serious salinity problems for the water supply of Philadelphia.[48] Similar problems have been reported for the Ohio and the Mississippi Rivers. To "solve" these problems, schemes have been proposed for diverting water from Lake Michigan into the Mississippi![49]

It is important to recognize that energy is not an end product in itself, but is a means to an end. The end is a better quality of life. It is often claimed that an increasing use of energy is necessary to achieve a better quality of life. It is also taken for granted that a higher per-capita GNP necessarily means a better quality of life. This is not so. Thus, for example, one of the factors entering the quality of life is health of the population and provision of health-care facilities. Sweden, which has a lower GPN/capita than the US, has a higher human life expectancy (by about 10 years), 35% lower infant mortality, and twice as many hospital beds/capita than the US.[3]

However, let us concentrate on energy. It may be possible to reduce energy consumption and at the same time increase the quality of life. Transportation offers almost a classic example. Professor Rice of Carnegie-Mellon University has estimated[50] that a commuter train is six times more efficient and a bus ten times more efficient (more passenger miles/kWh) than the automobile. In addition, the same highway-lane would carry 12 times more people/hour by bus than by automobile.[52] The reductions in highway congestion, air pollution and dead-space savings (parking, *etc.*), as well as the increase in the ease of travel may be considered to be improvments in the quality of life. And these were achieved at a saving in energy. What is more, the automobiles, not having to travel as far, would last longer, leading to a reduction in solid-waste and a saving of resources.

Table VIII — Local energy balance (1970).

	Area (km^2)	*Population (10^6)*	*Energy cons. W/m^2*	*Net insolation W/m*
Los Angeles County	10^4	7.0	7.5	108
New York City (Manhattan)	59.0	1.7	630	100
New York City*	950.0	7.8	100	100
14 Northeastern States	9.32×10^5	90.0	1.11	100
U.K.			1.21	60-80
Benelux			1.66	"
Federal Republic of Germany			1.36	"

*Assuming National energy consumption average. This overestimates, probably by a factor of 2.0.

Table VII — Costs of energy.

I. *Electric Power*	*Capital cost \$/kW*	*mills/kWh*	*Fuel \$ O+M cost mills/kWh*	*Total cost mills/kWh*
1. Nuclear fission[31]	450	9.0	2.0	11.0
2. Nuclear breeder[32]	565+	11.2	1.0	12.2
3. Fossil plants[33]	230	4.6	6.0	10.6
4. Combined cycle Turbines[34]	115	2.3	6.0-10.0	8.3-12.3
5. Solar power-heat engine[13,35]	1000?	13.8	1.0	14.8
6. Cost to consumer[36]				30.0

II. *Fuel costs*	*mills/kWh (fuel)*
1. Coal[33]	1.6
2. Gas	1.54
3. Gas from coal[37]	2.75
4. LNG from Algeria	3.2
5. Wellhead oil[38] (domestic)	1.83
6. Gasoline at refinery[39]	3.4
7. Gasoline at gas station[40]	9.5
8. Fuel oil to customer[41]	4.55
9. Gas to customer[42]	4.80

III. *Cost of environmental improvement*	*mills/kWh*	*% of generation cost*	*% of consumer cost*
1. Cooling tower[43] (wet)	0.6	5.45	2.0
(dry)	1.47	13.4	4.9
2. Reclamation of Strip-mined land[44]	0.5	4.7	1.67
3. SO_2 control[45]	2.1	19.7	7.0

Similar consideraions hold for the building industry, to offer another example. It is certainly possible to design housing to blend with, and take advantage of, the natural environment in order to reduce the energy-intensive space-conditioning load. A modest investment in insulation offers a more than proportionate saving in household energy consumption.

Many such examples can be found in all walks of life. The reason most of them have not found favor in the US is the relatively inexpensive energy resource that has been available until now. Now that the energy is beginning to be priced at its true cost, we shall have to alter some of technological and behavioral thinking to maximize the quality of life.

Energy: short- and long-term strategy

Short term: impact of new technologies

Let us first deal with the short-term strategies for dealing with the energy crises. These are primarily changes in technologies that will achieve a larger energyutilization efficiency and a substantial reduction in environmental degradation. These strategies could be fully operational by 1990, for example. It will be recognized that this is a reasonable short-term period, because the lead-times for new energy technologies are so long (5 to 10 years).

To study the impact of new technology on the short-term energy picture, we shall examine in detail the probable energy budget for the US in 1990. Table IX is based on the assumption that the present trends in national economy will continue. Each energy sector is broken down into its major components, the growth of each of these components over the next 20 years is examined. We deliberately look at the growth in effective energy utilization by each of these sectors, and then examine two different ways of providing for this energy output. These two ways are listed under the heading of case A and case B. Case A provides the energy required by the extension of present technology (water reactors, modified gasoline cars, electric space heating, *etc.*) Case B involves the use of new technology that is already proven today, but not popular, or technology that has a reasonable chance of being fully operational by 1990 if there is a national will to do so. Thus, for example, we have deliberately excluded fusion as being too speculative for full operation in 1990. The new technology embraces such things as electric cars instead of gasoline cars, heat pumps instead of resistance heating, a 20% reduction in new house-heating demand by better insulation, a 5% improvement in energy utilization efficiency by industry, the introduction of coal-gas-powered advanced-power-cycle, HTGR instead of PWR or BWR for nuclear power, and introduction of solar-heat powered water heaters and space heating in 30% of new construction. It is obvious that none of the above represents a quantum jump in technology, but is a gradual and deliberate evolution over the next two decades.

It is clear from examining cases A and B that a modest improvement in appropriate technologies sharply reduces the net energy input to the system, and also reduces the fossil-fuel consumption rate without any changes in lifestyles or affluence. The introduction of modest changes in lifestyles (use of mass transportation instead of automobiles, restriction on excessive air-conditioning demands, *etc.*) would improve the picture significantly. It is also important to note that we have almost stabilized the fossil-fuel consumption rate, and reduced the thermal pollution rate significantly by going to case B instead of A. Notice also that the technological modifications were deliberately chosen to be environmentally superior (electric cars instead of gasoline cars, for example).

Table IX — Energy budget for the US in 1990.

I. *Assumptions*

	1970	1990
1. Population	205×10^6	240×10^6
growth		1%/year
2. GNP (real)	\$724 $\times 10^9$	\$1400 $\times 10^9$
growth		3.3%/year
3. Housing units	58×10^6	88×10^6
4. Automobiles	89×10^6	140×10^6
5. Miles driven/auto	10^4	10^4
6. Energy/industry grows as GNP		
7. Energy for heating grows as number of households.		
8. Energy for transportation taken from ref. 50.		
9. Nonfuel energy grows as GNP		

II. *Energy budget* (10^{12} *kWh/year*)

	1970		1990 Case A		1990 Case B	
	Input	*Output*	*Input*	*Output*	*Input*	*Output*
1. Elec. Energy (Total)	5.0	1.52	14.25	4.79	12.22	4.86
Elec. → house & comm.		0.85		2.90		2.6
Elec. → industry		0.67		1.29		1.23
Elec. → heat*		0.0		0.60		0.12
Elec. → auto.		0.0		0.0		0.91
2. Fuel → house & comm.	3.8	2.85	4.96	3.72	4.57	3.44
Solar heat		0.0			.36	0.36
3. Fuel → transport	4.8	1.21	8.0	2.0	3.4	0.85
4. Fuel → industry	5.4	4.03	10.43	7.78	9.88	7.40
5. Total energy use	19.0	9.61	37.54	18.29	30.43	16.91
6. Efficiency of energy	50.6%		48.5%		55.6%	
7. Energy input growth			3.5%		2.47%	
8. Fuel → nonenergy use	1.23	1.23	2.37	2.37	2.37	2.37
9. Use of nonrenewable resources	20.23		40.01		32.44	
10. Use of fossil resources	20.1		32.20		25.97	

*The electric heat portion of 1970 is included in the residential electric budget.

Long-term strategy: changes in lifestyle

It is obvious that no amount of technological sophistication can take care of an ever-increasing exponential growth rate. Over the longer time period (beyond 2000) we cannot live in a decent environment with a high quality of life without a change in attitudes and lifestyles.[53]

The necessity for a stable, zero-growth population is almost obvious. As the population density increases, there is a much faster increase in communication links, leading to a rapid increase in transportation energy. Increasing population density can also change the local heat balance, leading to the need for more air conditioning, for example.

Once the population becomes stable, it would be possible to achieve a stationary state economy with a high affluence level. To minimize energy (and resource) consumption in such an economy would require some changes in attitudes by all of us. We all know about the abuse of energy, be it excessively powerful cars or loud rock music or the road of the snowmobile in the winter night. Just as the society has chosen to regulate speed or loud noises at night, it may also have to place reasonable limits on per capita energy consumption, probably by a progressive tax. Thus, somebody with a power-everything automobile may have to pay a much higher tax, while the owner of an "economy" car may pay no tax at all.

It may also be necessary to alter some of the present town-planning methods. Most suburban developments of today are exclusive — residential in one area, commercial in another, work in a third *etc.*, often with several miles separating the different areas. This forces numerous nuisance-type trips every day, as well as leading to multi-car families. It may be necessary for us to modify the planning process so as to create a better blend of work, use, and residential-oriented areas within a community. This may also lead to more commonly owned green-space around the small communities, thereby further leading to a better environment.

Conclusions

The energy crisis is far more than a problem of supply or environmental obstacle. To tackle the dual problems of supply and demand properly within the context of a better environment, significant technological changes will be required within the next two decades. Tremendous opportunities lie ahead for improving energy technology and many of the established industries of today are well suited to take on this challenge. The solid-state and electronics industries, for example, will have useful roles to play in research on fuel cells, electrolytic batteries, solar energy, laser fusion, direct energy conversion, solid-state controls for electric cars, communication equipment for mass and personalized rapid transit, *etc.* In the longer run, though, the problem cannot be solved by sophisticated technology alone, but will require the combined efforts of economists, technologists, and sociologists in devising a stable, affluent society that will exist in harmony with nature — and with each other!

Acknowledgment

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Environmental and operational constraints on the design of the Lunar Communications Relay Unit

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The LCRU (Lunar Communication Relay Unit) was designed by RCA for use in long-range surface explorations of the moon which occurred during the later Apollo missions. Installed on the Lunar Rover, the LCRU provided a communications link to the Earth when the astronauts had driven out of range of the Lunar Excursion Module. It performed the full range of communications functions, including: voice transmission, relay of the astronauts' biomedical data, relay of ground commands from Earth to the television camera system, television transmission, and telemetry transmission.

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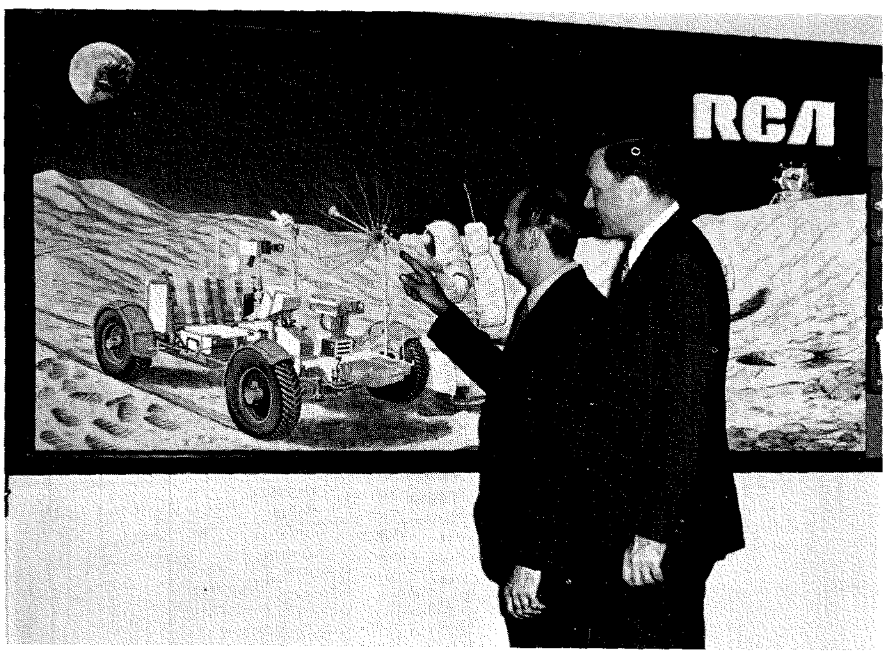
Authors Bonacquisti (left) and Holston.



THE LCRU is about the size of a briefcase (6 x 16 x 22 inches) and weighs 50 Earth pounds. A replaceable battery provides more than 4 hours of continuous use. Three unique antennas—an S-band high-gain antenna, an S-band low-gain antenna, and a VHF omni antenna—relay communication between the astronauts and Earth. The LCRU concept is shown in Figure 1.

Design of the LCRU was an especially challenging task with a large number of environmental constraints. The environmental problems associated with the LCRU design encompass vibration during take off, flight, landing, and lunar traverse; thermal control while in operation; and lunar dust and vacuum. These problems were compounded by the necessity of keeping deployment and operation of the system weight at a minimum, and by the fact that on-site lunar testing was virtually impossible.

Vibration and shock isolation

Space transport

The most severe vibration environment for the LCRU was encountered in the space transport vehicle. Here the equipment had to withstand levels of $0.25g^2/Hz$ minimum with frequency ranges of 20 to 2000 Hz in three mutually perpendicular axes. Low frequency vibration levels are particularly severe on lightweight structures like the antenna stowage case which was used to protect the antennas and adapt them to the LEM stowage volume during the launch and flight to the lunar surface. To damp vibrational inputs, the antenna stowage case was constructed of a combination lightweight aluminum structure and molded polyurethane foam blocks.

During deployment

The vibrational environment encountered when the LCRU was fully deployed on the lunar rover vehicle and

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LRV was traversing the lunar surface presented additional dynamic problems.

The LCRU was mounted to the LRV as an unorthodox cantilever off the front cross member of the vehicle. This arrangement, although structurally poor in concept and offering little protection from lunar surface obstacles, was dictated by the fact that there was no other space available on the LRV. Hence, two 1-inch diameter tubes were initially provided on the front frame of the Lunar Rover Vehicle to mount the LCRU subsystem and tv camera.

The most significant decision with regard to this interface was to mount the components of the LCRU subsystem and ground controlled television assembly in a parallel fashion along the front frame of the LRV. The original concept, series mounting, would have placed the camera and high gain antenna on top of the LCRU which in turn would be cantilevered on the front of the vehicle frame. In a vibration environment, this mechanical system would behave like a series of cascaded amplifiers, with the response of the LCRU unit being the input to the antenna and the camera mounted on top of it. In the vicinity of the resonant points, the inputs would be greatly magnified to the antenna and the color television camera, resulting in excessive loading. The approach that was adopted was parallel mounting, whereby the LCRU unit fit over two post assemblies which were pre-stowed on the front crossmember of the LRV. The television camera assembly was mounted on an independent support point, as was the high gain antenna assembly.

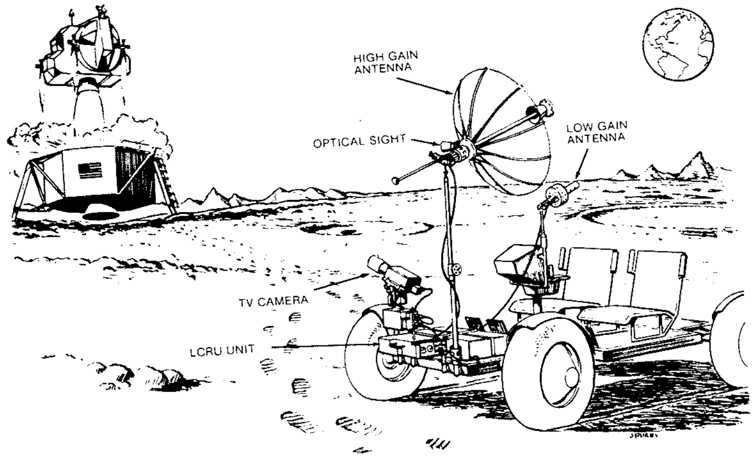


Fig. 1 — LCRU deployed on LRV televising lunar liftoff.

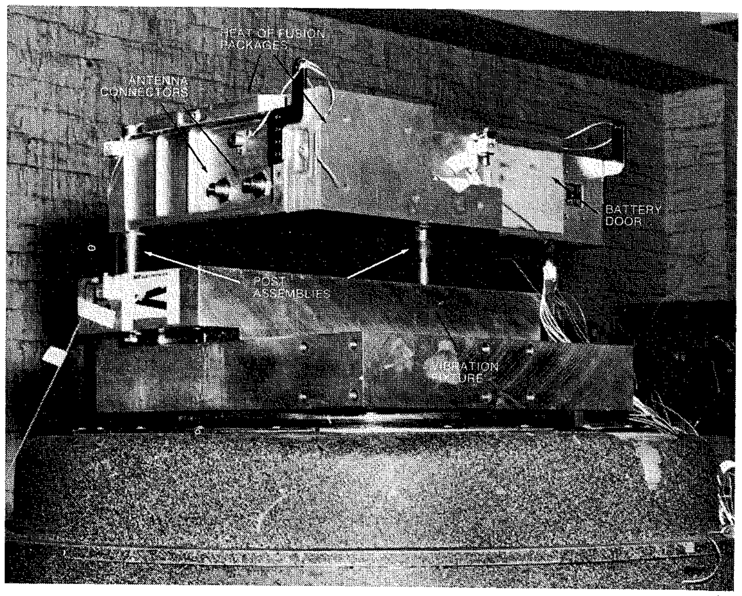


Fig. 2 — LCRU vibration test.

Vibration testing

Fig. 2 shows the LCRU during vibration testing. The resonant frequency of the high gain antenna and its mast when fully deployed, extended and excited in the fore-aft and lateral directions, was approximately 4.0 Hz. However, with the rigid fit of the mast into its tapered receptacle and the damping of the mast/antenna system, maximum stresses were maintained at a safe level, as previously predicted by a computer analysis.

Battery mounting

One additional subsystem of the LCRU which presented unique vibration problems was the battery assembly. Permanent structural mounting of this considerable mass could not be accomplished as this would conflict with the operating requirement that the battery be easily removed and replaced prior to each lunar excursion. The mechanical support for the battery when installed to the LCRU was provided by four pins, two on each end of the battery. The pins on the rear end of the battery engaged a structural block in the LCRU; the two pins on the front of the battery were supported by slots in the battery door. Guidance for the battery was provided by two teflon rails on the top, two rails on either side of the battery case flange, and a heat sink assembly on the bottom of the battery case. Thus, with the battery access door closed, the battery was firmly supported by the four pins and heat sink assembly, yet the battery could be removed and replaced easily once the access door was opened.

Thermal design

The LCRU had to operate and survive over a wide range of thermal environments. The lunar surface beneath the LCRU had a temperature range of −200° F to +200° F. The space heat sink temperature above the LCRU was at −460° F. In addition, solar radiation on the order of 440 BTU/hr ft^2 was incident on the LCRU at various angles and for various time periods, and the LCRU-

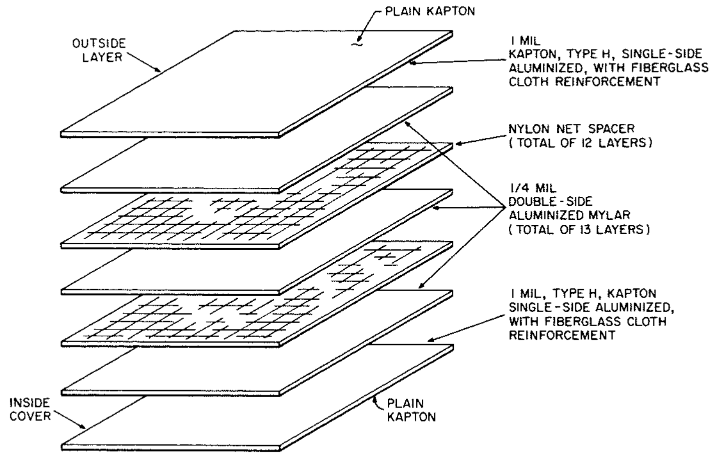


Fig. 3 — Thermal blanket construction.

generated heat was on the order of 100 W. The design requirement for reliability purposes was to maintain the LCRU unit between +120° F and +50° F.

Three techniques were combined to control the temperature limits of the LCRU: multifoil blankets, heat of fusion packages (wax packs), and thermal control mirrors. In addition to these devices, good thermal discipline was maintained in the package design of the equipment. Judicious location of high heat generating devices and the use of thermal compounds at critical interfaces contributed significantly to the thermal design.

Blankets

The LCRU was completely covered with a multifilm thermal blanket. Construction of the thermal blanket is shown in Fig. 3. Each of the 15 layers is separated from an adjacent layer by a single layer of nylon net thermal separator. The individual layers were sewn together with nylon thread to form the required configuration. To limit absorption, the blanket was made to fit as tightly as possible to the LCRU for line-of-sight radiation. Special covers, slits, and fasteners were employed to minimize the size of openings. In addition, projections through the blanket were thermally decoupled from the LCRU by use of interface materials with poor thermal conductivities.

Wax packs

There were three heat-of-fusion packages on the LCRU which employed the principle of phase-change cooling to maintain temperature control. The LCRU operated for 6 hours at a relatively high dissipation rate and then remained inoperative for 14 hours. Because of this cyclic operation, all of the dissipated energy was not required to be rejected as it was generated but could be stored in the thermal mass of the equipment. As long as the heat rejection means of the system were adequate to reject the stored heat during the inoperative period, no cumulative effects would occur and the system could be cycled indefinitely.

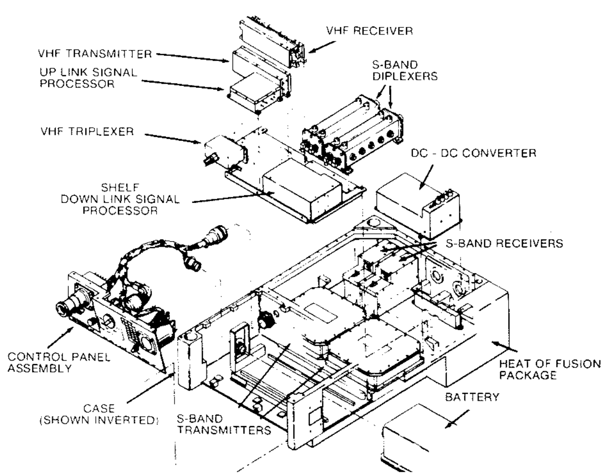
The thermal storage capacity of the LCRU equipment is 330 BTU or 98 watthours when the equipment is heated from 90° F to 120°F. By adding 5.75 pounds of phase change material (wax packs), the thermal capacity was raised to over 945 BTU, almost a three-fold increase.[1,2]

Mirrors

Second-surface thermal-control mirrors, mounted between the LCRU case and the thermal blanket, effectively reflected incident solar radiation while simultaneously radiating internally generated thermal energy to the space heat sink.

Construction

With the hybrid thermal control technique employed, heat flowed from the case of the LCRU through the heat of fusion package to the mirrors and then by radiation to deep space. Good thermal discipline required that subassemblies be mounted as directly as possible to the top surface of the case. This was accomplished by mounting the high heat-dissipating subassemblies of the system to the inside of the top surface of the unit, thus providing direct conductive coupling by the shortest possible path from the



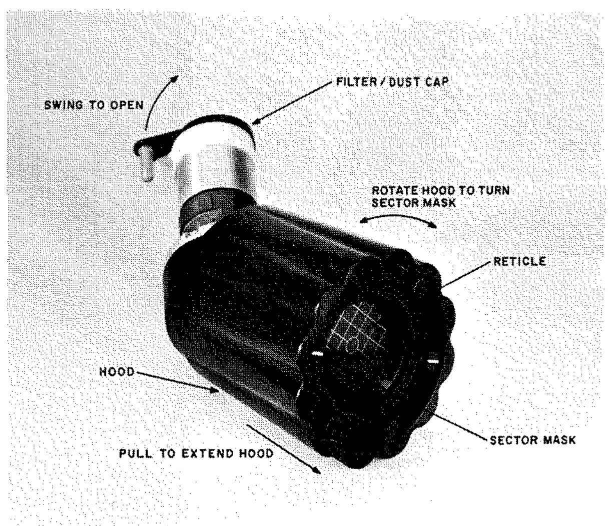


Fig. 4 (above) — LCRU component configuration.

