RCA ENGINEER

Vol. 4—No. 6
APRIL—MAY, 1959

OBJECTIVES

To disseminate to RCA engineers technical information of professional value.

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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 engineering 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.

OUR COVER

Our cover this issue features Sidney Sternberg, Chief Engineer of the Astro-Electronic Products Division, Princeton, N. J., who is shown with an orrery, which simulates all the relative motions between the Earth and a satellite. The orrery is self-powered and illuminated, and is used for demonstration and discussion purposes.

SPACE ELECTRONICS AND RCA

The man-made satellite, the lunar probe, and the space vehicle have become the inspiring symbols of a new technology destined to extend human knowledge and experience far beyond the confines of the earth.

Engineering and developing the special systems, devices, and techniques for space application demand the organization of our talents in an environment in which they may be directed exclusively toward the solution of unprecedented technical problems. It is for this reason that RCA established the Astro-Electronic Products Division in March, 1958, and assigned to it the responsibility for satellite and space vehicle programs.

Backed by all of the engineering resources of RCA, this new division draws upon more than seven years of RCA experience in space electronics and many more years of RCA experience in electronic technology as a whole. Its engineering staff and facilities, situated near Princeton, are occupied with a number of important space projects having firm delivery dates.

In its relationship to the rest of RCA, the Astro-Electronic Products Division relies upon the healthy interchange of ideas and skills which characterize all successful engineering. Thus, the Astro-Electronic Products Division is both a specialized organization with primary responsibility in space electronics and a new channel through which the research and engineering talents of *all* of RCA may contribute to the advancement of space technology.

This is a technology which moves ahead with amazing speed. The early earth satellites of today may soon be superseded by far more sophisticated satellite systems of communication, exploration, and defense. The first exploratory probes launched toward the moon will give way in the near future to more highly developed vehicles for defense purposes and for scientific studies and investigation of nearby space. Ultimately, these steps will lead to exploration and travel through space by human pioneers.

In this pattern of swift development, RCA intends to play a leading part. Its contributions will result from the cooperative work of the Astro-Electronic Products Division, RCA Laboratories, and all of Defense Electronic Products' divisions. For the corporation, these contributions can assure leadership in a new business of unlimited promise. For the nation, they can add to national security and prestige in an era of world tension. Beyond these aspects, they can secure for all of us a full measure of participation in the greatest adventure yet experienced by man.

E. W. Engstrom

Dr. E. W. Engstrom
Senior Executive Vice President
Radio Corporation of America

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WHY DON'T YOU WRITE AN ENGINEERING PAPER?

by **F. D. WHITMORE**
Technical Publications Administrator
Defense Electronic Products
Camden, N. J.

THOUGH EVERY ENGINEER can write; some will, and some won't. Fortunately for the engineering publications, enough do write to keep their pages full. But, unfortunately, these aren't always the best articles; they are only the best the editors can get. Publications need up-to-the-minute articles covering current engineering effort. Many have established pay scales for those they accept.

Practically all professional writers complain about the engineer's writing. Their trite expression is: "Engineers can't write." Maybe engineers don't write well. Maybe they don't or can't take enough time to express themselves clearly and logically. But, I claim, if you can talk, you can write. A few guiding rules and some practice will prove it.

Before committing yourself one way or the other, let's explore your question, "Why should I bother to write?" You are now doing work you understand. Your education trained you for it. It is work you enjoy because it taxes your engineering ability. You are happy in it.

Injection of a foreign activity like technical writing into your already busy schedule presents a burdensome extra load. It must seem like a mountainous chore. You're not sure just how to start it. You aren't familiar with the writing attack-methods. Just thinking about the task riles you. Soon you revolt. Well, I don't blame you. I would too.

ADVANTAGES OF WRITING

On the other hand, the engineer-author reaps numerous benefits from writing technical papers. Until you burst forth in technical prose, you are practically just an unknown man with a degree. You perform work assignments as delegated; but, outside of your immediate section, no one knows what you are doing or how well you are doing it. Measurement of your progress rests solely within your section.

As an author, however, you promptly gain prestige. Immediately, others within your chosen scientific field learn of you and what you have been doing. If your paper appeared in the RCA Engineer, you became known throughout RCA. But if a technical publication outside the Company accepts your article, your acquaintanceship may leap national boundaries and land in various foreign countries.

The second benefit from authorship is opportunity. Once your name appears under a printed technical article you are considered somewhat of a specialist. The article indicates authority; so you can expect correspondence to arrive full of queries and comments. Others have pursued similar problems to yours; they may want to compare notes, or they may be seeking advice. Having know-how that others seek puts you in the position of consultant.

Sometimes a timely paper brings requests to present it in person on a slanted or more detailed scale. Now to your status of specialist and consultant there is a tinge of expert. Your knowledge is in demand. This is the position where you begin to "write" your own check. From here on, expect to receive requests to write many articles.

Professional societies constantly seek papers for their conventions. Many of these take place in distant cities. If you like a bit of travel, having a paper accepted by them provides some nice excursions from the daily grind.

Presenting papers in person always affords opportunities to get personally acquainted with many people from many companies. Sometimes comparing notes directly with contemporary experimenters sparks a new line of interest. When presented properly to your Company, it may influence their product line and start you off on an unsuspected career.

Finally, authorship strengthens your presence with management. Through your articles, your name and the Company's are kept before the specialized public. This is good for the Company. And what is good for the Company generally proves good for the employee.

HOW TO WRITE

Let's not fool ourselves: Writing is work. It's hard work. It takes practice and rewrite to produce concise smooth-flowing articles devoid of abstract wordiness while containing active verbs and logical organization. However, we don't expect you to be as good a writer as you are an engineer. When you understand how to apply a few writing-guide regulations, organizing difficulties disappear leaving only the writing to do. This will produce the kind of papers we want.

When you write, you must think of your readers. Your writing must be pitched to the level of this reading audience. The easiest guide I can give you for doing that is to keep in mind some friend who you think is typical of those who will read the article.

With a mental picture of this person before you, start writing the article. Tell this imaginary person all about it. Only, as you silently tell him, write down what you supposedly say.

When you do this, you'll tell first things first. Looking over the completed article you will find it organized in logical sequence. You will find the purpose of your work at the beginning. Following will be the conclusions reached. From there on will be a description of how you proceeded together with proof of each step.

If you think that's difficult, take a practical example. You attended a Phillies ball game last night. We met on the street today and I asked you how the game went. I'll bet you would tell me something like this: "The

F. D. WHITMORE graduated from Oglethorpe University in 1935 with an AB degree in Liberal Arts. He joined RCA in 1936 as a transmitter tester, and transferred to International Sales in 1938 as a service engineer on the Russian television system contract. In 1941 he became head of the Instruction Book department of Special Apparatus.

In 1957, Mr. Whitmore became Manager of Administrative Services in DEP, where he served until his present appointment. Mr. Whitmore has been active in Amateur Radio since 1930. His call letters are W2AAA.

Phillies won 5-4 when Anderson homered in the twelfth inning." From there on you would probably give me a detailed description of the game.

That's fine. That's just what we want you to do when you write—put first things first. Keeping an acquaintance in mind and writing as you tell him performs this feat. If the inquiry as to how the ballgame went brought the reply, "Well, it was a fine warm night. The park was almost full. One of the umpires limped throughout the game . . .", I would have butted in every other breath demanding the pertinent facts first. Keep this in mind when you write. You can hold or lose your reader in the first paragraph. After all, he probably doesn't have to read it.

As you "tell" your friend about the article, keep writing until you finish. Now put it away for a few days and forget it. After this rest, get it out and start reading it. Smooth up the wording and punctuation as you go along. You'll be surprised to find how well organized it is.

Naturally you won't write as well or as easily as a professional writer. You weren't trained for it and you lack the constant practice. But neither is your main interest technical writing. Tell the story in your own words. Try to leave out abstract words; keep facts in your sentences. If you do this and get first things first, the editor will smooth up a point here and there and strengthen the punctuation.

HELP WITH YOUR WRITING

An organization exists in RCA to procure engineering papers and secure quick Company approval. The board comprises Technical Publications Administrators from each of the Company's divisions.

Within their respective departments or divisions, all these people will gladly help you with your writing problems. They will not write it for you; they will give you suggestions, pointers, examples, and references to good guides.

Some of these Administrators have an editorial board to assist them. The editorial representatives are located in the various engineering sections so they can render maximum assistance to engineers writing papers. They know the subjects that various periodicals and house organs are interested in, and also the dates of forthcoming scientific symposiums and the kind of papers they want. You can find the name of your editorial representative by checking the classified list on the inside back cover of the *RCA Engineer*.

HOW IT WORKS IN DEP

The Technical Publications Administrator in Defense Electronic Products has an Editorial Board. This Board comprises members from each of the engineering sections (see the inside back cover for an up-to-date listing of Board Members).

See your Board member first concerning your writing problems. He will tell you the "hot" subjects for which articles are wanted. He will also steer you straight concerning the writing arrangement, security clearance, preparation of supporting artwork, and photographing of equipment. From him you can get the eight part submittal form to go with the eight copies of the article required for submission.

APPROVAL OF PAPERS

Papers covering your activities cannot be published or given until the Company clears them. When you submit a paper to your DEP Editorial Board Member, he sees that it has complete Section management approval before forwarding it to the Technical Publications Administrator.

The Administrator sends the eight copies to various departments in the Company for clearance in their categories.

The approval cycle is two weeks. When timing your paper for conference or publishing deadlines, allow two weeks for Company approval. If your paper requires security clearance, the approval time may extend two additional weeks depending upon the branch of Service involved. When all returns are in, a copy of the submittal form stamped APPROVED or NOT APPROVED is returned to the submitting DEP Editorial Board member for delivery to the author. If approved, the author is free to send it to the publication or conference for which it was approved.

CONCLUSION

Well, how do you feel about that writing job now? Is it a chore, or is it an opportunity?

Look into nineteenth century engineering effort. Note how completely those engineers covered their activities in electricity. By following each other's detailed writings, they injected into their own experiments the successes of others. This produced quick scientific benefits to mankind.

You worked hard for your degree—now get the most out of it. Try writing! You will help yourself, your section, and your Company.

HE DOESN'T WRITE;

HE DOES

AEP AND SPACE TECHNOLOGY

SIDNEY STERNBERG
Chief Engineer
Astro-Electronic Products Division
Princeton, N. J.

SIDNEY STERNBERG, Chief Engineer of the ASTRO-Electronic Products Division, graduated from C.C.N.Y. in 1943 with a B.S. in Physics. He received a certificate in Communications from M.I.T. in 1944 and a M.E.E. from N.Y.U. in 1949. He served as a radar officer in the U. S. Navy during World War II. From 1946 to 1950 he was engaged in Naval computer research being closely associated with the early plan of the Whirlwind Digital Computer. In 1950 Mr. Sternberg joined RCA in the Special Systems Lab at Princeton and was employed in circuit research for d-c analog computers, project typhoon, general feedback systems, and multiplier developments. He has been involved in satellite systems work since 1955.

In January of 1957 Mr. Sternberg joined the Special Systems and Development of DEP as Manager of the Reconnaissance and Intelligence Systems Group. In March of 1958 the Astro-Electronic Products Division was formed and he was appointed Satellite Projects Manager, and subsequently in September Chief Engineer of this Division.

Mr. Sternberg received the RCA Laboratories Research Achievement Awards in 1953 and 1955. He is a member of Sigma Xi, a Senior Member of the IRE and a member of the American Rocket Society.

THE EVENTS OF THE last year and a half have been exciting for many and rewarding for the relatively small number of scientists and engineers who have contributed to the dawn of the Space Age. Today, the field of satellite technology has grown, and ambitious plans are being formulated for more advanced systems. The success of these plans will depend largely on the ingenuity, imagination, and high technical capability of the men who will lead perhaps the most exciting of explorations—the exploration of outer space.

The challenge is indeed great; however, the requirements and demands on the engineer are severe. He must have a broad knowledge of basic physical laws and, at the same time, must achieve great depths in understanding. The new environments in which the systems of his invention must operate and perform their required task defy the intuition of everyday living. In the development and design of equipment systems, the engineer must deal with the concepts of weightlessness, vacuums heretofore unobtainable on earth, tremendous extremes of temperature, and the control of thermal energy through the sole mechanism of radiation. He must understand an environment of meteorite bombardment, of charged particles, and of intense ultraviolet. Kepler's laws and celestial mechanisms must be as much a part of his technical knowledge as circuit theory, solid-state instrumentation, and mechanical design.

But more important than just understanding and being able to control this environment, he must be capable of using it. In the future, equipment systems will be conceived that will differ markedly from anything used on earth, taking special advantage of this new environment and being capable of existing and operating only in outer space.

The technical department of the Astro-Electronic Products Division has been formed by drawing together people from many different parts of RCA—most heavily from the RCA Laboratories and Defense Electronic Products. The experience of RCA in satellite and space research and development programs dates back seven years. The earliest work was carried on in the Defense Electronic Products and later by the Special Systems Laboratory of the RCA Laboratories. The establishment of AEP in early 1958 brought together the experience and skill of RCA and focused the future efforts of this team on space technology.

The capability of the AEP technical organization has been developed to the extent that it now has a working responsibility for developing complete space systems, excluding only the primary rocket power necessary to place the satellite in orbit or to start the space vehicle on its journey. The range of technical activity in AEP is extremely broad and includes space physics, orbital mechanics, space-vehicle stabilization, auxiliary power, electronic propulsion, structures, environmental testing, communication, television and IR instrumentation, information handling, computer application research, physical research, and materials development. In all of its activities, the work in AEP has been complemented in the past by the capabilities existing in many of the RCA Divisions. It will be necessary as this division grows to depend, to a large degree, on technical services and special skills from several of the operating divisions of RCA.

What space systems can we concern ourselves with in the not-too-distant future? These would be systems that could be implemented within the limits of the present state of the art of instrumentation and the limitations imposed by rocket capability. The latter would indicate that large packages for deep space probes would be on a somewhat longer time scale compared with rather significant and heavy earth satellites materializing much sooner. Some of the uses to which these earth satellites will be placed fall into the following general listing; here no categorizing into military or nonmilitary is being made:

- Earth-Space exploration
- Meteorology and Weather forecasting
- Cloud Cover information systems
- Early Warning systems
- Communication Relay systems
- Reconnaissance and Surveillance
- Mapping and Geodesy
- Navigation systems

Describing all of the above uses in detail would be beyond the scope of this article. However, the following discussion will treat earth-space exploration, meteorology, and communications relays in order to better illustrate the scope of technical problems that must be solved.

EARTH-SPACE EXPLORATION

There are many measurements which would be important in describing the nature of our earth-space (as differentiated from other planet and deep-space experiments). These are important from a scientific viewpoint as well as to supply data for engineering purposes in developing satellite systems for other uses. *Atmospheric density* is important and will determine altitude, configuration, and operational modes of satellite systems. Important data has already been collected. However, the complete distribution of air density over all points of the earth will require more measurements from satellites launched at greater inclination angles to the equator. *Temperatures* determine the operating characteristics of our satellite instruments and equipment. Here the thermal balance is dependent solely on radiative characteristics of materials, the sun as the primary source of thermal energy, and outer space and the earth as heat sinks. The temperature of outer space from a thermal-noise viewpoint at different radio frequencies is important information in designing communications systems. *Meteoric density* and surface-penetration characteristics are of significance. Preliminary results obtained from the Explorer and Vanguard experiments have shown meteorites to be less of a problem to earth satellites than previous extrapolations seemed to indicate. Cosmic rays, magnetic-field measurements, Lyman Alpha measurements (Hydrogen at 1215.7A), the distribution of hydrogen, and the nature of the ionosphere all form part of an earth-space exploration program that will be pursued with intensity during this year.

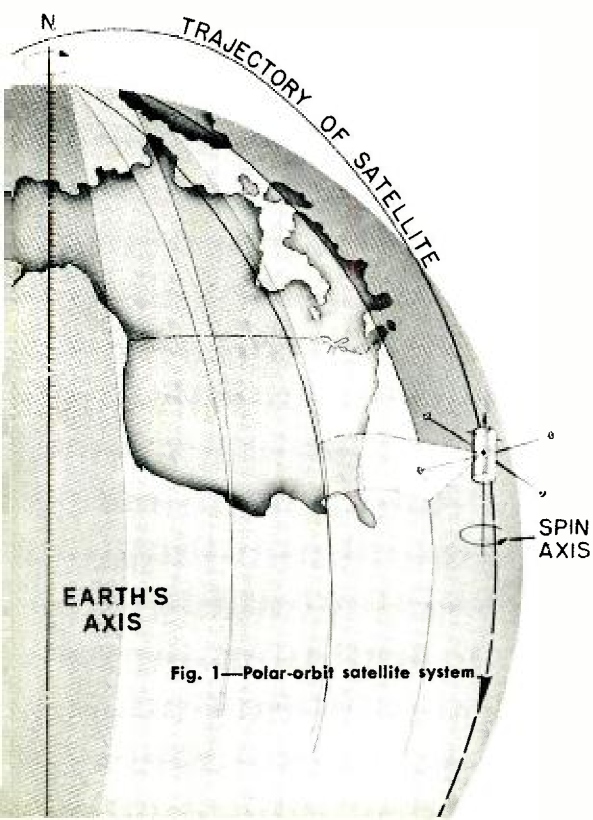


Fig. 1—Polar-orbit satellite system.

METEOROLOGY

The weather, in all of its myriad forms, is a reflection of the motion of the atmosphere. This motion and the kinetic energy therein is derived in the end from solar energy. The process may be viewed as a heat engine in which the sun provides the input power to a working fluid, in this case the atmosphere. Understanding the weather and its causes can best be served by observing and measuring the energy budget of the atmosphere and the physical and dynamical processes by which the retained energy is utilized as either kinetic energy or sensible heat. One of the most obvious indicators of atmospheric motion is cloud structure. The earth satellite is a uniquely suited vantage point from which, for the first time on a global basis, these indications can be observed with high spatial resolution at least once daily.

Observation stations on the earth's surface are inherently inadequate for thorough meteorological studies. Those located at present on land are nonuniformly distributed; the difficulties of locating adequate stations in ocean areas, which account for three-fourths of the earth's surface, are obvious.

The radiation budget of the earth is determined by the magnitude of three radiation currents: the direct radiation of the sun; the portion of this reflected back into space by the earth, clouds, and atmosphere; and the portion converted into heat and re-radiated back to space in the infrared part of the frequency spectrum from 3 to 40 microns. Measurements of radiation can be made by using thermistor elements and recording the equilibrium temperatures of these sensors. Furthermore, by surrounding these elements with filters, specific frequency bands can be sampled. Frequency sampling can provide useful information on the distribution of the variable constituents. As examples, water vapor has a strong absorption band at 6.3 microns, carbon dioxide at 2.7 and 4.2 microns, and ozone at 9.7 microns. The irregular distribution of these

WIDE BANDWIDTH TRANSMITTER AND RECEIVER CHARACTERISTICS	
I-F Bandwidth	10 mc
Frequency	2-10 kmc
Satellite	
Antenna Beamwidth	20 degrees
Antenna Size	1.75-0.4 ft. diameter
Radiated Power	50 watts
Power Input to Transmitter	500 watts
Transmitter Weight	75 pounds
Ground Station	
Receiver Noise Figure	5-10 db
Receiver Signal-to-Noise	46 db
Antenna Size	60 ft. diameter
Amplifier Design	Maser

TABLE 1

constituents leads to the perturbations in the normal heat balance of the earth which in turn conceivably yield the perturbations in atmospheric flow that are the weather-producing circulations.

Cloud data provides an important description of atmospheric kinematics as well as liquid-water content. The prime cause of almost all clouds is the adiabatic cooling by the pressure reduction of ascending air, thus condensing water vapor into small, liquid water drops. The character of the clouds is determined by the nature of the ascending motion.

The cloud information discussed earlier can be obtained by high-resolution television instrumentation carried on board a satellite. Global cloud data can be sensed by television-type cameras, with the video data stored and the information broadcast back to earth when the satellite is in view of a microwave receiving station.

Consider a system designed around a polar orbit, 300 miles in altitude, whose orbital plane contains the earth's poles, the satellite, and the sun (see Fig. 1).

An orbital period of 90 minutes would provide 16 revolutions of the satellite to one revolution of the earth. A television camera with an angular view intersecting 1/16 of the earth's circumference at the equator would be capable of scanning all of the earth's clouds once a day with considerably greater frequency coverage at the higher latitudes. A small, retrograde, angular shift of the orbital plane, 7° from the pole, would cause

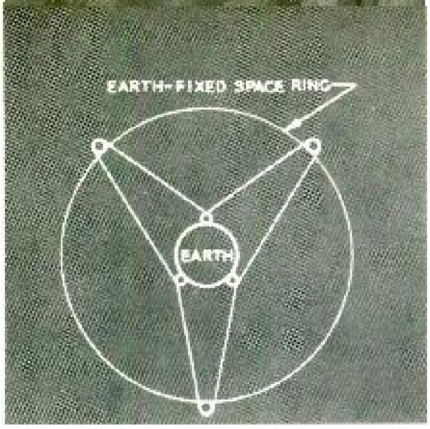


Fig. 2—System of three satellite and ground relay points.

the orbit to precess 1° per day because of the oblateness of the earth, thus keeping the sun in the plane of the satellite orbit as the earth moves about the sun. Video storage would have to be provided, since playback of the information would be dependent on the availability, within line of sight, of earth-bound receiving stations. The frequency of coverage of the system could be increased by a factor of two if nighttime viewing of cloud information were possible. This could be accomplished by highly sensitive pickup devices of reflected white light such as the sensitive orthicon TV camera tube or IR vidicons for sensing radiation at longer wavelengths.

SATELLITE COMMUNICATION RELAY SYSTEM

An earth satellite can act as a radio-relay point. Basically, it may be considered a microwave radio-relay tower placed so high in the sky as to minimize the number that may be required to transmit information beyond line of sight and completely around the globe. In addition, the satellite relay tower moves at some angular rate, with respect to the earth, as a function of altitude. This feature adds to the flexibility of the relay point in that it may not only repeat and relay data on an instantaneous basis but may also receive, store, and rebroadcast when its changing position places it within line of sight of an earth-fixed reception station. This latter mode of operation is a trade between delay in communications and numbers of satellite relay points. One can conceive of a large number of different systems of satellites at different altitudes in combination with earth-fixed points. The optimizations of such a system depends on the specific mission requirements.

A satellite system has been proposed for communication purposes which uses an orbit approximately 26,200 miles above the center of the earth. At that altitude, the satellite rotates in its orbit synchronously with the rotation of the earth. This communications system has general significance, since it uses an orbit which is essentially earth-fixed and as such will have use for other system missions.

Fig. 2 shows a system of three satellite relay points on the earth-fixed ring plus three ground-relay stations. This is a minimum configuration covering most of the earth's surface, with the exception of small areas at the poles. For an active repeater system, powerful ground transmitters can work into the less-sensitive vehicle receivers in a complementary fashion, and the less-powerful vehicle transmitters work into larger ground antennas and low-noise receivers. Carrying this philosophy to its extremes, it may be possible to have a completely passive system where the satellite is a reflecting surface with no transmitter or receiving equipment on board. This would require very large reflecting surfaces on the satellite and more-powerful ground-transmission equipment. For an active system, Table 1 gives some typical characteristics for the satellite-ground communications link.

Since the satellite communications link is dependent on ground stations capable of viewing two adjacent satellites simultaneously, it is necessary that each satellite maintain its station within certain tolerances. The errors introduced by launching inaccuracies and the perturbations produced by extraneous forces will vary the orbits of each of the satellites. Thus, maintaining the geometry of the system will require a propulsion means within each vehicle in order to correct the orbits for the variations. Fig. 3 summarizes calculations giving the drift of stations per day as a function of perturbations in the radius and velocity of a circular, synchronous orbit.

In addition to the above station-keeping requirements, the antenna of the satellite must be stabilized. Depending on the system requirement of antenna gain and beamwidth, stabilization from several degrees to a fraction of degree may be necessary. Here again, some propulsive force must be provided on board in order to properly stabilize the vehicle and keep the antenna pointing at the ground-relay stations. Solid-fuel propellants, hypergolic fuels, and electronic propulsion are presently being investigated to solve the problems of both station keeping and stabilization for the earth-fixed ring communications satellite system.

SUMMARY

The specific problems and their solutions will take many different turns during the next few years of space-system research, development, and design. One can only be certain there will be many difficulties to be overcome and that the challenge will require tremendous commitments on the time and energies of all technical staffs involved in this effort, both in government and industry. I am confident that the Astro-Electronic Products Division, with the help of all the operating divisions of our company, will establish a position for RCA as a major contributor to this national effort.

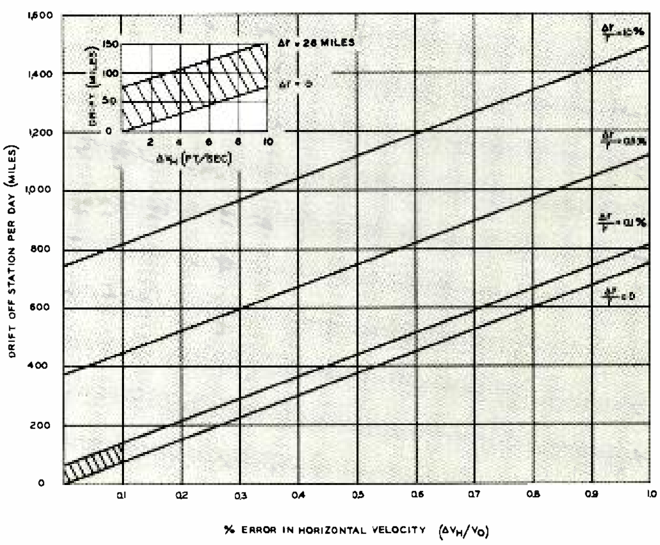


Fig. 3—Drift off stations as a function of initial conditions.

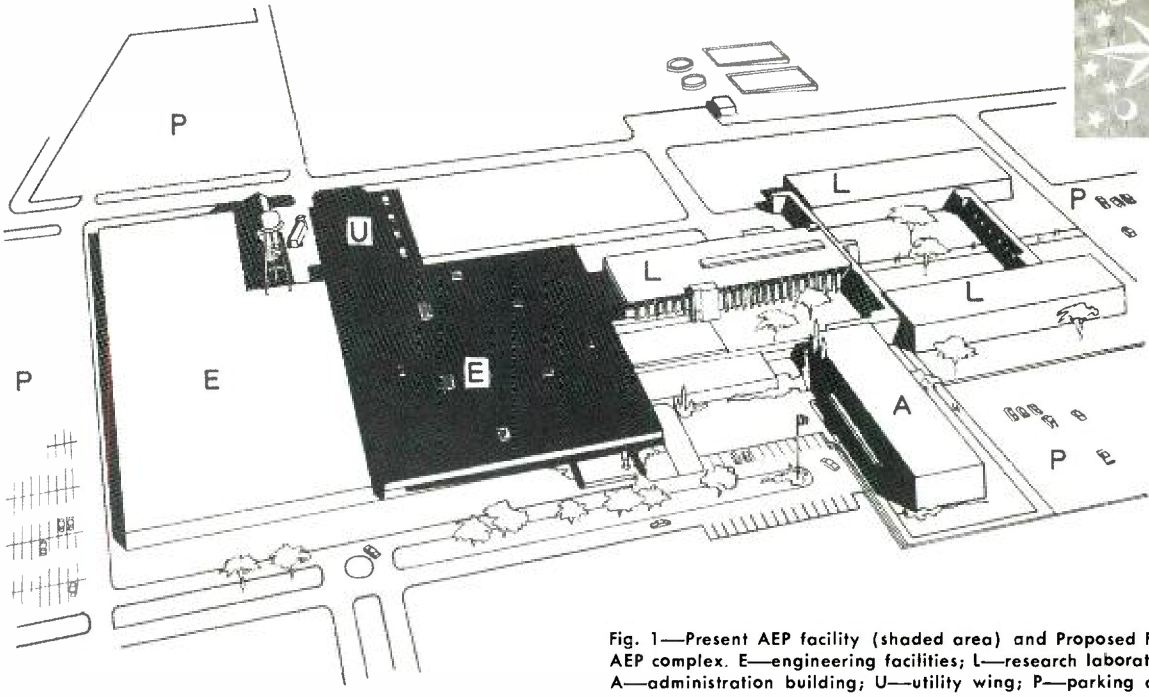


Fig. 1—Present AEP facility (shaded area) and Proposed Future AEP complex. E—engineering facilities; L—research laboratories; A—administration building; U—utility wing; P—parking areas.

FACILITIES, SERVICES, AND ORGANIZATION AT AEP

R. M. WILSON, Operations Control
and L. A. THOMAS, Engineering
Astro Electronic Products,
Princeton, N. J.

Of the many considerations involved in setting up AEP as a new division of RCA, one of the most important was ensuring flexibility—flexibility in laboratory and administrative facilities, in the organization and utilization of personnel, and in the variety and adaptability of supporting services. This approach has been particularly significant because of the varied scientific disciplines required and the dynamic, fast-moving nature of the new space technology.

FACILITIES

When AEP was formed in March 1958, it was initially housed in the David Sarnoff Research Center, Princeton, N. J. As the staff grew and the need for laboratory facilities increased, an initial three-stage acquisition was undertaken:

First, 37,000 square feet were leased and altered to suit AEP activities in a building six miles from the David Sarnoff Laboratories. Second, the balance of the building, some 40,000 square feet, was taken over in the fall of 1958, at which time AEP personnel, with the exception of a few engaged in certain research activities, moved to the new location. As the third step, in December 1958 ground was broken for a utility wing of 18,000 square feet with a completion date of June 1959.

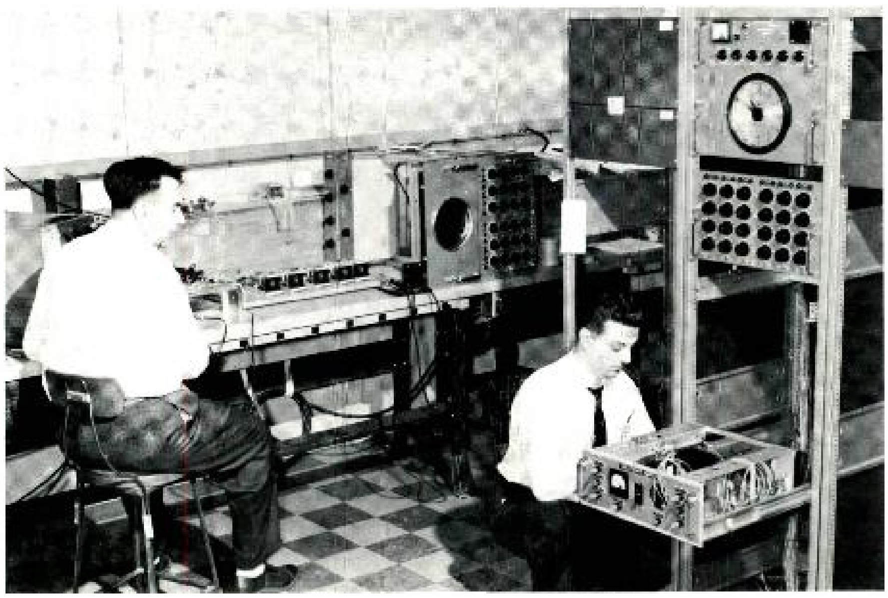
The first-year growth of AEP and the diverse potential application of electronics to space exploration has naturally made the Division very expansion-conscious. Plans for the foreseeable future include more laboratory and office facilities, an expanded model shop, computer equipment, additional environmental-test facilities, a cafeteria capable of handling increased employment, and a presentation room. Further expansion is foreseen along the lines of the architect's conception shown in Fig. 1, with greatly increased laboratory, engineering, and administrative facilities.

Inside the present one-story facility (see Fig. 1), bolt-together, half-height partitioning is used to form flexible office space and laboratory areas. Where security, engineering needs, or safety dictates, ceiling-height "Waylite" block construction is used in partitions. Some typical laboratory activities are shown in Figs. 2, 3 and 4.

A variety of special- and general-purpose equipment is presently available and planned for near-future procurement. Some of this is as follows:

Dust-Free Assembly Area (Figs. 5 and 6). This space, consisting of five assembly cubicles and a supply area is isolated

Fig. 2—C. Gierman and D. Canvella work on ground-control equipment for meteorological-satellite applications.



from the rest of the building. Conditioned air is provided by a separate closed-circuit system which not only maintains temperature and humidity at desired levels but also removes dust by both impingement-type and electrostatic filters.

Satellite Tracking and Communication Equipment. In a remote part of the property free enough from nearby high obstacles to give an unobstructed view of the sky in all directions from 5° above horizontal upward, a tracking antenna for transmitting signals to and receiving information from orbiting satellites is planned. Coaxial and power lines will connect this antenna with its amplifiers and power supplies and to the main laboratory building where complete ground-station facilities will be located.

Environmental Test Equipment (Figs. 7 and 8). The conditions of outer space and the extreme forces of launching are so different from the conventional operating environments of earth-bound communications equipment that satellite models must undergo rigorous testing before they can be considered acceptable. AEP's testing equipment now includes: a 5,000-pound-thrust Calidyne random-noise vibration system; several vacuum chambers, one of which (actually a metallizing unit) can accommodate equipment as large as 48 inches in diameter by 60 inches long under vacuum of 0.05 microns; a shock-test machine; and several high- and low-temperature boxes. Planned for future installation are a larger, walk-in, temperature-altitude environmental chamber and a large centrifuge.

Skin-Bonding Laboratory (Fig. 9). In order that known techniques of foaming and joining with adhesives and resins may be widely used and new techniques developed, a skin-bonding laboratory is maintained. Because of certain hazards inherent with this function, full-height, extra-thick walls separate this laboratory from other engineering space, and lighting fixtures and all wiring are explosion-proof. A number of exhaust air systems pick up any toxic or inflammable fumes at point of generation and discharge them to the outside. Modern ovens, hoods, dip tanks, and testing devices facilitate this unique activity.

Fig. 5—In the dust-free room, H. Singer works with a test setup of a shutter system for satellite-camera applications.

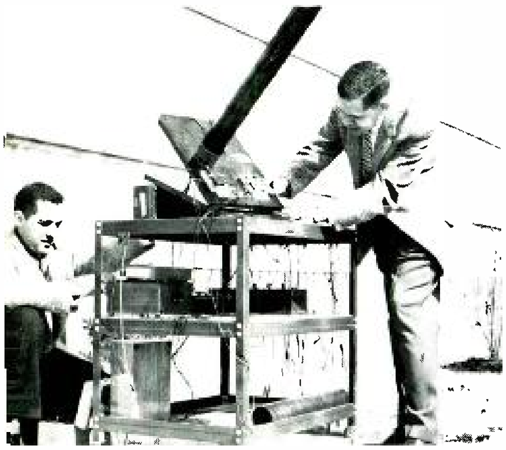


Fig. 3—W. G. DeWindt and P. Wiener adjust a normal-incidence sun rig for calibrating solar-cell efficiencies with a pyrheliometer.

Fig. 4—G. Corrington checks operation of the satellite tape transport described elsewhere in this issue. (see Goldberg et. al., "Electronic Devices for Space")

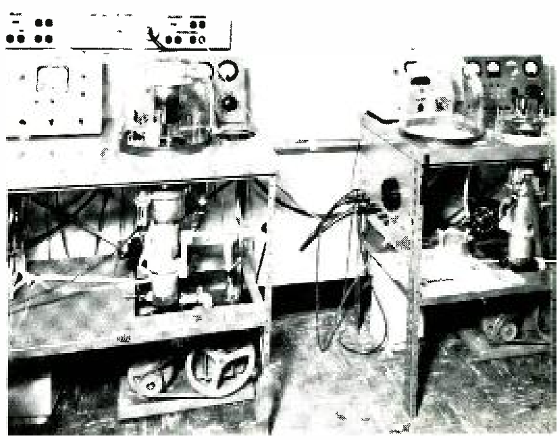


Fig. 7—High-vacuum evaporators for environmental testing of components under simulated space conditions.

Model Shop. A model shop is maintained to fabricate devices for research and development work and for pilot-run, preproduction models. As much emphasis has been placed on flexibility as on precision.

ORGANIZATION SERVICES

In a research and development organization, the major operating functions are three-fold: (1) the "hard-core" staff of scientists, engineers, and technicians essentially responsible for the research and development output; (2) a marketing organization with the vital job of soliciting customer interest and then coordinating delivery of the finished product; and (3) the operations organization that must supply the wherewithal of administrative services, facilities, and equipment for the day-to-day functioning of the whole organization.

In this basic concept, AEP is no exception. However, within the AEP En-

Fig. 6—R. Jorden determines focus properties of lenses for satellite TV-cameras in a dust-free area.

gineering staff, a dual organizational approach, or "team" concept, is extensively utilized. Basically, the engineering personnel are organized in an administrative framework dictated by major areas of interest (see Fig. 10). For work on specific programs, however, a more-fluid "project" organization is set up and staffed by drawing on particular skills from the basic organization. Personnel are utilized in this manner on a full-time, part-time, or consultant basis as needed, with this temporal project organization operating autonomously. In this manner, the project manager, group leaders, and staff may be selected on the basis of suitability for the specific project at hand, regardless of basic administrative allegiance.

This concept of a formal but immediately variable organization allows a more-complete and varied application of talents of personnel, in keeping with the basic criterion of utmost operating flexibility. To support this fluid approach, an Engineering Administration staff provides services which cut across project lines. These include drafting, technical editing and writing, technician coordination, a library, art and photographic services, laboratory and test equipment, and project coordination.

The complex problems associated with presently planned systems, the potential for the future, as-yet-unplanned systems —both factors demanded such an organization, geared to solve immediate engineering problems, yet flexible enough to tackle long-range basic research.

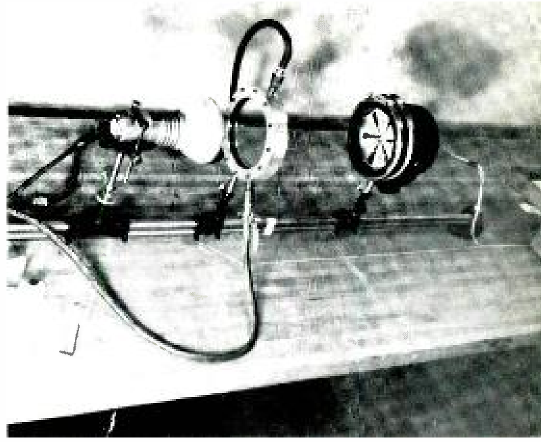


Fig. 8—Radiative heat-controller experiment. From left to right: light source; infrared-absorbing water filter; and bi-metallic, thermostatically actuated, tri-surface, radiation counter.

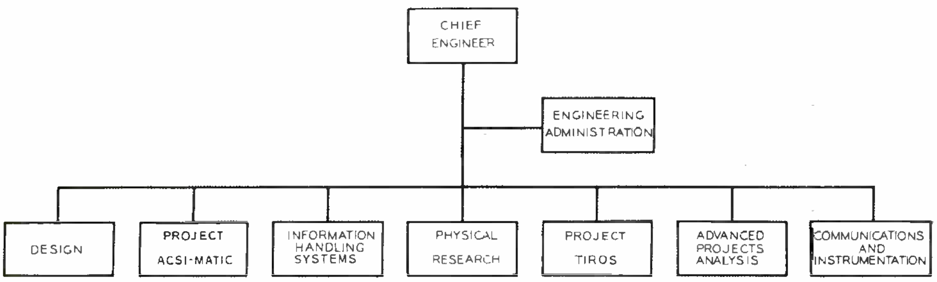


Fig. 10—Basic administrative organization of AEP Engineering.

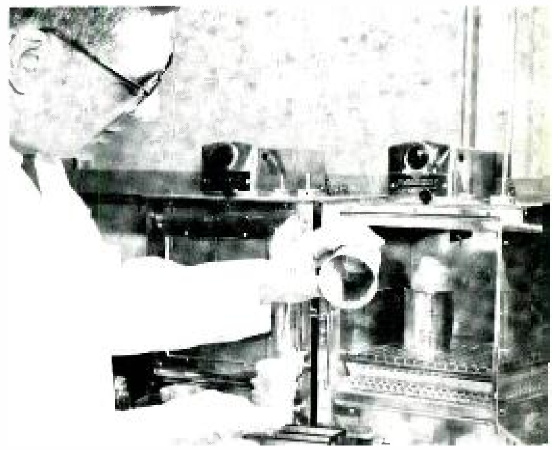


Fig. 9—O. Gosman pours polyurethane into a mold for foam-potting a satellite transmitter.

R. M. WILSON graduated from Oberlin College in 1927, also spent two years at Harvard Graduate School of Business Administration. The following fourteen years were spent with United Fruit Co. in research and marketing activities.

Mr. Wilson joined RCA Laboratories in 1943 working with Industry Service Laboratories in NYC from 1943 to 1947. He is one of the original members of Astro Electronic Products organization serving in the capacity of Manager of Facilities and Services, and unofficially as plant engineer.

L. A. THOMAS received the B.S. degree from Dartmouth in 1922, and studied Advanced Mathematics and Physics at Columbia University. He spent five years at Bell Telephone Laboratories, Inc., New York City, in the General Development Lab. in transformer and capacitor development and design. Mr. Thomas spent several years teaching in public schools and in private business, and joined RCA Victor Mfg. Co. in 1941 as a technical writer. He then served successively in RCA International Division in Engineering Sales Promotion, Consumer Custom Products in Advertising, EPD as Engineering Editor, and DEP Special Systems and Development as Manager of Technical Services. He is now Manager of Technical Services for AEP.

L. A. Thomas

R. M. Wilson

MARKETING ASTRO-ELECTRONIC PRODUCTS

By: **BARTON KREUZER**
Manager, Marketing
Astro-Electronic Products
Princeton, N. J.

BARTON KREUZER joined RCA in 1928 and was concerned with electronic development work, film recording engineering, theatre field engineering and film recording licensee contacts. In 1935 he entered the commercial phase of RCA activities as head of film recording equipment sales for RCA's Eastern industrial licensees, and in 1937 conducted similar activities for Hollywood film recording sales, becoming National Sales Manager in 1941.
In 1943 Mr. Kreuzer was appointed Manager of RCA Theatre Equipment activities with headquarters at Camden. He also served as General Product Manager of the Engineering Products Division and Marketing Manager of the Theatre and Industrial Equipment Department before becoming Director of Product Planning, RCA staff, in 1954. He is presently Manager of Marketing for Astro Electronic Products Division.
Mr. Kreuzer is Past President of the SMPTE. He is also a member of the IRE.

LESS THAN A YEAR ago President Eisenhower said:

> . . . the Science Advisory Committee has listed four factors which in its judgment give urgency and inevitability to advancement in space technology. These factors are: (1) the compelling urge of man to explore the unknown; (2) the need to assure that full advantage is taken on the military potential of space; (3) the effect on national prestige of accomplishment in space science and exploration; and (4) the opportunities for scientific observation and experimentation which will add to our knowledge of the earth, the solar system, and the universe.

Last May the RCA Stockholders' Meeting was told by RCA President, John L. Burns:

> This Division [AEP] has been set up to develop and produce earth satellites, space vehicles, and their associated electronic equipment. It is the first unit of its scope and purpose to be established by any electronics company.

The space activities of the nation have been entrusted to two Government agencies: the Department of Defense and the National Aeronautics and Space Administration. Within the Department of Defense, the Advanced Research Projects Agency (ARPA) and the Institute for Defense Analyses (IDA) are concerned with anti-missile and military space projects. The National Aeronautics and Space Administration (NASA) has as its mission basic space research and essentially nonmilitary space projects. NASA reports to the National Space Council on a level with the National Security Council, under the chairmanship of the President of the United States.

Among the ARPA projects are anti-missile systems and satellites for cloud-cover observation, early warning, communication, reconnaissance, surveillance, and navigation purposes. NASA projects include satellites for meteorology, lunar probes, space exploration for geophysical research, and man-in-space ventures.

MARKETING FUNCTION

What then is the marketing function? Working in harmony with the other parts of the Division, successful marketing obtains a satisfactory return on our Company's investment in the Division by securing business appropriate to its human and physical resources.

To accomplish this purpose in AEP, our marketing operation is divided between a planning function under the guidance of Maury Staton, a market development operation managed by Don Gunter, contract negotiation under the leadership of Ralph Teare, and contract administration managed by Fred Gedicks. Because of our present modest size, the entire group is kept informed of all operations in order that travel and customer-conference requirements will not deprive the Division of marketing representation on essential occasions.

Despite the vital job of day-to-day operation, one of the primary marketing functions is planning. The first step in this procedure is market research, which in the case of AEP may be summarized by the two charts of Fig. 1 showing a fiscal year '59 market of $811.5 million and a predicted market five years later of $2.766 billion.

NATURE OF PRODUCT PLANNING

A market analysis next reveals the categories comprising this market, shown in Fig. 2. By comparison with the AEP Division charter, which covers satellites, space vehicles, subsystems, and associated ground equipment, it is seen that our interest centers in the satellite and space-vehicle categories and in space propulsion. As AICBM become orbital in nature, the missile field will also be of interest.

In many business operations, one examines products not only in terms of inventory but also in terms of *product planning*. Although *product* in a certain sense develops from system and subsystem design and in a few years a more significant part of the Division's output will be represented by manufactured product, currently our most important inventory is composed of the AEP scientific and technical capabilities. Similarly, our *product planning* relates to these capabilities, too.

STUDY OF RELATED EFFORTS

A method of extending if not expanding these capabilities is to be found in the concept of the *contractor's team* method of performing contract tasks. This can be accomplished through association with a company or companies with complementary skills, such as an airframe company whose primary propulsion abilities may be used to carry an AEP satellite into orbit. Seldom is any substantial contract fulfilled without the use, also, of subcontractors to extend and complement our capabilities, as required, for the particular venture.

Before any attempt can be made to select desired areas of effort, reasonably comprehensive knowledge must be gained of the total market and of the contracts in particular that are to be awarded.

There are a number of sources for this information: published budgets, testimony before Congressional Committees, briefing sessions by the Armed Forces and Governmental agencies, and official proposal requests from these agencies. Sometimes, planning information can be secured from Technical Program Planning Documents (TPPD), which are an Air Force method of advising contractors of Air Force planning and projected requirements. On other projects, the award of small study programs serves to help qualify one or more contractors for more-extensive programs that may follow. Negotiated contract awards require industrial contractors to back their claims in proposals with facts and proof of unique ability to perform. This means that knowledge of a requirement is not enough—we must prepare ourselves in advance or we will not be competitive.

Close contact must be maintained with various laboratories and offices of NASA and ARPA, the Army Signal and Ordnance Corps, the Navy, and the Air Research and Development Command. Their offices and those of our associated contractors are located in all parts of the U.S.

"ENGINEERING-MARKETING" PROPOSALS

A key function in marketing activities is the submission either of unsolicited or requested proposals. The preparation of the technical phases, which are the bulk of such proposals, is primarily an engineering responsibility. Marketing responsibility extends to a coordinated effort with engineering not only to insure the best possible presentation of the material from the customer's viewpoint with the appropriate sales appeal but also to assist in accurate cost estimating. A similar responsibility exists with Accounting covering the pricing of the proposal.

If the proposal is successful and a contract is awarded, marketing effort is required to negotiate the contract to yield a suitable profit, to include terms and conditions satisfactory to our Company and to provide funding as required. Both in the original estimating and in subsequent operation, a close working relationship between Engineering and Marketing is vital to prevent over-runs; in this, careful estimating, skillful operation, and scrupulous recording of altered customer requirements or extensions of the scope of work is essential in order that Marketing may negotiate contract revisions.

As in other Company activities, one of the most important marketing functions is budgeting and control of departmental expense and the Division's revenue (i.e. the sales budget). This must be arrived at jointly with Engineering and Operations so that it may be realistic with respect to capabilities, manpower, and facilities; once established, it is our guide for marketing effort, expense factors, general engineering and development expenditures, and facility planning.

MARKET POSSIBILITIES

With a backward glance at the way in which our market knowledge has been gained, analyzed, evaluated, and resources matched to the tasks to be undertaken, a forward look at some of the fields of immediate interest may be indicated. Currently, these include satellites, space vehicles and key subsystems, including space propulsion methods, space prime power systems, auxiliary power systems, and methods of stabilization and attitude control.

These activities are by no means the end. Hypotheses as to the number and character of planetary systems other than ours have suggested that we may expect to find precellular or cellular life on many of these planets. Such thoughts—even if only theories at present—serve to emphasize the boundless opportunities in future years for the expansion of our space endeavors.

Our nation in 1958 expended some

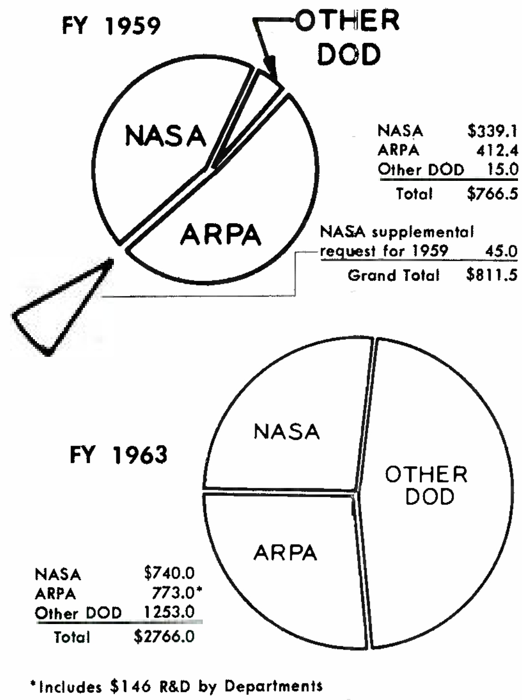


Fig. 1—Source of Federal appropriations for space (millions of dollars).

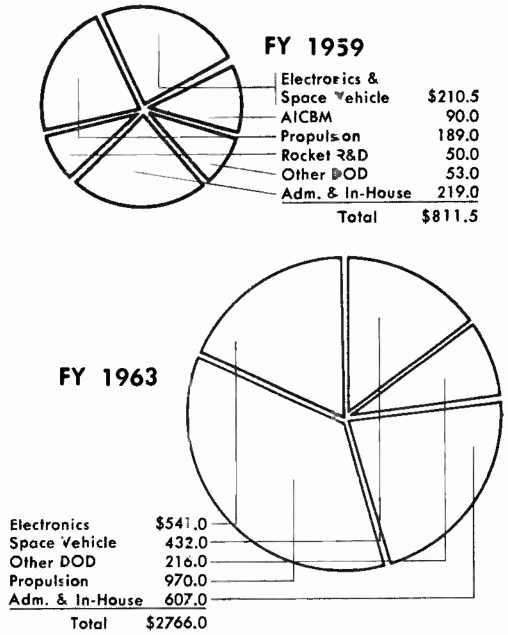


Fig. 2—Major categories of space appropriations (millions of dollars).

$10 billion on research and development. Half of this came from the Department of Defense. It is estimated that $120 billion will be spent on research and development during the next decade. Certainly this is an unparalleled opportunity for us as our Company, already the recognized leader in the electronics industry, entrusts much of its future in the field of space to the Astro-Electronic Products Division.

ELECTRONIC DEVICES FOR SPACE

by **E. A. GOLDBERG, K. G. MacLEAN, M. MESNER, J. ZENEL, J. R. STANISZEWSKI**

Engineering
Astro Electronic Products
Princeton, N. J.