Fig. 5 (right) — High gain antenna optical sight.

subassembly heat source to the external radiating surface. Fig. 4 shows the arrangement of the subassemblies in the LCRU unit.

Thermal considerations played an important part in the design of the high gain antenna optical sight (see Fig. 5). The considerations of environmental loading and temperature extremes led to the choice of quartz as the material for the mirror and to the use of Invar for the mating structure. Of all the common materials of construction which are suitable for the space program, the coefficient of thermal expansion of the Invar used most nearly matches the thermal coefficient of linear expansion of the quartz. Three Invar sleeves were used to mount and position the mirror; they were cemented to the two mirror halves, thereby also holding them together. The mounting of the mirror in the housing was thereby accomplished without clamping down on the quartz.[3]

Lunar dust

The presence of fine grain surface dust on the moon was a necessary consideration in the design of the various exposed linkages and moving parts, the radiating mirrors, and the high gain antenna optical sight. It is easy to visualize the equipment becoming covered with lunar surface dust through repeated handling by the astronauts. A dust brush was included as part of the astronaut's equipment to remove the dust that accumulated on the LCRU mirrors and other portions of the equipment. The LCRU electronics were completely sealed in a pressurized compartment of the LCRU case; an unpressurized volume, necessary for the replaceable battery, was totally enclosed since the battery door was gasketed.

A dust test plan was developed and executed using simulated lunar dust supplied by NASA. All deployment and assembly operations were successfully performed with dust sprinkled generously over all items of equipment.

The optical sight presented a special problem in that the objective lens was recessed in a barrel and inaccessable to the dust brush. Since dust on this lens would severly degrade the optical system, a movable dust cover/filter combination was placed in front of the lens barrel. This surface could be easily brushed clean by the astronaut.

Pressure and vacuum

The electronics compartment of the LCRU package was pressurized to prevent the possibility of corona and to provide environmental protection. A gasketed cover sealed the electronics compartment from the external environment. Fig. 6 shows the bottom view of the LCRU mock-up with covers removed. Electrical connections were made through hermetically sealed connectors that were mounted in the case walls with O-ring seals.

Pressure was also a consideration in the design of the optical sight. Any appreciable pressure differential between the interior of the sight and the surrounding environment might damage the optical elements. Accordingly, a porous plug was fitted to the optical-sight body. This plug allowed depressurization of the sight during launch and also prevented the infiltration of lunar surface dust.

Deployment of the LCRU

To prepare for the use of the LCRU during a lunar excursion, the assembly had to be removed from a stowage area in the LEM and mounted on the LRV. The antennas were then removed from their stowage container, mounted on the LRV, and connected to the LCRU via their cables.

The LCRU itself mounts on the LRV with a minimum number of operations. Two post assemblies which fit through holes in the LCRU package were installed on the LRV in their operational position before launch. The fit of the case to the post assemblies included sufficient clearance to prevent the case from jamming on the posts during placement and removal and to allow for differences in thermal expansion. In addition, a simple-to-operate locking device had to be provided to ensure that the LCRU could not be dislodged off the posts. To make the engagement of the case and posts smooth, and to provide a cushion for the LCRU unit, six pressure disks or rollers were mounted in slots in the upper portion of the posts. Controlled by a spring loaded plunger, the disks maintained a force in the radial direction. To lock the LCRU unit on to the posts, a detented handle was attached to the top of the post. When rotated down, the body of the handle projected both to the front and to the rear beyond the diameter of the post, thus locking the LCRU unit in place. In addition, a cam on the handle released a spring-loaded plunger inside the upper post, applying outward force to the pressure disks.

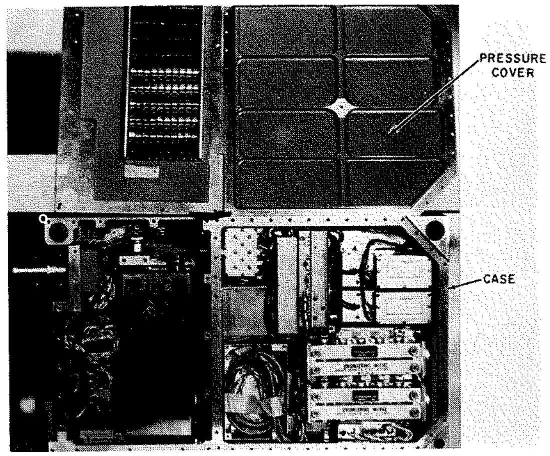


Fig. 6 — LCRU bottom view with covers removed.

The lower portions of the posts were fabricated from glass epoxy to isolate the LCRU case thermally and electrically from the LRV frame. The upper portion of the posts were fabricated from aluminum and the mechanism from stainless steel. The details of the post design are apparent in Fig. 7.

The high gain antenna assembly had to be removed from the stowage container for deployment. A primary design requirement for the stowage container was that the astronaut be able to remove the

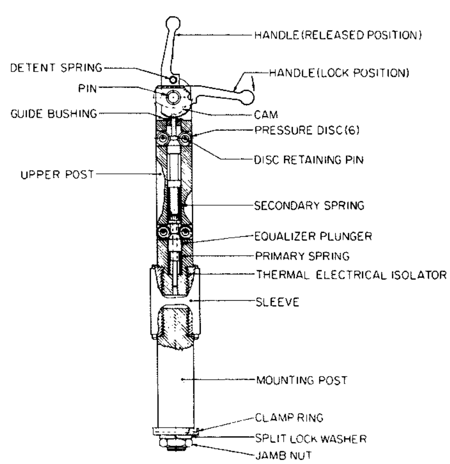


Fig. 7 — LCRU mounting post.

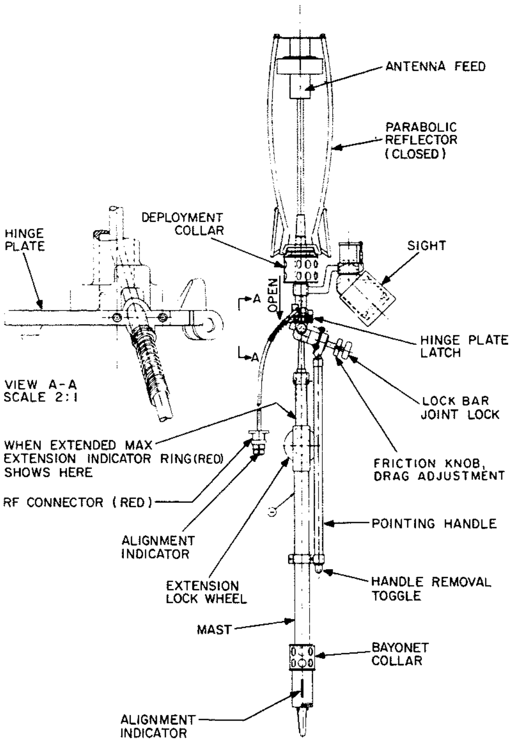


Fig. 8 — High gain antenna assembly.

antennas quickly and easily from the container for erection on the LRV. To simplify the deployment, all attachment of deployable parts was accomplished with pip pins and lanyards and extensive use was made of hook-and-pile tape in the stowage container.

The high gain antenna mast easily attached to its mounting interface on the LRV, and when the mast (which was folded double to fit in the stowage volume) was straightened — the mast hinge automatically locked the mast when upright. The low gain antenna — being much small — simply fit in a socket near the LRV control console.

The antenna cable connectors were "C" type rf connectors, modified with a special outside shell which could be easily handled with the astronaut's gloved hand. Color coding was provided, and to eliminate any ambiguity, the mating connectors on the LCRU case were appropriately identified with large colored rings and indicator marks for the clocking.

Ease of operation

Perhaps the most critical phase of LCRU design was the attention given to the operating features of the unit. The basic constraint in this effort was to enable the Apollo astronauts to make maximum use of the LCRU while requiring minimum time for operating or adjusting the unit.

Once the LCRU was properly installed on the LRV, the astronaut's attention was required only for aiming the two antenna assemblies toward Earth, replacing the battery for each EVA mission, and using the control panel switches to select mode of operation.

Positioning high gain antenna

The high gain antenna assembly, shown in Fig. 8, was designed to consist of a two-section telescoping mast, a positioning assembly, and the antenna assembly. The positioning mechanism greatly simplified the operation of erecting and positioning the antenna. The basic element of the positioning mechanism was a ball joint. A metal ball, rigidly attached to the top of the mast, was enclosed by a cage with a slot for the stem that supported the ball. Attached to the cage was a locking mechanism which permitted the ball to be clamped by turning a locking knob and which applied a constant force on the ball, counterbalancing the mass of the antenna in the lunar gravity field. With the ball joint, both the azimuth and elevation could be controlled by a single positioning handle and locked by a single locking knob. This design effectively halved the number of controls that would otherwise be required to position the antenna. Fig. 9 shows the high gain antenna being set up for operation.

Boresighting the HGA to the Earth required an optical aid since the full Earth subtends an angle of less than 2° when viewed from the lunar surface.

To aim the antenna accurately toward Earth, the optical sight was attached to the main feed support (see Fig. 5). A considerable design effort was allotted to the optical sight to make it effective and simple to operate. The contour of the front-surface mirror was carefully controlled and the mirror surface was allowed no flaws which might promote light scattering. Mechanical pointing of the sight (and the antenna) was accomplished by tilting the pointing handle on the HGA assembly shown in Fig. 10. The positioning handle could be employed in several configurations (see Fig. 11).

The sight contained a calibrated reticle visible at the viewing screen for centering

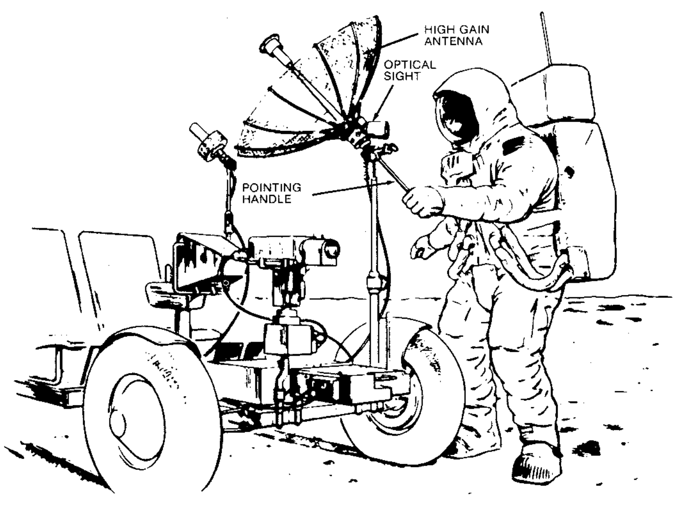


Fig. 9 (left) — Astronaut deploying LCRU high gain antenna. **Fig. 10 (above) Pointing high gain antenna.**

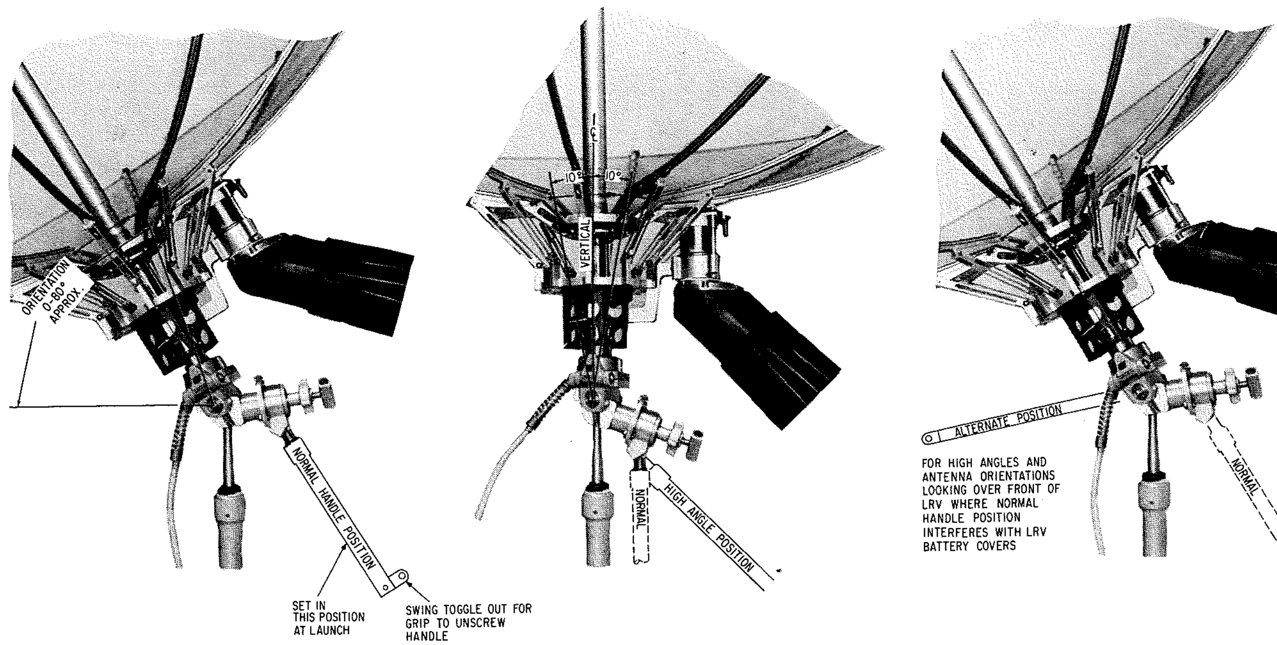


Fig. 11 — High gain antenna handle positions.

the Earth's image, as shown in Fig. 5. The astronaut would align the HGA roughly toward Earth and rotate the sight to the most convenient position. He then rotated the solar filter/dust cap away and pulled out the rear sight hood to decrease background lighting glare. The Earth's image could then be aligned within the circle at the center of the reticle using the pointing handle. When the Earth's image was centered in the bullseye, the antenna was essentially boresighted.

Positioning low gain antenna

The low gain antenna, mounted to a positioning mechanism and staff assembly, fit in a splined receptable in the Lunar Rover Vehicle hand grip adjacent to the LRV control console. This location placed the antenna assembly within reach of the astronaut during traverse on the lunar surface. The lower part of the staff had a hand grip for azimuth positioning. To rotate the staff, the hand grip was depressed downward to disengage a spline; rotation was then possible in multiples of one tooth (17°/tooth.) In addition to the coarse positioning provided by the spline, there was a slip clutch built into the hand grip, allowing the hand grip and staff to be turned to an infinite number of positions by twisting the hand grip without depressing it. This override capability permitted exact azimuth positioning.

For elevation positioning, a conical clutch operated by a locking knob was provided near the base of the antenna. The clutch was spring loaded to generate sufficient friction to hold the antenna in its position against lunar gravity when the knob was unlocked. Both clutches in the azimuth and elevation mechanism were designed to eliminate the high starting friction that would make the mechanism difficult to position accurately. This was accomplished by the conical shape which aided in distributing the load uniformly, and a teflon coating that reduced the overall friction level without the use of lubricants.

Replacing battery

Operations associated with the battery which had to be accomplished on the lunar surface included opening and closing the battery compartment door, mating and unmating the electrical connector, and inserting and withdrawing the battery.

To expose the battery, the thermal blanket could be peeled back and the battery door released by pressing a large flush-mounted button next to the door and pulling a lanyard attached to the door. With the door open, the springloaded battery handle swung out automatically so that the astronaut could pull the battery out with one or two fingers. After replacing the battery, pressing the door closed automatically folded the battery handle and seated the battery in its final position.

Since it would be difficult for the astronaut to engage and disengage a conventional multipin connector with his gloves on, the battery was designed as a plug-in module and a special connector was used. The female shell of this connector was mounted against a large coil spring which permitted a large amount of sperical float action (about ± 20°). In addition the shell had a bell-mouth entrance that aided in guiding the male shell into place prior to pin engagement.

Conclusion

The LCRU design program was especially formidable in that so many environmental and human factors constraints had to be respected. The approach was to carefully consider every possible situation and operating difficulty and make appropriate provisions in the design. The success of the LCRU was demonstrated by the exceptional communications maintained between the Earth and the lunar surface—most notably the video—on the later Apollo missions.

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Feature extraction by parallel pattern transformations using square neighborhood logic

D. B. Gennery | S. D. Jordan

This paper describes a programming language for controlling a hypothetical parallel computer that processes binary images. This processing can include such operations as noise removal and feature extraction performed prior to higher-level pattern recognition computations. The parallel computer contains elements that are similar to cellular automata. The type of cellular automata involved here operates on square lattices and uses transition rules based on the eight neighboring cells in a 3 x 3 square surrounding any given cell. The parallel computer has been simulated on a general-purpose computer. Examples of the use of the programming language and the simulator are given. One example involves the detection of objects in the presence of noise and the measuring of simple properties of these objects. Another example involves feature extraction for character recognition.

PATTERN RECOGNITION of pictorial data involves the computer analysis of two-dimensional images. For example, in character recognition the task may be to read printed characters that have been scanned and digitized.

Because of the large number of data points typically present in an image, the use of general-purpose computers for pattern recognition may be quite slow. Unger[1] has proposed the use of a parallel computer which would operate on all points in the image simultaneously. Such a machine would perform the earlier stages of the recognition process, and would reduce the large amount of data in the original image to a more compact form containing the essential information. Such machines have been built, including the ILLIAC III at the University of Illinois[2] and the Golay Processor at the Perkin-Elmer Corporation.[3]

Furthermore, most programming languages are not very convenient for expressing the types of operations needed in pattern recognition. A programming language designed to control such a parallel computer is more suitable for these early stages of the recognition process. This is true whether the parallel computer is actually built or is merely simulated on a general-purpose computer.

This paper describes a possible type of parallel computer and a programming language for controlling it. A program for simulating this parallel computer on a general-purpose computer has been written. Some examples of the use of this program will be shown later in the paper.

Basic task and approach

Consider a pattern-recognition scheme consisting of three stages.

In the first stage, a digitized two-dimensional image is converted to one or more binary (two-valued) images by comparison to suitable thresholds. In some cases, the thresholds can be obtained automatically by computing a histogram of the brightness values in the input image. In the case of a primarily black-

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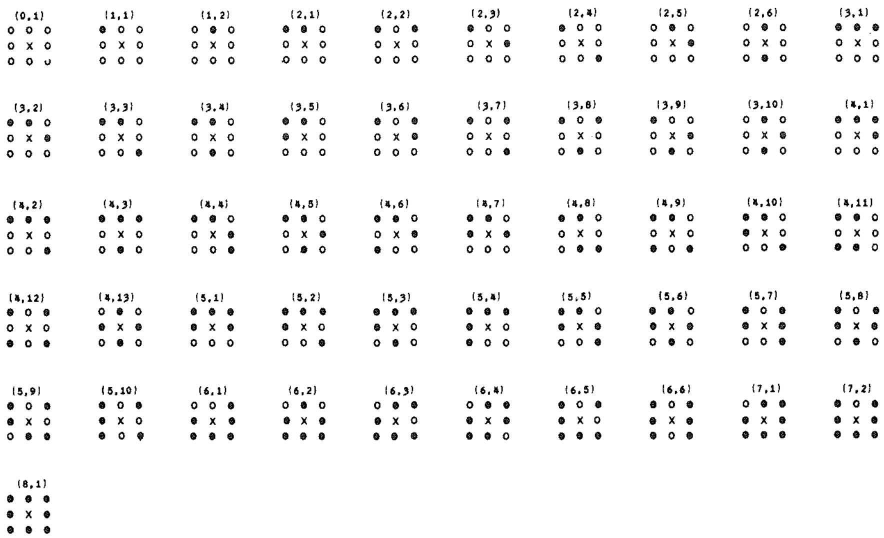

Fig. 1 — Definition of surrounds considered equivalent under rotations and reflections. Black dot denotes 1, open circle denotes 0, and x denotes center cell in question. The name of the surround appears above the pattern.

and-white image with no grays (such as printed characters), a single threshold corresponding to the gray level midway between black and white would be suitable. For certain applications, some preliminary processing, such as differentiation for edge enhancement, would be performed before thresholding.

In the second stage, the binary image is subjected to processing that will remove imperfections and extract features. For example, noise would be removed, small gaps might be filled in, outlines of objects could be detected, and the size and position of the objects could be measured. Also, hand-printed characters could be reduced to skeletons, the nodes of the resulting graphs could be detected, and various properties of the branches could be measured.

In the third stage, the information obtained from the second stage is used by a higher-level pattern recognition device which (perhaps after extracting further features) compares the results to stored pattern information and decides what type of pattern is present. A simple classification scheme might be used here, or elaborate processing such as that discussed by Evans[4] might be performed.

This paper is concerned with the second of the above three stages. The methods used here are based on concepts in cellular automata theory.[5] A cellular automaton is a device which operates upon a uniform unbounded space divided into cells. For any given cellular automaton, there is a finite number of possible states for each cell, and there is a definition of which cells are considered to be neighbors of any cell. A set of transition rules then determines how each cell changes its state at each step according to its state and the states of its neighbors (prior to this step).

The cells of the particular type of cellular automaton used here form a square lattice, such as the squares of a checkerboard. The space must be limited to a finite size in practice. As presently implemented, it consists of 50 x 50 cells. Each cell has two states, and the neighbors of each cell are the eight nearest cells consisting of the four orthogonally adjacent cells and the four diagonally adjacent cells. The transition rules can be varied to perform various operations, as controlled by logic external to the cellular automaton proper.

Instead of a single space of 50 x 50 cells as described above, there are actually several of these square lattices, each of which will be called a field. The currently implemented version has eight fields. These fields can be considered from three points of view. First, each field can be considered to be a separate cellular automaton, but information can be fed from one field to another so that it is possible for one cellular automaton to influence another, contrary to the nature of a pure cellular automaton. Second, the eight fields together can be considered to be a single automaton operating on a three-dimensional cellular space, in this case 50 x 50 x 8. The neighborhood of a cell must then be defined to include the corresponding cell in each of the other seven fields and the eight neighbors, as defined above, in all eight fields (a total of 71 neighbors). Third, the eight fields can be considered to be combined into a single two-dimensional automaton in which each cell has 256 states, where each of these states is one combination of the possible binary states of the corresponding cells in the eight fields. The first of these points of view will usually be used, but for some purposes the third point of view occasionally will be used.

In some operations, each field is further subdivided into subfields (described later). This fact is another departure from pure cellular automata theory.

Of the earlier work previously mentioned, the techniques used here are most similar to those developed by Golay.[3] However, Golay used a hexagonal lattice, with six neighbors. The use of the square lattice with eight neighbors introduces some complications but produces superior results in some cases. Also, the purpose of the subfields here is different from that of Golay. Many of the particular operations used are also quite different.

Description of processor

The data to be operated upon consist of eight fields of 50 x 50 cells each. The contents of each cell can have one of two values, which will be denoted here by 0 and 1, or equivalently by *empty* and *filled*. Twenty six arithmetic registers are also available, each of which can contain any integer from -2^{31} to $2^{31}-1$. These registers are useful for controlling looping and branching and for containing information extracted from the fields.

The operations to be performed are specified in terms of the pattern of 1's present in the eight neighboring cells (within a given field) surrounding any given cell. These neighborhood patterns will be called *surrounds*. (A border of 0's is considered to surround the 50 x 50 area so that operations on the edge cells are defined). The possible surrounds neglecting the effects of rotations and reflections are shown in Fig. 1. These are specified by two integers within parentheses as shown. Note that the first integer states the number of 1's in the

1	2	4
128	×	8
64	32	16

Fig. 2 — Weights for assigning values to specific surrounds.

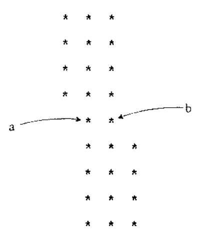

Fig. 3 — Example requiring subfields when shrinking. (Asterisks denotes cells containing 1's.)

1	2	1	2	1	2	...
4	3	4	3	4	3	
1	2	1	2	1	2	
4	3	4	3	4	3	
1	2	1	2	1	2	
4	3	4	3	4	3	
⋮						

Fig. 4 — Arrangement of subfields.

Table I — Surround notation relationships.