BECAUSE OF THE nature of the environment, electronic components for use in satellites and space vehicles must meet specifications more rigid, in some respects, than those of similar components meant for use in ground installations or aircraft. The space vehicle generally subjects these components to considerable vibration and acceleration during periods of thrust which they must withstand without being damaged. Once in orbit, vibration and acceleration cease, the components become weightless, and a high vacuum surrounds the vehicle. Radiation environment is different in space than on the earth's surface and at altitudes where aircraft fly. Electrical, electronic, and mechanical devices in the space vehicle must be constructed to survive and operate satisfactorily in this environment for the useful life of the vehicle.

The ratio of fuel plus structure weight to payload for rockets used to place satellites into orbit is very large. Economically, this means that each pound of payload requires the expenditure of a considerable sum of money to put it into orbit. Consequently, all components should be designed for minimum weight consistent with meeting performance requirements. The energy of electrical power sources suitable for satellites is, in general, a direct function of weight. Batteries, solar cells, or rechargeable batteries in combination with solar cells are frequently used. The electrical and electronic system and associated components should be designed for a minimum power consumption in order to minimize the required weight for the electrical power supply.

A most important factor in satellite equipment is reliability. The requirement of reliability is especially severe, since it is impossible to service the satellite once it has been launched. A satellite mission costing hundreds of thousands of dollars could conceivably become useless through the failure of just one relatively insignificant component. All designs should be carefully reviewed, and components and workmanship painstakingly inspected and tested to insure high reliability.

Several different types of electronic components for satellites have been designed and built to meet the aforemen-

L. to R.—J. R. Staniszewski, M. Mesner, K. G. MacLean, and J. Zenel, E. A. Goldberg inset in photo.

tioned requirements by the Astro-Electronic Products Division. Some of these items have been successfully operated in orbiting satellites, while others will be used in future satellites. The communication gear, television camera, and tape recorder to be described are typical.

COMMUNICATIONS EQUIPMENT

An example of the type of equipment used in satellite vehicles is illustrated in Fig. 1. This is a completely transistorized, frequency modulation receiver that has been operated in a satellite. A commercial, "Personalfone" type CPC-R3 receiver designed by RCA Industrial Electronic Products was modified by IEP to meet AEP electrical and environmental specifications. Modifications included adding a low-noise radio-frequency amplifier stage, substitution of temperature-stabilized components, and repackaging of modules with conformal coating to endure vibration and shock.

The circuitry of this receiver includes a double conversion superheterodyne with two crystal-controlled conversion oscillators and a battery-saver circuit that switches the receiver on 0.3 second out of every three seconds. During the 0.3 second of *on* time, the reception of a tone signal locks the receiver on continuously.

This type of receiver is used for reception of voice or teletype tones. The

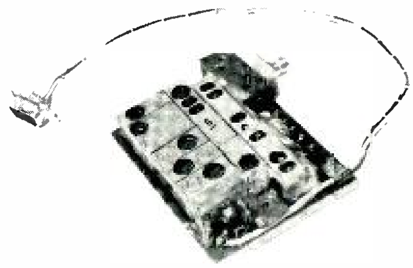


Fig. 1—Transistorized FM receiver for satellites; weight, 0.7 pound.

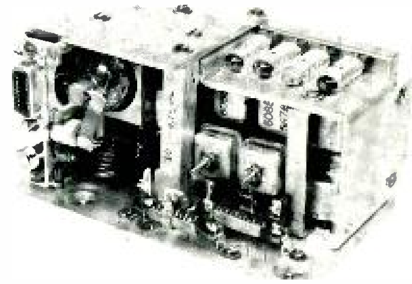


Fig. 2—Phase-modulation transmitter as used in a satellite package.

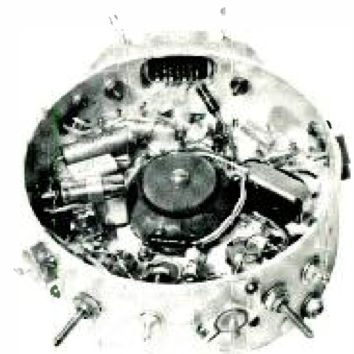


Fig. 3—Typical satellite beacon transmitter; weight 0.5 pound.

Fig. 4—Magnetic-tape transport for video storage on board a satellite. Tape speed is 50 ips, with a 1½-minute running time.

EDWIN A. GOLDBERG received the degrees of B.S. in Electrical Engineering in 1938 and M.S. in Electrical Engineering in 1940 at the University of Texas. He joined the RCA Manufacturing Company in 1940 and was assigned to the Research Division in 1941. He became a member of RCA Laboratories Division when it was established in 1942, where he engaged in the development of electronic analog computers and computer components for fire control, missile simulation, and guided missile control. He also did circuit development work in color television. He is presently serving as Manager, Design and Development Engineering in the Astro-Electronic Products Division.

Mr. Goldberg has twenty issued patents. He is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and the American Institute of Electrical Engineers.

KENNETH G. MacLEAN received the B.S.E.E. degree from Northeastern University in 1928. From 1929 to 1931 he was assigned to the RCA Transmitter Development Laboratory at Rocky Point, N. Y., where he did experimental work on circuits, transmitters, and HF directive antennas. From 1931 to 1936 he worked as an engineer for the RCA Communications Division. From 1936 to 1952, he worked in the Radio Reception Laboratory at Riverhead, N. Y. on design, development and research in the fields of VHF-UHF, which included FSK system tests, SSB receivers, and frequency-division diversity receivers. In 1952, he joined the RCA Laboratories at Princeton, where he worked on HF propagation and SSB communications systems studies for a classified BuShips project, and on a communications system analysis on Project Janus, Phase B. Upon the formation of Astro-Electronic Products, he joined that Division, where he is presently supervising the development and design of communication equipment for a military satellite vehicle. Mr. MacLean is a senior member of the I.R.E.

JOSEPH A. ZENEL received the B.S.E.E. degree from Bucknell University in 1949, and the M.S.E.E. degree from Princeton University in 1956. He joined the RCA Laboratories in 1949 where, for 9 years, he did research work in the audio-frequency field. He received the RCA Achievement Award in 1954 and in 1957 for outstanding work in research on video tape recording. In March 1958, Mr. Zenel transferred to the Astro-Electronic Products, where he is presently a project engineer in charge of the development of video recording equipment for satellite applications. He is a member of Pi Mu Epsilon, Tau Beta Pi, and Sigma Xi; the AIEE, and the Acoustical Society of America.

J. STANISZEWSKI received the B.S. in Physics from the Carnegie Institute of Technology in 1950 and is currently taking graduate courses at the University of Pennsylvania for an MS degree. From 1950 to 1953 he worked as a field engineer attached to the Military Assistance Advisory Group in the Netherlands where he was an instructor on radar, fire control computers, and field radio. In 1953 he joined RCA-DEP and engaged in the design and development of automatic tracking circuits for Mod. II Shoran. He also participated on the design and development of a closed loop television system for airborne (military) application utilizing a sensitive image orthicon. Recently his activities have been directed toward a miniature television camera for use in space vehicles.

MAX MESNER received his B.S.E.E. degree from the University of Missouri in 1940. That same year he joined the RCA Manufacturing Company in Camden as a radio engineer assigned to airborne radar equipment. In 1942, he went with the RCA Laboratories in Princeton as a research engineer. There, he did research and development work on television cameras, studio equipment, and color TV receivers as well as storage and computer devices. Mr. Mesner joined Astro-Electronic Products upon its formation, and has been engaged in the development and design of TV cameras for satellite use. He currently is the project engineer in charge of TV camera design for a satellite project.

Mr. Mesner is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and the Association for Computer Machinery. He is a senior member of the IRE.

voice or multichannel teletype tones may then be stored in a tape recorder or reradiated directly for relay operation. In addition, functions in the satellite such as *start* transmitter, *record*, *relay*, etc. are controlled by command signals to the receiver.

This receiver weighs 0.7 pound and measures 4.5 by 5.25 by 1 inch in overall dimensions. In the standby condition, the total power input is 24 milliwatts at 12 volts. A fully modulated carrier of 2 microvolts produces a 20-db signal-to-noise ratio in a 3-kc output audio band.

Fig. 2 illustrates a phase-modulation transmitter design that has been used in a satellite package. The circuits are conventional, with a crystal-controlled oscillator, phase modulator, frequency multipliers, and a power-output stage. This unit is capable of 8 watts output in the 130-mc band with a total power input of 38 watts. Because of the extremely low air densities at satellite altitudes, vacuum tubes cannot be cooled by convection, but each tube envelope must be heat-sinked to some large-enough mass of metal such that radiation cooling may take place. In this transmitter, the power-output tube envelope has a blackened metal wrap in contact with both the bulb and the large-mass metal enclosure. Heat is then conducted to the heavy metal base plate and thence to the system-package structure. Below-chassis wiring and small components were conformal coated to prevent motion under vibration.

Fig. 3 shows a beacon transmitter such as carried in most satellite devices. The beacon is essential for tracking the satellite and for orientation of antennas intended to command or exchange information with a satellite station. This unit consists of a stable transistor crystal-controlled oscillator followed by a transistor doubler stage, giving an output of 30 milliwatts in the region of 108 mc.

In addition, this unit includes an amplitude modulator and subcarrier audio oscillator for telemetering use. This unit is 5 inches in diameter including projections, $1\frac{1}{2}$ inches high, and weighs 0.6 pound. Power input totals about 300 milliwatts.

Because of limitations in space, weight, and power drain, telemetering in satellites has not yet approached the complexity of that used in missile flights. Telemetering is generally confined to basic desired experimental data such as the cosmic-ray counter in the Explorer flights or the micrometeorite gauges and temperature measurements. For example, in the beacon illustrated here, the subcarrier oscillator frequency was varied by a temperature-sensitive thermistor element. This varying-frequency subcarrier was then used to telemeter temperature of the beacon unit to the ground tracking station. A more advanced system would use a sampling-switch technique to sample a number of such thermistors, thus measuring the temperature of any critical portion of the satellite package.

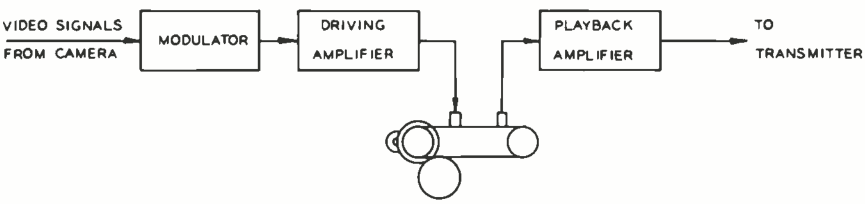


Fig. 5—Block diagram of magnetic tape recorder.

MAGNETIC TAPE RECORDER

In any role in which a satellite is used to extend the range of human vision by enabling man to view the earth or some other area of interest from a point inaccessible to man himself, the problem of delivering the image for ultimate human observation must be solved. If the satellite is within radio communication distance of a ground station while it is observing an area of interest, the image, in the form of television signals, can be transmitted to the ground station directly; if the satellite is not within radio communication distance at that time, the image must be stored, in one form or another, for eventual transmission under proper circumstances. One possible form of storage is by means of a magnetic tape recorder, in which television signals are stored in point-by-point fashion as patterns on magnetic tape, to be read out later on command from a ground station.

A magnetic tape recorder suitable for such a task has been developed by AEP. The transport can provide the high order of tape-motion stability and the information-handling capacity necessary for video recording without exceeding the limitations of weight and power consumption imposed on a device intended for a satellite. The electronic portion of the recorder is designed to accept d-c coupled signals from a television camera at the input to the recorder and deliver at its output terminals a correspondingly modulated carrier FM suitable for use as input to a transmitter.

The transport (Fig. 4) is of unusual design. Input power to the transport is applied only to the 12-watt, 500-cycle, synchronous-hysteresis motor. The motor is coupled to the capstan by means of a frictional rubber-rim drive. The capstan moves the tape, which in turn pulls the supply reel; the supply reel is coupled to the take-up reel by means of an assembly of constant-tension springs. These springs permit rotation of one reel relative to the other while maintaining constant and continuous tension on the tape. This arrangement thus conserves power by avoiding the brake methods ordinarily used to develop tension, while at the same time, it dispenses with one of the major sources of tape-motion instability. The cause of weight conservation is also served by this configuration. Tape speed is 50 inches per second; running time is about $1\frac{1}{2}$ minutes. Tape width is $\frac{3}{8}$ inch. A block diagram of the complete recorder is given in Fig. 5.

The modulator generates a carrier at 85 kc and frequency-modulates it with the incoming video signal. Deviation is $\pm$ 15 kc. The video signal contains frequencies ranging from 0 to 62.5 kc. Since this means a low modulation index (0.24), only the first-order sidebands are of importance. The driving amplifier develops a current waveform suitable for driving the recording head. The equalization of this unit, together with that of the playback amplifier, is based primarily on the premise that all frequencies (and therefore all amplitudes of the video signal) are equally probable. The bandwidth of the playback ampli-

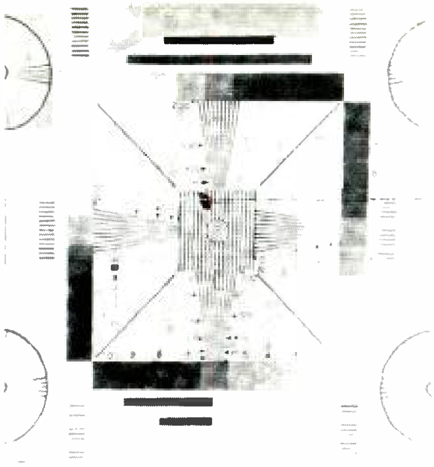


Fig. 6—Test pattern as reconstructed by complementary ground-station equipment from satellite tape recorder. The pattern was originated by a flying-spot scanner. (The apparent slight jitter is not attributable to the tape recorder.)

fier is sufficient to handle both first-order sidebands. The power converter develops 500-cycle power from the d-c input for driving the transport motor. The 500-cycle power bears a synchronous relationship to the television-scanning frequencies.

An example of the results obtainable with this recorder is shown in Fig. 6. This is a test pattern which has been originated by a flying-spot scanner, processed through the recorder and reconstructed by complementary ground-station equipment. The picture is a 500-by-500-element picture, developed by the flying-spot scanner at a 2-second, noninterlaced frame rate. The slight jitter apparent in the photograph is attributable to the tape recorder.

The recorder proper described here is capable of storing considerably more information. Since the video signal occupies only 0.040 inches of the tape width, there remains available space for at least three additional channels of comparable bandwidth for whatever other information is required to be stored.

TELEVISION CAMERA

One of the important functions of a satellite is collecting data from its vantage point in space. Television techniques offer one good method for taking and transmitting pictorial data. Since power sources are limited, transmission of the picture must be accomplished with a radically reduced bandwidth. The sort of pictures of interest are of the earth and of its cloud coverage, of animals and humans within the vehicle, and of celestial bodies such as the moon and planets. Reducing bandwidth for such pictures can be accomplished by slowing the information rate and by minimizing redundancies. The first is done by slowly scanning the picture pick-up tube and the second by transmitting only still pictures.

Since a series of still pictures is in order, image immobilization must be accomplished in any of these cases to prevent smearing on the photosensitive pick-up tube. A shutter similar to that used on a photographic camera is required, but more-stringent requirements for durability and reliability must be met. With the use of pulsed light on the vidicon, the same compromises must be made between sensitivity and image smear as beset the film-camera photographer. In addition, this type of camera must operate for the present without the usual battery of cameramen and technicians who are necessary to make commercial television an operating success.

The camera which functions in the manner described can be designed by utilizing a vidicon pick-up device, an electrically operated shutter, and transistorized circuits (see Fig. 7). Using printed-circuit techniques and miniaturized components, such a camera system can weigh less than five pounds and consume less than eight watts. Variations in these values may be experienced as the particular end use of the camera is specified.

A TV picture may be obtained using a ½-inch vidicon with a resolution of 500 lines at a frame-rate frequency of 0.5 per second. The bandwidth of such a picture will be on the order of 62.5 kc, with new pictures occurring every few seconds. A 1-inch vidicon will yield higher-resolution pictures with some increase in weight and bandwidth. On the other hand, if a still greater reduction in transmitter power is desired, either fewer or poorer-quality pictures will be the consequence.

The use of vidicons at extremely slow scan rates is a relatively new technique. At slow scans, the problem of erasure becomes more critical, with several time-consuming scans being necessary to reduce the residual image. How fast this erasure needs to be done depends on its usage. Viewing a man's movements, for example, would require more-rapid renewal of pictures than viewing terrestial or celestial sequences. The photoconductor, consequently, would have to be selected for the appropriate erase and sensitivity characteristics.

Fig. 8 shows a block diagram of a typical satellite camera system. Shutter pulses in this case are furnished from a clock synchronized to the vertical-frame period.

The construction of the camera, designed to minimize weight, volume, and power consumption, is of the printed-circuit variety. Conformal coating by an epoxy resin and a layer of foam to a metal heat sink provide a heat-conduction path for use in an environment where convection does not exist. This construction also minimizes motion or vibration of components and damps out mechanical resonances. The camera shown uses these techniques and is capable of withstanding the rigors of a rocket launching and the environment of outer space.

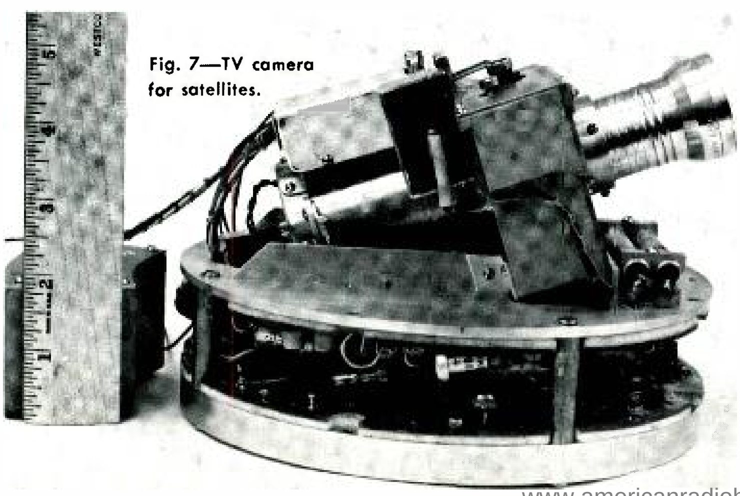


Fig. 7—TV camera for satellites.

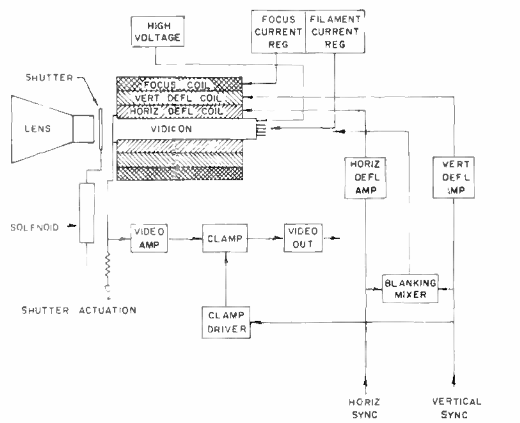


Fig. 8—Block diagram of typical satellite TV-camera system.

ELECTRONIC PROPULSION FOR SPACE VEHICLES

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To most of us, a rocket implies chemical combustion of a fuel and an oxidizer. The significant operational principle of a rocket does not lie in the act of burning, however, but rather in the production of thrust by the forcible ejection of the exhaust gases. Except for the possible use of radiation pressure to permit so-called "solar sailing," the rocket is the only known means of propulsion in a vacuum in which there are no other objects to which force may be applied.

In a chemical rocket, the internal energy of the heated products of combustion is converted by the nozzle into kinetic energy of the expanded gases, which are ejected to provide the thrust. The faster the ejected gases can be made to travel, the greater the thrust which can be produced per unit mass flow of ejected propellant. All of the propellant must be carried aloft at a great expense of initial-launching rocket energy, so that saving of propellant weight is of vital importance for very long space flights. Herein lies the potential advantage of electronic propulsion schemes: much higher ratios of gained vehicle velocity to ejected propellant mass, because electronic methods of accelerating propellants can produce exhaust velocities higher than those produced by heating either with chemical combustion or nuclear energy. The reasons for this fact and an explanation of some of the special conditions under which electronic propulsion is expected to have the greatest advantages can best be seen from the following simple application of Newton's laws of motion and elementary thermodynamics.

GENERAL FUNDAMENTALS OF CHEMICAL AND ELECTRICAL ROCKETS

Let us suppose that in a time Δt there is ejected a mass of propellant ΔM with a velocity C. Then the momentum of the ejected mass is ΔMC, and the change of momentum in the interval of time Δt is $(\Delta M/\Delta t)C$. For a continuous flow of propellant we may replace $\Delta M/\Delta t$ by $\dot{M}$, the mass flow rate, and because the force causing this momentum change is also the thrust on the vehicle, we may write

$$F = \dot{M}C \qquad (1)$$

The kinetic energy rate or power being supplied to this rocket will be $\frac{1}{2}\dot{M}C^2$.

If we have a propellant heated to an absolute temperature T_h, then it can be shown from thermodynamics that the maximum possible exhaust velocity into a vacuum when the propellant is ejected isentropically is given by the expression

$$C = \sqrt{\frac{2\gamma}{\gamma-1}\,\frac{R}{\mathcal{M}}T_h} \qquad (2)$$

where R is the universal gas constant, $\mathcal{M}$ the molecular weight of the propellant, and γ the ratio of the specific heats at constant pressure and constant volume, C_p/C_v.

At this point, it is convenient to introduce the term "specific impulse," I_s, which is simply a measure of the total impulse (thrust times time) obtainable per unit weight W_p (equal to $M_p g$) of propellant. Thus from equation (1):

$$Ft = \dot{M}C_t = M_p C = \frac{W_p}{g}C \qquad (3)$$

where M_p is the total mass of matter expelled as propellant. I_s is then expressed in seconds for any consistent set of units by the equation

$$I_s = \frac{Ft}{W_p} = \frac{C}{g} \qquad (4)$$

From equation (4) we see that I_s is proportional to the exit velocity C. But, for heat-operated rockets, C is limited by the maximum temperature T_h, of equation (2), and in practice T_h is limited by the materials comprising the combustion chamber and exhaust-nozzle walls. For an advanced, high-energy, liquid-fuel rocket using fluorine and hydrogen, for example, the maximum temperature T_h might be of the order of 4600°K. From equation (2) this might lead to an idealized maximum velocity in the order of 4×10^3 m/sec, or a specific impulse of about 400 sec; because of unavoidable losses, the velocity and specific impulse in any real engine operating at this temperature would be less.

By the use of nuclear energy to supply heat to a very light propellant such as hydrogen or helium, it might be possible to increase this specific impulse by a factor of two or three, provided electromagnetic or other specialized containment methods could be used.

If we turn our attention from high temperature as a means of obtaining high velocity and consider other means of accelerating a gaseous propellant, two electrical means become obvious: the acceleration of charged particles or ions by means of electrostatic fields, and the acceleration of a neutral ionized conducting gas, called plasma, by the interaction of a current through the plasma with a magnetic field. These two acceleration methods form the basis of most of the present work on electrical propulsion. Thrust devices using the electrostatic field acceleration will hereafter be referred to as "ion rockets," those using electromagnetic interaction as "plasma rockets."

While with chemical rockets the limiting factor in space flight arises from the large mass of propellant to be carried, the limiting factor for a number of proposed electrical rockets arises from the high power requirements. As was shown above, the specific impulse increases directly with C, but the power required increases as C^2. From a power standpoint, a rocket engine in force-free space is most efficient at a given instant when the exhaust velocity C equals the forward velocity of the vehicle, because under those conditions there is no wasted kinetic energy left in the ejected propellant. But for a given mission, where total increment ΔV of the velocity of the vehicle over a period of time t_o is more important than the efficiency of the engine at a given moment, the situation becomes much more complicated, and it is important to minimize both the expended propellant mass and the power-supply weight.

A convenient measure of power-supply performance for space-vehicle applications is given by the parameter α, defined by the equation

$$M_w = \alpha W \qquad (5)$$

where M_w is the total mass of the power supply system, and $W = \dot{M}C^2/2$, the power effective for propulsion. High-flux nuclear reactors can give very low values of α, in the order of 0.03 kg/kw, but conventional power-conversion equipment, such as turbines and generators, is likely to have α values of the order of 1 to 10 kg/kw.

It can be shown that, in general, there is an optimum exhaust velocity (lying between $0.5\sqrt{2t_o/\alpha}$ and $\sqrt{2t_o/\alpha}$, where t_o is the flight time) which minimizes the total initial mass of propellant and power supply and maximizes the velocity increment or average acceleration. Too high an exhaust velocity increases the power for a given thrust, too low a velocity increases propellant mass, but unfavorably high values of α can be compensated by longer times of flight, t_o, if other considerations permit this.

D. B. Langmuir (Reference 2) cites as an example a relatively short mission where exhaust velocities much higher than those obtainable by chemical rockets are important; for example, a trip to the moon and back from an earth satellite orbit. In addition to the orbital velocity, he computes a necessary incremental velocity ΔV = 10 km/sec, and assumes $t_o = 10^7$ sec (4 months) and α = 10 kg/kw. Then the optimum value of C = 36 km/sec. For a payload M = 294 kg, a power supply mass M_w = 85 kg, the propellant expended M_p = 120 kg and the continuous thrust = 44×10^{-5} newtons (44 dynes). The computed energy consumption rate for the entire trip would be 8.5 kw.

If a chemical rocket with an exhaust velocity of only 3 km/sec were used to produce the same thrust for the same time, the propellant weight is calculated to be $M_p = 36/3 \times 120$ = 1.440 kg.

ION ROCKETS

We can envisage a simple ion rocket employing a broad-area, ion-emitting electrode with a closely spaced accelerating grid at a potential V with respect to it—in other words, a diode in which the charge carriers penetrate the accelerating electrode and are not collected by it. A cesium vapor contacting a hot tungsten electrode is a convenient means of obtaining ions of relatively high mass (M for cesium = 132). If we assume the ions have a charge each of e coulombs, a mass of m kg, and that V is in volts, then

$$C = \sqrt{\frac{2eV}{m}} \text{ km/sec.} \quad (6)$$

For V = 100 volts, this expression gives $C = 1.2\times10^4$ m/sec, or $I_s \cong 1200$ secs. An accelerating potential of 10,000 volts would give $C = 1.2\times10^5$ m/sec and a specific impulse $I_s \cong 12{,}000$ secs. Comparison of this figure with the idealized chemical-rocket I_s of 400 sec points out comparative propellant economy, but comparison with the sample moon mission shows the value of C now to be much too high.