(0)	(0,1)	0
(1)	(1,1)	1, 4, 16, 64
	(1,2)	2, 8, 32, 128
(2)	(2,1)	3, 6, 12, 24, 48, 96, 129, 192
	(2,2)	5, 20, 65, 80
	(2,3)	9, 18, 33, 36, 66, 72, 132, 144
	(2,4)	17, 68
	(2,5)	10, 40, 130, 160
	(2,6)	34, 136
(3)	(3,1)	7, 28, 112, 193
	(3,2)	11, 26, 44, 104, 134, 161, 176, 194
	(3,3)	19, 25, 49, 70, 76, 100, 145, 196
	(3,4)	35, 38, 50, 98, 137, 140, 152, 200
	(3,5)	14, 56, 131, 224
	(3,6)	13, 22, 52, 67, 88, 97, 133, 208
	(3,7)	21, 69, 81, 84
	(3,8)	37, 73, 82, 148
	(3,9)	41, 74, 146, 164
	(3,10)	42, 138, 162, 168
(4)	(4,1)	15, 30, 60, 120, 135, 195, 225, 240
	(4,2)	23, 29, 71, 92, 113, 116, 197, 209
	(4,3)	39, 114, 156, 201
	(4,4)	27, 108, 177, 198
	(4,5)	43, 106, 154, 166, 169, 172, 178, 202
	(4,6)	45, 75, 90, 105, 150, 165, 180, 210
	(4,7)	46, 58, 139, 142, 163, 184, 226, 232
	(4,8)	51, 102, 153, 204
	(4,9)	53, 77, 83, 86, 89, 101, 149, 212
	(4,10)	57, 78, 147, 228
	(4,11)	54, 99, 141, 216
	(4,12)	85
	(4,13)	170
(5)	(5,1)	62, 143, 227, 248
	(5,2)	61, 79, 94, 121, 151, 211, 229, 244
	(5,3)	47, 122, 158, 167, 188, 203, 233, 242
	(5,4)	31, 124, 199, 241
	(5,5)	59, 110, 155, 179, 185, 206, 230, 236
	(5,6)	171, 174, 186, 234
	(5,7)	55, 103, 115, 118, 157, 205, 217, 220
	(5,8)	107, 173, 182, 218
	(5,9)	91, 109, 181, 214
	(5,10)	87, 93, 117, 213
(6)	(6,1)	63, 126, 159, 207, 231, 243, 249, 252
	(6,2)	175, 190, 235, 250
	(6,3)	111, 123, 183, 189, 219, 222, 237, 246
	(6,4)	187, 238
	(6,5)	95, 125, 215, 245
	(6,6)	119, 221
(7)	(7,1)	191, 239, 251, 254
	(7,2)	127, 223, 247, 253
(8)	(8,1)	255

surround. A single integer within parentheses denotes any surround with the stated number of 1's. If it is desired to denote a particular surround, considering rotations and reflections as different, weights are assigned as shown in Fig. 2 to produce a single integer from 0 to 255, which is used without parentheses. The relationships among these notations appear in Table I. For example, surround (1) is composed of surrounds (1,1) and (1,2); and surround (1,1) is composed of surrounds 1, 4, 16, and 64. Note that surrounds 0, (0), and (0,1) are all identical.

Logical operations can be specified in terms of Boolean combinations of the cells of any given fields and the surrounds of any given fields, and the results are used to change the contents of any specified field. These operations are considered to be performed in parallel simultaneously to all cells of a given field (or a subfield). It is also possible to operate simultaneously on more than one field. Operations of these types can be repeated as desired, and different operations can be performed in sequence under the control of a program.

For example, if it is desired to expand all filled regions of a given field to fill in gaps and holes, any cell in this field with surround (1), (2), (3), (4), (5), (6), (7), or (8) could be set to 1 (regardless of its present state). In other words, any cell adjacent to at least one 1 would be set to 1. This operation would be repeated a sufficient number of times to produce the desired amount of swelling.

Suppose that it is desired to shrink each connected filled region to a single point or to a skeleton one-cell thick. In these operations the connectivity of the filled regions must not be changed. (Filled cells that are adjacent either orthogonally or diagonally are considered to be connected in this paper.) The skeletonization can be performed by setting to 0 all cells with surrounds (2,1), (2,5), (3,1), (3,2), (3,5), (4,1), (4,4), (5,1), (5,4), or (6,1). The shrinking to a point can be done in the same manner by including in addition (1,1) and (1,2). These operations would be repeated until there is no further change.

However, a problem arises in the above shrinking operations due to the fact that, although operating on any one cell in the above manner will not change the connectivity, operating on adjacent cells simultaneously might do so. For example, an isolated adjacent pair of points or a double thickness skeleton would be completely eliminated in one move. Also, in Fig. 3 the cells labelled *a* and *b* can both be set to 0 according to the above rules, and this would separate the filled area into two regions.

To avoid the above problem, each field is divided into four subfields as shown in Fig. 4, so that no two cells of the same subfield are adjacent. Where the use of subfields is specified (which is done where connectivity is important), the operations are done sequentially to subfields 1, 2, 3, and 4 to complete one move, instead of all cells being operated on simultaneously as usual.

A parallel computer to implement the above type of operations could be built. This computer would actually operate simultaneously on all cells as described above. Clocked flip-flops could be used to insure that the previous state of the cells would determine the new state. A control unit would decode the instructions in a program and would send commands over busses to the logic circuitry associated with each cell. Input and output circuitry would exist to read in the arrays to be processed and to deliver the results to other devices for further processing. Such a computer would be able to process images quite rapidly.

A program that simulates the above parallel computer has been written for the IBM 360/65 computer. Part of this program is an interpreter which executes an internally stored code that would be suitable for execution by the hypothetical parallel computer. Upon deciphering one instruction, the interpreter, where appropriate, operates sequentially on each cell throughout a field, but it is constructed in such a manner so as to simulate parallel operation. When subfields are not used, this necessitates the use of a duplicate field to accumulate the results, so that the new state of a cell will not affect the changes to be made on a neighboring cell on the same move.

The program also contains a compiler. The compiler translates a programming language more convenient for human use into the internal code suitable for use by the interpreter or by a parallel computer.

The use of the interpreter on a general-purpose computer (such as the 360/65) is of course much slower than using a parallel computer, but it is very useful for studying the techniques involved. In addition, the use of the compiler and interpreter is a convenient way of having the processing done on a general-purpose computer, because of the nature of the compiler language. Therefore, where high speed is not important, the methods described here are useful even without a parallel computer.

Programming language

In this section the main features of the programming language accepted by the compiler will be described.

Capital letters will be used here to denote fields and lower-case letters will be used to denote arithmetic registers. This is done for ease of reading. There is no distinction between capital and lower-case letters in the computer; the compiler recognizes whether fields or registers are meant by the context in which the symbols occur.

The 26-integer arithmetic registers are denoted by the letters *a* through *z*.

The eight fields are denoted by the letters *A*, *B*, *C*, *D*, *E*, *F*, *G*, and *H*. By itself such a letter denotes the individual values (1 or 0) of each cell in the field. When such a letter is followed by parentheses enclosing a list of one or more surrounds separated by commas, the value 1 or 0 is denoted at each point in the field according to whether or not any of these surrounds exists at this cell. (The nomenclature for the surrounds was defined in the previous section.) Note that the parentheses to enclose the surrounds following the field name are in addition to the parentheses used as part of the surround nomenclature. For example, in order to indicate surround (3) in field *A*, one must write *A*((3)). (This quantity is equal to 1 wherever a cell is surrounded by exactly three 1's in field *A*.)

Instead of using numerical values to specify the surrounds, it is possible (with some restrictions) to name registers which contain the numerical values. For example, if *r* contains the value 4, *A*(*r*) is equivalent to *A*(4).

The symbols defined above for fields and their surrounds can be combined in logical expressions by using the following symbols:

- * *and*
- \+ *or*
- − *exclusive or*
- / *not*

(*, +, and − are binary operators located between their arguments, whereas / is a unary operator which precedes its argument). The hierarchy of operations is /, *, −, +; but this can be overridden with parentheses in the usual manner. As examples, note that the expressions *A*((2,4),(2,6),(3),32) and *A*((2,4)) + *A*((2,6)) + *A*((3)) + *A*(32) are equivalent and that /*B*((0),(1)) and *B*((2),(3),(4),(5),(6),(7),(8)) are equivalent. Note also that *A*−*B* and *A**/*B* + /*A***B* are equivalent.

A field can be operated upon by a statement which contains an equals sign, a logical expression of the above type on the right side of the equals sign, and symbols on the left side of the equals sign naming the field to be changed and stating the nature of the operation according to the following description. First occur the symbols $, 1$, or 0$, which mean respectively to set the named field to the value of the logical expression on the right of the equals sign, to set the named field to 1 if the value of the expression is 1 (otherwise no change), and to set the named field to 0 if the value of the expression is 1 (otherwise no change). These operations are performed in parallel for the whole field. Next is the name of the field, followed by a comma if subfields are to be ignored or an apostrophe if subfields are to be used, followed by a positive integer indicating the maximum number of times to perform the operation sequentially. (The interations terminate automatically when there is no change in the entire field.) If only one iteration is desired, the integer 1 can be omitted, and, if it is, the comma (but not the apostrophe) can also be omitted. Instead of the integer, a register name can be given, in which case the contents of the register (before executing the statement) determine the maximum number of iterations. In this case, at the termination of the iterations the register contains the number of iterations actually used. For example, the statement $*C* = *A*+*B* will cause field *C* to be set to 1 wherever either field *A* or *B* is a 1; *C* will be set to 0 elsewhere; the statement 1$*D*, *a* = *C**/*D*(0) will cause field *D* to be set to 1 wherever a 1 in field *C* occurs adjacent to one or more 1's in the field *D*, and this operation will be repeated a number of times equal to the contents of register *a*.

Arithmetic operations can be performed on the contents of the registers by a statement (in the manner of Fortran) consisting of a register name, an equals sign, and an arithmetic expression. The arithmetic expressions are made up of register names; integer constants; the symbols +, −, *, and / for add, subtract, multiply, and divide; and parentheses. (In division, the quotient is truncated to an integer, and the remainder is discarded.)

Additional statements are defined according to the following description, in which *F* represents any field, *r* represents any register name, (*r*) represents the contents of register *r*, *c* represents any integer constant, and *n* represents a statement number (an integer constant which can precede a statement).

COUNT *F*,*r*: (*r*) is set equal to the total number of 1's in the field *F*.
ZERO F_1, F_2, ... : All cells of the specified fields are set to 0.
ONE F_1, F_2, ... : All cells of the specified fields are set to 1.
IF r, n_1, n_2, n_3: Control is transferred to statement n_1, n_2, or n_3 according to whether *r* is negative, zero, or positive, respectively.
GOTO *n*: Control is transferred to statement *n*.
FIND F_1, F_2, r_1, r_2: Starting at coordinates $x = (r_1)$ and $y = (r_2)$, field F_1 is searched (by scanning $x = 1$ to 50 for each value of $y = 1$ to 50) until the first 1 is found. Field F_2 is set to 1 at this point (and is unchanged elsewhere), and the *x*, *y* coordinates of the 1 found are put into registers r_1 and r_2. If no 1 is found, (r_1) and (r_2) are set to zero.
PUT r_1, r_2, r_3: Weights 1, 2, 4, 8, 16, 32, 64, 128 are assigned to fields *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*; and the contents of all fields at coordinates $x = (r_2)$ and $y = (r_3)$ are set to the binary number equal to the eight low-order bits of (r_1).
GET r_1, r_2, r_3: (r_1) is set to the binary number represented by the contents of all fields at coordinates $x = (r_2)$ and $y = (r_3)$, with weights assigned as in PUT.
VALUE $F, r_1, r_2, r_3, r_4, r_5$: The cell at $x = (r_4)$ and $y = (r_5)$ in field *F* is examined. First (r_1) is set to 0 or 1 according to the contents of this cell, then (r_2) is set to the

number of 1's in the surround of this cell, and finally (r_3) is set to the specific surround value of this cell (0 to 255) considering rotations and reflections as different.

PLOT F: Field F is plotted on the printer with * for 1 and blank for 0.

PLOT* $F_1, F_2, \ldots$: The one to four fields specified are assigned weights 1, 2, 4, 8 and the resulting sum 0 to 15 is plotted with the characters blank, 1 to 9, and A to F.

Some other statements that will not be defined in detail are as follows:

RANDOM and RANDOM* are used to fill a field randomly (for simulating noise).

READ and READ* are used to fill a field from input data.

PUNCH is used to output the contents of fields on cards.

INPUT and OUTPUT are used for input and output of the contents of arithmetic registers.

GOTO* transfers control to a statement whose address was previously put into a register by an ASSIGN statement.

STOP terminates cmputation.

END is always the last statement in a program.

MICRO and MEND make it possible to write a form of subroutine that can operate effectively in parallel on more than one field and that can be called from more than one place in the program by the EXECUTE statement.

Some additional statements are used to refer to some frequently-used operations that could be specified by the $ statements ($\$F$, $1\$F$, or $0\$F$), but are built-in to be faster and more convenient to use. These all have the following format:

Name F, r, c_1, c_2

where *Name* represents the name of the individual operation. The operation is done to the specified field F for c_1 iterations or until there is no change, and the actual numer of iterations used is put into register r. If $c_2 > 0$, field F is plotted as in PLOT after every c_2^{th} iteration. If c_2 equals 0 or is omitted, no plotting is done. Definitions for these operations are given below by stating $ statements that are equivalent (except for the plotting) provided that they are preceded by the statement $r = c_1$.

CONSOL: $\$F,r = F{*}F((4)) + F((5), (6), (7), (8))$

SHRINK: $0\$F'r = F((0,1), (1,1), (1,2), (2,1), (2,5), (3,1), (3,2), (3,5), (4,1), (4,4), (5,1), (5,4), (6,1))$

SHRINK*: $0\$F'r = F((1,1), (1,2), (2,1), (2,5), (3,1), (3,2), (3,5), (4,1), (4,4), (5,1), (5,4), (6,1))$

SHRINK$: $0\$Fr = F((2,1), (2,5), (3,1), (3,2), (3,5), (4,1), (4,4), (5,1), (5,4), (6,1))$

SWELL: $1\$F,r = /F(0)$

LIFE: $\$F,r = F((3)) + F{*}F((2))$

These built-in operations have the following uses:

CONSOL is useful for smoothing, since it sets each cell equal to the contents of the majority of its neighbors and itself.

SHRINK$, if repeated a sufficiently large number of times, thins each connected filled region to a skeleton.

SHRINK* is similar, except that it continues to nibble away the ends of the skeleton until only closed paths or isolated points remain.

SHRINK also eliminates the isolated points.

SWELL causes each filled region to grow in size and causes holes to be filled in.

LIFE simulates the game "life" invented by John Horton Conway.[6]

```
*       PROGRAM FOR REMOVING NOISE AND MEASURING
*       PROPERTIES OF CONNECTED FILLED REGIONS
*
*           READ AND SMOOTH
        READ      A
        PLOT      A
        CONSOL    A,m,100
        PLOT      A
*           MOVE A CONNECTED REGION INTO FIELD B
        u = 1
        v = 1
      1 ZERO      B
        FIND      A,B,u,v
        IF        u,2,2,3
      2 STOP
      3 1$B,100 = A*/B(0)
        $A = A-B
*           FIND CENTER (IN C) AND EDGE (IN D)
        $C = B
        1$C,100 = /C((0),(1),(2),(3,1),(3,5))
        SHRINK*   C,m,100
        $D = B*/B((8),(7,1),(4,13),(5,6),(6,2),(6,4))
        PLOT*     C,D
*           COMPUTE CENTER XY, AREA, AND PERIMETER
        x = 1
        y = 1
        FIND      C,C,x,y
        COUNT     B,a
        $B = D*D((2,4))
        $C = D*D((2,3))
        $D = D-(B+C)
        COUNT     B,b
        COUNT     C,c
        COUNT     D,d
        p = d + (7*b + 6*c + 2)/5
        OUTPUT    2,x,y,a,p
        GOTO      1
        END
```

Fig. 5 — First sample program.

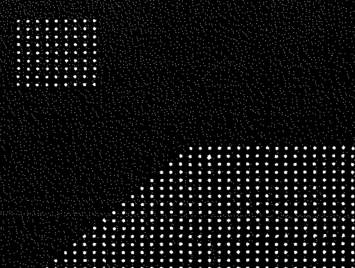

Fig. 6 — Ideal image.

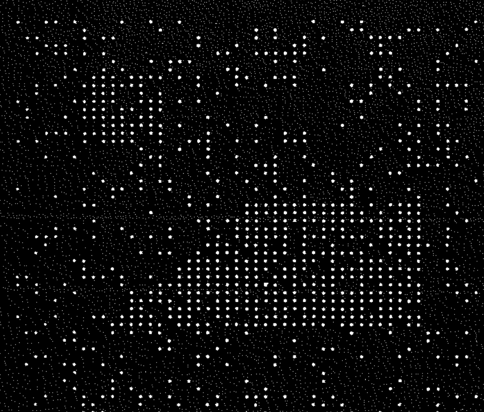

Fig. 7 — Actual input image for first example.

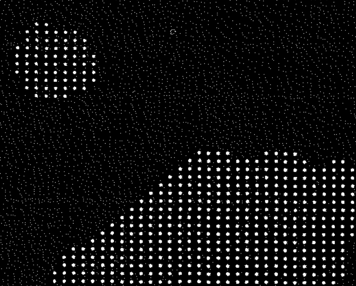

Fig. 8 — Smoothed image.

Fig. 9 — Results for first connected region.

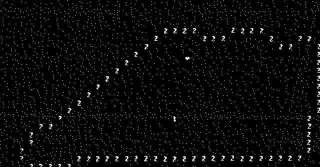

Fig. 10 — Results for second connected region.

```
*       READ, SKELETONIZE, FIN" NODES
    READ      A
    PLOT      A
    $B = A
    SHRINK    A,m,1
    1$A,100 = B*/A(0)
    PLOT      A
    SWELL     A,m,1
    PLOT      A
    SHRINK$   A,m,100
    PLOT      A
    $B = A
    0$A,4 = A((1))
    $B = B-A
    $C = A*A((1))
    1$C,100 = B*C((1))
    $A = A+C
    SHRINK$   A,m,100
    PLOT      A
    $B = A*/A((2))
    $C = B
    SHRINK*   B,m,100
    PLOT*     A,B
    $A = A-C
*       NUMBER NODES, LABEL BRANCH ENDS
*   NODES IN B, NODE REGIONS IN C, BRANCHES IN A
    OUTPUT    0
    n = 0
    x = 1
    y = 1
    ZERO      E,F,G,H
 10 ZERO      D
    n = n+1
    FIND      B,D,x,y
    IF        x,30,30,20
 20 OUTPUT    2,n,x,y
    x = x+1
    1$D,100 = C*/D(0)
    $D = D*/A(0)
    u = 1
    v = 1
    m = 16*n
 21 FIND      D,D,u,v
    IF        u,10,10,22
 22 PUT       m,u,v
    u = u+1
    GOTO      21
 30 $D = E+F+G+H
    $C = A+D
*       COMPUTE SLOPES
*   BRANCHES IN A AND C, BRANCH ENDS IN C AND D
*   BRANCH END NODE NUMBERS IN E,F,G,H (MARKED IN D)
*   SLOPES WILL GO IN E,F,G,H (MARKED IN A)
    1$E = A*C(66,36)
    1$F = E*/D
    1$F = A*C(68)
    1$E = A*C(132,72)
    1$G = A*C(9,144)
    1$E = G*/D
    1$F = G*/D
    $B = A*C(17)
    1$F = B
    1$G = B
    $B = A*C(18,33)
    1$E = B
    1$G = B
    1$G = A*C(20,34,65)
    1$H = A
    PLOT*     A,D
    PLOT*     E,F,G,H
```

Fig. 11 — Second sample program, part 1.

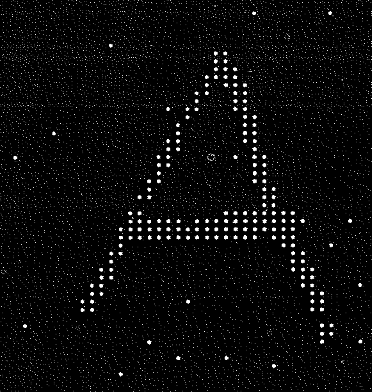

Fig. 12 — Input image for second example.

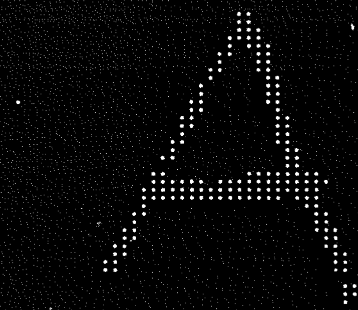

Fig. 13 — Image after noise removal.

Fig. 14 — Image after swelling.

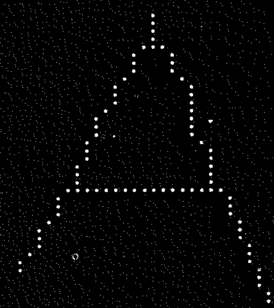

Fig. 15 — Skeleton.

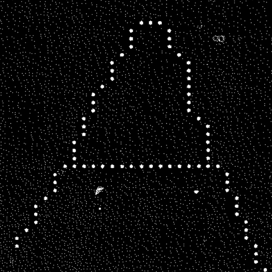

Fig. 16 — Skeleton with short spurs removed.

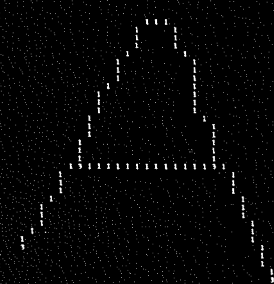

Fig. 17 — Skeleton with nodes marked.

An asterisk is used to introduce a comment statement, which has no effect on the operation of the program.

Examples

Two sample programs and results will be presented in this section.

The first example is a program that reads in an image, removes noise by means of the CONSOL operation, separates the resulting image into its disjoint filled regions, finds the outline and approximate center of each of these regions, and measures their areas and perimeters. The program is shown in Fig. 5. A sample input was made up by generating the ideal image in Fig. 6 and changing each point with probability 0.2 to obtain the input image shown in Fig. 7. The output of the program is shown in Fig. 8 (plotted after the repeated CONSOL operations) and Fig. 9 and 10 (plot of outline and center and values for center coordinates, area, and perimeter for each connected region). (x is to the right and y is down on the plots.)

The second example concerns feature extraction for character recognition. The first part of a program for this purpose is shown in Fig. 11. A hand-printed letter **A** used as a sample input is shown in Fig. 12. The program first does a SHRINK for one iteration to remove small noise specks, and the next statement restores any removed points that were not in completely removed connected regions. One iteration of SWELL is done to fill in small gaps or holes, then SHRINK$ is done until there is no change in order to reduce the character to a skeleton. The subsequent statements through the next SHRINK$ serve to remove any spurs than five points. (Various PLOT statements have been interspersed among these steps to illustrate their operation. The resulting outputs appear in Fig. 13 through 16). The nodes are then found, and the skeleton with the nodes marked is plotted in Fig. 17. (It would be quite easy to mark differently the two types of nodes consisting of end points of spur branches and points where three points of spur branches and point where three or more branches meet, but this was not necessary for the methods used in this example.)

Next the program finds and numbers each node. For each node it prints the

```
1 (N)      18 (X)      32 (Y)
2 (N)      32 (X)      32 (Y)
3 (N)      12 (X)      42 (Y)
4 (N)      38 (X)      46 (Y)
```

Fig. 18 — List of nodes with x,y coordinates.

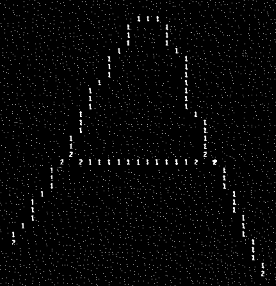

Fig. 19 — Branches (1's) with ends marked (2's).

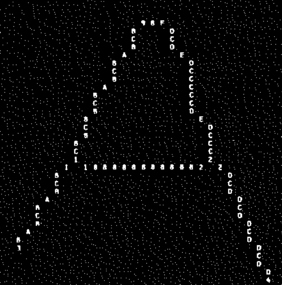

Fig. 20 — Branches labelled with slopes and ends labelled with node numbers.

node number and x,y coordinates as shown in Fig. 18. The program marks the ends of the branches as shown in Fig. 19. It labels each end of each branch with the number of the adjacent node. The slope at each point on each branch is then computed and stored. These slopes are in units of 22.5°, measured counterclockwise from the x axis. At this point, the direction along a branch is underfined. Therefore, there is an ambiguity of 180° in these slopes. The slope values would range from 0 to 7, but have been increased by 8 for ease of distinguishing them from node numbers in Fig. 20. The plot in Fig. 20 shows the endpoints of branches labelled with the node numbers and all other points labelled with their slopes, using characters A through F for values 10 through 15.

This completes the output of the program shown in Fig. 11. It would probably be most efficient in practice to pass the output as shown in Figs. 18, 19, and 20 to another device to perform the rest of the processing. However, for purposes of illustration, the program is continued in Fig. 21 to resolve the ambiguities in the slopes and to print a list of the properties of each branch. The output of this section of the program is shown in Fig. 22. Note that each branch is listed by starting at one end with the node number, continuing with the slopes at each point, and ending with the node number at the other end. Following this is the length of the branch (a simple count of points from one end to the other).

It can be seen in Fig. 21 that this part of the program consists primarily of statements similar to FORTRAN which operate sequentially on one data value at a time. This is why it was stated above that this part of the program is more suitable for another processor, since it is not efficient to tie up a parallel computer doing sequential computations. This is in contrast to the part of the program in Fig. 11, which consists in large part of statements which operate on an entire array of image values.

Many other examples could be given to illustrate the wide range of operations and areas of application which are possible.

Conclusions

The approach described here to performing preprocessing and feature extraction of binary images for pattern recognition is quite versatile. This versatility derives from the power of the programming language to define and control cellular automata. Although simulating the special-purpose image processor on a general-purpose computer is inherently slow, it does provide a useful tool for investigative work (and for actual processing where time is not critical). It also aids in determining the architecture that the special-purpose machine should have.

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```
*           OUTPUT EACH BRANCH AS FOLLOWS
*           NODE NO., SLOPES, NODE NO., LENGTH
       OUTPUT    0
       x = 1
       y = 1
    40 ZERO      B
       FIND      A,B,x,y
       IF        x,100,100,41
   100 STOP
    41 1$B,100 = A*/B(0)
       0$A = B
       $C = D*/B(0)
       1$B = C
*      A BRANCH HAS BEEN FOUND AND TRANSFERRED TO B
*      ITS ENDS HAVE BEEN MARKED IN C
       ℓ = -1
       i = 0
       w = 1
       z = 1
*      CHECK FOR NO ENDS (INSERT NODE 0) OR ONE END (SAVE END)
       COUNT     C,c
       c = c-1
       IF        c,81,82,84
    81 FIND      B,C,w,z
       m = 6
       PUT       m,w,z
       GOTO      83
    82 FIND      C,C,w,z
    83 $C = B*/C(0)
       i = 1
       GET       t,w,z
       q = 1
       r = 1
       FIND      C,A,q,r
       GET       j,q,r
       j = j-5
       0$B = A
       0$A = C
       $C = C((2))*B
       GOTO      85
    84 q = 1
       r = 1
       FIND      C,C,q,r
       GET       j,q,r
       j = j-6
       PUT       j,q,r
       j = j+2
*          ONE END HAS BEEN ELIMINATED IN C,
*          NOW THE BRANCH WILL BE TRACED STARTING AT THE OTHER END
    85 OUTPUT    2
       u = 1
       v = 1
    50 FIND      C,C,u,v
       IF        u,70,70,51
    51 IF        ℓ,45,52,53
*      DETERMINE INITIAL SLOPE
    45 VALUE     B,p,p,p,u,v
       k = -1
    42 p = p/2
       k = k+1
       IF        p,43,43,42
    43 s = 6 - 2*k
       IF        s,44,60,60
    44 s = s+16
       GOTO      60
    52 n = m
       OUTPUT    1,n
       PUT       j,q,r
       GOTO      60
*      RESOLVE AMBIGUITY IN SLOPE
    53 m = m-8
       d = s-m
       IF        d,54,56,55
    54 d = d-4
       GOTO      56
    55 d = d+4
    56 d = d/8
       s = m + 8*d
       OUTPUT    1,s
       IF        i,60,60,57
    57 PUT       t,w,z
       i = 0
    60 GET       m,u,v
       1$C = B*/C(0)
       m = m-6
       PUT       m,u,v
       m = m/16
       u = u-1
       v = v-1
       ℓ = ℓ+1
       GOTO      50
    70 n = m
       ℓ = ℓ+1
       OUTPUT    1,n
       OUTPUT    1,ℓ
       GOTO      40
       END
```

Fig. 21 — Second sample program, part 2.