In such excessive velocity lies one of the difficulties of diode accelerators, because high accelerating voltages are necessary for overcoming space-charge limitations at the cathode to produce adequate current densities with reasonable electrode spacing. Neutralization of the space charge of the ions being emitted is also essential to prevent charge buildup on the vehicle from neutralizing the momental thrust. Various means of emitting electrons behind the accelerating grid are being proposed for diode ion rockets. Other types of ion accelerators may possibly obviate both space-charge limitations, such as one using an alternating gradient electrostatic field.

Other major research problems lie in the design of very high efficiency power supplies with lower α's and in the production of very high ion and/or electron densities. The production of ions with much smaller e/m ratios than are obtainable with single atoms would also help to secure exit velocities nearer the optimum. The general field of ion rockets is being actively investigated by several major companies. The space-vehicle accelerations expected from the types of ion rockets currently under study are very low, of the order of 10^{-4} to 10^{-5} g, but they may be sufficient for certain types of space flight.

PLASMA ROCKETS

Plasma rockets offer the hope of producing higher thrusts at an earlier date than those foreseen with the simpler types of ion rockets. Their main disadvantage lies in the fact that the passage of high currents through the plasma produces very high temperatures; in fact, some proposed plasma rockets may produce more thrust from the pressure of the heated gas than from electromagnetic forces. An arc discharge has also been proposed as a substitute for combustion in more-conventional thermal rockets.

There have been a number of intermittent-action plasma jets demonstrated in principle. These include acceleration of a linear gas discharge between two long, parallel rails with the current loop through the rails and traveling discharge providing the magnetic field, and acceleration of a circular gas discharge down the length of a solenoid. A current wave traveling down the solenoid induces current in the ring and "drags" the discharge ring along as it progresses down the solenoid. At the end the ring discharge or "plasmoid" is ejected; because the plasmoid consists of macroscopically neutral plasma, no space-charge problems arise.

Other continuous-operating acceleration schemes are under study, and exit velocities of the order of 10^5 m/sec are being considered. Major research problems, in addition to the power-supply problems, include the production of fully ionized plasmas, heat-transfer prevention, plasma containment, and the achievement of continuous, controllable operation.

The AEP Division of RCA is interested in both types of electrical propulsion because of their expected use in future space flight systems and because the disciplines required for the advancement of the electrical propulsion field are those in which RCA as a whole has had much experience.

The writer wishes to thank C. M. Burrill of AEP for his helpful suggestions.

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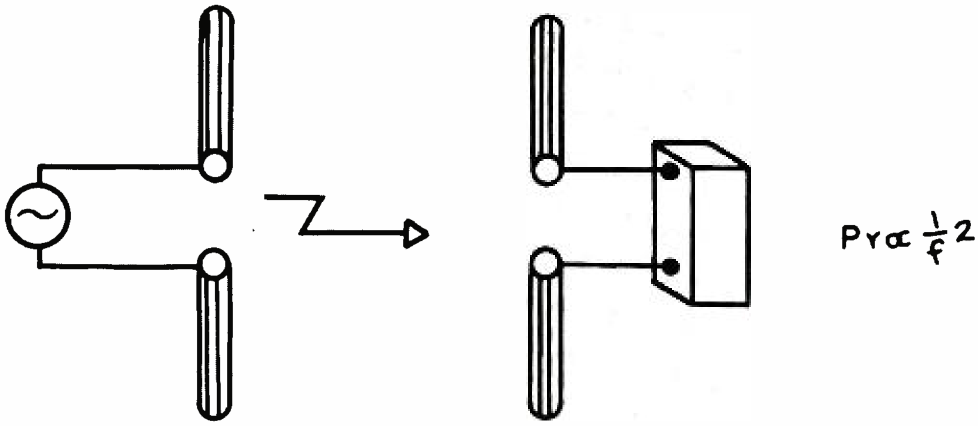
In 1951 he returned as a research physicist to RCA Laboratories at Princeton and was connected with Project Typhoon and other general flight simulation projects before participating during the past few years in various satellite and related system studies and component developments. He is presently Manager of the Physics Research and Development Laboratory of Astro-Electronic Products.

REFERENCES

1. G. P. Sutton, *Rocket Propulsion Elements*, John Wiley and Sons, Inc., 1949.
2. D. B. Langmuir, *Power Limited Flight in Field Free Space*, Lecture 5A, February 17, 1958. University of California Engineering Extension, Physical Sciences Extension Space Technology Course.
3. E. Stuhlinger, "Electrical Propulsion System for Space Ships with Nuclear Power Sources," *Journal Astronautics* 1955, pp. 149-52; 1956, pp. 11-14.
4. H. Seifert, M. Mills, and M. Summerfield, "Physics of Rockets," *American Journal Physics* 15, pp. 266-272.
5. H. S. Tsien, "Take-Off from Satellite Orbits," *ARS Journal*, July-August 1953, pp. 233-236.



ELEMENTS OF A SATELLITE COMMUNICATION SYSTEM

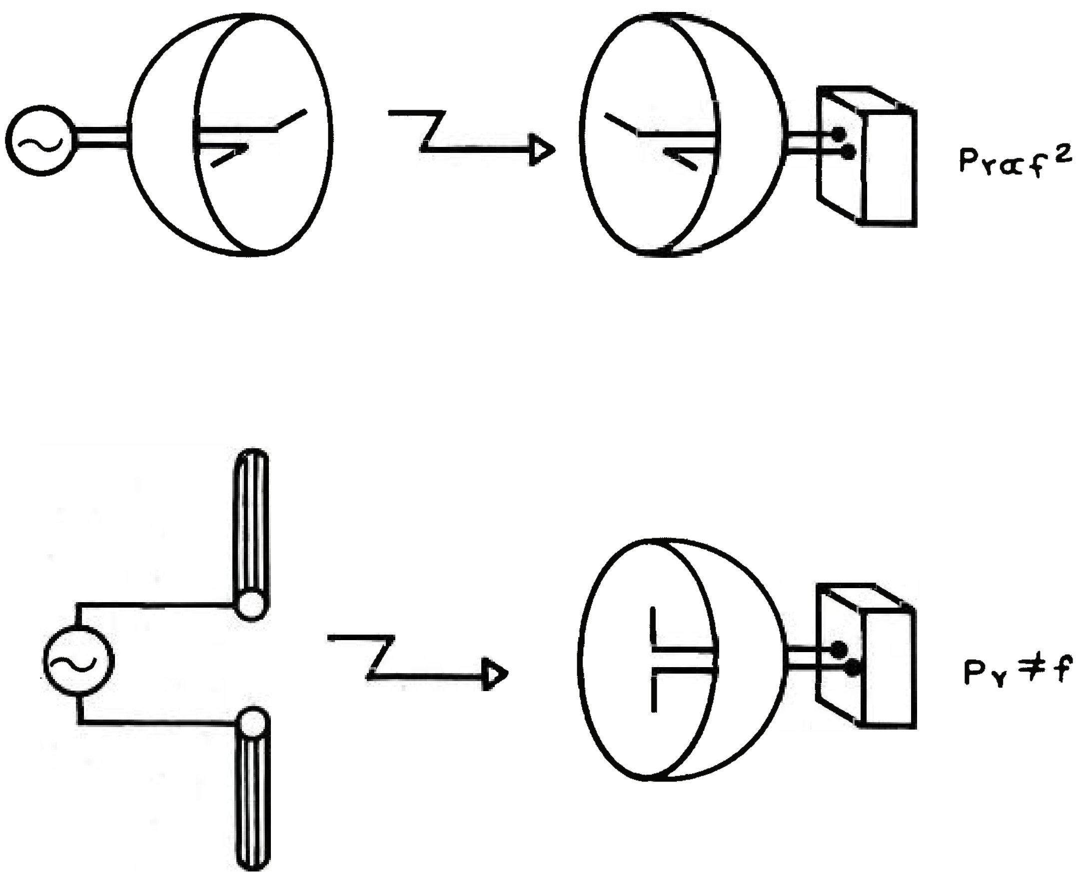


Fig. 1—Free-space transmission.

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THE PURPOSE OF this paper is to discuss the major problems which have to be considered in the design of a system for communication between the earth and a satellite. These problems include selection of frequency; considerations of noise, both internal and external to the receiver; choice of modulation method, bandwidth, and demodulation method; type of satellite and ground-based antennas; and equipment state of the art.

SELECTION OF FREQUENCY

The power density radiated by a dipole antenna in free space is independent of frequency. Thus, if the receiving antenna has a parabolic reflector of fixed area, the received power will be proportional to that area but also independent of frequency. This is useful in the case where a satellite tumbles, spins, or otherwise assumes an arbitrary attitude with respect to the receiving antenna on the earth. This requires the satellite to use a nondirectional transmitting antenna (such as crossed dipoles fed 90° out of phase). Since the received power is independent of frequency, any frequency may be used which is high enough to penetrate the ionosphere. The upper limit is that due to excessive atmospheric attenuation. Therefore earth-satellite frequencies are generally limited to the region from about 30 to 10,000 mc.

If a dipole antenna must be used at the ground station (and also in the satellite) the received signal (voltage) will be proportional to the dipole length so that the received power will be inversely proportional to the square of the frequency. Thus, the frequencies toward the lower end of the band are preferred for this application. The third case involves future satellite systems where steerable antennas will be used on the satellite. The satellite reflector will be as large as practicable, to get maximum gain, and a large antenna reflector will also be used on the ground. For this case, of two fixed-area antennas, it can be shown that the received power is proportional to the square of the frequency; thus, frequencies toward the upper end of the useful band would be preferable.

Fig. 1 summarizes these three cases, but it must be stressed that factors other than dependence of received power versus frequency must also be considered in selecting the frequency. These include noise and state of the art which will be discussed below.

NOISE

The communications engineer is more interested in the signal-to-noise ratio of the received signal than in its absolute level. Noise is introduced by various sources and includes internal receiver noise, atmospheric noise, man-made noise, and extraterrestrial (cosmic) noise. This latter item includes contributions from our galaxy (and others) as well as contributions from the sun. The noise sources come from all parts of the sky, but in addition to this general background level, there are a number of discrete sources which generate noise at a much higher than average level. Work is continuing on charting "noise maps" of the sky. The average cosmic noise at 100 mc corresponds to a receiver noise figure of about 6 db. The cosmic noise power decreases by 23 db for a ten-fold increase in frequency; i.e., it is proportional to $1/f^{2.3}$.

Atmospheric noise is caused by thunderstorms, and a typical distribution of such noise versus frequency is shown in Fig. 2.

The thermal noise arising in the input circuits of the receiver is a function of the receiver techniques used. Fig. 2 shows a curve of noise figure versus frequency for a receiver with a low-noise triode (416-B) input circuit. Until recently, this curve represented the ultimate in performance at frequencies up to 1000 mc. At higher frequencies, traveling-wave tubes and special cooled crystal mixers were superior. However, work on the parametric amplifier and on the maser amplifier has resulted in an order of magnitude improvement, as shown in Fig. 2. Thus, cosmic noise, whose contribution could be neglected with respect to noise from high-quality receivers above about 200 mc, now must be considered out to about 1000 mc. Also, the effect of antenna side lobes looking at the "hot" earth (with respect to the "cold" sky of 5° to 10° K), must be considered when using masers. Other factors, negligible until now, become important sources of noise. These include transmission-line losses and losses due to oxygen and water-vapor absorption in the atmosphere, especially at low elevation angles.

MODULATION AND BANDWIDTH

Because of weight limitations in a satellite it is essential to reduce the bandwidth of the transmitted data to a minimum in order to reduce transmitter weight. Fortunately, on a voyage to the moon or the planets there will be plenty of time and not much action, so that bandwidths in the order of a few cycles may be used at the expense of stretching a given amount of information over a longer period of time. The noise bandwidth of the receiver should not be greater than needed to encompass the useful transmitted spectrum. Here a problem arises in that the i-f bandwidth of a VHF, UHF, or SHF receiver will be several orders of magnitude greater than the desired bandwidth to allow for local oscillator drift, satellite transmitter drift, and Doppler effect. The effect of this wide band can be visualized by referring to Fig. 3, which shows the comparison of wide-band and narrow-band i-f amplifiers of receivers with the same audio bandwidth in both cases. The signal-to-noise ratio out of these two receivers will be the same, for equal carrier voltages, provided that the carrier is large compared to the noise. This is because noise voltages (in the wide-band case) of a frequency greater than F_a from the carrier will beat with the carrier, but the resulting frequency will not be passed by the low-pass filter, which cuts off at F_a. Beats between noise components with a resulting frequency less than F_a will be negligibly small compared to beats between the carrier and the noise. However, as the carrier amplitude decreases, beats between the noise components become of increasing importance. Since there will be a greater number of these beats in the case of the wide-band receiver than in the narrow-band, it is seen that the signal-to-noise ratio of the wide-band receiver will be poorer than from the narrow-band receiver for small values of carrier.

One method of decreasing the effect of beats between noise components, even in the case of a narrow-band receiver in which the i-f amplifier is but twice the audio-frequency cut off, is to use a locally generated signal which is locked in frequency and phase with the incoming carrier. A system for accomplishing this is shown in Fig. 4 (phase locked loop demodulator). This arrangement is sometimes called a synchronous demodulator. A local oscillator from a source whose frequency can be varied by means of an electrical signal is fed into a phase detector (product demodulator) along with the incoming carrier. The output of the phase detector will be proportional to the phase difference between the incoming signal and the local oscillator. This output is filtered by the low-pass filter of cutoff frequency F_a, whose output is used to control the frequency of the voltage-controlled oscillator. In order for phase lock to occur, it is necessary that the local oscillator first be brought into step with the incoming signal. This can be accomplished by either manual or automatic means. Once phase lock is acquired, the system will stay in synchronism until the carrier voltage becomes less than about twice the rms noise in the output of the low-pass filter. Since the voltage-controlled oscillator can follow the incoming carrier frequency, the effective noise in the system will be determined by the low-pass filter bandwidth rather than by the i-f bandwidth. If the incoming signal is phase or frequency modulated, this system may be used as shown in the diagram for demodulation, since the output of the voltage-controlled oscillator faithfully follows the variations of the incoming signal.

Alternatively, it is possible to use this arrangement for demodulation of an AM signal.

The choice of modulation methods to be used in the satellite (and multiplexing method, if necessary) must be determined on a basis of the particular system. The choice is made not only on the basis of transmission efficiency but also on such considerations as the weight, power drain, and complexity of the circuits needed for each of the modulation methods considered. As an example, the satellites which have been launched since Sputnik I have used amplitude modulation, phase modulation, and frequency modulation. Undoubtedly still other methods will be used in future satellites.

ANTENNAS

For early types of satellites with no attitude stabilization, it is desirable to use a satellite antenna whose pattern approaches the ideal—that of an isotropic radiator pattern. Since the shape and size of satellites is determined by considerations other than antenna pattern, it becomes necessary for the antenna designer to exercise a great deal of ingenuity to approach the ideal pattern. Satellite shapes vary so widely that it is impossible to give any general design information regarding their antennas.

It is possible to be more specific about the ground antennas. These should, of course, be as large as possible in order to permit the use of low-power satellite transmitters. There are available on the market today parabolic reflectors 60 feet and even 83 feet in diameter, with elevation-azimuth mounts which could be used to pick up satellite signals. The largest steerable antenna constructed

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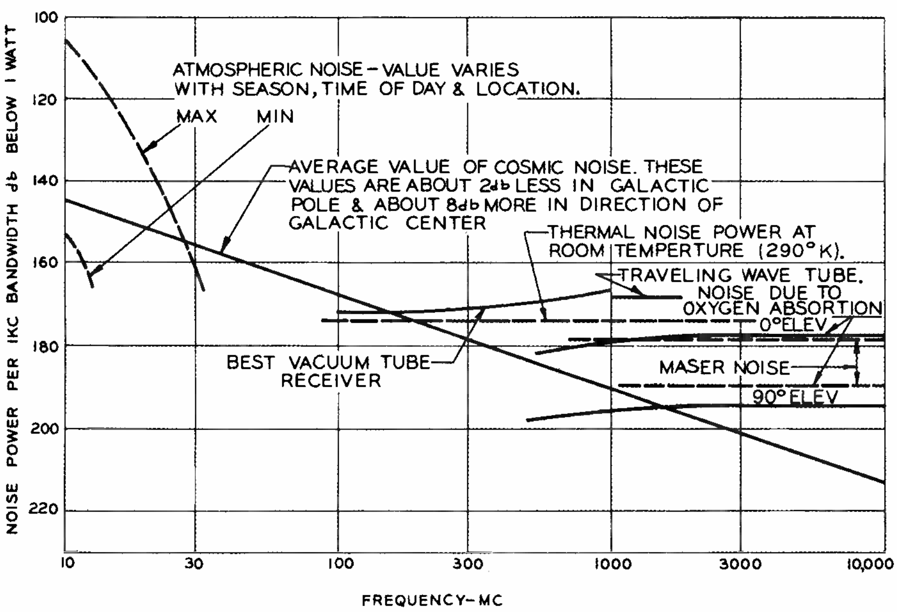


Fig. 2—Typical noise sources.

to date is one of 250-foot diameter at Jodrell Bank, England. While a large antenna is desirable from the viewpoint of intercepting signal power, it presents difficulties in following the satellite in its orbit. For example, a 250-foot parabolic reflector at a frequency of 1000 mc would have a beam width of about 0.3 degree between half-power points. For narrow beams of this type it is essential that automatic tracking be used.

STATE OF THE ART

The selection of the operating frequency, type of modulation, and other parameters of communication systems is strongly affected by the state of the art. For example, if the satellite application calls for a radio receiver to be on constantly, it is very desirable that this receiver be completely transistorized to reduce power drain. This restriction immediately limits the upper frequency to that available with present-day transistors. With time, this upper frequency limit will undoubtedly be increased. The choice of modulation method is also strongly affected by the state of the art. This has led to the use of FM rather than AM in at least one case because of the lower power drain of transmitters for FM (besides other advantages).

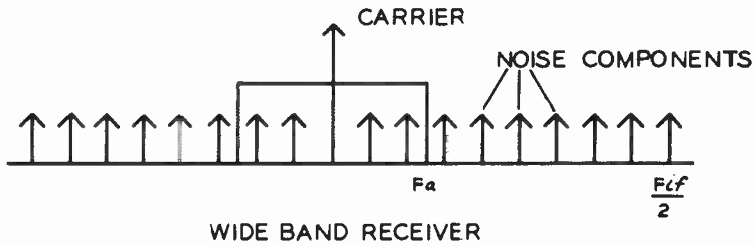
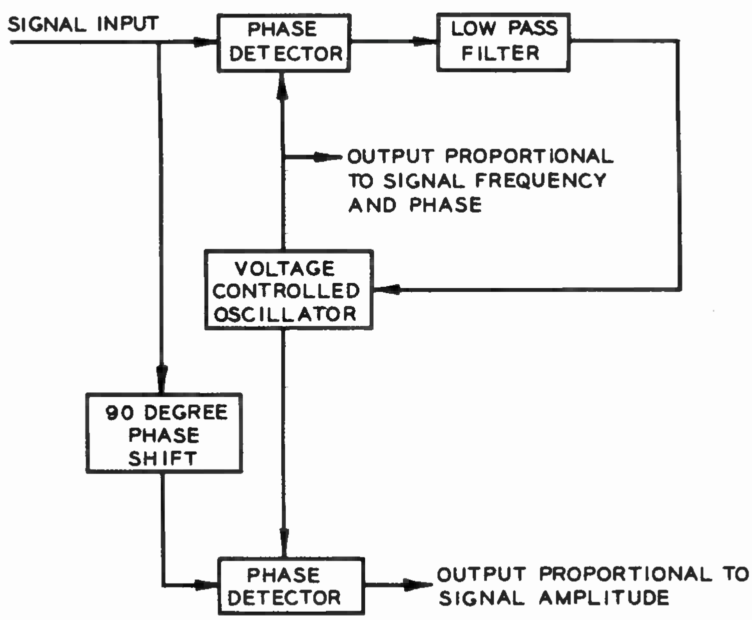


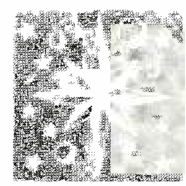
Fig. 3—Carrier and noise components for narrow- and wide-band receivers.

Fig. 4—Phase-locked loop demodulator.



The designer of equipment for use in a satellite is forced to compromise between two major conflicting pressures: on the one hand, the designer would like to be conservative in order to improve the reliability of his system; this is usually done by running components well below their rated maximum values. On the other hand, because most present-day satellites are limited so far as available weight and power are concerned, the designer would like to obtain maximum efficiency from his circuits and to use parts having minimum possible weight; this tends in the opposite direction from the first requirement. In some cases, equipment has been duplicated in the satellite to obtain greater reliability, but as satellites are called upon to go on longer and longer trips, the weight constraint becomes increasingly important, and this means of increasing reliability by duplication of equipment may no longer be allowable.

ATTITUDE STABILIZATION OF AN EARTH-COORDINATE SATELLITE



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THE EARTH-COORDINATE SATELLITE is defined as an orbiting vehicle whose coordinate system is such that one axis is always approximately aligned with the local earth vertical, as shown in Fig. 1, and hence is always facing the same side toward the earth as it traverses its orbit. The moon is an example of an earth-coordinate satellite. Other heavenly bodies stabilized in the same manner include the four innermost moons of Jupiter, which always show the same face toward Jupiter, and the planet Mercury, which always shows the same face toward the sun.

SATELLITE SCANNING

An earth-coordinate satellite is obviously in demand for applications where the earth's surface is to be viewed or scanned by the satellite. A television camera may be placed in the satellite for observing cloud cover for meteorological purposes and, with greater resolution, for observing targets for military reconnaissance. Communications satellites will require antennas which are always directed toward the earth, and proposed manned satellites will require earth-coordinate stabilization.

NEED FOR STABILIZATION

If a satellite could be placed into orbit precisely in the desired attitude and in so doing impart no undesirable torques to the vehicle, and if the satellite's environment while in orbit produced no perturbations or disturbing torques, and if the satellite payload were absolutely quiescent, then the satellite's orientation in orbit would be determined at injection and would remain unchanged. However, there exist external disturbing torques produced by differential radiation pressure from the sun and earth, differential aerodynamic drag due to the earth's atmosphere, bombardment by ions and meteorites, gravitational field gradients, and electric and magnetic fields. Internal torques can be produced by the starting and stopping of instrument motors, the movement of magnetic tape from one storage portion to another, the actuation of relays, and with larger satellites, the movements of personnel. It is therefore apparent that the earth-coordinate satellite will have to be stabilized at all times with respect to attitude with a built-in stabilization system.

STABILIZATION PROBLEMS

The problems involved in stabilizing an earth-coordinate satellite are numerous, but essentially they can be grouped as follows: How will the vehicle be forced to return to its stable position upon being disturbed? How will the energy of the disturbance be removed from the vehicle to reduce oscillation in its motion? What will act as position reference for the system?

Restoring torques can be produced by causing an interaction between the satellite and one of its environmental fields such as the earth's magnetic field and the earth's gravitational field or by inertial reaction utilizing jets or spinning flywheels. Combinations of the above systems may be used. A practical restoring-torque generating system consists of three large-diameter, mutually perpendicular, current-carrying coils attached to the vehicle. A magnetic dipole is thus produced which interacts and aligns itself with the earth's magnetic field. For orbits other than approximately equatorial, the currents must be programmed to compensate for the change in field direction with respect to the orbit. Neglecting anomalies in the earth's dipole field, the program is found to be simple sine and cosine functions of the orbital angle and can be generated by rotating potentiometers at the orbital frequency. Power required for this system is in the order of a few watts.

The *difference in gravitational* pull from the outermost to the innermost side of the satellite produces restoring torques directly about the pitch and roll axes, and indirectly by cross coupling about the yaw or azimuth axis. For ordinary satellite configurations such as the Explorer models and the Sputniks, this effect is very small and is probably much below the level of other disturbing torques. However, if a very-large, massive body is used, say of the order of 20 to 30 feet long and several thousand pounds in weight, restoring torques of sufficient magnitude can be realized. By proportioning the mass so that the moment of inertia about the pitch axis is greater than that about the roll axis, and the moment of inertia about the roll axis is greater than that about the yaw axis, usable restoring torques about all axes are produced.

The *torque about the yaw axis* arises from the cross-coupling that exists between the yaw and roll axes. Consider a disturbance about the yaw axis that produces a yaw rotation of the vehicle. This rotation represents an angular momentum that must be conserved in the absence of external torques. Hence, as the vehicle moves in its orbit the vector representing this momentum tends to remain unchanged in direction with respect to inertial space. At a position along the orbit 90° from the original position, this vector will lie along the roll axis of the vehicle. In this manner, a yaw motion is transferred into a roll motion, and since there is a direct differential gravity restoring torque in roll, this motion will generate a restoring torque. This is the familiar cross-coupling that exists between the two axes of a gyro that are normal to the spin axis. In the satellite case, the spin is the orbital angular velocity.

REACTION-JET SYSTEMS

A straightforward system of producing restoring torque is by the use of reaction jets arranged to produce torques about each vehicle axis. A sensing system initiates a valve or servos the position of a nozzle when-

Fig. 1—Satellite coordinate system.

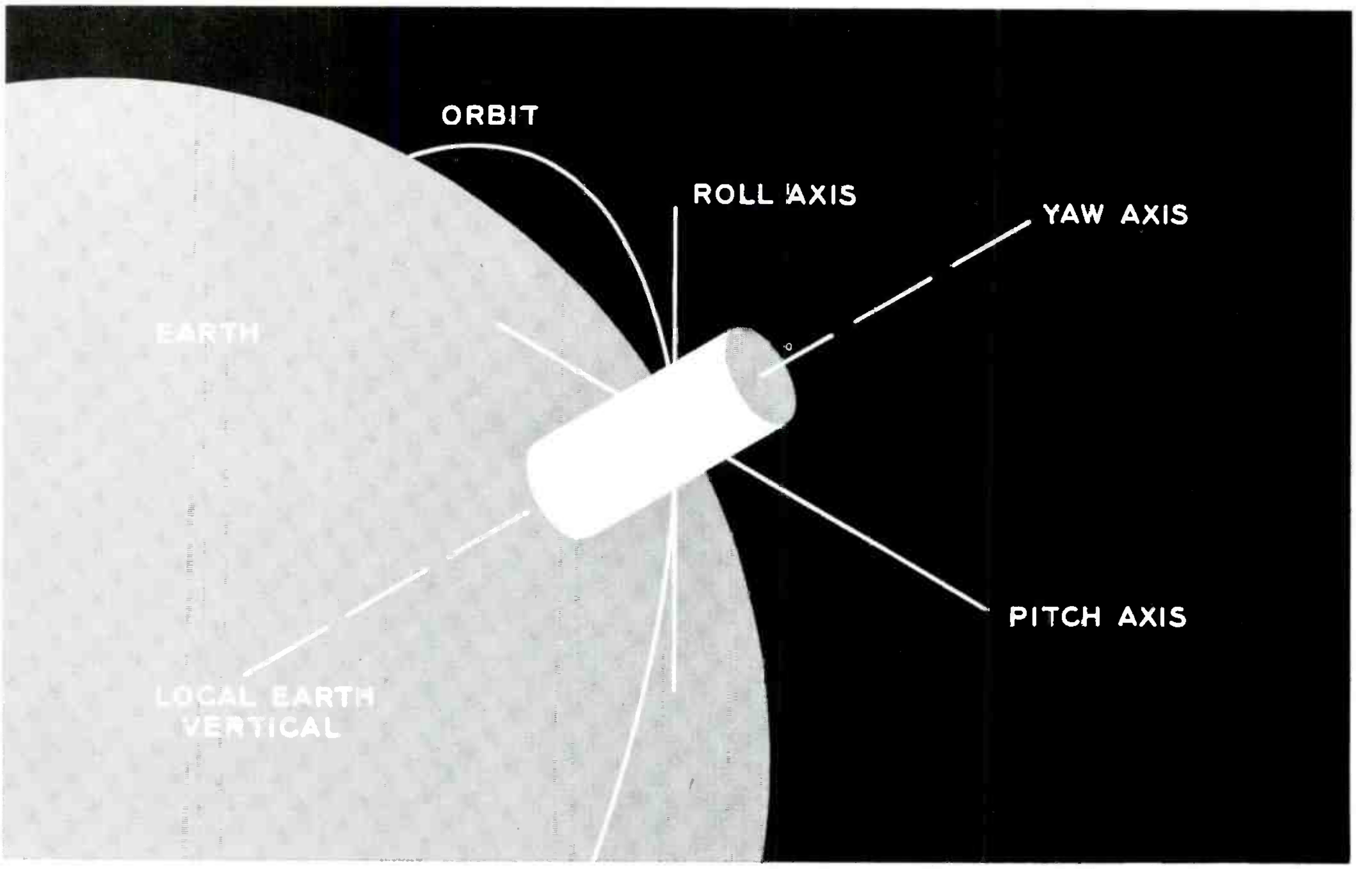
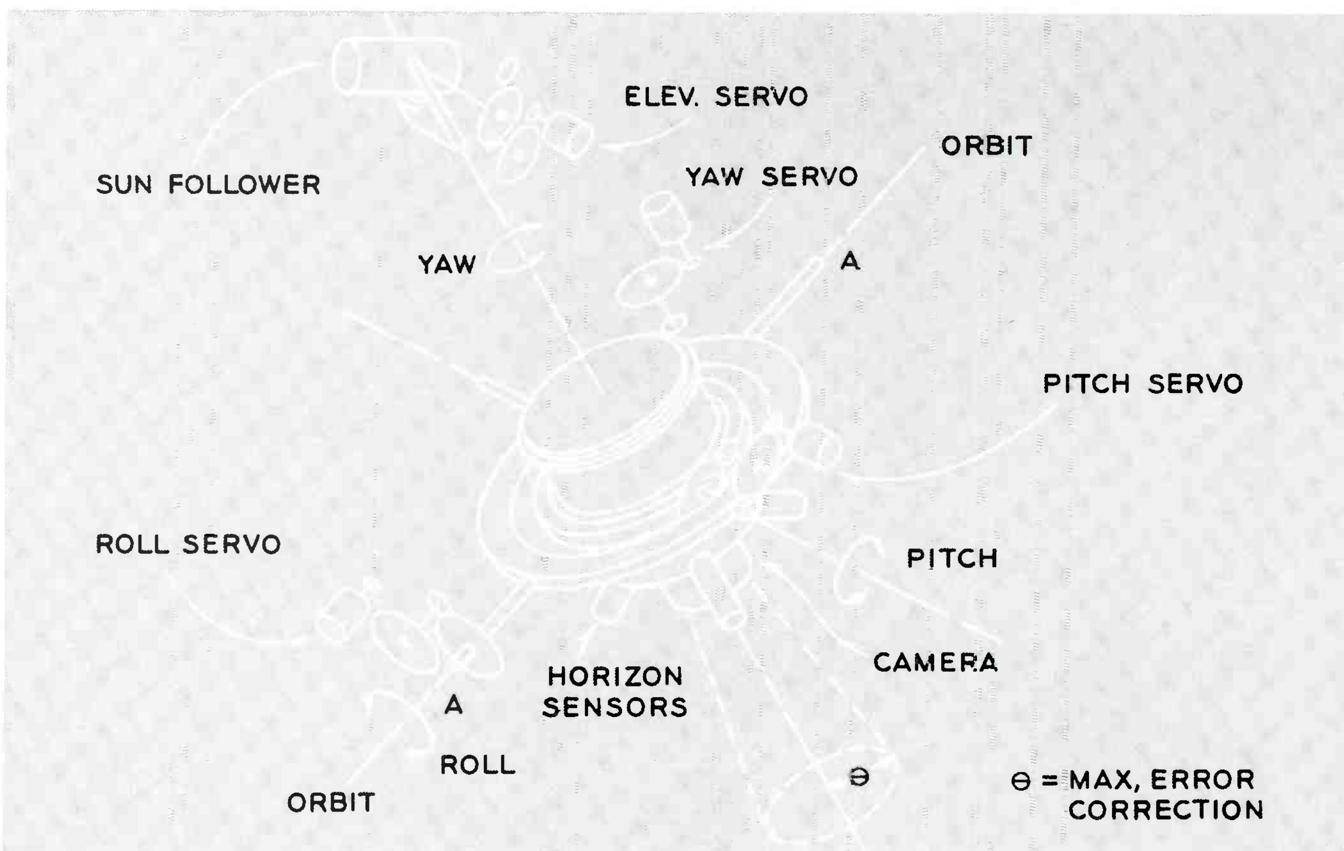


Fig. 2—Reference platform.



ever a displacement of the vehicle takes place as a result of a disturbing torque. By proportionally blasting or pulsing gas in the opposite direction to the displacement, the vehicle is returned to its stable position. A pulse system which actuates when the displacement exceeds the tolerable position error and produces an angular impulse of nearly the exact amount required to "coast" the vehicle back to the stable position has merit, since it is very conservative of propellant, which of course must be carried in the satellite. It should be pointed out here that the natural frequencies encountered in satellite attitude-stability problems are very low and response times are of the order of minutes.

CONTROLLABLE FLYWHEELS

Another inertial reaction system consists of a sensing system similar to that described above, but instead of blasting jets to produce restoring torques, flywheels about each vehicle axis are accelerated or decelerated to produce a reaction on the vehicle. To understand how a system of this type may work, consider a disturbance in pitch on a quiescent vehicle. This will result in a rotation about the pitch axis. The sensing system will start a motor which will spin the pitch flywheel in the opposite direction at such a speed that all the angular momentum of the vehicle is absorbed in the flywheel. At this time, the vehicle will come to rest but will be displaced from its intended orientation. Now if the flywheel is accelerated, the vehicle will be caused to rotate back to its initial position. If braking is applied to the flywheel as the vehicle approaches its intended orientation, both flywheel and vehicle will decelerate, and the vehicle will come to rest at the time when the flywheel angular momentum equals the angular impulse of the disturbance. The energy of the disturbance will have been dissipated in the braking action, and the impulse of the disturbance will be stored in the angular momentum of the flywheel. If the average impulse over longer intervals of time is zero, the average flywheel angular momentum will be zero. However, if there is a finite average impulse about any axis, the flywheel will be required to accelerate and may reach the top speed of the motor, causing the system to saturate. To prevent this, it is proposed that the flywheel system be compounded with a low-thrust jet system. The average jet impulse must then be equal to or greater than the average disturbance impulse. The advantage of this system would be in its ability to absorb high disturbing-torque amplitudes of short duration.

DAMPING

The problem of damping is inherently resolved in the inertial systems above, since the energy of the disturbance is removed in the process of restoring the vehicle to its proper attitude. In the case of jet reaction, the energy of the disturbance is converted to kinetic energy of the propellant and is ejected into space, and as noted above in the case of the reaction flywheels, the energy of the disturbance is dissipated in the brake. However, when electromagnetic or differential gravity restoring-torque systems are used, some separate damping technique must be used. A passive system in the form of a viscous coupling between the vehicle and some other sizable mass within the vehicle may be used. Any motion of the vehicle will cause a relative motion between the vehicle and the viscously coupled mass, and hence, heating will occur in the viscous fluid which represents a conversion of the disturbance energy to heat. By the proper modulation of the current in the restoring coils of the electromagnetic system, an error-rate type of damping can be obtained. Here the energy of oscillation of the vehicle is converted to electrical losses.

Attitude stabilization of earth-coordinate satellites requires a system to produce references which must be sensed from within the vehicle. In the systems which produce restoring torque from environmental fields, the reference problem is inherently resolved. However, anomalies in the fields and uncertainties in the distribution of mass of the vehicle may require that the observational or scanning instrument be gimbaled to obtain the required accuracy, and hence, a separate and more-accurate reference system will be required.

REFERENCE SYSTEMS

For short-term operation, a conventional inertial platform may be used. This platform would have to be torqued to cancel out the orbital angular rate. Excessive drift and high power consumption prohibit the use of this type of system for lifetimes of more than one or two days with existing hardware. More-promising reference systems consist of horizon scanners and sun followers. The former utilizes the infrared radiation of the earth and interpolates between the presence and absence of radiation as the device scans from below the horizon (earth) to above the horizon (space). The sun follower uses visible radiation from the sun in conjunction with photosensitive elements in servo loops to keep a gimbaled system locked onto the position of the sun. The inertial reaction of the vehicle maintains the vehicle position during dark periods of the orbit, or memory can be provided by a short-term inertial platform. Fig. 2 shows an optical reference system which combines a camera for use in cloud-cover satellite applications.

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SOLAR CELLS FOR SPACE VEHICLES

by **S. H. WINKLER**
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FOR SPACE VEHICLES operating in a solar system such as ours, the energy of the sun can be used to produce electricity to power the vehicle's instrumentation, communications equipment, ionic-propulsion rockets, and human comfort conditioning. At present, the simplest method for this conversion employs solar cells.

The output of the solar cell is dependent on the available solar power. Since solar power per unit area varies inversely as the square of the distance from the sun, the cell's ability to produce current will increase as the vehicle travels toward the sun and decrease as it travels away from the sun. And, when the vehicle is shadowed from the sun (as may occur periodically in satellite orbits) the cells are inoperative. Thus, if a current supply is needed greater than that available from the solar cells, or if current is required during the "dark" periods, a storage-battery system is necessary to augment the solar-cell collectors.

COMMERCIAL SOLAR CELLS

The solar cells on the market today consist of a single-crystal silicon wafer on whose upper surface a thin boron diffusion has taken place to form the p-layer. The remainder of the silicon forms the n-layer. At present, the size of cell that gives the best utilization of the material with maximum conversion efficiency and minimum interconnection complexity is 1 cm. wide, 2 cm. long, and 0.4 cm. thick. The cells respond to radiation of 0.4- to 1.1-micron wavelength, which includes all of the visible spectrum plus some of the infrared. Peak response occurs in the region of 0.8 microns.

Solar cells are currently available with solar-conversion efficiencies of the exposed silicon up to ten percent. The available power from the sun at altitudes just outside the earth's atmosphere is 140 milliwatts/sq. cm. With ten-percent-efficient solar cells, this means that 14 milliwatts of electrical energy can be obtained for every square centimeter of cell at 25°C that is oriented normal to the sun's rays. This corresponds to approximately 13 watts/sq. ft. of active silicon. Unfortunately, there are many factors in the design and use of actual solar-cell collectors which reduce the best average available power to 30 percent of this figure, or 4 watts/sq. ft. of collector. With certain collector designs it is possible to achieve only 1 watt/sq. ft. of collector. Some of the factors which influence this reduction are described here.

EQUIVALENT CIRCUIT

A solar cell is represented, for static situations, by the following equivalent circuit: a constant-current generator I_i (which is a function of the light intensity and the spectral distribution) shunted by an ideal diode junction biased in the forward direction, an effective shunt resistance R_{sh}, and a series resistance R_s. For transient response, the cell is also shunted by the transition-region capacitance C_j in series with the built-in junction potential Φ. The diode gives the solar cell the knee in its i-v characteristic. With increasing temperatures, this knee causes the voltage at the maximum power point to be reduced. In addition, the diode causes the value of maximum power output to decrease with rising temperatures.

TEMPERATURE OF CELLS

Silicon solar cells experience an almost linear reduction in power output from their 25°C conversion value at a rate of 0.55% per degree centigrade increase. In other words, a cell which is 10% efficient at 25°C is only 7.25% efficient at 75°C.

When a collector operates over the range of temperatures encountered by space vehicles, there is the problem of selecting the optimum operating voltage per cell. As noted previously, the voltage for peak power shifts with changing temperature. A compromise voltage corresponding to some intermediate temperature must be chosen to minimize the drop-off in efficiency at the temperature extremes.

CELL ORIENTATION TO THE SUN

Since the power output of solar cells essentially follows a cosine relationship, it becomes apparent that the projected area of the collector, taken normal to the sun's rays, determines the power output. Therefore, a flat-plate collector maintained normal to the sun's rays makes the best use of solar cells. The other extreme in collector design would be a sphere, in which the projected area is one-fourth the covered area and hence would require four times the number of solar cells as an equal-diameter oriented disk.

CELL COATINGS

Cell coatings may serve many functions and may: (a) Improve radiative thermal emissivity of cell surfaces in order to cool cells; (b) Protect cells from micrometeorite abrasion; (c) Reflect that portion of the solar spectrum not effective in solar-cell electrical conversion; (d) Protect exposed plastics or adhesives, if any, over cells by reflecting and/or

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absorbing ultraviolet; (e) Provide anti-reflection surface to improve transmission of desired radiation, and (f) Reduce surface recombination of hole-electron pairs on silicon surface.

While performing some or all of these functions, the coatings must retain one significant parameter at a high value: overall transmissivity to the 0.4- to 1.1-micron-wavelength radiation to which the cells are sensitive. This transmissivity reduces cell output 5% to 15%.

MICROMETEORITE DUST AND ELECTROMAGNETIC AND PARTICLE RADIATION

The effect of these bombardments is assumed to be a deterioration of the cell and/or coating surface that levels out after a period of time to produce a net drop of 20% in cell output. RCA-AEP has had simulated micrometeorite tests run on cells and coatings at The Stanford Research Institute's high-velocity test facility.

SERIES-PARALLEL CELL INTERCONNECTION ARRANGEMENT

Solar cell arrays are fabricated from "shingles" consisting of five solar cells soldered in series. Three to six shingles are connected in "series strings," which in turn are combined in groups of three to five to form a module. Modules are paralleled to form the array.

Since the peak efficiency of solar cells is at the operating voltages between 0.33 and 0.42 volt, it is necessary to series-connect approximately

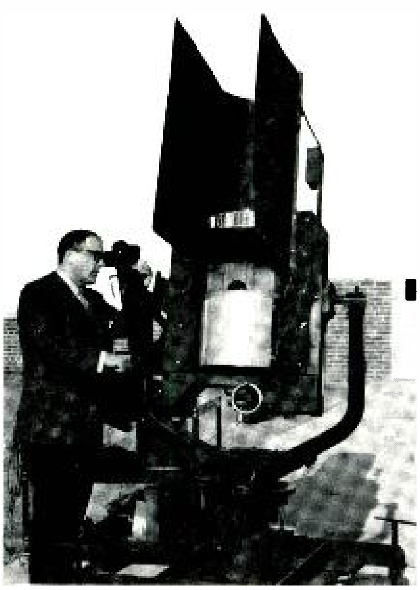


Fig. 2—The author using the sun-tracking, equatorially mounted, solar-collector test rig.

70 to 90 cells to give, for example, 27.5 volts. However, since a malfunction of any one cell in a series string would knock out the entire string, it is desirable to make parallel connections between strings and modules for reliability. There must be approximately twenty parallel paths for each string in which a cell may open, because each string is capable of handling no more than approximately 5% excess current over its design (peak efficiency) operating point. It is essential that all cells in a given series string be equally illuminated because one poorly illuminated cell would limit the current of the entire string. Hence, for a 27.5-volt system, RCA-AEP has developed a compact, flat, printed - circuit - type module board which contains the full 70 to 90 cells in series, with appropriate paralleling tabs to the other boards in the total collector. All the cells in each such board will have the same illumination because they are in one plane. The results of multiple interconnections have been studied and the losses can be made almost negligible if special attention is paid to matching of the current-voltage characteristics of the individual modules in an array. RCA-AEP has developed an indoor solar-radiation simulator for testing individual cells, shingles, modules, and arrays (see Fig. 1). There also is in use at RCA-AEP a sun-tracking, equatorially mounted, solar-collector tester (see Fig. 2) which permits measurements on single cells, shingles, modules, and cylindrical and plane arrays at various angles of solar-radiation incidence. This unit can be used in the sunlight, or in conjunction with a carbon-arc source now being built.

STORAGE SYSTEM EFFICIENCY

The electrical storage systems currently available consist of rechargeable chemical storage batteries. The two most-promising types are the nickel-cadmium and the silver-cadmium batteries. Although the silver-cadmium batteries have the superior energy-per-unit-volume and energy-per-weight properties, they are not at present developed in a hermetically sealed, ventless configuration. The energy-storage and delivery-cycle efficiencies are comparable and in the order of 75%. The advantages of the

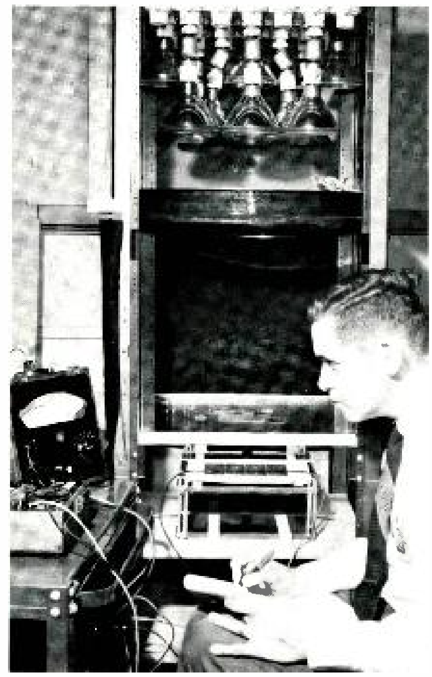


Fig. 1—P. Wiener works with solar-illumination simulator being used here to test electrical output of a module of 80 solar cells.

nickel-cadmium types are that they are presently being produced in hermetically sealed containers to obviate vacuum and electrolyte problems; they have the best demonstrated cycle life; they can be charged at a rate to bring them from discharge to full charge in one hour, without damage or leakage. RCA-AEP has conducted extensive tests on storage batteries. It is felt at this time that it is important to keep the battery temperature between 0° and 60°C because of their efficiency and voltage fall-off characteristics.

SHADOWS

Solar-cell collectors, when illuminated but subjected to shadows such as might be cast by the vehicle antennas or other protuberances, suffer a loss in output which may be greater than the percentage of collector area shadowed. This is because the result of a shadow on a solar cell is effectively to make the proportion shadowed an open circuit. Hence, if only one cell in a series group is shadowed, the current output of the entire group is reduced by that proportion of the shadowed cell which is dark. Studies conducted at RCA-AEP show that areas rendered ineffective by shadows average between three and ten times the area actually shadowed. Modifica-

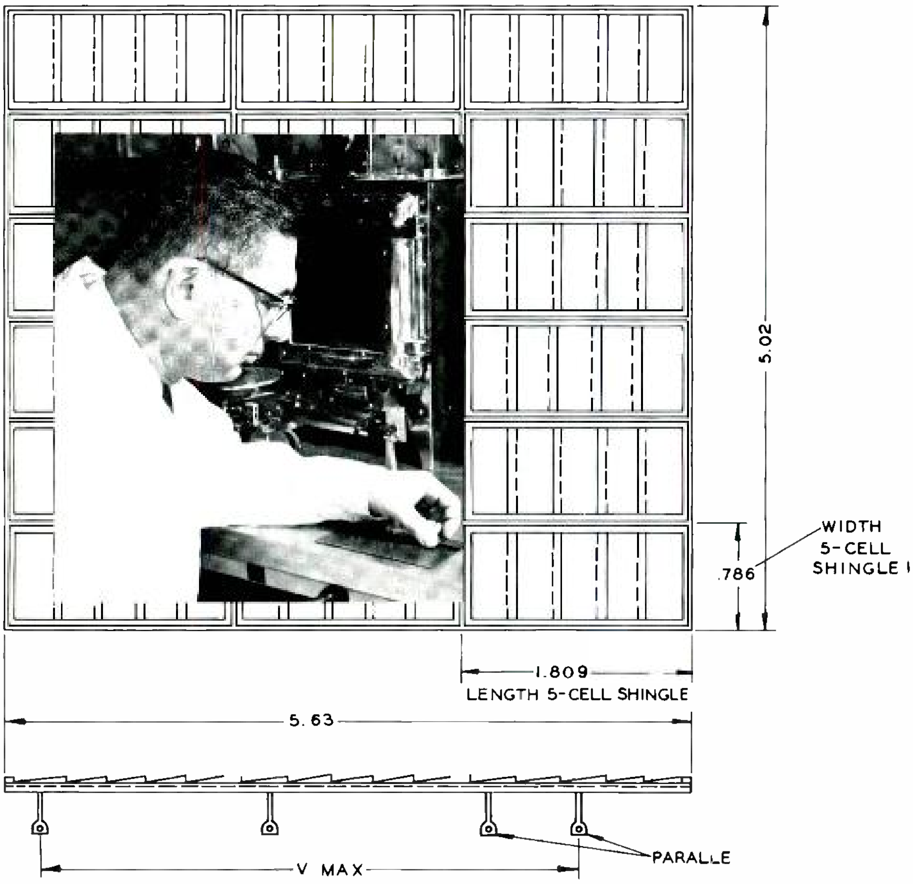


Fig. 3—Sketch showing layout of a 90-cell module made up of 18 five-cell shingles. In the photo, O. Gosman assembles a similar module.

tion of the series-paralleling to give fewer cells in series improves the situation.

VOLTAGE REGULATORS

These may be required, if the regulation that a storage battery system provides is insufficient for the loads. Losses may be 15 to 20%.

ILLUMINATION TIME

The number of cells must be increased to allow for the portion of the satellite's orbit time which is unilluminated. Since many instrumentation systems require voltages of, say, 30 volts, it is obvious that many solar cells must be placed in series. If temperature considerations indicate that the voltage for optimum power output from each solar cell is 0.33, it appears that the number of cells in series must be $30 \div 0.33 = 90$ cells. We have designed module boards which contain 90 cells in series (see Fig. 3), and include imbedded printed circuitry and paralleling tabs.

Each solar cell of the type commercially available is a 1-by-2-cm. silicon rectangle, with a metallic 0.1-by-2-cm. positive collector strip. This positive strip represents a 10% loss in active silicon area on a single cell collector. Hence, a "shingling" process is used which eliminates this dead area in all but the last cell of a shingled assembly (see Fig. 4). Our printed circuit board module shows 18 five-cell shingles. On a collector assembly, many such 90-cell modules are connected in parallel to deliver the required current.

SOLAR CELL COATINGS

The packaging of solar-cell collectors includes providing the aforementioned coatings on the cell surfaces. The most important reason for the coatings is the thermal one. In order to keep the cells as cool as possible, it is necessary to provide a surface which has a high emissivity to thermal radiation, at the temperature we desire the cells to reach. This means high emissivity in the far infrared, peaking at 10-microns wavelength. The reason for the coating is that the silicon has an emissivity of only 0.3 to 0.5 at these spectral regions. With these values, the solar cells would reach intolerably high temperatures. The coating desired will boost the emissivity to 0.8 to 0.9, which drops operating temperatures to the acceptable range of, say, 0° to 60°C. Such coatings fall into three classes: sprayed plastic, vacuum-deposited inorganic materials, or bonded plates of glass.

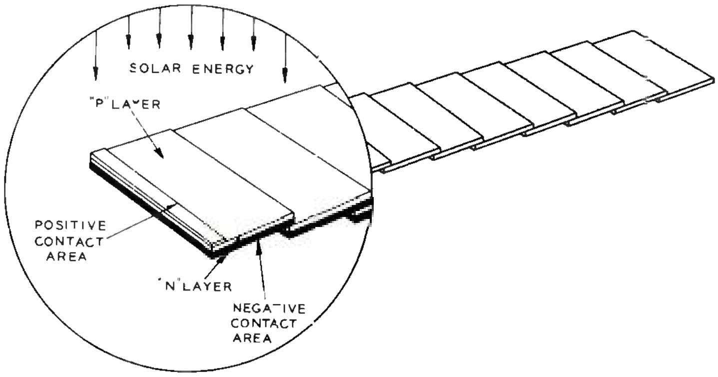
The sprayed plastic, such as a relatively stable transparent epoxy, would be the simplest and cheapest method. However, there are unknowns in the behavior of plastics in the high vacuum and radiation environments of outer space. Such coatings might become opaque or might boil off.