```
 2 (N)
 4 (S)      8 (S)
 4 (S)      8 (S)
 4 (S)      8 (S)
 5 (S)      8 (S)
 6 (S)      8 (S)
 5 (S)      8 (S)
 4 (S)      8 (S)
 4 (S)      8 (S)
 4 (S)      8 (S)
 4 (S)      1 (N)
 4 (S)     13 (L)
 5 (S)
 6 (S)      3 (N)
 5 (S)      3 (S)
 4 (S)      2 (S)
 5 (S)      3 (S)
 7 (S)      4 (S)
 8 (S)      3 (S)
 9 (S)      2 (S)
11 (S)      3 (S)
12 (S)      4 (S)
11 (S)      3 (S)
10 (S)      1 (N)
11 (S)     11 (L)
12 (S)
11 (S)      4 (N)
10 (S)      5 (S)
11 (S)      5 (S)
12 (S)      4 (S)
11 (S)      5 (S)
11 (S)      5 (S)
12 (S)      4 (S)
11 (S)      5 (S)
11 (S)      5 (S)
12 (S)      4 (S)
 1 (N)      5 (S)
37 (L)      5 (S)
            4 (S)
 2 (N)      5 (S)
 8 (S)      2 (N)
 8 (S)     15 (L)
```

Fig. 22 — Branches with node numbers of ends (n), slopes (s), and length (l).

Advanced uhf receiver development

D. W. Wern | C. T. Shelton

For the past several years, a program of Independent Research and Development has been carried out to improve and simplify the design of military receivers in the uhf communications band — 225 to 400 MHz. In general, the receivers in this band, used primarily by military aircraft, must meet high performance standards, be small in size and be highly reliable. However, detailed specifications vary depending on the applications: the aircraft may have one or several transmitters; satellite interface may be required; and, in some cases, space may be quite limited. Since the "best" approach is determined by the requirements, a variety of approaches have been investigated. This paper briefly describes some of these areas investigated.[1] While this investigation was underway, the tactical vhf band —30 to 80 MHz— was also being investigated. Although the requirements are somewhat different, the basic principles are the same and therefore there was substantial interaction between the two programs. This work is described in a companion paper.[2]

C. T. Shelton, Communications Equipment Engineering, Government Communications Systems, Camden, N.J., received the BSEE from Lehigh University in 1952. He joined RCA in 1952 and was initially assigned to the area of military application of television and displays. In 1961 he was assigned to the Cambridge Plant of the Communications Systems Division where he participated in the development of automatic component test equipment for the Minuteman Program and in the development of a variety of tactical radio circuits. These programs included the SRC-5 multi-party transceiver, participation in the RCA RADAS program, and early work on hybrid micro-circuits. In 1965 he returned to the Communications Systems Division in Camden where he particpated in pre-proposal system studies including the SAM-D Missile, the Mallard Program, and the MOL program. He was then given responsibility for techniques and high dynamic range circuitry. He has responsibility for the development of the test bed for the next generation vhf tactical radio. In 1971, he became responsible for the manpack receiver and synthesizer and the aircraft applique for the AN/URC-78 tactical radio system.

D. W. Wern, Communications Equipment Engineering, Government Communications Systems, Camden, N.J. received the BSEE from Cooper Union School of Engineering in 1954. He joined RCA in 1954 and was initially assigned to systems analysis and equipment development in the field of Ultra High Resolution Radar. He participated in both microwave and optical data processing design tests. In 1963 he was transferred to the Communications Systems Division where he participated in the design and development of several types of transceivers for Apollo and DYNA-SOAR. In 1966, he was assigned to Advanced Development for uhf and vhf military receiver design with emphasis on electronic tuning and improvement of dynamic range. In this field he also participated in the development of a tactical ranging system, and in the development of an advanced vhf manpack receiver. His work in uhf receiver front ends included hi-dielectric constant strip line development on a Navy contract. In 1971, he was assigned to the development of the CSAR radar. His task involved the generation of an ultra-linear sweep generator, voltage controlled oscillator, and associated CHIRP radar linearity testing. He participated in system test of the deliverable models.

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Authors Shelton (left) and Wern.

THE UHF RECEIVER development work was primarily directed towards improving upon the first generation of electronically tuned 225- to 400-MHz amplitude-modulated receivers. These equipments were limited by the characteristics of available uhf variable-capacitance diodes which afforded a very limited tuning range and comparitively low *Q*. To obtain a resonable compromise between dynamic range, sensitivity, and freedom from spurious responses — while at the same time taking advantage of electronic tuning — these early equipments used as many as nine rf amplifiers and as many as three first mixers to cover the desired band.

Several amplifier circuits were examined to arrive at a means for tuning these circuits over the desired range with a minimum of complexity and to achieve optimum performance from the first-mixer circuit. Advanced methods of fabricating and packaging the front end circuitry were also investigated.

Receiver front end

RF amplifier

The sensitivity and dynamic range of an rf amplifier depend largely upon the characteristics of the active device used. Previous work indicated that the dual-gate field-effect transistor had the best overall performance of available uhf devices, although it had somewhat higher noise figure than selected bipolar types. Its major advantage was improved dynamic range. Therefore, the RCA TA-7801, a dual-gate MOS transistor which had an improved noise figure and a lower input impedance was selected for this investigation. This transistor improves dynamic range because of reduced input voltages. Two types of improved bipolars using distributed geometry techniques were also examined: the RCA TA7486 and the Avantek AT25A. These three devices were evaluated in the circuit configurations shown in Fig. 1 using the test setup shown in Fig. 2. In this setup, the amplifier under test is driven with a laboratory signal generator, and followed by a high-dynamic-range diode mixer, a crystal filter to select the desired i.f. frequency and suitable measuring equipment. The signal levels are arranged so that noise and non-linearities in the test setup can be eliminated or compensated for by calculation. For dynamic range tests, a second signal generator modulated with a different frequency and detuned 3 MHz is fed in through a hybrid coupler and the combined effect of desensitization and cross modulation are measured in the detected output. All sensitivity and cross modulation are measured in the detected output. All sensitivity measurements are open-circuit microvolts required to give 10-dB $(S+N)/N$ measured with a 6-dB pad

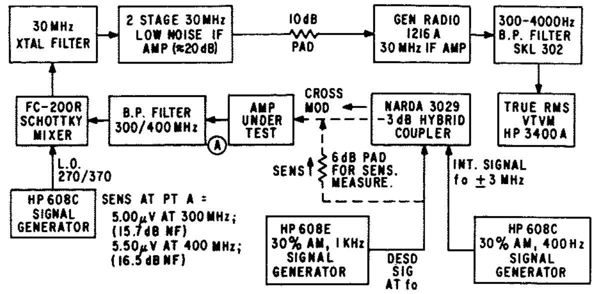


Fig. 2 — Measured data for several new uhf amplifier devices and test setup.

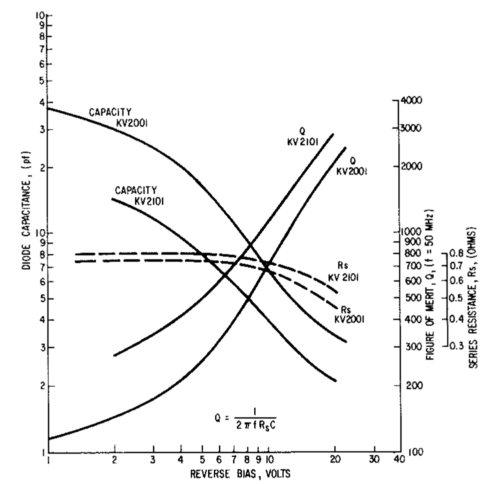


Fig. 3 — Typical electrical characteristics, KEV tuning diodes Vendor's Data (Junction temp. = 25° C).

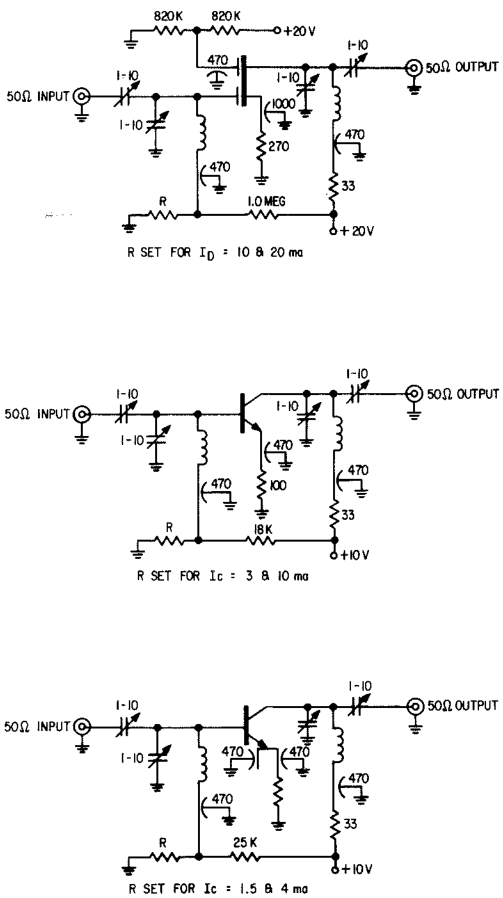


Fig. 1 — Amplifier test circuits

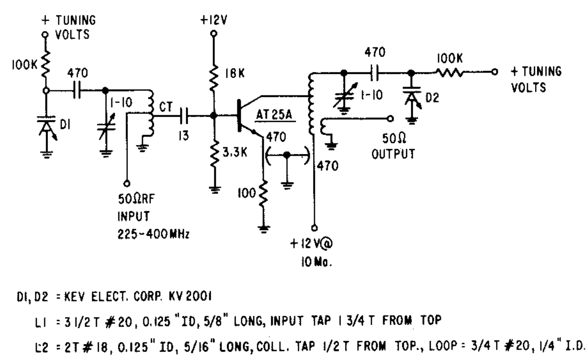


Fig. 4 — Tunable receiver rf amplifier to cover 225 to 400-MHz band using hyper-abrupt tuning diodes and AT-25A transistor.

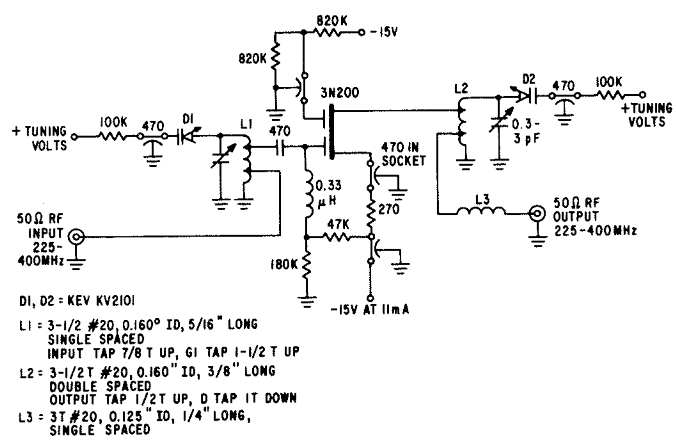


Fig. 5 — Tunable receiver rf amplifier to cover 225 to 400-MHz band using hyper-abrupt tuning diodes and 3N200 MOS-FET.

Table I — Measured data for several new uhf amplifier devices.

	RCA TA-7801 $V_D = 20$ V, $f = 300$ MHz		RCA TA-7801 $V_D = 20$ V, $f = 400$ MHz		RCA TA-7486 $V_C = 10$ V, $f = 300$ MHz		Avantek AT-25A $V_C = 10$ V, $f = 300$ MHz	
	$I_D = 10$ mA (*best NF*)	$I_D = 20$ mA	$I_D = 10$ mA (*best NF*)	$I_D = 20$ mA	$I_C = 4$ mA (*best gain*)	$I_C = 1.5$ mA (*best NF*)	$I_C = 10$ mA (*best gain*)	$I_C = 3$ mA (*best NF*)
Power gain (dBs)	20	20	19	20	20	20	19	20
Sensitivity (O.C. μV)	1.15	1.20	1.2	1.3	1.2	1.15	1.2	1.1
System *NF* (dBs)	3.1	3.5	3.5	4.1	3.5	3.1	3.5	2.8
Device *NF* (dBs)	2.3	2.8	2.3	3.3	2.75	2.3	2.5	2.0
Levels at amp. input								
Dynamic range (dBs)	107	108.5	102.5	103	88.5	−94	106.5	105
Int. level (dBm)	−5	−3	−9	−8	−23	−18	−5	−7
Desired level (dBm)	−112	−111.5	−111.5	−111	−111.5	−112.5	−111.5	−112

between the circuit under test and the signal generator.

It can be seen from Table I that the noise figures obtained are good in all cases. The major criterion, therefore, for selecting an appropriate device is dynamic range. The bottom half of the Table I shows the dynamic range at which a 4-dB signal-to-noise ratio degradation was obtained in the desired modulation otuput as a result of densensitizaiton and cross modulation. The level of the interferring signal and the desired signal are shown. It can be seen that the TA7801 gives comparable dynamic range performance to the Avantek AT25A. The TA7486 transistor is somewhat inferior.

A choice between the best two devices will depend upon a number of factors. The bipolar transistor lends itself to broadband untuned amplifiers while the field-effect transistor with its lower transconductance may require tuning to obtain adequate gain and noise figure.

An investigation was made of electronic tuning techniques to provide a single rf amplifier covering the entire 225- to 400-MHz band. Since variable-capacitance tuning diodes are non-linear, care must be taken to assure that dynamic range is not compromised. Also, the Q obtainable from such diodes is limited, and therefore a problem is sometimes encountered in preventing spurious responses such as the image and half i.f. frequencies.

Previous designs used abrupt junction diodes which have a capacitance inversely proportional to the square root of the applied dc voltage. This investigation was based on two types of hyper-abrupt diodes, the KEV Electronics Corporation types KEV-2101 and KEV-2001 which give greater capacitance variations. The characteristics of these diodes is shown in Fig. 3.

These diodes were evaluated in rf amplifier circuits using the Avantek AT25A transistor previously described and the RCA 3N200 dual-gate FET. These circuits, shown in Figs. 4 and 5, were evaluated in a test setup similar to the one described previously. The results of gain, noise figure, and bandwidth tests are shown in Fig. 6 and 7.

It can be seen that good gain and noise

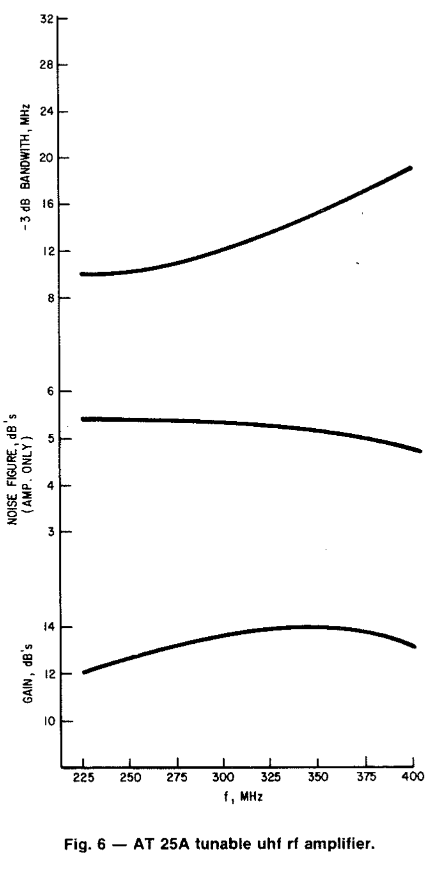


Fig. 6 — AT 25A tunable uhf rf amplifier.

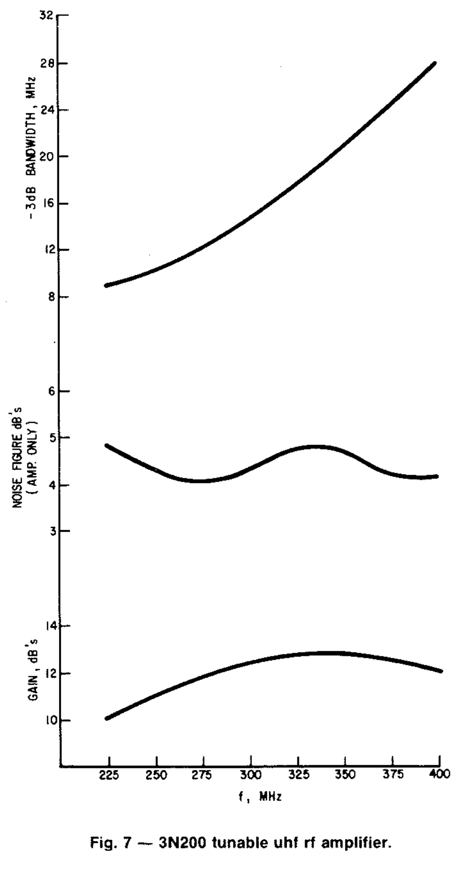


Fig. 7 — 3N200 tunable uhf rf amplifier.

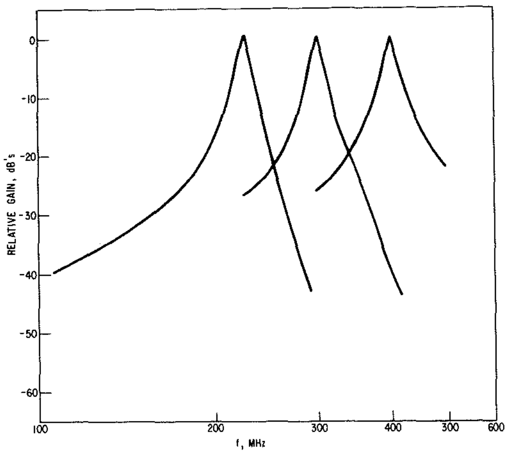


Fig. 8 — AT-25A tunable uhf rf amplifier selectivity.

figure are maintained in these circuits although the performance is somewhat reduced over that obtained previously with more optimum tuning elements. The selectivity curves obtained with the AT25A are shown in Fig. 8. The lower skirt of the selectivity curve tends to flatten out around 40 dB, which might cause excessive image response in some cases.

Improved variable capacitance diode designs might solve this problem. The dynamic range of these amplifiers is described in Figs. 9 and 10, based on the previously described test method. Here the undesired signal level is plotted against frequency. It can be seen that the performance of these amplifiers approximates the specification of an Air Force radio. By comparing data, it can be seen that the major dynamic range limitation is the amplifying device and not the tuned circuit.

Mixers

Overall, the best receiver mixer at uhf frequencies is the doubly balanced Schottky-barrier diode quad used in current uhf receiver designs. Mixers such as the one described in Ref. 2 for vhf frequencies do not function efficiently at uhf due to device limitations. Schottky diode mixers have better dynamic range than rf amplifiers; therefore mixer-input receivers are desirable. The conventional Schottky diode mixer, however, has a conversion loss of 7 to 8 dB. Therefore when they are combined with the necessary preselector filtering, i.f. filtering, and i.f. amplifier noise figure these receivers have noise figures of 10 to 12 dB. The principle of unwanted frequency termination presents the possibility of improving the diode-quad conversion loss substantially.

Unwanted frequency termination circuits of the type used at vhf [2] are not practical with a diode mixer since, with a two-terminal switching device, the pump signal would have to pass through the series-tuned circuits. This would require the generation of a large pump voltage to drive the diodes adequately at the pump frequency. A similar effect can be obtained by providing an external open circuit source impedance at the image frequency as shown in Fig. 11. In this circuit, a bandpass filter is used ahead of the mixer which provides a reactive source impedance at frequencies outside the passband. This reactance is adjusted to appear as an open circuit at the image frequency through an adjustable transmission line. At the signal frequency, the source impedance seen by the diode quad is approximately 200 ohms; at the 70-MHz i.f. frequency, the load impedance is approximately 400 ohms. These values agree with those given by Caruthers in ref. 3.

A Telonic ITF-290-20-4XX filter exhibiting a 20-MHz 3-dB bandwidth and a 290-MHz center frequency was used. This circuit varied between 3- and 4- dB conversion loss across the 280- to 300-MHz passband. It can therefore be seen that over limited portions of the uhf band, a satisfactory mixer input receiver can be developed. To make this circuit practical over the entire 225- to 400-MHz

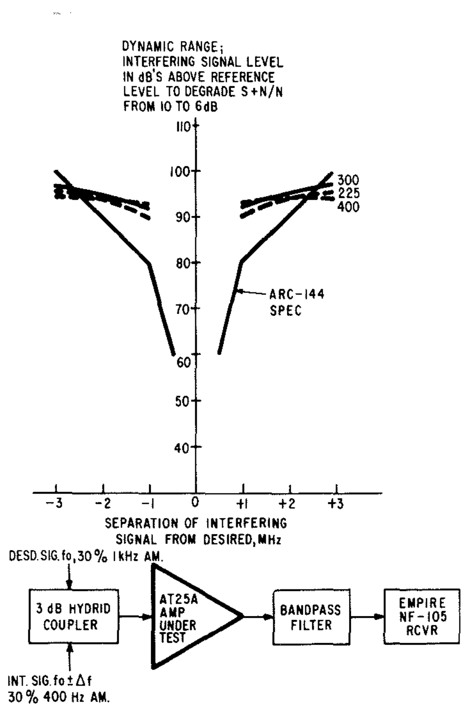


Fig. 9 — AT-25A tunable uhf rf amplifier dynamic range.

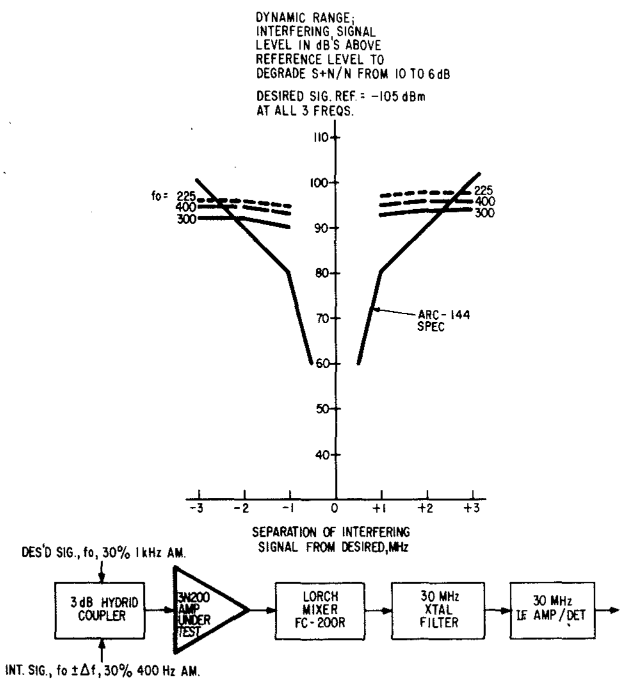


Fig. 10 — 3N200 tunable uhf rf amplifier dynamic range.

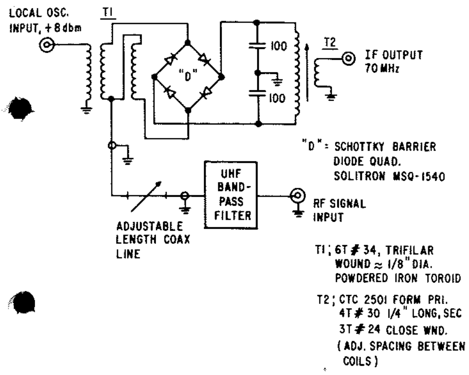


Fig. 11 — Image-terminated mixer.

frequency range, it would be necessary to develop an economical set of bandpass filters with the appropriate properties.

Stripline design

To make uhf receiver circuitry compatable with modern hybrid microcircuit fabrication techniques, an investigation was made of miniature stripline techniques. Conventional stripline uhf resonators would be excessively large, but it was felt that high dielectric materials (such as rutile with a dielectric constant of 31) would give compact resonators. These, combined with the electronic tuning and high dynamic range amplification techniques described previously, would provide a very practical receiver front end. This investigation had two phases. The first was to design stripline resonators which would give the proper resonant properties and could be tracked with a single dc voltage. The second phase involved the fabrication of a front end including the rf amplifier, voltage-controlled oscillator, and mixer.

A superheterodyne receiver design typically requires that the tuning of the rf-signal resonators and the local-oscillator resonator track one another with a constant (or nearly constant) difference frequency equal to the first intermediate frequency of the receiver. Use of resonators that consist of distributed inductances introduces added difficulties in the tracking analysis. The transmission line inductance, typically a shorted length of line less than one-quarter wavelength long, when tuned with a capacitance in shunt with the open end of the line, results in a frequency-vs-capacitance-resonance function which is unlike that of a lumped inductor resonator. This is evident when it is noted that the impedance as given by

$$Z = jZ_o \tan(\beta L)$$

$$\beta = 2\pi f/V \text{ and } \beta L < \pi/2$$

is a frequency-dependent tangent function rather than a function that is proportional to frequency.

For ease in analysis of the tracking problem, it has been assumed that the tuning capacitances for each tank circuit are identical voltage variable capacitance diodes for both tanks with a common tuning voltage. This problem must be solved by techniques of successive approximations. After investigation of the tuning curves of these resonators as a function of various parameters, it was discovered that there was an approach whereby the two tank circuits could be made to have the required difference frequency at two points with only a small error for points between.

A resonator is defined, as shown in Fig. 12, to be a shorted length of transmission line with given characteristic impedance, length, and dielectric constant, together with an associated tuning capacity.

In this particular analysis, it is assumed that the local oscillator frequency is higher than the rf signal frequency. The design constraints are that the two resonators produce a difference frequency exactly equal to the i.f. at two signal frequencies f_1 and f_2 (f_1 assumed lower than f_2). The corresponding local oscillator frequencies are, therefore, $f_1 + f_{i.f.}$ and $f_2 + f_{i.f.}$ at these tracking points.

The parameters of the two tank circuits are defined as follows:

	RF tank	*LO tank*
Dielectric constant	E	E
Characteristic impedance	Z_1	Z_2
Line length	L_{rf}	L_{LO}
Tuning capacity @f_1	C_1	—
Tuning capacity @f_2	C_2	—
Tuning capacity @$f_1 + f_{i.f.}$	—	C_1
Tuning capacity @$f_2 + f_{i.f.}$	—	C_2

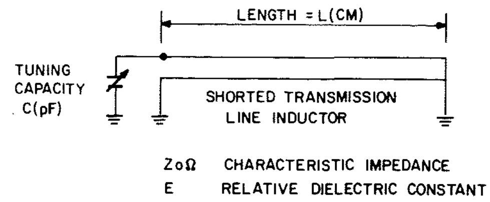


Fig. 12 — Basic transmission-line resonator.

The impedance of the line is expressed as follows for the rf signal tank:

$$Z = j\, Z_1 \tan(\beta L) \quad (2)$$

where $\beta = 2\pi f/VP$ and VP is the propagation velocity ($VP = 3 \times 10^{10}/E^{1/2}$) (cm/s).

For resonance at f_1

$$Z(f_1) = j\, Z_1 \tan(2\pi f_1 L_{rf}/VP) \quad (3)$$

The capacitor's impedance is,

$$Z_C(f_1) = -j/2\pi f_1 C_1 \quad (4)$$

Then for resonance, in terms of ω (radian frequency),

$$1/\omega_1 C_1 = Z_1 \tan(\omega_1 L_{rf}/VP) \quad (5)$$

Likewise at f_2

$$1/\omega_2 C_2 = Z_1 \tan(\omega_2 L_{rf}/VP) \quad (6)$$

By dividing Eqs. 5 and 6 and rearranging,

$$\frac{C_2}{C_1} = \frac{\omega_1 \tan(\omega_1 L_{rf}/VP)}{\omega_2 \tan(\omega_2 L_{rf}/VP)} \quad (7)$$

Design considerations can be used at this point to specify the maximum total tuning capacity (C_1) to be used to tune to f_1. Having specified C_1, the tuning capacitance ratio (C_2/C_1) required may be found once the remaining unknowns are determined. The dielectric constant (E) and Z_1 may be selected on the basis of size and Q considerations.

By rearranging Eq. 5 as an arc tan statement,

$$L_{rf} = (VP/\omega_1) \arctan[1/(\omega_1 C_1 - Z_1)] \quad (8)$$

Thus, the length of line for the rf tank may be determined, and the required tuning capacitance ratio may be ascertained from Eq. 7.

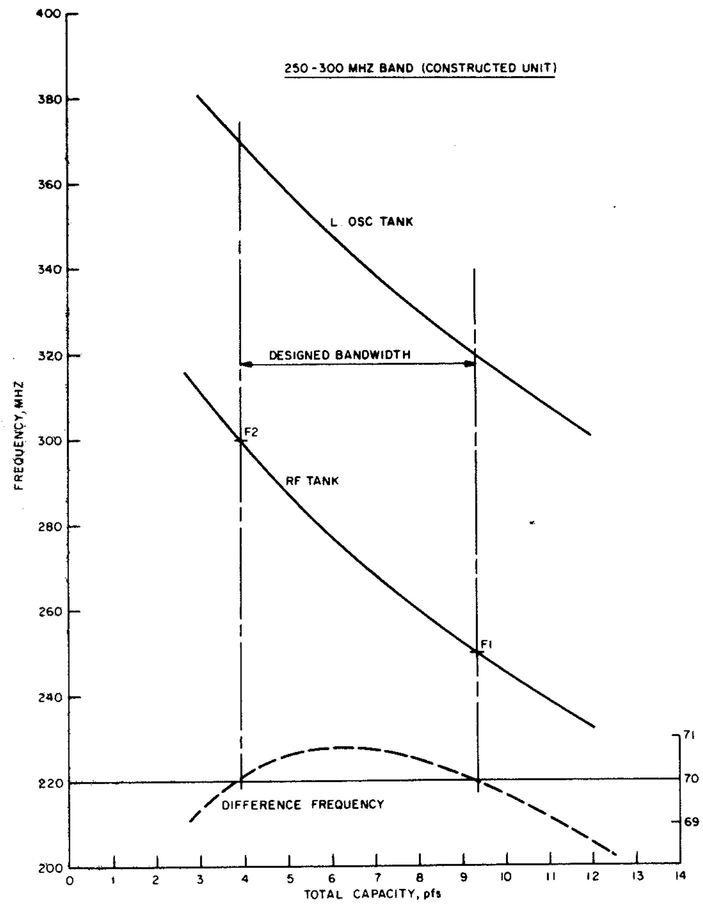
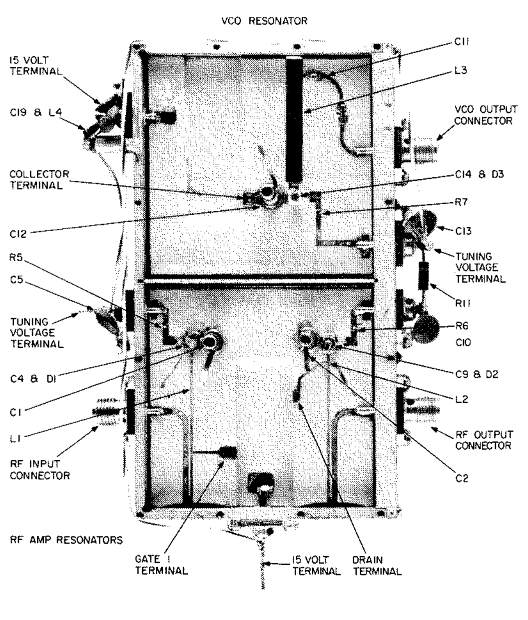
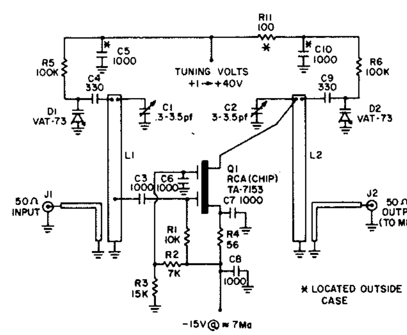


Fig. 13 — Theoretical tuning and tracking-error curves.





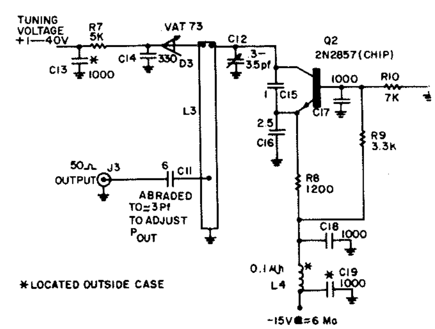


Fig. 14 (above) — VCO and rf amplifier resonators. Fig. 15 (right, top) — Final model of rf amplifier. Fig. 16 (right, bottom) — Final model of vco.

To define the local oscillator resonator, one starts with equations of the same form as Eqs. 5 and 6. From these the following can be derived:

$$0 = \frac{\omega_1 + \omega_{if}}{\omega_2 + \omega_{i.f.}} \arctan[1/C_2Z_2(\omega_2 + \omega_{i.f.})] - \tan[1\ C_1Z_2(\omega_1 + \omega_{i.f.})] \qquad (9)$$

This equation has all quantities defined except Z_2. Solving for Z_2 requires an iteration of numerical approximations. By using this value of Z_2, the value of L_{LO} may be solved by re-writing Eq. 5 as:

$$L_{LO} = (VP/\omega_1 + \omega_1 + \omega_{i.f.}) \arctan[1/(\omega_1 + \omega_{i.f.})\ C_1\ Z_2] \qquad (10)$$

Thus, a solution has been described whereby when Z_1, C_1, f_1, f_2 and $f_{i.f.}$ are assigned values, the remaining unknowns Z_2, C_2, L_{rf}, and L_{LO} may be found.

To determine the resonant frquency of the rf tank with tuning capacity of C (pF), Eq. 5 may be rewritten as:

$$Z_1 \tan(\omega\ L_{rf}/VP) - (1/\omega C) = 0 \qquad (11)$$

For a given value of C, all parameters are known except ω. Eq. 11 may be solved by iterative numerical approximations, to provide the resonant frequency of the rf tank for a given value of C. Likewise, the oscillator tank resonant frequency may be determined, given the same value of C. The difference frequency should be the i.f. desired. By stepping C over the tuning range desired, the tracking error may be examined by noting the deviation of the difference frequency from the desired i.f.

The foregoing has been incorporated within one program written in Fortran IV. This program was used to evaluate the final design based on the following parameters:

Material selected for the substrates was rutile with a dielectric constant of 31.0;

Tuning band selected was 250 to 300 MHz with a 70-MHz i.f.;

Tuning diodes selected are Varian VAT-73 with a 0-V bias capacity of 12 to 15 pF;

Maximum total tuning capacity was chosen as 9.3 pF which allows for a minimum tuning voltage of about 3 to 4 V plus additional stray capacities of 1 to 2 pF;

Resonators lenghts based on the above analysis were 3.77 cm, $Z_1 = 35$ ohms, for the rf resonators and 3.20 cm, $Z_2 = 21.2$ ohms, for the LO resonators.

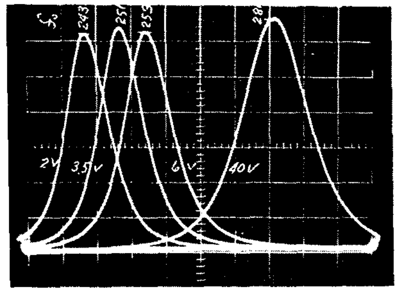
The calculated tuning tracking curves are shown in Fig. 13. The tracking curves show an error of 800 kHz or less across the tuning band which would be acceptable for a selectivity of about 3 or 4 MHz or a Q of about 80 to 100.

Based on the tracking analysis, a uhf stripline rf amplifier and voltage controlled oscillator were designed and fabricated on rutile substrates having a dielectric constant of 31. The resonators were designed and fabricated at RCA Laboratories Princeton, N.J. by Ross Stander. A photograph of the resonators is shown in Fig. 14. The trimmer capacitors are mounted near the ends of the resonators which are used for adjusting the resonant circuits for tracking purposes. The diodes are mounted at the ends of the resonators, but cannot be seen clearly in the photograph.