The vacuum-deposited coatings offer high promise, but must be developed to boost their transmission of the visible spectrum (plus 0.4 to 1.1 microns) to which solar cells electrically respond.

The bonded-glass-plate method is cumbersome and expensive, but is currently available with acceptable transmission properties and can include optical anti-reflection coatings that improve transmission of the peak-response (0.8-micron) wavelengths. It can also include multilayer reflection coatings that can reject the ultraviolet to increase cooling and protect the organic adhesive.

In conclusion, it is not advisable to run out and purchase some solar cells to power your household; an oriented collector generating 300 watts and using 12%-efficient solar cells at $11.00 each costs $259,000 for the solar cells alone.

Fig. 4—Example of a shingled assembly, showing a magnified view of cell construction.



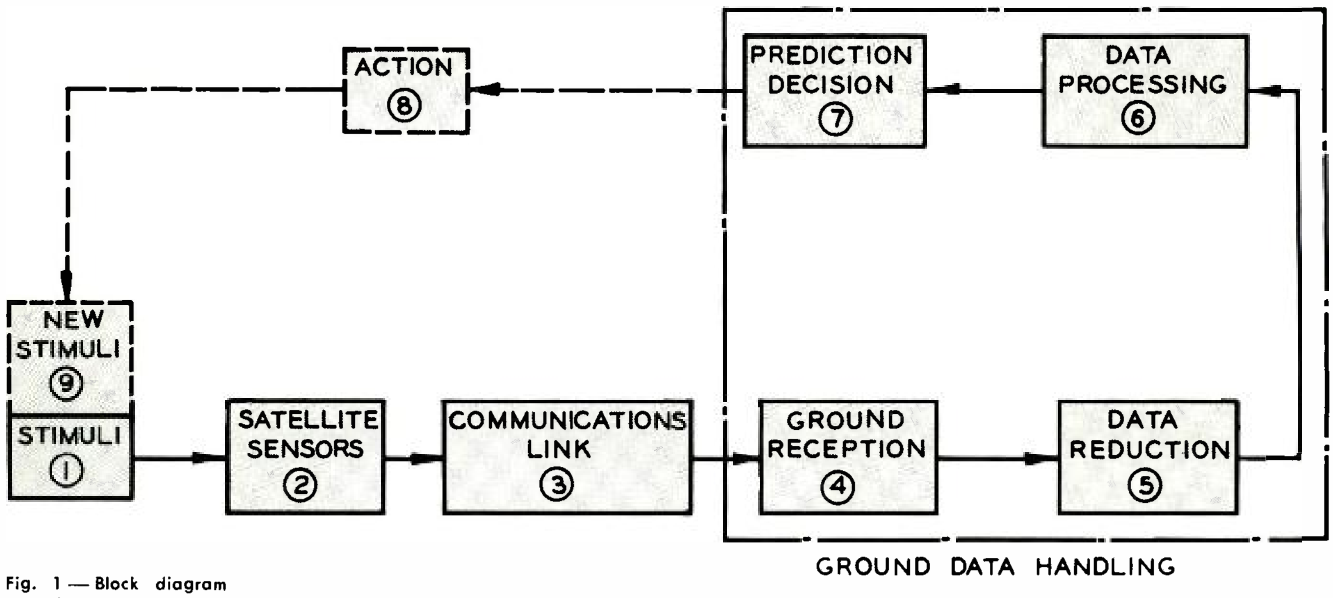


Fig. 1 — Block diagram of active satellite system.

GROUND DATA HANDLING FOR SATELLITE SYSTEMS

By **J. LEHMANN**
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THE TASK OF HANDLING data received from a satellite can range from a fairly trivial job to a very complex undertaking. When satellites are of the passive type such as a satellite communications relay, handling of data on the ground will be performed by well-known methods and equipment. Satellites containing active sensors present an entirely different and new problem, and it is with this type of "active satellite" that we are now concerned.

THE SATELLITE SYSTEM

A block diagram of an active satellite system is presented in Fig. 1. The block called "stimuli" at the lower left corresponds to the indicators that will activate the particular sensors carried on the satellite. If it carries a TV camera, for instance, the stimulus would be the reflected and emitted visible light from the objects that are scanned by the TV camera. For a satellite carrying infrared receptors, the stimuli would be the reflected and emitted IR radiation. The information gathered by the satellite sensors will be transmitted from the satellite to the earth through a communications link indicated in block 3 of the diagram. Blocks 4 through 7 correspond to the operations to be performed by the ground data-handling equipment.

DATA HANDLING PROBLEMS

Data is received in the most convenient form to satisfy both the satellite requirements as well as the requirements of the succeeding data reduction and processing operations. Data reduction indicated in block 5 is an editing operation which reduces the information to a form that can best be used by the data processor. In the case of pictorial data obtained from a TV camera, for instance, pictures must be identified as to time and location and orientation of the camera to be properly processed in the next step, shown in block 6. Both the data reduction and data processing are geared and implemented for the particular mission assigned to the satellite system. The data-processing operation will result in a fact, a prediction, or a decision—or possibly all three. A decision can generate an action indicated in block 8 and result, perhaps, in a new stimulus, thereby closing the loop of information flow. An example—hypothetical at this time—would be the discovery of an atmospheric disturbance through a meteorological earth satellite and the dispersion of that disturbance through some means like cloud seeding. For the near future, it is probable that the data flow will terminate at block 8, where a state-

ment of fact or prediction will be the end result of the information detected by the satellite sensor.

Let us consider the case of a satellite equipped with a TV camera. Pictures obtained in this manner will appear somewhat different from any conventional pictures with which the user might be familiar. The limited resolution due to the line structure and the need for large coverage complicate the problem of identification and interpretation. The number of pictures that can be obtained is large and is limited mainly by the power available in the satellite and the bandwidth required for transmitting the video information to the ground.

These two main points—the different character and the possible very large amount of pictorial data—are problems to be considered in the ground handling of satellite data. While the discussion of the satellite-system block diagram can be applied to almost all satellite sensors, the following paragraphs will be concerned with handling of pictorial data exclusively.

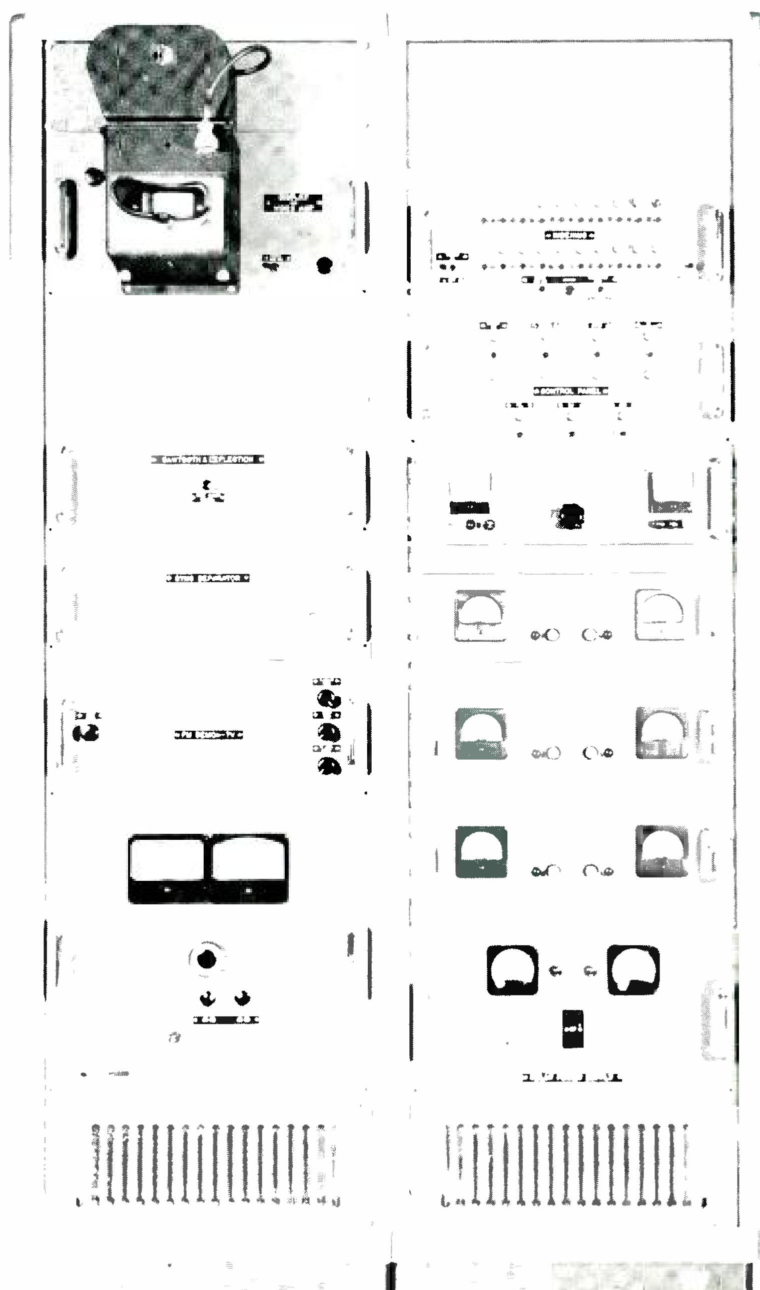
INSTRUMENTATION FOR VIDEO RECEPTION AND DATA REDUCTION

Receiver and Indexing. When pictures are to be obtained from satellites, one must know when, where, and how the pictures were taken to obtain useful information from the pictorial data. Satellite orbits can be computed very accurately, and the position of the satellites can be determined precisely as a function of time. Necessary also is a knowledge of the direction of the axis of the optical system projecting the images on the image-sensing device.

In addition, in the case of spinning satellites, the orientation of the image-sensing device about the optical axis must be ascertained to properly orient the pictures once relayed to the earth. Fig. 2 shows a TV receiver equipped with a recording camera (upper left) especially developed for the reception of satellite pictures. Included in the field of view of the recording camera are series of index lights from which the picture parameters (time, orientation, location) can be determined by referring to the orbital data. The process of recording the picture on film and actuating the index lights is completely automatic upon reception of the proper signals from the satellite.

Picture Rectification. Pictures received from satellites could possibly be located by recognizing surface features; however, this is not always feasible. For example, in the case of

Fig. 2—TV receiver equipped with recording camera (upper left) for reception of pictures from satellites.



JULES LEHMANN was graduated from the Optical Institute in Paris, France in 1935 with the degree of Optical Engineer, and from the University of Paris in 1937 with the degree of Licencie en Sciences (MS) in physics. From 1937 to 1939 he was an assistant in the Laboratories of the University of Paris. From 1939 to 1942 he was a development engineer in the S.A. de Tele-communications in Paris and Montlucon (France) where he was working on carrier telephone equipment.

Mr. Lehmann came to the United States in October 1942, and he served with the American Army from 1943 until 1945. He joined RCA Laboratories in July 1946 as a research engineer engaged in systems design of analog computers and feedback mechanisms. Mr. Lehmann joined Astro-Electronic Products when it was formed, and performed system research in the field of magnetic memory devices. He later became supervisor of satellite data analysis and synthesis groups, and is now Manager, Information Handling. Mr. Lehmann is a member of Sigma Xi.

viewing the earth's surface, cloud formations can completely obliterate such check points. As pointed out in the preceding paragraph, picture parameters (time, location, orientation) can be determined from orbit parameters in mathematical terms. The device shown in diagram form in Fig. 3 will make it possible to locate and orient pictures properly as well as rectify geometric distortion due to oblique attitude angles of the optical axis with respect to the surface.

Pictures obtained from the ground TV receiver are projected on a diffusing screen from a projector in a three-axis gimbal mount at the right. Also projected on the diffusing screen is the image of a reference-grid globe shown at the left. For observing the earth's surface, for instance, the operation of the device is as follows:

There are six parameters corresponding to the six degrees of freedom of the satellite. The first three establish the position of the satellite with respect to the earth: altitude, latitude, and longitude of the satellite sub-point. These parameters are adjusted by sliding the gimbal-mounted projector perpendicular to the screen (altitude) and by rotating the reference globe about two perpendicular axes (latitude and longitude). The three angle parameters of the satellite establish the location of the optical axis trace on the earth's surface and the orientation of the picture about the optical axis. These three angles are adjusted by rotating the projector about the three gimbal-mount axes. Dimensions of the components of this analog device are such that the pictures projected on the screen will recreate the area seen by the satellite camera and will locate this area by superimposing the picture of the reference globe. A recording of this projection on the screen will be obtained from a camera located at the center of curvature of the screen. A picture so obtained is a gnomonic projection of the earth's surface onto a plane tangent to the earth at the satellite sub-point. The rectified pictures provided with geographic coordinates will constitute the input material for the data processing operation.

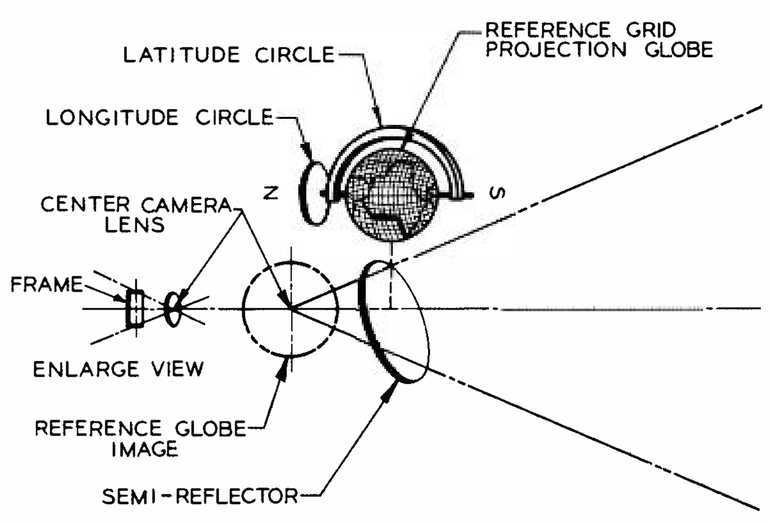
STUDY PROGRAM WITH RCA IMAGERY SIMULATOR

The use of pictorial data obtained from satellites for various purposes has been contemplated for some time. From the start it was apparent that the nature of such visual data should be studied before actual satellites were utilized. This was one of the main reasons why RCA undertook the construction of an imagery simulator. This device described below makes it possible to simulate satellite pictures by processing aerial photography or similar material through the simulator.

Simulated pictorial information is used as study material for engineers and in training programs for users. The engineers have to determine design specifications for the sensors and associated apparatus on the basis of the requirements of the user. The user in turn has to learn to interpret pictorial data with limited resolution and a given signal-to-noise ratio. Interpretation of pictorial data is a subjective process, and tests have to be conducted on a statistical basis to obtain valid results. Tests such as the following are applicable to a number of pictorial data-handling systems.

Conventional pictorial material is processed through the imagery simulator, resulting in pictures of a given resolution, contrast, and signal-to-noise ratio. The pictures are submitted to a number of interpreters whose task it is to identify certain features and to infer meanings. In the second part of the test, the interpreters are shown the original photography and associated data. The interpreters have to study a reason-

Fig. 3—Oblique-view picture-rectification equipment.



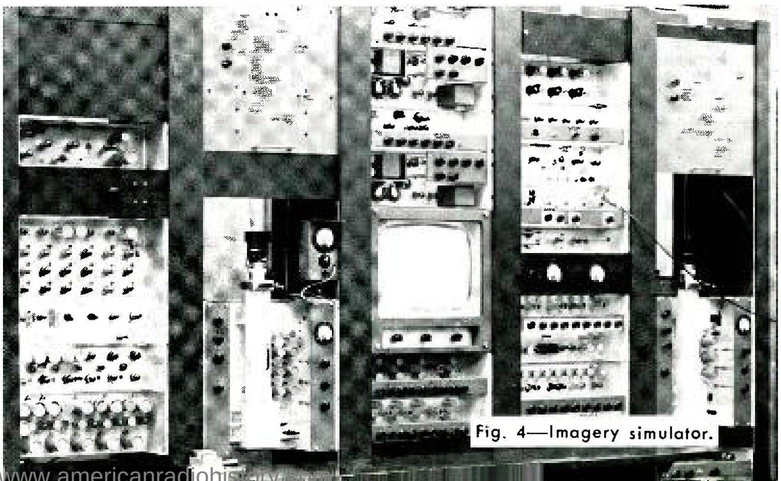


Fig. 4—Imagery simulator.

able number of pictures to become proficient in picture reading and picture interpretation. Results obtained from these tests feed back to the engineer who now has a sort of transfer function from specific design parameters of a pictorial system to the information content of the data produced by the system. These results also make it possible to assign a "price tag" for specific requirements of the user by determining the necessary resolution, the bandwidth, the transmitter power, and the receiving-antenna size.

Abstracting information from pictorial data obtained from the satellite is the first operation of the data processing shown in block 6 of Fig. 1. Training sessions using simulated data will help the interpreters to analyze satellite data. One important problem, however, has been mentioned only briefly: the large amount of data to be received from the satellite and the correlation of this with information obtained from other sources. Work of this type, classified generally under "information handling" is presently being pursued at AEP.

IMAGERY SIMULATOR

Fig. 4 is a photograph of the imagery simulator. Pictures are presented to the simulator in the form of 35-mm transparencies. A high-resolution, flying-spot scanner followed by a photomultiplier transform the picture into electronic video signals. This video information is amplified and shaped in a number of steps, and the resulting TV image is presented on a monitor. The picture so obtained can be observed directly or may be photographed and studied in a remote location.

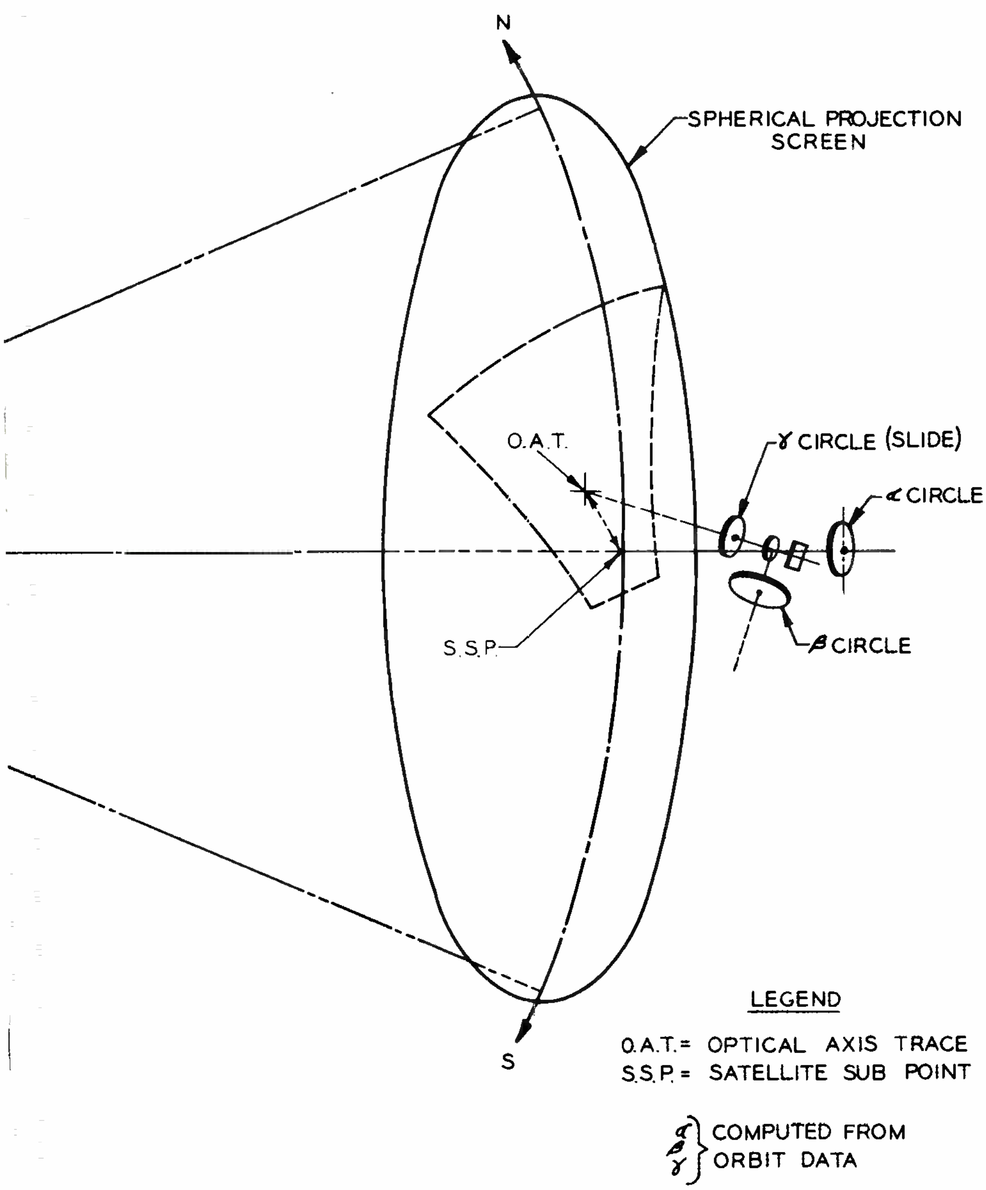
The equipment making up the simulator is designed to enable the user to vary the picture parameters over a wide range. The number of horizontal scanning lines can be varied from a maximum of 1,024 to 128 lines per frame. Cut-off frequencies of the amplifiers in the chain can be varied from a maximum of 20 mc down to 2 mc and potentially even lower. Filter characteristics, phosphor compensation, and gamma corrections can be varied in prescribed fashion by direct adjustments and plug-in units.

Included in the TV chain is a provision for introducing controlled noise into the video information. Random noise generated by a photomultiplier tube can be used directly or filtered; transmission characteristics of the noise filters may be selected and inserted with plug-in elements.

A microphotometer with automatic scanning and recording is used to test and calibrate the transmission characteristic of any simulator setup. By using the proper test slides, the equipment can plot automatically the aperture response of a complete system. It is used also in the measurement and calibration of noise of the complete system under simulation. In summary, the microphotometer is a metering facility that enables the user to specify completely the parameters of the TV system under simulation.

The following features have been included to help in the interpretation of pictorial data. Pictures can be differentiated in the horizontal direction resulting in outline drawing type pictures. A gamma-slicer can select any small portion of the gray scale and expand it to the full black and white range. The latest feature that has been added is a circuit that can generate a black or white outline for any selected gray level.

The equipment making up the simulator was constructed in Princeton, New Jersey by AEP engineers. Dr. Otto Schade of Harrison, New Jersey has contributed extensively to the development of the facility through his consulting services.



"OPERATION LEADERSHIP"

DURING FEBRUARY RCA's four hundred engineering managers were given the opportunity to observe personally and to evaluate some of the factors that contribute to successful leadership. This was accomplished during Management Seminar No. II which was led by the National Training Laboratories of Washington, D. C., a widely recognized advisory training group which uses modern principles of training by introspection.

Managers were grouped into four separate contingents consisting of one-hundred managers per group, each scheduled to participate in a different three day session. These groups were then further sub-divided into six or more experimental workshops ("E groups") each having about twelve to fifteen engineering managers from all Divisions throughout RCA. Each group was led by one of the representatives from the National Training Laboratories in addition to one RCA representative from the Manager's Seminar Program Committee.

At these sessions, the engineering managers had a chance to see co-operative group effort in action; they had a chance to see decision-making carried out in a way that encompassed the full agreement of everyone; they had a chance to "see ourselves as others see us"; and they had an opportunity to turn human relations theories into action. Whether or not each increased his self-awareness or obtained a better look at leadership is a matter for each to judge. Many post-session comments heard were favorable, particularly after the managers had a chance later to reflect back on their experiences. Photographs are included here to show the "E groups" in action. Credit for arranging and carrying out the Seminar II training sessions, with skits and "E group" activities goes to Patrick C. Farbro, Manager, Professional Personnel Programs, RCA Staff, R. F. Maddocks, Administrator, Training, RCA Staff, and L. H. Good, Director of Engineering Utilization, Product Engineering. These men directed the program using the resources of the representatives from the National Training Laboratories of Washington, D. C.

"OPERATION LEADERSHIP" Program and Training Committee — Standing (l to r) Dr. Gilbert K. Krulee (Case Institute of Technology), W. J. Underwood (Training Manager, Moorestown), Lowell H. Good (Director, Engineering Utilization), George J. Bader (Administrator, Personnel Practices, IEP), Seated (l to r) John M. Cook (Administrator, Personnel Research RCA Staff), Robert F. Maddocks (Administrator, Training RCA Staff), J. Tabor Bolden (Training Instructor Specialist, Camden Plant), Dr. Herbert Thelen (University of Chicago), Dr. Donald C. Klein (Human Relations Service of Wellesley Incorporated), Robert C. Vandivier (National Training Laboratories, National Education Association), Dr. Willard W. Blaesser (University of Utah), Dr. Gilbert Brighouse (UCLA). P. C. Farbro, Mgr., Professional Personnel Programs is missing from the picture.

WORKSHOP "E" GROUP #6—(l to r) W. M. Patterson (DEP Camden), L. Smith (Semiconductors), A. J. Torre (TV-RV Divisions), R. F. Maddocks (Personnel), M. E. Hawley (DEP Moorestown), R. C. Vandivier (National Training Labs), C. E. Moore (IEP Camden), W. M. Pease (DEP Burlington), A. D. Zappacosta (DEP Camden), B. T. Svihel (DEP Camden), and H. V. Knauf (Tubes Harrison).