The remainder of the circuitry was mounted on a Fluroglas substrate and consisted of miniature chip components mounted to a gold metalization pattern. This substrate was fabricated by Robert R. Bigler of the Camden Hybrid Laboratory. The schematic for the vco and rf amplifier are shown in Figs. 15 and 16.

After considerable experimentation with substrate dielectric constants and physical configurations, tracking was obtained between the vco and rf-amplifier tuned circuits. This performance is shown in Fig. 17. The discontinuity in the vco curve apparently resulted from some spurious resonance whose origin was not determined. It is felt that this phenomenon is caused by some characteristic of this particular experimental model and is not fundamental to the approach. The selectivity curves obtained in the rf amplifier are shown in Fig. 18. In evaluating these circuits a Lorch diode mixer was used and a specially designed buffer amplifier was used to raise the vco output from approximately 1 mW to the 100 mW necessary to drive the mixer. The performance of the amplifier is shown on Fig. 3. The dynamic range, tested in the same way as described previously, is given in Fig. 19.

This investigation has shown that amplifiers of this type can be designed in hybrid microcircuit form and that several of them in combination could provide a satisfactory receiver front end covering the 225- to 400-MHz band. The investigation also indicated that design and production engineering effort is required to determine methods of fabricating and aligning such circuits economically.



Frequencies given are center of each passband. Voltages given are tuning voltages for each passband. Markers are VCO output translated 70 MHz lower, for each tuning voltage shown.

Fig. 18 — Final model rf amplifier and vco swept tracking display.

Conclusion

The investigations described in this paper have shown that high performance receiver front ends in the uhf band can be designed and fabricated having noise figures varying from 4 to 6 dB and dynamic ranges of 90 dB or better depending on the particular combination of components selected. A variety of tuning diodes and active devices are available to obtain this range of performance and the particular combination selected will depend upon the specific performance requirements as well as size and economic considerations.

Acknowledgments

The authors wish to recognize the major contributions made by Ross Stander of RCA Laboratories in Princeton, N.J. for the design and fabrication of uhf stripline resonators and Robert Bigler of the Camden Hybrid Lab for the fabrication of the UHF hybrid circuits.

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3. Caruthers, R. S., "Copper Oxide Modulators in Carrier Telephone Systems, *BSTJ* (April 1939) p.305-337

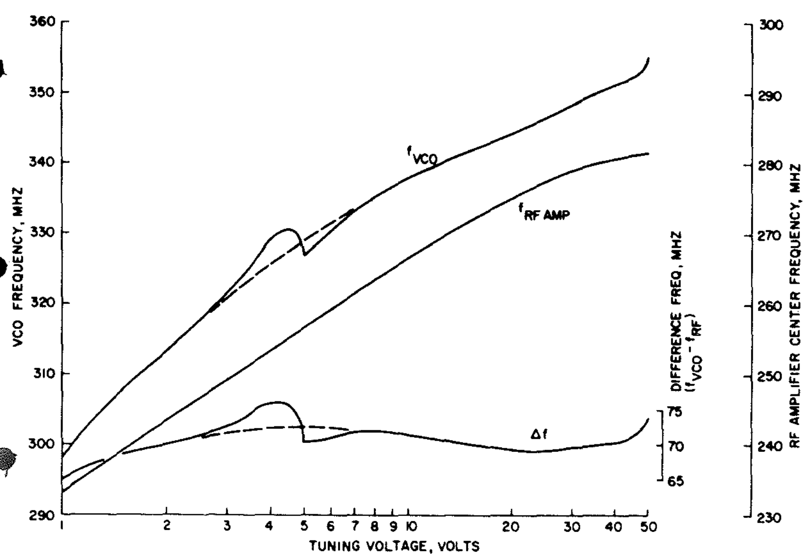


Fig. 17 — Tuning characteristics of rf amplifier and vco.

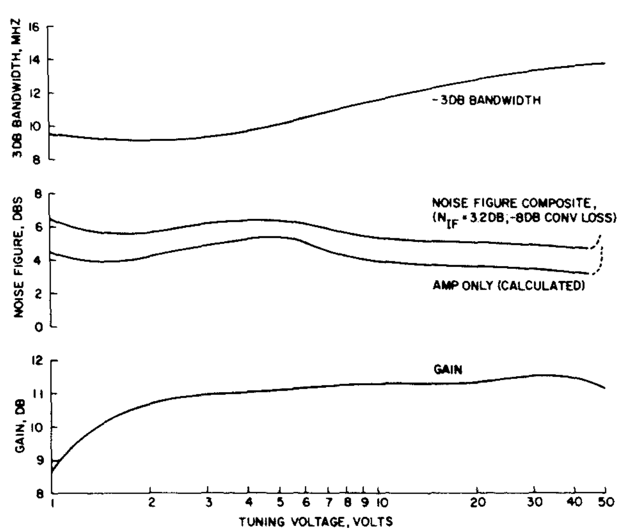


Fig. 19 — Performance of rf amplifier.

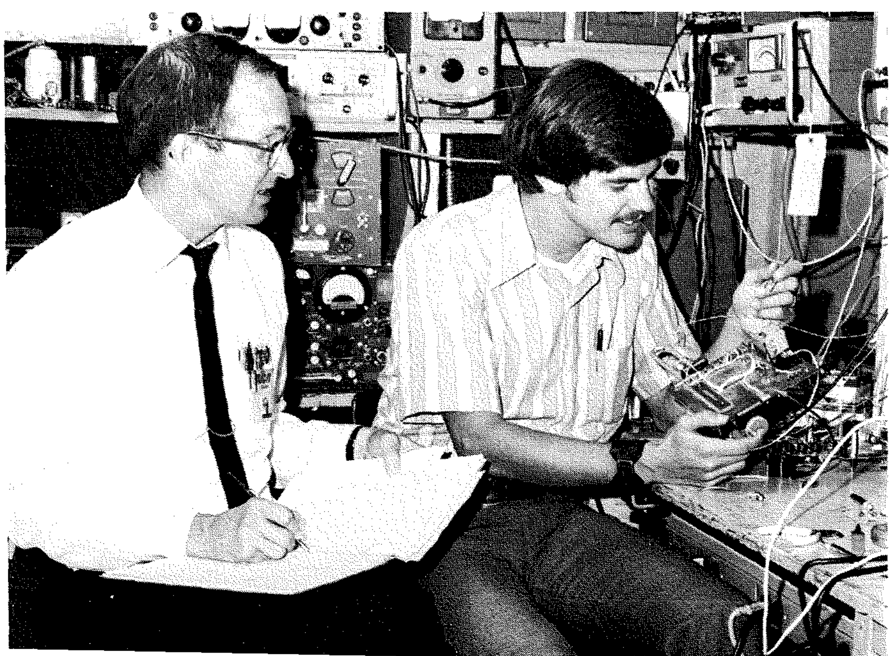
Advanced vhf receiver development

R. H. Brader | C. T. Shelton

An Independent Research and Development program has been carried out over the past several years aimed at improving military receiver front ends in the tactical vhf band — 30 to 80 MHz. This paper describes some of the most recent results of this program. While the experimental work is concentrated in the 30- to 80-MHz band, it is applicable, in many respects, to other frequency bands of military interest such as 2 to 30 MHz and 108 to 174 MHz. This paper highlights a few of the significant results.[1] A companion program has also been carried out with similar objectives in the military uhf band of 225 to 400 MHz. While many of the specifications are different in this band, the same general principles apply and there was considerable interaction between the two programs. The uhf program is described in a companion paper.[2]

A SIGNIFICANT IMPROVEMENT in the dynamic range of mixer circuits at hf and vhf has been achieved in this program using MOS field-effect transistors in the double-balanced switching mixer configuration. This mixer has displayed a dynamic range 30 dB higher than any bipolar or FET active amplifier front end circuit requiring less than 200 mW of dc power. To achieve maximum dynamic range, the receiver front end has been based on a mixer input configuration since use of an rf amplifier would limit the dynamic range of the receiver. With a mixer input, however, noise figure becomes a problem. Normally, a doubly-balanced switching mixer would display 6 dB of conversion loss, which when added to the preselector loss and i.f. amplifier noise figure, would give unsatisfactory receiver sensitivity. Since typical noise figure requirements for vhf receivers are 8 dB or better, some improvement must be obtained.

Authors Shelton (left) and Brader.



Receiver front end

It has been shown by Caruthers[3] that by properly terminating unwanted frequencies generated in the mixing process, the conversion loss of a switching mixer can be theoretically reduced to 0 dB. Using reactive termination for these unwanted frequencies will reduce the bandwidth of the passive mixer, but by making the proper tradeoffs between bandwidth and conversion loss and by allowing for non-ideal switching by the FET devices, a conversion loss of 4.5 dB or less can be maintained for a 30% bandwidth. If a low-noise i.f. amplifier is also used, a satisfactory receiver noise figure can be maintained.

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Filtering is required in front of the MOS quad mixer to eliminate responses at the image frequency and the i.f. frequency, and to minimize local oscillator radiation. Fixed tuned bandpass filters have been selected for this function since they eliminate the tracking problem between rf and local oscillator frequencies and also they do not present the dynamic range limitations of VVC-diode-tuned preselector filters. The local oscillator chain for this receiver consists of a VVC-diode-tuned voltage-controlled oscillator and associated buffer amplifier. The buffer amplifier driving the mixer uses a VVC-diode-tuned output to optimize the impedance match and conserve dc power. An important aspect of this problem has been to minimize power drain for battery operation. Fig. 1 is a block diagram of the front end.

The system uses three mixers driven by two vco's. The band was broken up in this fashion due to the tuning limitations of the VVC diodes, and the bandwidth limitations of the unwanted frequency terminating circuits. A 17-MHz i.f. frequency was selected to remove the local oscillator and image frequencies sufficiently far from the rf band to minimize the complexity of the preselector filter. Each mixer band was divided into two preselector filter bands to minimize shape factor requirements and to allow low insertion loss.

Mixer

At the start of this program, commercially available MOS switches were designed

R. H. Brader, Government Communications Systems, Communications Systems Division, Camden, N.J., received the BEE from the University of Delaware in 1967 and the MSEE from the University of Pennsylvania in 1972. He joined the Communications Systems Division in 1967 and has been a design engineer with the advanced technology section assigned to advanced receiver development. He designed an electronically-tuned vhf front-end incorporating varactor diodes and dual-gate MOS FET's. He worked with the Solid State Division on the design and layout of a monolithic vhf front-end. He worked on the thick-film hybrid vhf test bed program and designed a digital-to-analog converter for the DME applique to the PRC-77. He developed a very low-conversion-loss, high-dynamic-range vhf mixer. This required working with advanced MOS device engineers at Somerville to devleop a transistor especially tailored to the requirements of this circuit. This mixer has been the center of his design for a high-performance mixer input receiver. He is presently working with the URC-78 design group on a high dynamic range receiver for military manpack communication.

Mr. Shelton's biography appears with his other article in this issue.

Table I — TA7800 device characteristics

Parameter	Value	Test conditions				
		V_{G-S} (volts)	V_{sub-S} (volts)	V_{D-S} (volts)	I_D (μA)	Freq. (MHz)
Channel resistance	15 ohm	+15	−13	0	—	35
Breakdown voltage (drain-source)	15 volts	−10	−13	—	1	
Drain capacitance	1.8 pF	−10	−13	—	—	35
Gate capacitance	6.0 pF	0	−13	—	—	50
Real gate impedance	75K ohm	0	−13	—	—	50

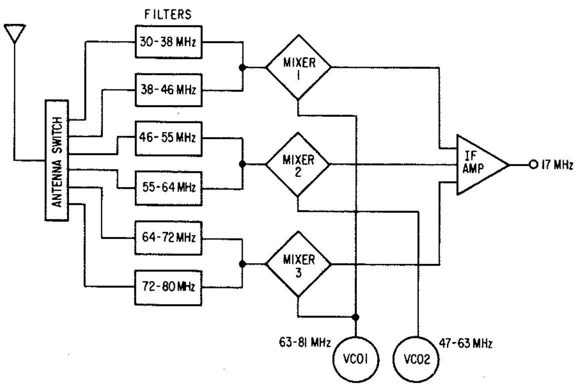

Fig. 1 — Block diagram of vhf receiver front end.

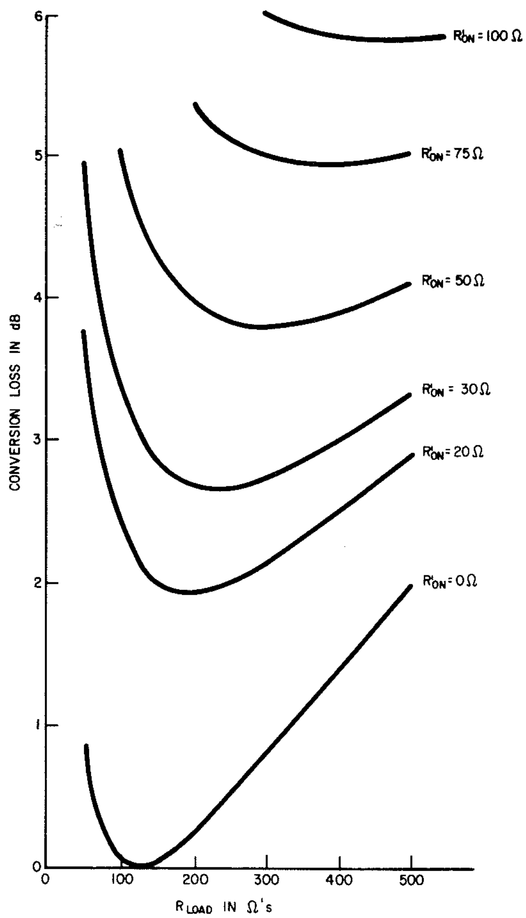

Fig. 2 — Conversion loss contours — source impedance of 50 ohms.

using large geometry patterns for low frequency switching applications. For this program, R. H. Dawson[4] of the Solid State Division designed and fabricated a high-frequency switching MOS transistor based on the following requirements:

1) Device symmetry giving interchangeable source and drain.
2) Minimum input, output, and parasitic capacities.
3) Accessible substrate terminal for external biasing to prevent forward bias of MOS source and drain diodes.
4) Closely matched transistor device characteristics for circuit balance.
5) Channel *on* resistance much less than load impedance to minimize conversion loss.
6) High drain-to-source breakdown voltage to maintain linearity.
7) High gate input impedance to minimize local-oscillator power drain.
8) Minimum gate capacitance for minimum load on local oscillator buffer.

Requirements 1) and 3) dictate the basic configuration of the device in that the device drain and source geometries must be identical. The substrate terminal must be brought out on a separate pin.

The performance of the TA-7800, the device resulting from this program, is given in Table I. The static channel resistance of 15 ohms represents a small series resistance with respect to a 200-ohm load impedance. In practice, the average *on* resistance over a switching cycle is about 30 ohms. The drain-to-source breakdown voltage of 15 V is adequate for handling rf input signals of up to 10V rms. The drain capacitance of 1.8 pF represents a large impedance for the frequency range of interest up to 100 MHz. The gate impedance of 75 kilohms paralled by 6 pF represents small loading of the local oscillator for a tuned local oscillator port, if large value VVC diodes are used to maximize the tuning range.

Since reduction of mixer conversion loss is extremely important, the theoretical aspects of conversion-loss reduction were investigated. From the model of a double-pole, double-throw reversing switch with perfect unwante frequency terminations, the theoretical conversion loss can be found from:

$$\Gamma = 10 \log_{10} \frac{[R_L + R'_{on} + (\pi^2/4)(R_s + R'_{on})]^2}{\pi^2 R_s R_L}$$

where R'_{on} is the average *on* resistance; R_s is the source impedance seen by the quad;

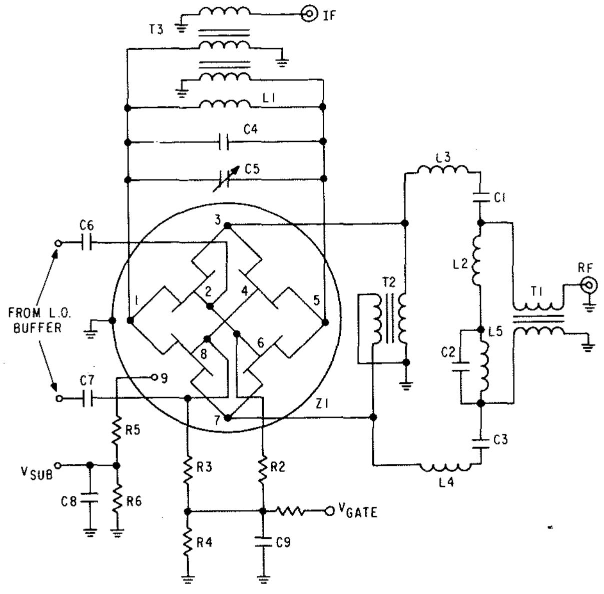

Fig. 3 — MOS quad mixer.

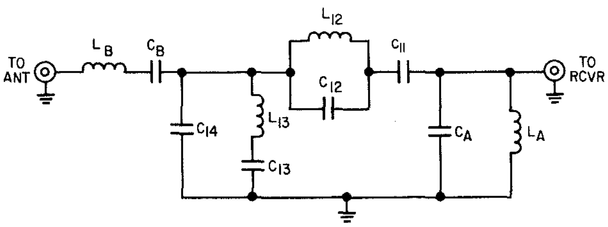

Fig. 4 — Front-end filter schematic.

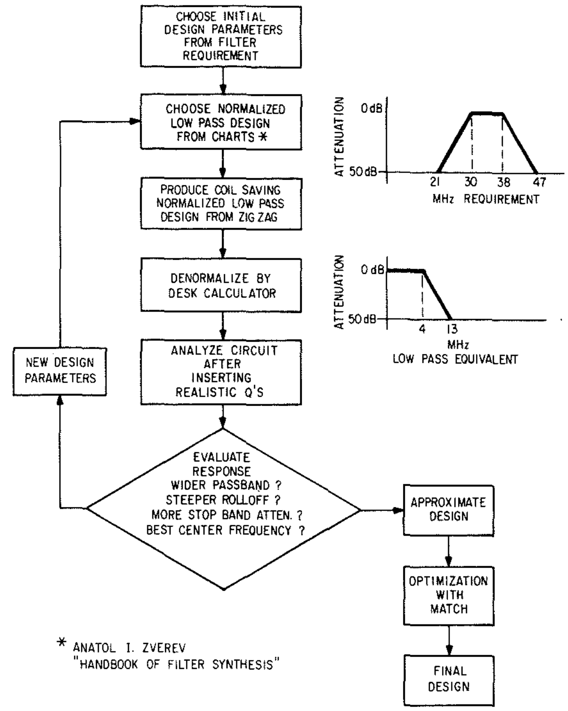

Fig. 5 — Flow diagram of the filter design procedure.

and R_L is the load impedance seen by the quad.

A solution of this equation is plotted in Fig. 2 for a source impedance of 50 ohms. It can be seen that for minimum conversion loss, the optimum load impedance changes for different values of average *on* resistance of the device.

Once the basic impedance levels of the circuit are chosen, the remainder of the design concerns the realization of conversion-loss reduction techniques. The basic idea of conversion-loss reduction is the elimination of power dissipation at unwanted frequencies which are created during the mixing process. Most important of these unwanted frequencies is either the sum or difference frequency. Since the difference frequency has been chosen for the i.f., the sum frequency must be eliminated by presenting a short circuit to this frequency at one port and an open circuit at the other port. In this design, it was decided to have the short circuit at the i.f. port and the open circuit at the rf port; see Fig. 3.

The parallel tuned circuit — made up of elements L1, C4, and C5 — resonates at the intermediate frequency, 17 MHz, and the elements are chosen so the LC ratio is made to present a load impedance for the sum frequency which is much less than the load impedance at the desired frequency. The open circuit at the sum frequency in the input port is created by the series-tuned circuits of elements C1, L3, C3, and L4. This circuit must series resonate at the center of the rf band, and present a much higher source impedance at the sum frequency. The circuit has the additional constraint that it must be sufficiently broad so that the proper bandwidth of the mixer can be achieved; that is, the reactive impedance of the series tuned circuits must remain small with respect to the source impedance at all frequencies in the rf band and present a large impedance at the sum frequencies. Actual implementation of this circuit can be aided by choosing a properly constructed coil for the series-resonant circuit which displays a self-resonance in the sum band. Since most of the sum frequencies lie above 100 MHz, this can be readily accomplished. The transistors are biased at their threshold point since the conversion loss is affected by the duty cycle of the transistors; that is, the transistors should be *off* for half the cycle and *on* for half the cycle to provide maximum symmetry in the circuit and also maximum efficiency. Substrate biasing forces the transistors to operate in a proper switching mode and improves the dynamic range.

The measured conversion loss of this circuit was 3.7 dB. Using an average value of R_{on} = 30 ohms for the TA-7800, and refering to Fig. 2, it can be seen that about 2.7 dB loss would be predicted. About 0.5 dB must be added for transformer loss giving a total of 3.2 dB. The difference between 3.7 and 3.2 dB results from a variety of circuit imperfections.

Preselector

The MOS quad mixer requires a preselector for i.f. rejection, image rejection, and to prevent local oscillator radiation. The preselector is composed of fixed band pass filters which must have low passband insertion loss for minimum noise figure, small shape factors to minimize the number required, and high stop-band rejection. An elliptic function filter was chosen since it can be made to exhibit a small shape factor in applications where passband and stop band ripple can be tolerated. Also the elliptic function filter provides the option of a coil saving feature. The schematic of the basic filter is shown in Fig. 4. The design requirements for each filter are that the passband loss be less than 1 dB and that the L.O., i.f., and image rejection be at least 50 dB.

The filter design is based on several computer programs. The design procedure is shown in simplified form in Fig. 5. The filter requirement for one of the six filters is shown in the upper righthand corner. Below it is the low-pass equivalent. Using this plot, a set of normalized low-pass design values are selected from the design charts. A program known as ZIGZAG produces an equivalent design which uses fewer coils. The design is then denormalized and analyzed on a network analysis program. Realistic circuit values including coil Q values and major stray capacities are used in this step. If the final result is not satisfactory, the initial requirement is modified and new design parameters are selected. This process eventually yields a filter which approaches the desired response.

The final step uses an interactive program called MATCH. This program, with continuous supervision by the designer, makes final corrections to the filter. The use of MATCH is not practical until an almost acceptable design has been achieved. Therefore, none of the previous steps can be omitted.

Fig. 6 shows the response of a filter which was designed with the above procedure.

Low noise i.f. amplifier

Since the preselectors and the mixer introduce loss, it is important for the i.f. amplifier to have the lowest possible noise figure. Its dynamic range must also be comparable to that of the mixer. Noise figures on the order of 1 dB have been obtained with both bipolar and FET amplifiers, but the FET is used since it displays significantly better dynamic range. The FET amplifier falls approximately 30 dB short of the MOS quad mixer in dynamic range and therefore, must be protected with 30 dB of attenuation at frequencies 200kHz or more removed from the intermediate frequency. The filter must also have extremely low loss since its loss will add directly to the overall noise figure of the system. A crystal filter was chosen due to the high unloaded Q of its elements.

A normal crystal filter requires a conjugate match at the output port to obtain proper passband characteristics, but an amplifier must be appropriately mismatched to display its best noise figure. For this purpose a special filter was designed by Damon Electronics which operates into the high impedance load presented by an FET while displaying the proper output impedance for best noise figure. The filter displays an insertion loss of approximately 0.6 dB, has a 1 dB bandwidth of 50 kHz, and a 30 dB bandwidth of 350 kHz.

The low-noise FET i.f. amplifier is shown in Fig. 7. This amplifier is in a cascode configuration using junction FET's with a low Q matching circuit in the output. The cascode stage is used to add stability while retaining good noise figure. The crystal filter is matched to the mixer with a step-up transformer. The amplifier and filter have a noise figure less than 2 dB. The filter has approximately 0.6 dB of insertion loss and the amplifier has approximately a 1 dB noise figure.

Performance

The complete receiver front end as shown in Fig. 1 was tested for noise figure, third-order intermodulation, and 2-dB compression level. The local oscillator signal was supplied by a VVC-diode-tuned class-B buffer amplifier driven by a voltage-controlled oscillator.

The performance results are shown in Table II. The frequency range covered by the receiver is 30 to 80 MHz. The data was taken at numerous frequencies within this band and the range of data is given. The noise figure of the front end varied from 7.0 to 9.6 dB. Although better noise figures are obtainable through the use of rf amplifiers, the usefulness of lower noise figures in this frequency band is sometimes limited due to atmospheric noise levels. The third-order intermodulation performance ranges from 94.5 to 108 dB when referenced to a threshold signal of -112 dBm. This performance is also indicative of low spurious response. The 2-dB compression level, which is the level that causes the output response of the mixer to fall 2 dB below linearity, ranges from +25 to +34.5 dBm. This represents a signal level of several volts at the antenna terminal of the receiver. The local oscillator power required by the mixer, 4 to 6 mW, is low because of the high input impedance of the MOS devices when the input capacitance is tuned out.

The dc power for the entire front end ranges from 192 to 285 mW, including 44 mW for the i.f. amplifier, 35 to 45 mW for the voltage-controlled oscillator, and 112 to 200 mW for the class-B tuned buffer amplifier. This relatively low power is significant for battery operated receivers. The performance of this receiver front end represents a 30 dB increase in dynamic range over previous receiver front ends utilizing comparable dc power. Application of this mixer to lower frequency bands has shown similar performance. Operation of the mixer above 100 MHz is limited at present by MOS device technology. New techniques will probably be developed which will allow operation well above this frequency.

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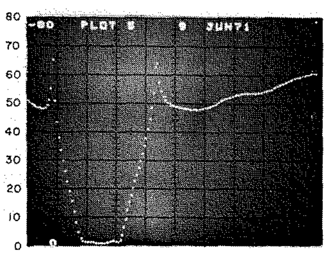

Fig. 6 — Filter response.

Table II — Measured performance of front end.

Frequency range	30 to 80 MHz
Noise figure	7.0 to 9.6 dB
Third order IM distortion	94.5 to 108 dB referenced to − 112 dBm
2-dB compression level	25 to 34.5 dBm
Pump power	4 to 6mW
DC power	192 to 285 mW, includes: 44 mW for i.f., 35 to 45 mW for vco, 112 to 200 mW for tuned pump amplifier

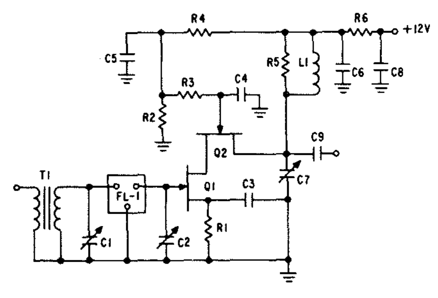

Fig. 7 — Low-noise FET i.f. amplifier.

ITR—a new reverse conducting thyristor for horizontal deflection

L. S. Greenberg | E. F. McKeon

The ITR discussed in this paper is presently being produced for tv horizontal deflection circuits, however, the ITR's usefulness is not limited to this type of circuit. The ability to block 1000 V, the excellent turn-on and turn-off times, and the fast-reapplied-voltage capability make this device extremely well suited for use in inverter circuits where reverse blocking is not required.

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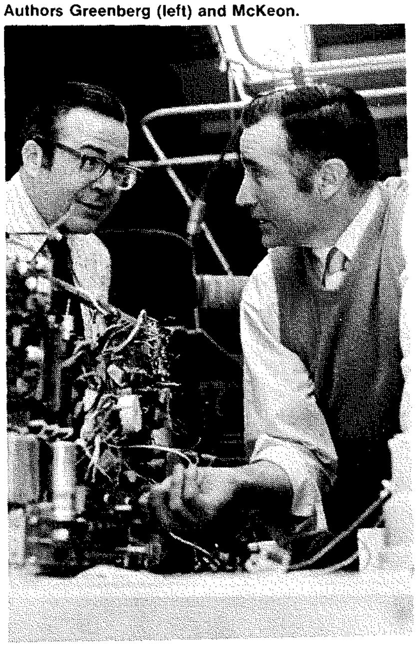
Leon Greenberg, Ldr. Linear IC Engineering, Solid State Division, Somerville, N.J. received the BSCE and the MS in Mathematics and Physics from Northeastern University. He joined Raytheon, Inc. in 1950, and during the following 12 years worked in product development and manufacturing in their Solid State Division. As Engineering Group Leader, he was responsible for the product development of all germanium high-frequency transistors. For the past 10 years, Mr. Greenberg has been with RCA in the Solid State Division. As Engineering Leader in Thyristor and Rectifier Engineering he was responsible for the development of high-frequency thyristors and rectifiers. Mr. Greenberg was responsible for the development of the tv deflection SCR and the ITR, and, in 1967, he received an Engineering Achievement Award. He recently transferred to the IC operation where he is involved in the process development of Linear IC's. Mr. Greenberg is a member of the Electrochemical Society, and is a registered Professional Engineer in the state of Massachusette. He is the author of several papers and has been awarded several patents.

Authors Greenberg (left) and McKeon.



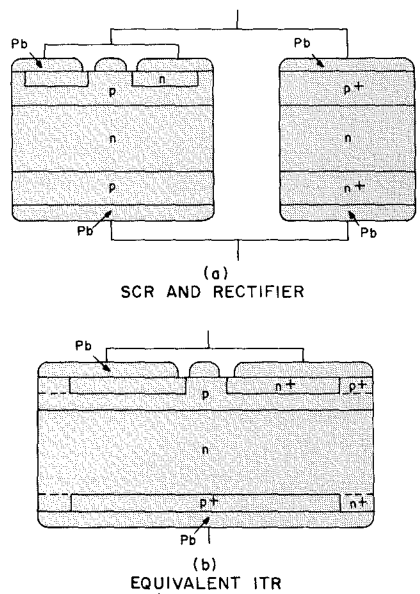


Fig. 1 — (a) SCR and rectifier, (b) equivalent ITR.

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THE ITR, integral thyristor rectifier, is combines an SCR and rectifier on the same pellet, as shown in Fig. 1.