Part of the "E Group" Activity

WORKSHOP "E" GROUP #3—(clockwise starting at lower l-h corner) D. D. Van Ormer (Tubes), C. L. Sharp (DEP), N. E. Hjorth (DEP Moorestown), R. Whempner (DEP Camden), D. W. Bantle (DEP Moorestown), H. M. Elliott (IEP), G. H. Goodman (DEP Camden), E. S. West (DEP Moorestown), C. W. Steeg (DEP Burlington), J. W. Vick Roy (DEP Camden), C. W. Hoyt (RV-TV), W. B. Harris (DEP Camden), N. E. Edwards (IEP), I. D. Kruger (DEP Moorestown), R. D. Faulkner (Semiconductors), J. J. Rahn (DEP Burlington), G. K. Krulee (Case Institute of Technology), and S. L. Simon (DEP Burlington).

View of one of the "general session" meetings which preceded the smaller "workshop" group sessions.

DEVELOPMENTAL STATUS OF PARAMETRIC AMPLIFIERS*

by
WEN YUAN PAN
RCA Victor Television Division
Cherry Hill, N. J.

POTENTIALLY, THE PARAMETRIC amplifier possesses low noise and other desirable characteristics for operation at any frequency from the high microwave region down to very low frequencies. In the simplest form it comprises a nonlinear reactance device, a pump oscillator and associated resonant circuits. During the past two years the development of parametric amplifiers has progressed to assume the role of major competition to the maser. This progress is now approaching the stage where designers of various electronic systems and products begin to recognize its potential applications, particularly to systems and products which must work into a high noise-temperature background.

HISTORICAL REVIEW

The basic theory of parametric amplification stemmed from Lord Rayleigh's argument some 75 years ago that free oscillation could be sustained in a resonant system when one storage element drew energy from an external source. Hartley substantiated this concept in 1916 by analyzing the reaction of currents of different frequencies on one another in a nonlinear reactance device. He concluded that the flow of current out of the device at the difference frequency introduced a positive resistance into the high-frequency source but a negative resistance into the low-frequency source, and that the high-frequency source supplied much greater power to the device.

Recently, Manley and Rowe[1] extended the early work and established the conditions under which parametric amplifiers might exhibit power gains.

CONDITIONS FOR POWER GAINS

For simplicity, let's first consider a synchronous parametric amplifier, where the pump frequency (f_p) is twice the signal frequency (f_s), or $f_p = 2 f_s$. As shown in Fig. 1, a variable capacitance diode is used for the nonlinear reactance device. The diode capacitance (C_d) is a function[2] of its developed instantaneous voltage, the sum of the pump voltage E_p sin ($\omega_p t + \theta_p$) and the signal voltage E_s sin ($\omega_s t + \theta_s$). Since $|E_p| \gg |E_s|$, C_d varies sinusoidally with time at the rate of f_p and at the expense of power supplied by the pump oscillator. When the phases θ_p and θ_s are such that C_d becomes minimum at $\omega_s t + \theta_s = \frac{1}{2} n\pi$, where n is an odd integer, the amplitude of the signal increases with time. This condition is analogous to the case of "Johnny on the swing." He pumps energy to the peddle at the right instants at a rate twice the frequency of the swing; the swing amplitude builds up until Johnny stops pumping.

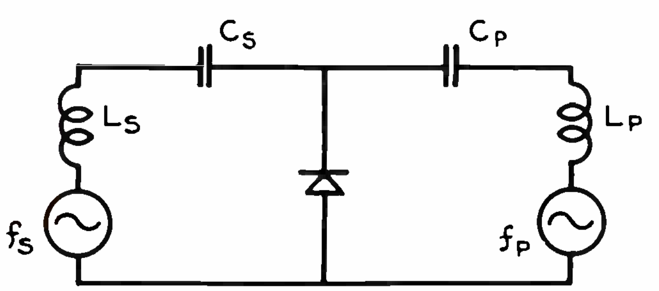


Fig. 1—Synchronous Parametric Amplifier, fp = 2fs.

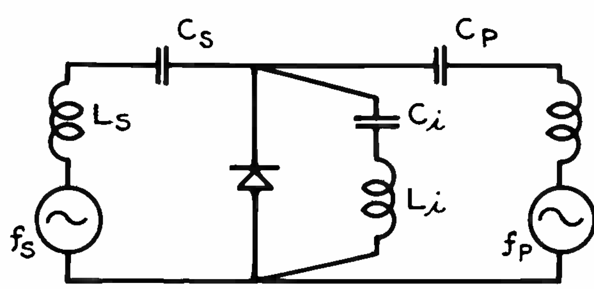


Fig. 2—Generalized Parametric Amplifier

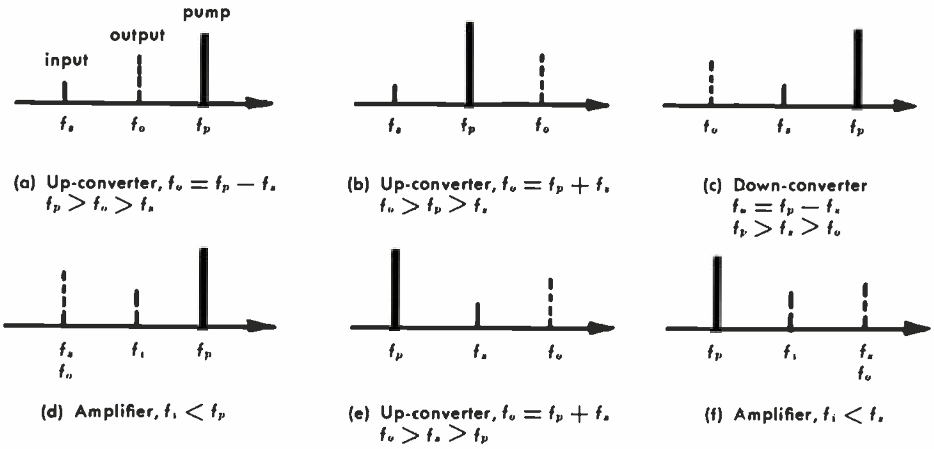
In the generalized case of Fig. 2, an idling circuit consisting of C_i and L_i is added to the amplifier which is resonant at the idling frequency (f_i), where $f_i = f_p \pm f_s$ or $f_s \pm f_p$. Under this condition, the nonlinear device absorbs power from the pump oscillator and delivers power to the signal source if only the signal circuit (C_s and L_s) is initially excited. The excitation of the idling circuit results only through the action of the pump. For this reason the signal will be set up in the proper phase automatically, any tendency to set up the opposite phase being damped out. By the same reasoning, power gain can be secured by taking the output at f_i, where $f_i \neq f_s$.[3,4,5] Let the frequency of the output signal be f_o; then when $f_o > f_s$ the parametric amplifier is known as an up-converter, and when $f_o < f_s$ it is known as a down-converter.

More specifically, power gains are possible in parametric amplifiers operated according to the relations indicated in Fig. 3a to Fig. 3f inclusive. The amount of power gain depends on operating conditions. With the exception of the up-converters shown in Figs. (3b) and (3e), the other configurations of parametric amplifiers and converters are regenerative. For these cases, very high regenerative gains may be obtained, but accompanied by narrow bandwidth and instability. Techniques of controlling the operation of these configurations are yet to be developed.

NOISE CONSIDERATIONS

Owing to the absence of shot and partition noises,[6] the noise contribution of parametric amplifiers approaches the Johnson thermal noise. Since all nonlinear reactance devices dissipate some power, a noise factor of 0 db can never be realized at room temperature. Carefully designed parametric amplifiers and converters have shown noise factors in the range of 1 to 6 db at fre-

*This paper has been requested by the editors of the RCA ENGINEER to provide a background on this subject for those who are not currently engaged in work related to parametric amplifiers.



Figs. 3 (a to f)—Parametric Amplifiers exhibiting power gains.

quencies between 200 mc and 10 kmc, according to Nergaard, Bloom and Chang of RCA, Wade and Heffner[7] of Stanford University, Engelbrecht[8] and Uenohara[9] of the Bell Telephone Laboratories, and others.

Wave transmission through space at frequencies below 200 mc is masked by the effect of galactic noise, while at frequencies above 10 kmc is attenuated by atmospheric absorption. Parametric amplifiers seem to be operable satisfactorily throughout the most favorable frequency band from the standpoint of system noise factor, using either variable capacitance diodes or ferromagnetic materials.

To realize the low-noise characteristic of parametric amplifiers and down-converters, care must be exercised to nullify the coupling of the noise in the load to the signal source. In either operation, amplifier or down-converter as shown in Fig. 4, the Johnson thermal noise of the load resistance is also amplified parametrically. Because of the two-terminal configuration of this amplifier or down-converter, this amplified noise in the load also appears at the input terminals, which may dominate the noise contribution of the stage. One method of accomplishing this objective is the use of an isolator connected between the input source and the load. This isolator transmits the signal from the amplifier or down-converter to the load, but attenuates the noise from the load to the signal source. In up-converters the noise of the load resistance is not amplified; therefore, no isolator or equivalent network is required.

BANDWIDTH LIMITATION

Excluding the use of traveling-wave and other elaborate techniques, parametric amplifiers and converters have been reported to have a bandwidth in the order of 0.1% of the signal frequency.[7,9,10] For television and high-speed computer applications, broader bandwidth is mandatory, preferably with relatively simple circuit elements. Wasson, of the Television Division, an associate of the writer, proposed the multiple-tuned configurations such as illustrated in Figs. 5(a) and 5 (b), whereby bandwidths as much as 5% have been observed with substantial power gains. Schlegelmilch, another associate of the writer, measured less than 3 db noise factors at very high frequencies (vhf) with broad-band up-converters.

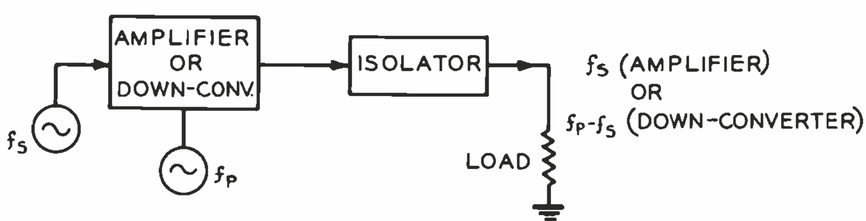
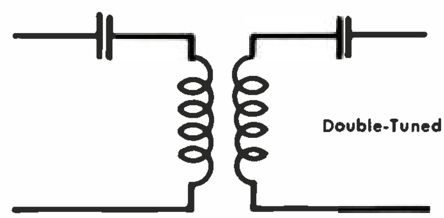


Fig. 4—Parametric Amplifier or Down-Converter stage.

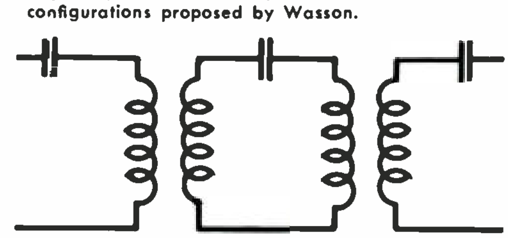
A NEW SELECTIVITY CONCEPT

Macouski of RCA pointed out that in the synchronous mode, $f_p = 2f_s$, and taking the output off at the idling frequency, the parametric amplifier exhibits gain at the difference frequency but loss at the sum or image frequency. Consequently, interfering signals which fall at the image frequency are severely rejected by the parametric process; pre-selection at the signal frequency is no longer the sole protection against image responses. This property of parametric amplifiers makes possible the use of a low intermediate frequency (i-f) in radar and communications receivers without resorting to the difficulties of double conversion. Incidentally, image rejection has been an inherent problem in conventional all-channel television receivers where the i-f, 41-47 mc, corresponds to approximately 5% of the signal frequency at channel 83.

The bandwidth of the input system, for a completely resistive source, will depend directly on the impedance function of the idling circuit. In configurations using very low idling frequencies, such as down-converters, a highly selective low-frequency response can be transferred to any signal frequency, thus realizing tunable signal-frequency selectivity without having to track tuned circuits. Heretofore, the cost of amplification in receivers for most services is by far the highest at signal frequencies, next at i-f, and least at video or audio frequencies. The advent of parametric amplifiers and down-converters may alter this design concept to a substantial extent.



Figs. 5 (a and b)—Multiple Tuned configurations proposed by Wasson.



Triple-Tuned

NONLINEAR REACTANCE DEVICES

Both time varying capacitances and inductances are capable of storing and exchanging energy. They are both potentially suitable for parametric operation. Such is not the case with respect to a time-varying resistance, however, because no energy storage is involved. Theoretically, the ferromagnetic device[11,12,13] may prove superior in noise performance due to less power dissipation. On the other hand, the variable capacity device such as junction diodes seems to be preferred at present for simplicity and continually improving technique of fabricating semiconductor materials.

The diode must exhibit as little base resistance as possible.[14] The larger the diode resistance the lower the diode Q and more pump power is drawn by the amplifier. In addition, this diode resistance is also a source of the Johnson thermal noise. For parametric operation, Schwartz of RCA concluded that the diode Q is at least 10 under the operating conditions, and that abrupt junction capacitance diodes may have some inherent advantage over linearly graded junction diodes. Materials with high energy band gap such as GaAs and Si are usually preferred over low band gap materials such as Ge.

Ramanis, also an associate of the writer, has evaluated the pertinent parameters of a large number of various available diodes. A partial list of some of these data is tabulated as follows:

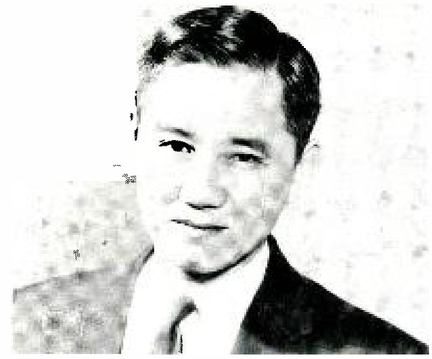
Type	PIV volts	R ohms	C_d, uuf —2v	—4v	—10v	Q, —4v 250mc	40mc	Manufacturer
V-15E	128	9.3	21.7	17	11.5	25	128	Pacific Semi. Inc.
V-33E	44	3.8	43.5	33	22.5	5.1	32	
V-415	315	14	6.4	5.2	4.1	8.7	55	
PS-3	18.5	1	64	53	40	14	85	
SX-104	14.5	0.7	41	30	20	30	200	RCA, Experimental
SX-105	5.7	3.5	10	7.5	—	24	150	
1N205	16.3	4.2	14	11	7.6	14	87	National Semi.
1N208	37.4	5	13	10	7	12.7	80	
1N306	62	22.5	2.2	1.8	1.2	16	100	Raytheon Mfg. Co.

Most of these diodes may be used as parametric amplifiers to produce useful power gains at vhf. For operation at still higher frequencies, special diodes yield better results.

THE PUMP OSCILLATOR

With variable capacitance diodes as nonlinear reactance devices, pump power in the order of 1-100 mw are currently used by the experimenters. The exact amount of excitation depends primarily on the Q's of the diode and the associated circuits. As the state of the art progresses, it is predicted that the pump power required for satisfactory parametric operation will be comparable to that needed for superheterodyne mixers. To provide a pump power of a few milliwatts, conventional vacuum tubes, transistors, or the "dener" diodes being developed by Sommers of RCA are appropriate oscillators at vhf. Microwave pump oscillators may prefer special devices.

In contrast to superheterodyne operation, the amplitude stability of the pump oscillator is a critical criterion in determining the performance of parametric amplifiers. A means of automatic amplitude control (AAC) is still one of the problems which are confronting us at present.



WEN YUAN PAN received the E.E. degree in 1939 and Ph.D. in 1940 from Stanford University. He was a research associate at the Radio Research Lab. at Harvard University during the last war. Since 1945, he has been with RCA. He is now Group Manager of Signal Circuits Development, Advanced Development Engineering of the Television Division.

Dr. Pan served as advisors to the China Defense Supplies in 1941, the International Civil Aviation Conference in 1944, and the Advisory Committee of the United Nations Telecommunications in 1946. He is a fellow of I.R.E., honorary member of the Veteran Wireless Operators' Association, member of Sigma Xi and many other societies. Dr. Pan holds more than thirty patents in Electronics.

CIRCUIT CONFIGURATIONS

To illustrate some of the practical aspects of parametric amplifiers and converters, the performance characteristics of several typical circuit configurations, Figs. 6 to 9 inclusive, are given below.

The Wasson down-converter illustrates the broad bandwidth possibility. An isolator is required to insure low noise characteristic.

CONCLUSIONS

Parametric amplifiers are presently still in the developmental stage. There are problems remaining to be solved. Potentially, however, their application to electronic systems and products at vhf, uhf or microwave frequencies seems to be opening up a whole new variety of amplifiers exhibiting the desired characteristics of low noise, low cost, simplicity and reliability.

The low noise characteristic promises longer ranges of communications, and radar and other target trackings. The combination of low noise and low

1. Engelbrecht VHF Traveling-Wave Amplifier[8]

Forward signal gain at 380 mc. .	10-12 db
Down-converter gain at 250 mc. .	8-10 db
Dump power required	1-2 mw
Bandwidth	10-20 mc
Noise factor	3.5 db

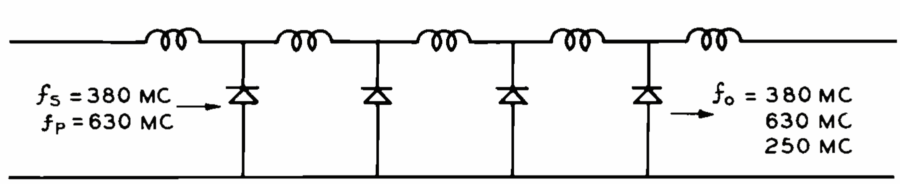


Fig. 6—VHF Traveling Wave Amplifier and Down-Converter.

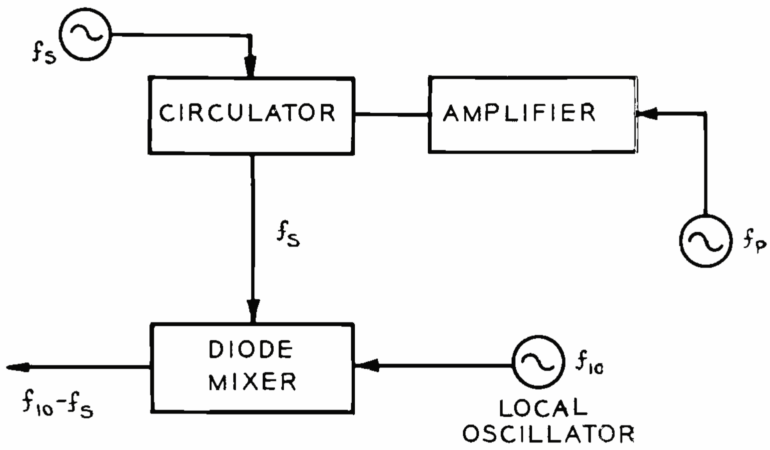


Fig. 7—Microwave Amplifier.

2. Herrmann-Uenohara Microwave Amplifier[9]

f_s	6 kmc
f_p	12 kmc
Amplifier gain at 6 kmc	18 db
Bandwidth	8 mc
Noise factor	5-6 db

cost appears exceedingly attractive for television and broadcast receivers. Finally, simplicity and reliability are always pertinent properties of high-speed computers.

REFERENCES

1. Manley, J.M. and Rowe, H.E., "Some General Properties of Nonlinear Elements," *Proc. I.R.E.*, July 1956.
2. Shockley, W., "The Theory of P-N Junction in Semiconductors, and P-N Junction Transistors," *B.S.T.J.* vol 28, July 1949.
3. Hines, M.E., "Amplification in Nonlinear Reactance Modulators," Presented at the 15th Annual Conference on Electron Tube Research, Berkeley, California, June 1957.
4. Herrmann, G.F., "Low-noise Up-converter from 500 mc to 10 kmc Using Variable Capacitance Diodes," Presented at the 16th Annual Conference on Electron Tube Research, Quebec, Canada, June 1958.
5. Wade, G. and Heffner, H., "Microwave Parametric Amplifier and Converter," Presented at the International Convention on Microwave Valves, London, May 1958.
6. Uhlir, A., Jr., "The Potential of Semiconductor Diodes in High Frequency Communications," *Proc. I.R.E.* June 1958.
7. Wade, G. and Heffner, H., "Gain, Bandwidth, and Noise Characteristics of the Variable Parametric Amplifier," *Jour. of Applied Physics*, September 1958.
8. Engelbrecht, R.S., "A Low Noise Nonlinear Reactance Traveling-wave Amplifier," Presented at the Solid State Device Research Conference, Ohio, June 1958.
9. Uenohara, M., "Parametric Amplification at 6 kmc Using Semiconductor Diodes," Presented at the 16th Annual Conference on Electron Tube Research, Quebec, Canada, June 1958.
10. Chang, K.K.N., "Four-terminal Parametric Amplifier," *Proc. I.R.E.* p 81-82, January 1959.
11. Weiss, M.T., "A Solid-state Microwave Amplifier and Oscillator Using Ferrites," *Physics Review*, July 1957.
12. Suhl, H., "Proposal for a Ferromagnetic Amplifier in the Microwave Range," *Physics Review*, April 1957.
13. Tien, P.K. and Suhl, H., "A Traveling Wave Ferromagnetic Amplifier," *Proc. I.R.E.*, April 1958.
14. Pan, W.Y. and Ramanis, O., "AFC of Television Receivers Using Germanium Junction Diodes," *RCA Transistors I.*

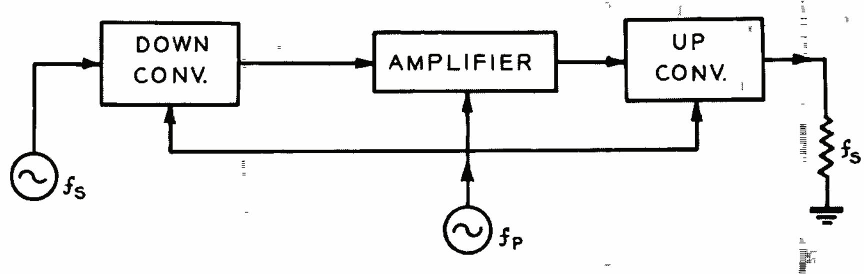


Fig. 8—VHF Amplifier.

3. Chang VHF Amplifier[10]

f_s	210 mc
f_p	150 mc
Pump power	100 mw
Amplifier gain	20 db
Bandwidth	250 kc
Noise factor	2.5 db

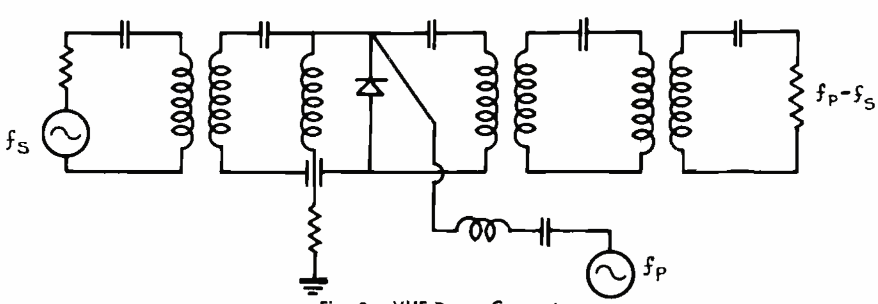


Fig. 9—VHF Down-Converter.

4. Wasson VHF Down-Converter

f_s	85 mc
f_p	129 mc
Pump power	100 mw (approx.)
Converter gain at 44 mc.	10 db
Bandwidth	3.6 mc

THE ULTRASCOPE | *An Experiment in Engineering and Product Planning*

by

H. F. KAZANOWSKI and R. G. STOUDENHEIMER

Electron Tube Division

Lancaster, Pa.

THE DESIGN AND DEVELOPMENT cycle for introduction of new tube products traditionally has been 2 to 3 years or more. This "lead time," of course, depends upon the tube complexity and the individual electrical, mechanical, chemical or thermal problems encountered during the development period. However, when the factory facilitation and production build-up cycles are added to this lead time, the over-all elapsed time from idea to product often is considered longer than it need be.

Early in 1958, the Electron Tube Division decided to test the theory that this cycle can be compressed in certain instances. Consequently, a small Special Product Team was established in mid-1958 to survey the tube field for new product ideas which could be brought to market by the end of the year. Included on this team were representatives from Sales, Operations, and Planning.

As the team began to function, it screened hundreds of ideas generated both within and outside the group. Several of these ideas appeared to pass the initial tests of marketability and profitability and were further evaluated by Engineering. Although some of the suggestions were found unsuitable in original form, they appeared to offer further potential with slight modification. Such was the case with the selected product.

THE ULTRASCOPE PROPOSAL

A suggestion was made to market infrared image tubes for use in binocular viewers for fog penetration. Early in the Fall of 1958, this suggestion was reoriented to cover an ultraviolet-sensitive image tube for use in ultraviolet microscopy. This tube, which would be called an "ultrascope," not only appeared to meet all the marketing criteria for a successful new product, but also gave promise of an exciting advance in the field of medical electronics by providing an inexpensive research instrument.

WHAT IT IS

The RCA-7404 ultrascope, shown in Fig. 1, was visualized as an ultraviolet-sensitive version of the recently introduced RCA-6929 infrared image tube. In use, the tube is housed in a simple adapter which replaces the standard microscope eyepiece. The operation of the tube is as follows: The subject material is imaged by means of an ultraviolet objective lens onto the ultraviolet-sensitive photocathode of the tube. The electron image on the photocathode is then focused on a fluorescent viewing screen at the opposite end of the tube by electron optical methods to form a visible image which can be viewed with an optical magnifier. The inverted image produced on the photocathode by the ultraviolet optical system is reinverted within the tube to provide an observed image which is erect.