The best way to gain an understanding of the performance features and advantages of the ITR in tv deflection circuits is to trace its development through that of the SCR, and to compare the characteristics and performance requirements of both devices in such a circuit.

Development of the SCR

The SCR has been used in power-switching circuits since its introduction in the late 1950's. These early devices, configured as shown in Fig. 2, were used mainly in 60-Hz applications because they were severely limited in voltage blocking capability and switching speed,

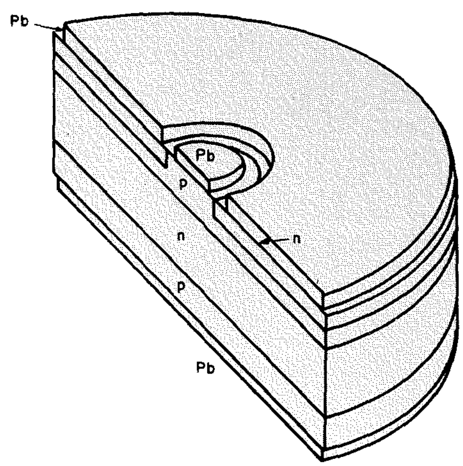


Fig. 2 — Early SCR design.

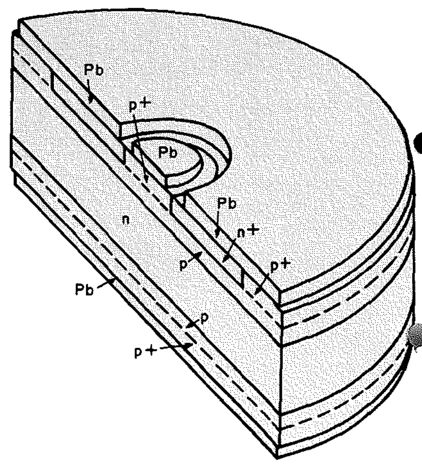


Fig. 3 — Present-day SCR.

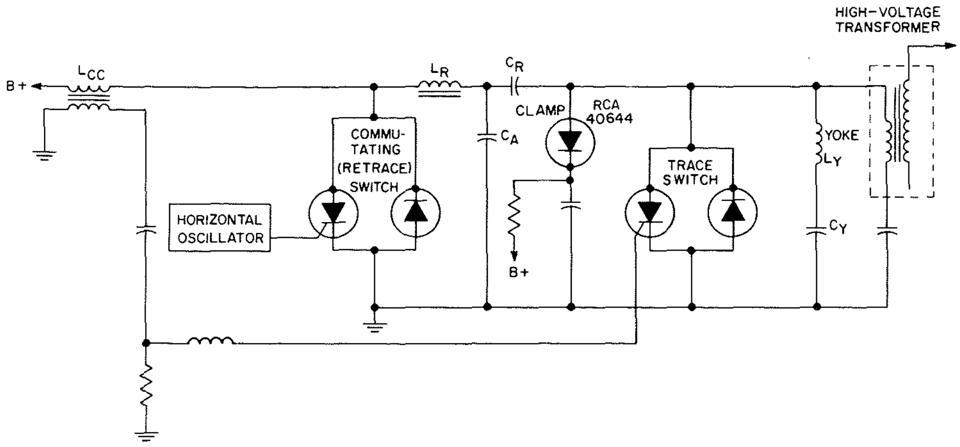


Fig. 4 — Simplified schematic diagram of horizontal-deflection circuit.

especially at elevated temperatures. The gate current required to turn the device *on* was difficult to control and the rates at which current or voltage could be impressed across its blocking junctions were limited. In addition, the instantaneous current that flows during voltage build-up across the device junctions could switch the SCR to its conducting state.

During the 1960's the design of the SCR was improved to that shown in Fig. 3, and its circuit capabilities correspondingly expanded. The addition of p+ and n+ regions just under the contact areas improved forward drop and reduced the voltage required to turn the device *on*. The incorporation of a shunt between the gate and the cathode stabilized the gate current and improved the blocking voltage and dv/dt capability of the SCR, especially with temperature fluctuations.

The incorporation of gold doping in the SCR fabrication process reduced the time for stored carriers to be eliminated from the base regions and improved the frequency performance of the device. The capability of the latest SCR now easily matches the requirements of tv horizontal deflection circuits.

TV deflection circuits

Since 1968, RCA has been using a highly reliable horizontal-deflection system for color tv, the CTC-40, which incorporates two SCR's in a unique retrace-driven circuit. An improved version of this SCR circuit is presently used by RCA in all XL100 receivers.[1] Fig. 4 shows that the basic circuit functions with two active bipolar switches, each consisting of an SCR and anti-parallel diode. The trace switch carries yoke current throughout scan while the commutation or retrace switch is used to activate flyback or "shut-off" of the trace switch.

The salient features of the trace and commutating devices are shown in Tables I and II, respectively; the total current and voltage waveforms for the commutating and trace portions of the circuit are shown in Figs. 5 and 6, respectively.

The ITR — integral thyristor rectifier

In both the trace switch and the commutating switch of Fig. 4, an SCR-rectifier combination is required. Again, Fig. 1(a) shows the construction and interconnection of the discrete SCR and diode, while Fig. 1(b) shows the equivalent ITR. Fig. 1(a) shows that the rectifier permanently bypasses the reverse blocking junction of the SCR and makes this capability superfluous. Since the cathode side of the SCR already has a built-in shunt, the equivalent ITR is easily constructed by eliminating the reverse blocking junction of the SCR pellet.

For the ITR to perform as well as the SCR-diode combination customarily used in tv deflection circuits, it must have all the characteristics of these devices as shown in Tables I and II. The most difficult characteristic to be achieved in an ITR used in a deflection circuit is a type of commutating ability. Fig. 7 shows the deflection-circuit waveforms for an SCR and an ITR. The SCR does not have the same commutating requirement because the negative portion of the deflection

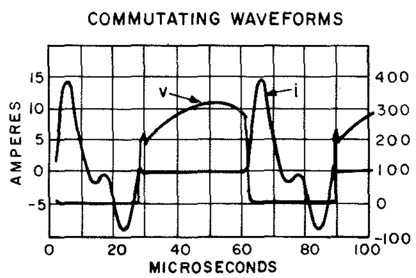


Fig. 5 — Waveforms of commutating-switch current (5A/div.) and commutating-switch voltage (100V/div.). Time scale is 10 microseconds/div.

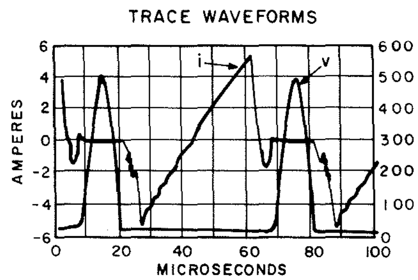


Fig. 6 — Waveforms of trace-switch current (2A/div.) and trace-switch voltage (100V/div.). Time scale is 10 microseconds/div.

Table I — Trace device requirements.

SCR

- High forward blocking: V_{DROM} = 750V
- Fast turn-off capability: 4 μs (actually more stringent than trace-device requirements because of the current and voltage conditions: 1/2 sinewave at 10A to 20A, reapplied voltage up to 500V with dv/dt = 700V/μs, 2V negative gate bias)
- Fast turn-on properties to minimize dissipation and di/dt problems
- Controlled forward gate-cathode characteristics needed to match oscillator drive and to provide adequate SCR turn-on during oscillator start-up when tv set is first turned on
- Good dv/dt capability under all receiver operating conditions including arcing

DIODE

- Similar to trace diode but with concern for turn-on transient de-emphasized

Table II — Commutating device requirements.

SCR

- High forward blocking: V_{DROM} = 800V
- Fast turn-off time: <2.5 μs, peak *on* current 4A to 8A, di/dt = 2A/μs
- Good turn-on properties at low anode-cathode voltage to avoid switch discontinuities which cause linearity and white-line problems as the yoke current passes from the trace diode to the trace SCR
- Low forward drop (V_T)
- Reverse gate-cathode impedance characteristics sufficient to support a negative 35 V
- Negative bias for good turn-off capability
- All above requirements must hold up to +70°C

DIODE (*reverse switch*)

- PIV = 800V
- Rapid turn-on without the transient voltage spike that causes black-bar and/or device reliability problems
- Low V_F
- Fast turn-off switching to minimize dissipation

sweep current is flowing through a separate rectifier. In addition, the excess carriers in the lightly doped n-region of the rectifier portion of the ITR must be removed, as they will act as a triggereing current and switch the SCR portion of the device to its conducting state. Fast turn-off times are required in both the SCR and the rectifier; therefore, both of these devices are gold diffused to reduce the minority carrier lifetime.

Using standard design calculations, a set of compromises must be achieved in the ITR between starting resistivity, wafer thickness, and the amount of gold diffusion. If these specifications are properly determined and the masks properly designed, high forward blocking voltage, low forward voltage drop, low dissipation, and fast turn-on and excellent turn-off times with good commutating ability can all be achieved.

The ITR presently being produced for tv horizontal deflection circuits is shown in Fig. 8; it uses the same amount of wafer area as the SCR it replaces. The processing of the ITR differs from that of the SCR in the following respects:

1) The T_2 side must not have a p-type blocking junction across the pellet.

2) The geometry of the T_1 shunt must be adjusted to carry the rectifier current.

3) Discrete p+ and n+ areas must be incorporated on the T_2 side.

The discrete p+ and n+ areas on the T_2 side of the device makes it similar to a triac. Anode and cathode terminology can no longer be used, because the T_1 side is the cathode of the SCR and the anode of the rectifier.

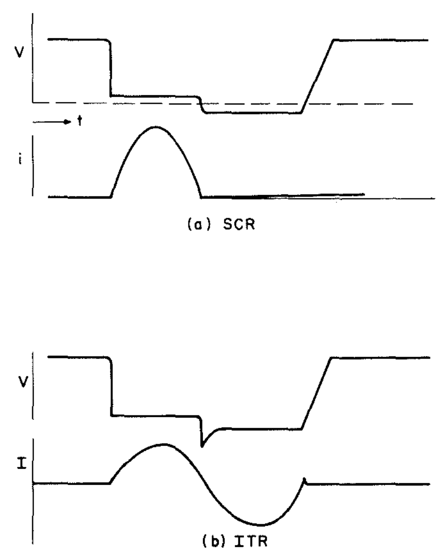


Fig. 7 — Deflection circuit waveforms (a) SCR, (b) ITR.

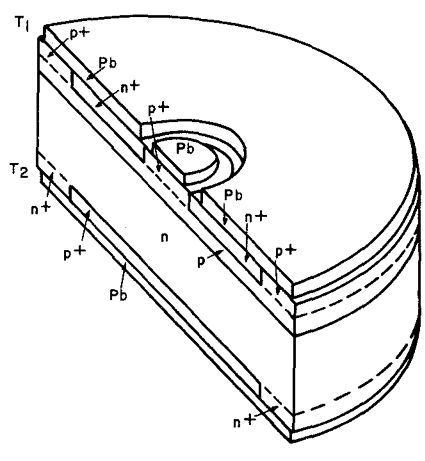


Fig. 8 — ITR presently used for tv horizontal deflection circuits.

Advantages of the ITR

The cost of an ITR is about the same as an SCR and less than that of the two discrete components, SCR and rectifier. Multiple yield losses do not apply because the silicon area of both devices, SCR and ITR, are the same, and bulk-defect losses are equal. The rectifier portion of the ITR has been positioned on the outer periphery of the pellet. Surface stabilization procedures for rectifiers are well known and the device is not subject to degradation by the formation of a p-type channel across the high-resistivity n-base region. Forward blocking-voltage capability has been found to be at least equal to that of the SCR.

The advantage of the ITR to the manufacturer of tv receivers is obvious. He now needs two components, sockets, and heat sinks instead of four, and realizes savings in insertion cost and chassis space.

The advantages provided by the ITR in tv deflection circuits is clear, but, again, it should be remembered that the device's usefulness is not limited to such circuits. It is safe to predict that other higher current ITR's will be designed and built for many future applications.

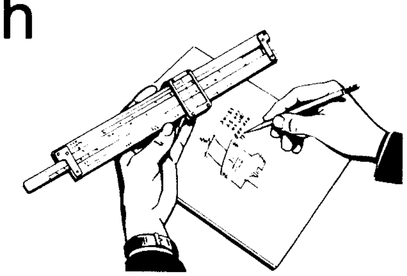
Acknowledgments

The authors are grateful to J. Neilson and A. Thomas for their assistance in the design and development of ITR's, to N. Barber for his aid in constructing the devices, and to H. Grisset for assistance in building test sets and measuring units. The tv deflection circuits were designed by W. Deitz.

Reference

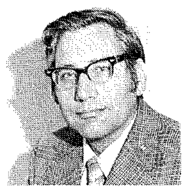
1. A detailed description of the operation of this circuit is included in RCA Application Note AN-3780, "A New Horizontal-Deflection System Using RCA 40640 and 40641 Silicon Controlled Rectifiers," available from RCA, Commercial Engineering, Harrison, N.J., 07029.

Engineering and Research Notes



Frequency divider

L.J. Striednig
Electronic Components
Harrison, NJ



There are many applications in which it is desired to obtain a pulse train at a pulse repetition frequency lower than but not integrally related to the frequency of a reference wave.

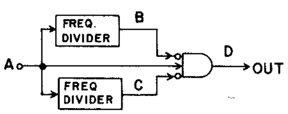


Fig. 1 — Basic frequency divider concept (divide by 5/3).

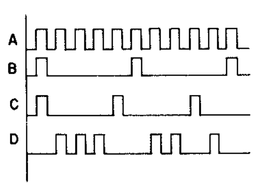


Fig. 2 — Operation of the circuit in Fig. 1.

In the circuit of Fig. 1, a reference pulse train (A) is applied to one input terminal of an AND gate and to two frequency dividers. The divided-down pulses (at B and C) are applied to inhibit terminals of the AND gate. The circuit operation is shown in Fig. 2. Each time a divided-down pulse occurs, the AND gate is inhibited and one pulse of the train drops out. In the example illustrated, the dividers divide by 4 and 5, respectively, and if the input frequency is say 20 Hz the output is 12 Hz. The result may be calculated by subtracting the number of B and C pulses produced per second from the number of A pulses produced per second and adding one each time the B and C pulses are concurrent.

Fig. 1 is an example only. It is to be understood that there may be more or fewer than the number of frequency dividers illustrated, depending upon the particular requirement. The gate, shown to be an AND gate, may instead be a NAND gate, and other alternatives also are possible.

In the circuit of Fig. 3, the input pulse train (A) is applied to one input terminal to an AND gate and to two frequency dividers. The pulse trains produced by the frequency dividers (B and C) are applied to a NAND gate. These pulses are applied to the second input terminal of the AND gate.

The circuit operation is shown in Fig. 4. Each time the pulses (C and B) are present concurrently, an inhibit pulse is produced at D and this inhibit pulse causes a pulse to drop out of the wave train at E. In the example illustrated, one of the dividers divides by 4 and the other by 3. Thus, an inhibit signal occurs at ¼ × ⅓ = 1/12 times the input signal frequency. In the case of an input at say 12 Hz, the output pulse train at E would be at 11 Hz.

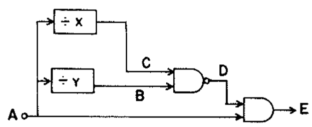


Fig. 3 — Frequency divider using AND and NAND gates (divide by 12/11).

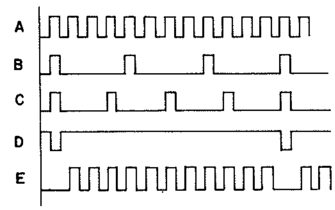


Fig. 4 — Operation of the circuit in Fig. 3.

As in the embodiment of the concept shown in Fig. 1, it is understood that the NAND gate may have more than two inputs, and moreover a number of stages such as shown in Fig. 3 may be cascaded in the manner shown generally in Fig. 5.

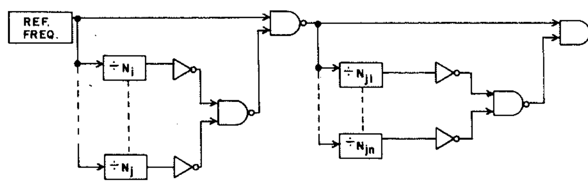
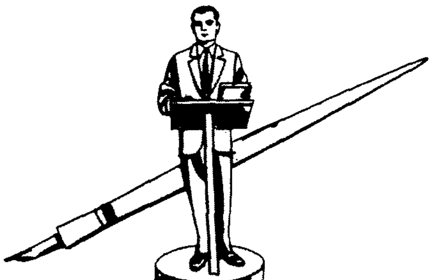


Fig. 5 — General embodiment of the frequency divider concept.

A typical application for this circuit is for the conversion of a 60-Hz line frequency to a frequency suitable for operating a digital clock. In this application, the 60-Hz wave may be full-wave rectified and then shaped to provide a 120-Hz pulse train. This pulse train is then employed to drive an AND gate and a divide-by-6 frequency divider. The latter is connected to inhibit the AND gate at a 20-Hz rate so that the AND gate produces 100 pulses a second. Such pulses serve as an adequate 0.01-second reference in spite of unequal pulse spacing, since the maximum error from this source is less than 1 digit or 0.01 second. Any subsequent division greater than 5 eliminates this pulse space unevenness so this error is deleted for the normal higher units of time, such as a tenths of a second, minutes, and so on.

Reprint RE-19-3-25| Final manuscript received May 31, 1973.



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EPITAXIAL DEPOSITION OF SILICON in a barrel reactor — F.W. Dittman (Labs,Pr) 3rd Intl. Symp. on Chemical Reaction Eng., Evanston IL; 8/27-29/73

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ELECTRONIC ACUPUNCTURE — V.K. Zworykin, R.E. Morey, F.J. Olessi (Labs,Pr) Intl. Conf. on Medical & Biological Eng., Dresden, East Germany: 8/13-17/73.

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MATCHED FILTER, Increase radar detection capability with acoustic wave — G.D. O'Clock (EASD,Van Nuys) *Electronic Design*; 7/5/73

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PHASER for millimeter wavelengths, Distributed PIN diode — Dr. B.J. Levin, G.G. Weidner (ATL,Cam) 73 IEEE G-MTT Int'l Microwave Symp., Univ. of Colo. 6/4-5/73

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SIMPLE INTERFEROMETER in turbulent air, angle-of-arrival difference Spectrum of a — D.A. deWolf (Labs,Pr) *J. Opt. Soc. Am.*, Vol. 63, No. 6 pp. 657-660; 6/73

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MICROWAVE systems, Performance evaluation of hybrid — K. Feher (Ltd., Canada) Int'l Conf. on Communications, Seattle, Washington; 6/73

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CARTRIDGE SYSTEM for 16mm television film — A.H. Lind, A.E. Jackson (BSD,Cam) NAB Conf., Washington, DC; 3/27/73

COLOR TELECINE CAMERAS, New developments in — J.J. Clarke, L.J. Bazin (BSD,Cam) 1973 Int'l TV Symp. & Tech. Exhibition, Montreux, Switzerland; 5/18-24/73

VIDEO HEADWHEEL PANELS, Techniques in manufacturing and reconditioning — D.C. Pastore (BSD,Cam) 1973 Int'l TV Symp. & Tech. Exhibition, Montreux, Switzerland; 5/18-24/73

VIDEO TAPE RECORDING, Toward improved broadcast — A.C. Luther (BSD,Cam) 1973 Int'l TV Symp. & Tech. Exhibition, Montreux, Switzerland; 5/18-24/73

VIDEO RECORDING STANDARD, a New compatible — A.C. Luther (BSD,Cam) *Wireless World London; Broadcast Management Engineering*

QUADRUPLEX VIDEO RECORDING STANDARD, Feasibility study for a new compatible — K. Sadashige (CSD,Cam) Conf. of Fernseh *Technische Gesselschaft*. Berlin, Germany; 10/10/73

LUMINANCE TRANSIENT RESPONSE, Television transmitter — T.M. Gluyas (CSD,Cam) 23rd Annual Broadcast Symp. IEEE GBC; 9/21/73; *IEEE Trans. on Broadcasting - IEEE Trans. on Broadcast & TV Receivers*

360 Computer Equipment

processors, memories, and peripherals.

COMPUTER PERFORMANCE evaluation, a Date base for — R.O. Winder (Labs,Pr) *Computer*, Vol. 6, No. 3, pp. 25-29; 3/73

365 Computer Programming and Applications

languages, software systems, and general applications (excluding: specific programs for scientific use).

MICROPROGRAMMING, Structured — L. Vandergriff (ATL,Cam) ACM 6th Annual Workshop on Microprogramming, Univ. of Maryland; 9/24-25/73

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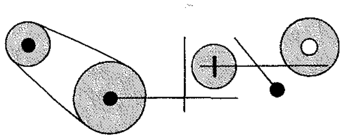

As reported by RCA Domestic Patents, Princeton

Government and Commercial Systems

Aerospace Systems Division

Signal Transition Detection Circuit — M.G. Coles, Jr. (CP Sys. Dev., Marlboro) U.S. Pat. 3751636, August 7, 1973.

Missile & Surface Radar Division

Discriminating Signalling System — J.N. Breckman (G&CS Plans, Mrstn.) U.S. Pat. 3755811, August 28, 1973.

Dielectrically Loaded Waveguide Assembly — R.J. Mason, N.R. Landry (MSRD, Mrstn.) U.S. Pat. 3760305, September 18, 1973.

A Radar Apparatus with Directional Discrimination and Increased Radar Sensitivity — H. Urkowitz, S.M. Sherman (U.S. Pat. 3742501, June 26, 1973 (assigned to U.S. Government).

A Versatile in-Line Waveguide-to-Coax Transition — N.R. Landry, J.P. Grabowski (MSRD, Mrstn.) U.S. Pat. 3758886, September 11, 1973 (assigned to U.S. Government).

Communications Systems Division

Television Special Effects Control Pulse-Generating Apparatus — L. J. Thorpe, J. A. Killough (CSD, Camden) U.S. Pat. 3757041, September 4, 1973

Government Engineering

Home Television Receiver Modified to Operate as Video Terminal — W.A. Helbig, Sr., W.L. Ross (ATL, Camden) U.S. Pat. 3750133, July 31, 1973.

Label Writing Apparatus — L. H. Fulton (ATL, Camden) U.S. Pat. 37557349, September 4, 1973.

Electronic Components

Magnetic Core Memory Plane Construction — T. P. Fulton (EC, Needham Hts.) U. S. Pat. 3750118, July 31, 1973

Method for Photoexposing a Coated Sheet Prior to Etching — J. J. Moscony, R. L. Kennard (EC, Lanc.) U. S. Pat. 3751250, August 7, 1973

Electron Emissive Device Incorporating a Secondary Electron Emitting Material of Antimony Activated with Potassium and Cesium — A. H. Sommer (EC, Pr.) U. S. Pat. 3753023, August 14, 1973

Method of Defining a Detailed Pattern on a Surface of a Body — F. Sterzer (EC, Pr.) U. S. Pat. 3761264, September 25, 1973

Image Intensifier Camera Tube Having an Improved Electron Bombardment Induced Conductivity Camera Tube Target Comprising a Chromium Buffer Layer — W. N. Henry, W. M. Kramer (EC, Lanc) U. S. Pat. 3761762, September 25, 1973

Consumer and Solid State Electronics

Solid State Division

Apparatus for and Method of Correcting a Defective Photomask —M. Tarabocchia (SSD, Som.) U. S. Pat. 37489752, July 31, 1973

Apparatus for Processing Semiconductor Devices — E. H. Voigt, W. B. Hall (SSD, Som.) U. S. Pat. 3749383, July 31, 1973

High Frequency Insulated Gate Field Effect Transistor for Wide Frequency Band Operation — R. H. Dawson (SSD, Som.) U. S. Pat. 3749985, July 31, 1973

Semiconductor Device Employing Darlington Circuit — W. G. Einthoven, C. F. Wheatley, Jr. (SSD, Som.) U. S. Pat. 3751726, August 7, 1973

Method for Making an Intermetallic Contact to a Semiconductor Device — H. S. Veloric (SSD, Som.) U. S. Pat. 3753774, August 21, 1973

Coupling Circuit — J.Y. Lee (SSD, Som.) U.S. Pat 3755693, August 28, 1973

Monostable/Astable Multivibrator — R. C. Heuner, J.P. Paradise (SSD, Som.) U.S. Pat. 3755694, August 28, 1973

Low Voltage Reference Circuit — A.A.A. Ahmed (SSD, Som.) U.S. Pat. 3757137, September 4, 1973

Integral Cycle Thyristor Power Controller — P. J. Howard (SSD, Som.) U. S. Pat. 3761800, September 25, 1973

Consumer Electronics

High Voltage Hold Down Circuit for Horizontal Deflection Circuit — P.R. Ahrens, J.B. Bean, Jr. (CE, Indpls.) U.S. Pat. 3749966, July 31, 1973

Wide Band Recording and Reproducing System — H. R. Warren (CE, Indpls.) U. S. Pat. RE27734, August 14, 1973

Torodal Deflection Yoke Having Conductors Wound in Flyback Manner — D. P. Over, I. F. Thompson (CE, Indpls.) U. S. Pat. 3757262, September 4,1973

Pincushion Corrected Vertical Deflection Circuit — L. E. Smith (CE, Indpls.) U. S. Pat. 3760222, September 18, 1973

Apparatus and Process for Thermomagnetically Replicating Magnetic Recordings Using a Scanning Beam of Radiant Energy — A. L. Stancel, Jr., W. R. Isom (CE, Indpls.) U. S. Pat. 3761645, September 25, 1973

Patents

Carry Generation Means for Multiple Character Adder — C. M. Wright (Pats. & Lic., Cherry Hill) U. S. Pat. 3757098, September 4, 1973

Services

Loop Antenna with Distributed Impedance Near the Terminating Gap — P. J. Smalser (P&A, Deptford) U.S. Pat. 3761933, September 25, 1973

Special Contract Inv.

Shadowing System for Color Encoding Camera — H. F. Frohbach, A. Macovski, P. J. Rice (Special Contract Inv.) U. S. Pat. 3757033, September 4, 1973

Dates and Deadlines

As an industry leader, RCA must be well represented in major professional conferences . . . to display its skills and abilities to both commercial and government interests.

How can you and your manager, leader, or chief-engineer do this for RCA?

Plan ahead! Watch these columns every issue for advance notices of upcoming meetings and "calls for papers". Formulate plans at staff meetings—and select pertinent topics to represent you and your group professionally. Every engineer and scientist is urged to scan these columns; call attention of important meetings to your Technical Publications Administrator (TPA) or your manager. Always work closely with your TPA who can help with scheduling and supplement contacts between engineers and professional societies. Inform your TPA whenever you present or publish a paper. These professional accomplishments will be cited in the "Pen and Podium" section of the *RCA Engineer*, as reported by your TPA.

Dates of upcoming meetings —plan ahead

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

NOV. 26-29, 1973 — **National Telecommunications Conf** IEEE S-AES, S-Comm, G-GE Hyatt Regency Hotel, Atlanta, GA, **Prog info**: R.M. Langelier, 6448 Johns Rd., Falls Church, VA 22043.

DEC. 2-5, 1973 — **Int'l, Electron Devices Meeting** IEEE G-ED Washington Hilton Hotel, Washington, D.C. **Prog info:** Fred Lindholm, EE Dept., Univ. of Florida, Gainesville, FL 32601.

DEC. 4-5, 1973 — **Vehicular Technology Conference** IEEE G-VT, Cleveland Section Sheraton Cleveland Hotel, Cleveland, OH **Prog info:** J.S. Sawvel, Jr., Ohio Edison, Co., 47 N. Main St., Akron, OH 44301.

DEC. 5-7, 1973 — **Decision & Control, Symposium on Adaptive Processes** IEEE S-CS, S-SMC, G-IT Sheraton Harbor Island Hotel, San Diego, CA. **Prog info:** D.G. Luenberger, Stanford Univ., Stanford, CA 94305.

DEC. 9-11, 1973 — **Computer Architecture** IEEE S-C, CIR, ACM, Univ. of Florida et al **Prog info:** Steve Szygenda, Dept. of Computer Sci., Univ. of Texas, Austin, TX 78712.

DEC. 10-12, 1973 — **Jt. Conference on Sensing of Environmental Pollutants** EQC, ISA, AIAA Sheraton Park Hotel, Washington, D.C. **Prog info:** Maurice Ringenbach, Engrg. Dev. Lab., NOAA, 6001 Executive Blvd., Rockville, MD 20852.

JAN. 14-16, 1974 — **Winter Simulation Conference** IEEE S-SMC et al, Washington Hilton Hotel, Washington, DC. **Prog info:** Harold Steinberg, IBM Corp., 909 Third Ave., New York, NY 10022.

JAN. 21-24, 1974 — **Topical Meeting on Integrated Optics-Guided Waves, Materials & Devices** IEEE G-EC, OSA, Int'l Comm. for Optics, Fairmont Roosevelt, New Orleans, LA. **Prog info:** P.K. Tien, Bell Labs, Holmdel, NJ 07733.

JAN. 27 - FEB. 1, 1974 — **IEEE Power Engineering Society Winter Meeting** IEEE S-PE Statler Hilton Hote, New York, NY. **Prog info:** J.G. Derse, 1030 Country Club Rd., Somerville, NJ 08876.

Calls for papers —be sure deadlines are met.

Ed note: Calls are listed chronologically by meeting date. Listed after the meeting title (in bold type) are the sponsor(s), the location, and the deadline information for submittals.

APRIL 2-4, 1974 — **1974 IEEE International Reliability Physics Symposium** IEEE Groups on Electron Devices and Reliability, MGM Grand Hotel, Las Vegas, Nevada. **Deadline info:** (abst) 50 word descriptive; (sum) 300-500 word 10/13/73 **to** I.A. Lesk, Technical Program Chairman, 1974 Reliability Physics Symposium, Motorola Inc., 5005 E. McDowell Rd., MS. A112, Phoenix, AZ 85008.

APRIL 9-11, 1974 — **1974 International Optical Computing Conference** IEEE Computer Society, Zurich, Switzerland. **Deadline info**: (sum) 200 word 10/15/73 to Dr. David Casasent, Technical Program Chairman, Carnegie-Mellon University, Department of Electrical Engineering, Pittsburgh, PA 15213.

APRIL 16-18, 1974 — **Optical and Acoustical Micro-Electronics** G-MTT, G-SU, PIB et al, New York, NY **Deadline info:** (abst) 12/1/73 **to** PIB, M.R.I. Symp. Comm., 333 Jay St., Brooklyn, NY 11201.

APRIL 28-MAY 1, 1974 — **Cost Effectiveness in the Environmental Sciences** IES, Shoreham-Americana, Washington, DC **Deadline info**: (abst) 11/1/73 (ms) 2/15/74 **to** Technical Program Committee, Institute of Environmental Sciences, 940 East Northwest Highway, Mt. Prospect, IL 60056.

APRIL 28-MAY 2, 1974 — **76th Annual Meeting & Exposition** ACS, Conrad Hilton Hotel **Deadline info:** (abst) 12/15/73 **to** Program Chairman: Dr. David L. Wilcox, IBM Corporation, Dept. K16, Bldg. 282, San Jose, CA 95193.

JUNE 10-13, 1974 — **G-AP Symp. and USNC/URSI Meeting** G-AP, URSI Georgia Inst. of Tech., Atlanta, GA **Deadline info:** (ms) 2/4/74 **to** R.C.Johnson, Georgia Inst. of Tech., Engrg. Exp. Sta., Atlanta, GA 30332.

JUNE 16-19, 1974 — **Int'l. Conference on Communications** S-Comm., Twin Cities Section, Leamington Hotel, Minneapolis, MN. **Deadline info**: (ms & sum) 12/17/73 **to** M.S. Ulstad, POB 35366, Minneapolis, MN 55435.

JULY 1-5, 1974 — **Precision Electromagnetic Measurements Conference** Royal Soc., IEE, IERE, G-IM et al, IEE, London, England. **Deadline info:** (abst) 10/31/73 **to** 1974 CPEM Secretariat, c/o Conf. Dept., IEE, Savoy Pl., London, WC2R OBL England.

JULY 14-19, 1974 — **IEEE Power Engineering Society Summer Meeting** S-PE, Disneyland Hotel, Anaheim Conv. Ctr., Anaheim, CA **Deadline info:** (ms) 2/1/74 **to** S.H. Gold, Southern Calif. Edison Co., POB 800, Rosemead, CA 91770.

AUG. 26-30, 1974 — **Electronics Conference New Zealand (INTERRLCON NZ)** New Zealand Sec., New Zealand Nat'l Soc. et al Univ. of Auckland, Auckland, New Zealand. **Deadline info:** (abst) 12/15/73 **to** D.R. Hutt, IEEE N.Z. Section, POB 6291, Auckland, New Zealand.

AUG. 26-30, 1974 — **9th Intersociety Energy Conversion Engineering Conference** AIAA, ACS, AIChe, ANS, IEEE, SAE, San Francisco, CA. **Deadline info:** (abst) 1/10/74 **to** Dr. Hsuan Yeh, Towne School of Civil & Mechanical Engineering, University of Pennsylvania, Philadelphia, PA 19104.

SEPT. 8-12, 1974 — **Jt. Power Generation Tech. Conference** S-PE, ASME, ASCE, Deauville Hotel, Miami Beach, FL. **Deadline info:** (ms) 4/26/74 **to** J.J. Heagerty, Gen'l Elec. Co., POB 2830, Terminal Annex, L.A. Ca.

Engineering News and Highlights

A. Luther receives SMPTE award

Arch C. Luther, Jr., Chief Engineer, RCA Broadcast Systems, has been awarded the David Sarnoff Gold Medal for 1973 by the Society of Motion Picture and Television Engineers.

The David Sarnoff Gold Medal was presented to Mr. Luther for his major contributions to the field of magnetic video recording including development of the broadcasting industry's first quadruplex video tape cartridge recording system, and for contributions to the national and international standardization of quadruplex recording.

Arch Luther graduated in electrical engineering from M.I.T. In the fifties he was engaged in circuit design of color television cameras and monitors for RCA Communications Systems Division. Towards 1960 he began the activity for transistorization of broadcast products and contributed heavily to the extension of this technology throughout broadcast equipment.

During the sixties, Mr. Luther's principal accomplishments included: development of the TR-22 recorder, the industry's first all solid state video recorder; a complete line of products based ont he TR-22 design; the TR-70 highband video recorder; the development of longlife video headwheels; and the development and introduction of the TCR-100 automatic video cartridge recorder system.

In his present position Mr. Luther is responsible for technical planning and direction of all engineering and advanced development programs for broadcast systems including video recording equipment, television and radio studeio equipment, and television and radio transmitting equipment. He is the holder of twenty-nine U.S. patents relating to the circuitry and equipment he had designed and is the author of numerous papers published in technical journals and presented before the SMPTE and a member of IEEE and Eta Kappa Nu.

Hirsch receives SMPTE award

Charles J. Hirsch, has been awarded the Herbert T. Kalmus Gold Medal Award for 1973 by the Society of Motion Picture and Television Engineers. The Award was presented to Mr. Hirsch in recognition of his leadership in the development of the Hazeltine Color Analyzer.

Mr. Hirsch retired from RCA in 1967. He received his early education in France and a degree in electrical engineering from Columbia University. After working as Chief Engineer for radio manufacturers in the USA, France, and Italy he joined Hazeltine Corp. in 1942, rising from Design Supervisor to Executive Vice-President for Research and Director of the Hazeltine Research Corp. His principal work was with the development of color television and specifically with the development of the Hazeltine Color Film Analyzer, which won an Academy Award and was the basis for this SMPTE award.

In 1959, he joined RCA Research and Engineering staff in Princeton, where he concerned himself with problems of color tv, stereophonic sound, phonograph recording, and radio aids to aviation. He acted as liaison between the Laboratories and the relevant RCA division.

Since retirement he has done consulting work on ground beacons for air navigation and patents for FM stereo and color tv.

Licensed engineers

When you receive a professional license, send your name, PE number (and state in which registered), RCA division, location, and telephone number to: *RCA Engineer*, Bldg. 204-2, RCA, Cherry Hill, N.J. As new inputs are received they will be published.

Communications Systems Division

A. Mack, CSD, Camden, N.J., PE-A21740, New Jersey

J.W.Seymour, CSD, Tucson, AZ, PE 012479E, Pennsylvania; PE 14609, New Jersey; PE 8340, Arizona

R.W. Rostrom, GCS, Camden, N.J., PE 19578, New Jersey

D.A. Tannenbaum, GCS, Camden, N.J., PE 20154, New Jersey

Solid State Division

H.R.Meisel, SSD, Somerville, N.J., PE 20307, New Jersey

Astro-Electronics Division

J. Herrmann, AED, Hightstown, N.J., PE A21789, New Jersey

Global Communications

S.L. Latargia, Global Communications, 60 Broad St., New York, PE 048947, New York

Electronic Components

H.K. Jenny, EC, Lancaster, PA, PE 19775, New Jersey

G. Palty, EC, Harison, N.J., PE 20053, New Jersey

Missile & Surface Radar Division

B.F. Bogner, MSRD, Moorestown, N.J., PE 19875, New Jersey

Degrees granted

R.D Bachinsky, MSRD, Mrstn.	Ph.D., Engineering, Drexel U., 6/73
T.W. Branton, EC, Marion	BSEE, Purdue U., 6/73
J. Cammerata, EC Lancaster	MS, Physics, Franklin & Marshall College 6/73
V. Coughlin, EC Lancaster	MS, Physics, Franklin & Marshall College 6/73
J. Davin, EC, Marion	MA, Industrial Operations, Purdue U., 5/73
J. Helm, CE, Indpls.	MS, Engineering, Purdue, U., 5/73
H. Kauffman, EC, Lancaster	MS, Physics, Franklin & Marshall College 6/73
F. Kharouba, Globcom, New York	MSEE, New York U. 6/73
R.F. Kolc, MSRD, Mrstn.	MBA, Engineering Supervision, Drexel U., 6/73
R.E. Moore, MSRD, Mrstn.	BSEE, Drexel U., 6/73
W. Parker, EC, Lancaster	MS, Physics, Franklin & Marshall College 6/73
C.E. Profera, MSRD, Mrstn.	Ph.D., Engineering Drexel U., 6/73
R.J. Smith, MSRD, Mrstn.	MEE, U. of Pa., 5/73
S. Vercrumba, EC, Lancaster	MS, Physics, Franklin & Marshall College 6/73

Staff announcements

President and Chief Operating Officer

Anthony L. Conrad, President and Chief Operating Officer, has announced the election of the following officers of RCA Limited (Canada): **Daniel O'C. Doheny, Q.C.**, Chairman of the Board and **G. Denton Clark**, President.

Laboratories

Fred Sterzer, Director, Microwave Technology Center has appointed **Markus Nowogrodzki** as Manager, Division Liaison for the Microwave Technology Center.

Marketing

R. W. Sonnenfeldt, Acting General Manager, Electronic Industrial Engineering Division has announced the appointment of **Henry Duszak**, Director, Marketing for the Electronic Industrial Engineering Division.

Electronic Components

John B. Farese, Executive Vice President, Electronic Components has announced the appointment of **David O. Price** as Manager of Materials.

Entertainment Tube Division

Stanley S. Stefanski, Director, Manufacturing, Television Picture Tubes has announced the appointment of **Richard H. Hynicka** as Plant Manager, Lancaster Color Picture Tube Plant.

William G. Hartzell, Division Vice President, Engineering, announced the appointment of **Leonard F. Hopen** as Manager, Product Support Engineering; and **Robert J. Konrad** as Administrator, International Coordination (Canada & Europe).

RCA Service Company

Joseph F. Murray, Division Vice President, Government Services has announced the organization of Government Services as follows: **John J. Connors**, Division Vice President, Marketing; **Donald M. Cook**, Director, Education Services; **James A. Gavin**, Manager, Budgets and Price Administration; **William F. Given**, Division Vice President, Operations; **William J. Hazeley**, Manager, Contracting; and **Lloyd R. Yoh**, Administrator, Special Projects.

RCA Records

Rocco M. Laginestra, President, RCA Records has announced the appointment of **Robert D. Summer** as Division Vice President, RCA Records, International.

Consumer and Solid State Electronics

Bernard V. Vonderschmitt, Vice President and General Manager, Solid State Division has announced the appointment of **Edward K. Garrett** as Division Vice President, Finance.

B. V. Vonderschmitt, Vice President and General Manager, has announced the following appointments: **E. M. Troy**, Director, Solid State Planning and Services; **H. A. Uhl**, Manager, Integrated Circuits Administration and Services; **R. A. Donnelly**, Plant Manager of the production facility in Findlay, Ohio; and **R. C. Reutter**, Manager of the Solid State Division's manufacturing operations in Taiwan.

Promotions

Global Communications, Inc.

P. B. Silverman from Group Leader, Wideband Leased Channel Projects to Manager, Customer Projects (S. Schadoff, 60 Broad St., New York)

J. M. Reeves from Sr. Engineering Associate to Coordinator, Project Control (O. T. Rhyne, Anchorage)

F. J. Woelfle from Ldr., Satellite Engrg. to Mgr., Earth Station Implementation (J. M. Walsh, 60 Broad St., New York)

RCA Service Company

N. J. Bockover from Assoc. Engr. to Mgr., FORACS (R.S. Maloney, Puerto Rico)

D. R. Exley from Sr. Data Acquisition Technician to Data Instrumentation Engineer (R. E.Suggs, Greenbelt, Md.)

W. J. Schnell from Systems Svc. Engr. to Ldr., Systems Svc. Engr. (T. J. Barry), Springfield, Va.)

Aerospace Systems Division

E. M. O'Brien from Sr. Member, Technical Staff to Mgr., Design Engineering (R. J. Monis, Burlington)

A. F. Dirsa from Sr. Member, Technical Staff to Mgr., Design Engineering (D. J. Cushing, Burlington)

J. J. Harrison from Sr. Project Member, Technical Staff to Mgr., Design Engineering (G. B. Harmon, Burlington)

J. Hallal from Sr. Project Member, Technical Staff to Mgr., Project Engineering, (R. P. Daly, Burlington)

Astro-Electronics Division

B. Fuldner from Engineer to Mgr., Special TYO Engineering (J. Newman, Hightstown)

Missile and Surface Radar Division

J. Arensberg from Assoc. Member, Engrg. Staff to Member Engrg. Staff (M. Korsen, Mrstn.)

E. Britt from Member Engrg. Staff to Sr. Mbr. Engrg. Staff (J. T. Nessmith, Mrstn.)

J. Kelble from Sr. Mbr. Engrg. Staff to Ldr., Engrg. Sys. Projects (L. Nelson, Mrstn.)

F. I. Palmer from Sr. Mbr., Engrg. Staff to Ldr., Engrg. Sys. Projects (L. Evans, Mrstn.)

N. Salzberg from Sr. Mbr. Engrg. Staff to Principal Mbr. Engrg. Staff (J. T. Nessmith, Mrstn.)

Communications Systems Division

P. Mrozek from Leader Eng. Staff to Mgr., Circuit Design (L. Crowley, Meadow Lands)

P. Buess from Leader Eng. Staff to Mgr., Mobile Product Engineering (L. Crowley, Meadow Lands)

L. Wigington from Sr. Engineer to Leader Engineering Staff (C. Hughes, Meadow Lands)

A. Missenda from Leader Engineering Staff to Mgr., Advanced Development Engineering (C. Newman, Meadow Lands)

E. Nester from Mbr. Engineer to Sr. Mbr. Engineering Staff (A. Missenda, Meadow Lands)

Electronic Components

J. J. Napoleon from Engr., Product Development, Microwave Techniques and Materials to Engineering Ldr., Product Development (T. E. Walsh, Harrison)

A. J. Campus from Engineer, Product Development, R/T Design and Applications to Resident Engineer (J. P. Wolff, Harrison)

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	DOMESTIC	FOREIGN
1-year	$6.00	$6.40
2-year	10.50	11.30
3-year	13.50	14.70

Ballard appointed TPA at Palm Beach

Bruce Ballard has been appointed Technical Publications Administrator for the Palm Beach Division, Palm Beach Gardens, Fla. In this capacity, Mr. Ballard is responsible for the review and approval of technical papers; for coordinating the technical reporting program; and for promoting the preparation of papers for the *RCA Engineer* and other journals, both internal and external.

Mr. Ballard joined RCA at Palm Beach Gardens in 1964 after attending the University of Maine. His initial assignments were in the electrical design of computer systems. He progressed through the ranks in the Drafting and Design area, to the position of Leader. He later became Manager of Reprographics with responsibility for the Reproduction and Printing Organization. In his present assignment as Administrator of Engineering Services for the PBD Engineering group he has responsibility for the technical library, Patent coordination, budget coordination, including working with the MIS Center establishing computer techniques to improve budget controls, coordination of Systems and Procedures affecting Engineering, and allied administrative tasks.

RCA scholarships to aid women EE students

RCA will sponsor three scholarships in electrical engineering for women students, to be administered by the Society of Women Engineers, starting in academic year 1973-74.

The annual stipend for each RCA scholar is $800, and RCA will provide an unrestricted grant of $500 to each non-tax-supported school attended by an RCA scholar.

In addition to the stipends to the scholars, and the grants to private schools, RCA will contribute $300 ($100 for each scholarship) to the Society of Women Engineers, to aid the Society in administrating the scholarships.

Astro-Electronics Division to supply domestic satellite

RCA Global Communications, Inc. and RCA Alaska Communicaitons, Inc. have announced that the Astro-Electronics Division, Princeton, N.J., has been selected to supply the spacecraft for the U.S. domestic communications satellite system the two companies plan to establish in 1975.

The award was based on competitive procurement and analyses of all relevant factors, including extensive technical and least cost evaluations, according to **Howard R. Hawkins,** Chairman of RCA Globcom and RCA Alascom.

In addition to the Astro-Electronics Division, competitive proposals were submitted by a Lockheed Missiles and Space Company/Communications Satellite Corporation team and a Fairchild Industries, Inc./TRW, Inc. team.

The $22.8 million fixed-price contract is for three flight spacecraft. In addition, it calls for an additional $2.7 million in ground telemetry, tracking and control equipment. It also provides for incentive payments of $3.3 million per spacecraft for successful injection into synchronous orbit, and other incentives for lifetime operation in orbit.

The contract also specifies penalties of up to $3 million per spacecraft for late delivery. It calls for first delivery in 24 months.

The spacecraft will be three-axis stabilized, meaning the body of the body of the spacecraft will remain fixed relative to a point on the earth rather than spinning in orbit as do present communications satellites. Each spacecraft will have 24 transponders, each of which can carry telephone conversations, color tv transmissions, high speed computer data, and other communications traffic.

"This design approach has been taken to achieve the maximum cost effectiveness for our domestic communications satellite system," Mr. Hawkins said. "It will benefit users of the system by offering them services at rates that can be substantially lower than those required when terrestrial means of communications are used."

The spacecraft will be launched into synchronous orbit by a special Thor-Delta rocket that is being uprated in payload capacity under an agreement between the RCA companies and McDonnell-Douglas Corporation.

Awards

Communications Systems Division

Gene Lachocki received a Technical Excellence Award in recognition of his consistently effective power supply design and development work.

Lew Hathaway dies at 67

Jarrett Lewis Hathaway, who retired from NBC in 1971, died on September 1 at the age of 67. Lew Hathaway's career at NBC spanned 42 years, starting with his graduation from the University of Colorado in 1929. Lew figured prominently in many of the technical innovations used in today's broadcast studios and field sites. His numerous inventions led to 37 patents and several awards, including the NAB Engineering Achievement Award (1969); the David Sarnoff Outstanding Achievement Award in Engineering (1970); and the IRE Scott Helt Award (1962). He also received two Emmy nominations. Just before his retirement, the *RCA Engineer* conducted an interview with Mr. Hathaway and published portions of the conversation in Vol. 17, No. 5, Feb. Mar. 1972 issue.

Professional activities

Solid State Division

Martin Oakes, Engineering Leader, Hybrid Group, is a member of the Program Committee for the 24th Electronic Components Conference.

Aerospace Systems Division

Barry Bendel is vice chairman, Merrimack Valley, IEEE Subsection. The group has planned seven meetings and an annual dinner. Barry is charged with selecting speakers, making arrangements and participating in the setting policy.

Amy Spear is Secretary, Boston Chapter, Society of Logistics Engineers and Treasurer, Reliability Chapter, Boston Section, IEEE. Amy has held several offices in the Society of Women Engineers, Boston Chapter including national convention chairman for 1972.

Don Simpson is Chairman, Reliability Chapter, IEEE Boston. Seven meetings have been planned for the 1973-74 season and a one-day reliability seminar next Spring. The Boston Chapter is the largest reliability group in the country.

Editorial Representatives

The Editorial Representative in your group is the one you should contact in scheduling technical papers and announcements of your professional activities.

Government and Commercial Systems	
Aerospace Systems Division	P.P. NESBEDA* Engineering, Burlington, Mass. J.J. O'DONNELL Industry Systems, Burlington, Mass.
Electromagnetic and Aviation Systems Division	C.S. METCHETTE* Engineering, Van Nuys, Calif. J. McDONOUGH Engineering, Van Nuys, Calif.
Astro-Electronics Division	I.M. SEIDEMAN* Engineering, Princeton, N.J. S. WEISBERGER Advanced Development and Research, Princeton, N.J.
Missile & Surface Radar Division	D.R. HIGGS* Engineering, Moorestown, N.J.
Government Engineering	M.G. PIETZ* Advanced Technology Laboratories, Camden, N.J. J.E. FRIEDMAN Advanced Technology Laboratories, Camden, N.J. J.L. KRAGER Central Engineering, Camden, N.J.
Government Plans and Systems Development	E.J. PODELL* Engineering Information and Communications, Camden, N.J.
Communications Systems Division	
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Government Communications Systems	A. LIGUORI* Engineering, Camden, N.J.
Palm Beach Division	B.BALLARD* Palm Beach Gardens, Fla.
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Services	
RCA Service Company	M.G. GANDER* Consumer Products Administration, Cherry Hill, N.J. W.W. COOK Consumer Products Service Dept., Cherry Hill, N.J. R.M. DOMBROSKY Techanical Support, Cherry Hill, N.J. R.I. COGHILL Missile Test Project, Cape Kennedy, Fla.
Parts and Accessories	C.C. REARICK* Product Development Engineering, Deptford, N.J.
RCA Global Communications, Inc.	W.S. LEIS* RCA Global Communications, Inc., New York, N.Y. G. ROBERTS RCA Alaska Communications, Inc., Anchorage, Alaska
National Broadcasting Company, Inc.	W.A. HOWARD* Staff Eng., New York, N.Y.
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RCA International Division	C.A. PASSAVANT* New York, N.Y.
RCA Ltd	W.A. CHISHOLM* Research & Eng., Montreal, Canada
Patents	M.S. WINTERS Patent Plans and Services, Princeton, N.J.

*Technical Publications Administrators (asterisked * above) are responsible for review and approval of papers and presentations