WHAT IT DOES

The use of ultraviolet rays in microscopy is based on the fact that the degree of absorption of the ultraviolet rays by materials under observation varies throughout the ultraviolet spectrum. Therefore, it is practicable to utilize monochromators or filters which pass narrow bands of the ultraviolet spectrum in order to make comparative observations. Observations made with several such narrow-band filters often reveal useful information not otherwise obtainable. Previously, the only available methods of converting ultraviolet images required the use of complex television systems employing ultraviolet-sensitive pickup tubes or flying spot scanners, or photographic methods employing ultraviolet-sensitive film. The photographic method was "static" because of the required processing time, and was often expensive, depending upon film consumption.

The use of the ultrascope attachment offers a considerably simplified and more flexible technique for ultraviolet microscopy because it permits the direct conversion of otherwise invisible ultraviolet images into visible light images in a yellow-green color.

The ultraviolet image converter tube, enclosed in an insulating housing, can be mounted on the barrel of a conventional optical microscope equipped with an ultraviolet lens, as shown in Fig. 2. A simple, compact, high-voltage power supply is connected to the tube. This assembly provides a new simple tool for pathological examination, particularly in the field of cell research and identification. Furthermore, the new technique eliminates the need for staining (which kills cells) in the preparation of specimens, and permits the immediate examination of live tissues. The brightness and resolution of detail of the tube are considered excellent. Because the cathode of the ultrascope, or image converter tube, is curved, a field-shaping lens is theoretically required for perfect focus of the image over the entire cathode. However, the depth of focus of an optical microscope is usually great enough to provide good resolution over a wide field without the field-shaping lens.

MAJOR DESIGN CONSIDERATIONS

In the development of the 6929, the infrared prototype of the ultrascope, a number of the desired characteristics were determined by their importance for the intended military applications. These characteristics included:

1. Electrostatic focus
2. High conversion gain (which requires a high operating voltage)
3. Self-focusing with only one applied voltage between two terminals
4. High resolution even with a poorly regulated voltage supply
5. Low screen background
6. High edge resolution
7. Low distortion
8. Flat viewing screen
9. Low power requirement
10. Small size

Fig. 1—Photograph of RCA-7404 Ultraviolet-Sensitive Image Converter Tube.

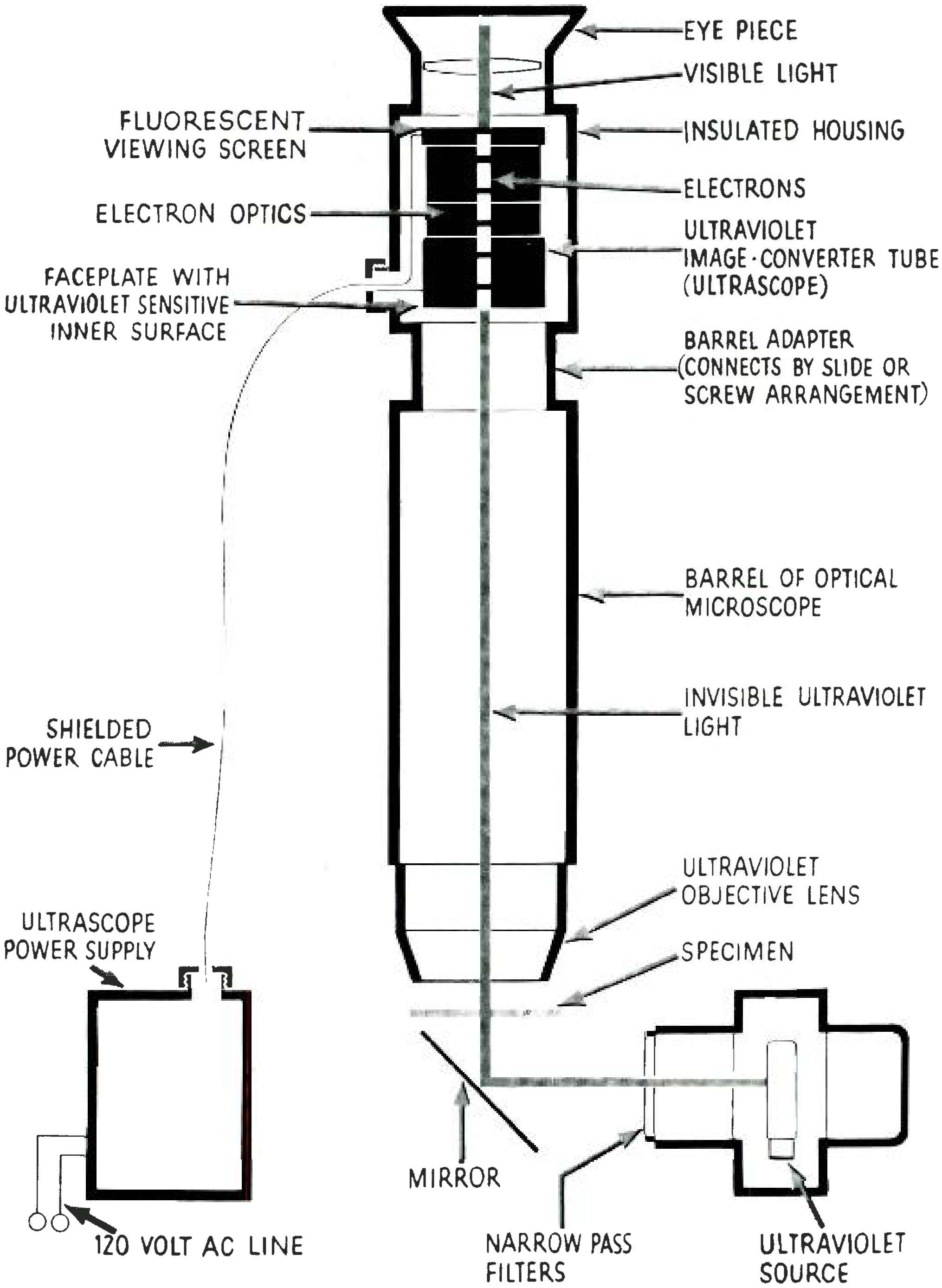


Fig. 2(a)—Functional Drawing of Ultraviolet Accessory Viewer as Used in Microscopy.

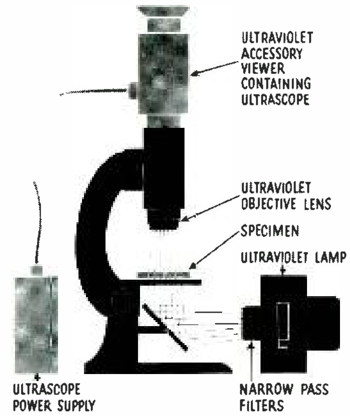


Fig. 2(b)—Drawing showing the Ultraviolet Microscope with Ultrascope Accessory.

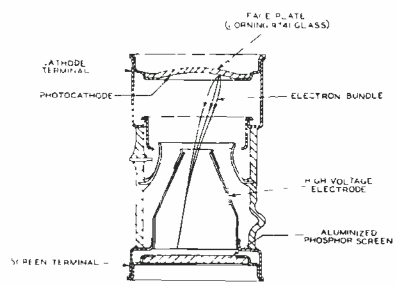


Fig. 3—Cross Section of Ultrascope with Major Elements.

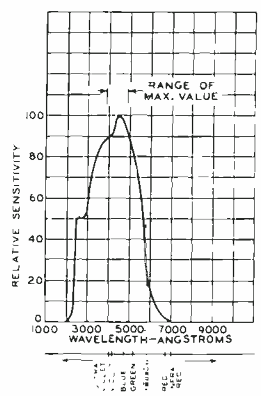


Fig. 4—Spectral Response Curve of Ultrascope.

R. G. STOUDENHEIMER received the B.A. degree in Physics from the College of Wooster in 1940 and the M.S. degree in Physics from Syracuse University in 1942. He joined RCA in 1942 as a physicist working on special-purpose tubes. In 1944 and 1945 he served as a production engineer on multiplier phototubes. Since 1946 he has worked on the design and development of phototubes and image tubes, and since 1954 he has been an engineering group leader in the Photo and Image Tube Design activity. He presently is concerned entirely with the development of image-converter tubes.

Mr. Stoudenheimer is a senior member of the Institute of Radio Engineers and a member of the American Physical Society.

HENRY F. KAZANOWSKI received the B.S. degree in Electrical Engineering from Northeastern University in 1948 and the M.S. degree in Physics from Franklin and Marshall College in 1954. He joined RCA in 1948 as a power tube design engineer, and was instrumental in the successful development of the first RCA ceramic-seal power tube for uhf television broadcasting. In 1952 he joined the Product Administration Activity of the Electron Tube Division as product analyst for power tubes. In this capacity he coordinated government contract programs and planned the introduction of a number of new tube types. In 1955 he was appointed Administrator of Microwave and Power Tube Operations Planning, and since 1957 has served as Administrator of Financial Controls for all industrial tube products.

All of these desired characteristics are not obtained independently. A modification which gives good performance in one characteristic may require a sacrifice in performance with respect to some other characteristic. However, the basic infrared tube design appeared to offer a good balance of performance, costs, and timing. A study of the 6929 characteristics indicated that its design would probably be acceptable for the ultrascope with only two changes:

1. The cathode faceplate would be made of a glass which is transparent to ultraviolet radiation, such as Corning 9741.
2. A new cathode of antimony and cesium having high ultraviolet sensitivity would be required.

PERFORMANCE CHARACTERISTICS

A cross section of the ultrascope is shown in Fig. 3. Electrons leaving a point on the cathode are confined to a relatively small beam crossing the axis near the apex of the high-voltage electrode. The beam is accelerated by a potential of 12,000 volts and is focused into a point image at the phosphor screen. The image on the screen is inverted and slightly demagnified. Luminous flux output from the screen is given by the expression

$$F = [VE_s] \int W_\lambda S_\lambda d\lambda$$

where F is the luminous flux from the screen in lumens, $W_\lambda d\lambda$ is the radiant flux in watts incident on the cathode in the spectral range from λ to $\lambda + d\lambda$, S_λ is the cathode radiant sensitivity at the wavelength λ, V is the voltage between the cathode and the screen, and E_s is the screen efficiency (50 lumens per watt).

The conversion efficiency (C.E.) at the wavelength λ is given by

$$\frac{F}{\int W_\lambda d\lambda} = VE_s S_\lambda.$$

At a wavelength of 2537 angstroms, therefore,

$$\text{C.E.} = 12{,}000 \text{ volts} \times 50 \text{ lumens/watt} \times .01 \text{ amp/watt} = 6000 \text{ lumens/watt}$$

For comparison, the highest conversion efficiency possible without image intensification is 680 lumens per watt. Even this efficiency is possible only if the ultraviolet energy is converted with 100-per-cent efficiency to light at 5560 angstroms, the wavelength of peak visual sensitivity.

The 7404 image converter tube provides sufficient intensification for comfortable viewing with standard ultraviolet microscopes when the specimen is illuminated with monochromatic radiation. The brightness of the image is far superior to the brightness of a conventional willemite screen excited directly with ultraviolet rays.

The spectral sensitivity of the 7404 covers the useful range from 2300 to 6000 angstroms, as shown in Fig. 4.

TECHNICAL EVALUATION

Recognition of the probable potentialities of the ultrascope was only the initial step in this experiment. The next step required a technical evaluation of the product. First, however, it was necessary to supply samples of the proposed product for evaluation. This phase involved procurement of special tube materials, assembly of tubes, and construction of viewers.

The necessary sample tubes were obtained through existing Electron Tube Division functions, including Purchasing, Manufacturing, and Engineering, on a rush basis with direct follow-up. Within six weeks, sample tubes were available for evaluation by Dr. V. K. Zworykin and his associates at the David Sarnoff Research Center.

Initial tests included microscopic observation of cell specimens under ultraviolet irradiation. Results were most encouraging, and it was recommended that further tests be made by leading U. S. scientists active in this field at the National Institutes of Health, Bethesda, Md.

A prototype viewer, tube, and power supply were delivered to scientists at the National Institutes of Health late in October. Exploratory tests using latex granules, blood cells, cancer tissue, and the like were so successful that the Institutes requested a loan of the equipment for further evaluation by other specialists.

Preliminary estimates of market volume and pricing were also obtained from scientists at the National Institutes of Health. Technical acceptance of the ultrascope with particular emphasis on its usefulness in protein chemistry, added impetus to RCA's product program.

Technical evaluation tests were also performed on different specimens by medical electronic scientists at the Rockefeller Institute for Medical Research. Satisfactory results were obtained, and other applications for the tube were uncovered, including its use as an ultracentrifuge accessory.

PRODUCT PLANNING

Concurrent with the latter phases of the technical evaluation period, a program of product and market planning showed considerable promise for successful commercialization of the ultrascope. Factors considered in this business study included:

1. Market research of microscope industry
2. Potential pricing structure
3. Methods of distribution
4. Projected sales forecasts
5. Materials and facilities requirements
6. Profit and loss analysis
7. Timing and method of announcement
8. Government, legal, and patent clearances

All segments of this program were reviewed periodically to assure a plan of action consistent with Electron Tube Division policies and yet implemented by "fast track" methods. A significant "ground rule" of the experiment was that the required work had to be accomplished on a crash basis without disruption of existing engineering or production activities.

Other Divisions of RCA were contacted when necessary to obtain assistance. In addition, the device was demonstrated to representatives of leading microscope suppliers to determine their degree of interest in supplying the viewer accessory package. The Bausch and Lomb Optical Company expressed interest in the ultrascope, and developed a separate image converter unit (containing the ultrascope and 35 millimeter camera) for use with an ultraviolet photomicroscope.

As the technical and planning phases of this product experiment successfully and rapidly approached completion, the final decision of how to announce the product had to be made. Evaluation tests proved that the ultrascope had exciting humanitarian value as a medical research instrument. Announcement plans, therefore, were made to obtain the maximum positive association of this new research tool with RCA. It was proposed that the ultrascope be introduced as another example of RCA interest in medical electronics instrumentation, adding a new dimension to medicine and biology.

ANNOUNCEMENT

On January 15, 1959, the ultrascope experiment culminated with a demonstration-announcement meeting for the press and leading medical scientists at the Waldorf-Astoria Hotel in New York. A significant highlight of the meeting was the presentation of the prototype tube and viewer to Dr. John R. Heller, Director of the National Cancer Institute, by RCA President John L. Burns (see Fig. 5).

Visual displays with ultraviolet microscopes and ultrascope viewers provided an opportunity to demonstrate cell specimens such as those illustrated by Fig. 6. Considerable interest was evidenced by pathologists, biologists, medical educators, and industrial researchers, both from product performance and availability points of view.

Although the public announcement concluded the activities of this product team, it also proved that the concept of a small but balanced task force may often provide the stimulus for exploiting new business programs. Ideas for new tube types and novel applications in new areas must continuously be developed for successful growth of the Corporation. Engineers, because of their fundamental knowledge of product design, are in an excellent position to suggest imaginative devices for future planning "experiments."

Fig. 5—Presentation of Prototype Ultrascope Viewer to Dr. John R. Heller, Director, National Cancer Institute, by John L. Burns, President, RCA and D. Y. Smith, Vice Pres., Electron Tube Division.

Fig. 6—Photomicrographs of Specimens.

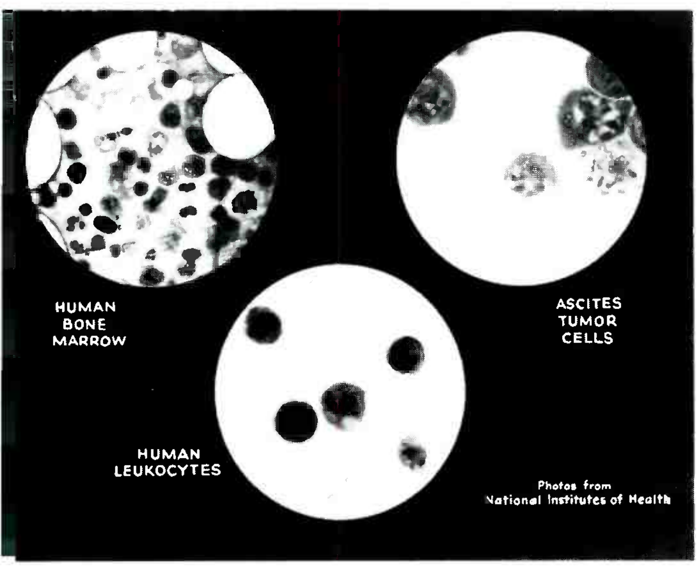


Fig. 1—Photograph of developmental Nuvistor triode, tetrode, and beam power tube compared with their conventional counterparts.

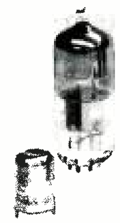


Fig. 1a—Nuvistor Triode.

NUVISTOR—NEW LOOK IN TUBE DESIGN

Early in March, the Electron Tube Division disclosed to the industry, the military, and the press a new development in receiving-tube design hailed as a major breakthrough in tube size, performance, power drain, and reliability. This development, a responsibility of the Receiving Tube Advanced Development Activity, has made possible rugged, thimble-sized electron tubes constructed almost entirely of ceramic materials and strong metals. This new tube development has been named "Nuvistor" because it represents a "new look" in receiving tube design. A photograph of a developmental Nuvistor triode, tetrode, and beam power tube, is given in Fig. 1 alongside their conventional counterparts. Based on a cantilever-supported cylindrical structure, the Nuvistor contains no micas which might fray under vibration, no glass which might shatter under mechanical or thermal shock, and no welds which might introduce strain or distort tube elements.

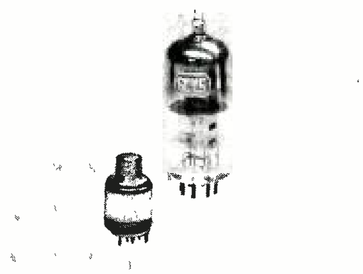


Fig. 1b—Nuvistor Tetrode.

Fig. 1c—Nuvistor Beam Power Tube.

DESIGN FEATURES

As shown in Fig. 2, the cylindrical electrodes of the Nuvistor, which are easier to make and hold to controlled dimensions than planar electrodes, are supported on short, tripod-like structures which, in turn, are fastened firmly to a ceramic base-wafer which serves as both a mount support and part of the tube envelope. The Forsterite base-wafer is metallized prior to use by "dunking" in a specially developed solution of molybdenum and lithium salts. The coated wafer is then fired in hydrogen to reduce the molybdenum salt to strongly adherent metal. A light grinding operation removes the metal from the top and bottom surfaces, leaving a metal layer on the edge of the wafer and lining the lead-wire holes. These metallized surfaces join readily to the metal parts during subsequent brazing operations.

The cantilever, or open-ended, construction permits the loading of all but two of the tube parts on a simple assembly jig. After the basic mount structure is assembled, it is brazed in a hydrogen atmosphere at a temperature of 1130 degrees Centigrade. This brazing operation not only provides strain-free joints in the tube, but also removes oxide coatings from the metal parts of the structure and burns away organic particles such as lint which may have gotten into the assembly. In addition, the hot hydrogen tends to replace other gases occluded in

Fig. 2—Cutaway view of Nuvistor showing cylindrical electrodes and tripod-like supports.

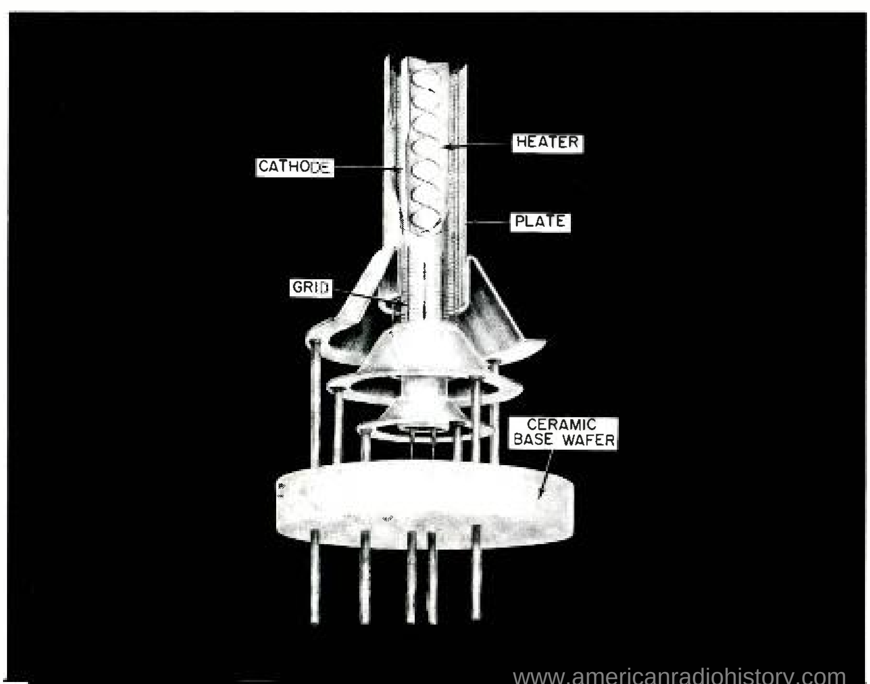
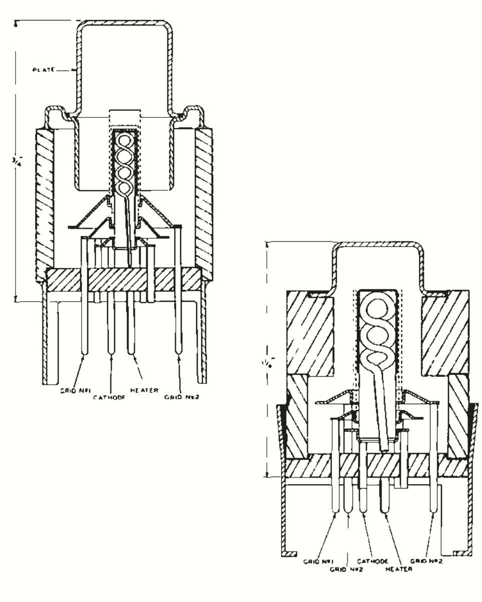


Fig. 3—Cross-sectioned views of the developmental small-signal tetrode and the proposed beam power tube.



by

G. M. ROSE, Mgr.

Receiving Tube Advanced Development
Electron Tube Division
Harrison, N. J.

the various tube parts and simplifies the final exhaust process.

The two remaining parts, the active cathode surface and the metal shell, are added just prior to exhaust. The coated cathode cup is slid over its cylindrical support and bonds to it metallurgically during exhaust and aging. The metal shell is joined to the ceramic base-wafer at the end of the exhaust operation by a brazing ring which melts and bonds the two parts together and completes the vacuum-tight seal.

RELIABILITY AND RUGGEDNESS

In the design, assembly, and processing of the Nuvistor, most of the known causes of tube failure on life have been minimized or eliminated. Although life tests have not yet been extensive, useful tube lives of tens or even hundreds of thousands of hours, are anticipated.

Other tests have demonstrated the remarkable ruggedness of the Nuvistor design. Triodes were still within operating limits after more than 1000 transverse and longitudinal blows of 850 g's on a Taft-Pierce shock machine. Vibration tests showed no appreciable noise output until the first major resonance point at approximately 4800 cycles. A change in grid structure raised this point to 6000 cycles, and further increases can be accomplished.

Operating tubes have been repeatedly cycled in temperature from plus 350 to minus 195 degrees Centigrade with no permanent change in performance. Tubes have also been operated for more than 50 hours in an oven at 350 degrees Centigrade with less than 10 per cent change in transconductance.

ADVANTAGES OF NEW DESIGN

The advantages of this new design concept are numerous. The cylindrical symmetry and cantilever construction provide high cathode efficiency and permit the use of accurate jigs for tube assembly. The high-temperature brazing of the assemblies in these accurate jigs eliminates the need for spot-welding and produces strain-free structure. The compact design also eliminates the need for mica spacers and thus removes one of the usual limitations to high-temperature operation.

A high degree of control can be maintained over the fabrication of Nuvistor parts and assemblies because of the simple structures used. Consequently, much closer spacings can be used to provide more efficient tubes with the same accuracy and uniformity now obtained in larger tubes. The improved control also makes it possible to obtain even higher uniformity of electrical characteristics.

The Nuvistor is better suited to operation under extreme environmental conditions than conventional tubes. One of the reasons is that it contains no glass to limit its ability to withstand mechanical or thermal shock. Moreover, its short, low-mass structure is inherently more rugged than that of conventional tubes. Because of its high-temperature processing, as well as the absence of glass and mica, it is also suited to operation in high-temperature environments. An additional feature is the indexing lugs provided on either side of the base which permit safe and easy insertion into tube sockets.

Fig. 4—Typical data for developmental small-signal Nuvistor triode.

Electrical:		
Heater, for Unipotential Cathode:		
Voltage (AC or DC)		6.3 volts
Current		0.14 amp
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate		2.4 μμf
Grid to Cathode, Heater, and Shell		5 μμf
Plate to Cathode, Heater, and Shell		2.2 μμf
Plate to Cathode		0.5 μμf
Heater to Cathode		1.8 μμf
Characteristics, Class A Amplifier:		
Plate Voltage	40	75 volts
Grid Resistor	1	— megohm
Cathode Resistor	—	150 ohms
Amplification Factor	32	32
Transconductance	10700	10500 μmhos
Plate Current	7	9 ma
Grid Voltage (approx.) for plate current of 10 μa	—	–6 volts
Maximum Ratings:		
PLATE VOLTAGE	100	max. volts
GRID VOLTAGE	—50	max. volts
PEAK POSITIVE GRID VOLTAGE	2	max. volts
PLATE DISSIPATION	1	max. watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100	max. volts
Heater positive with respect to cathode	100	max. volts

Fig. 5—Typical data for developmental small-signal Nuvistor tetrode.

Electrical:		
Heater, for Unipotential Cathode:		
Voltage (AC or DC)		6.3 volts
Current		0.14 amp
Direct Interelectrode Capacitances (Approx.):		
Grid No. 1 to plate		0.01 μμf
Grid No. 1 to cathode, metal shell and internal shield, grid No. 2, and heater		7 μμf
Plate to cathode, metal shell and internal shield, grid No. 2, and heater		1.5 μμf
Heater to cathode		1.8 μμf
Characteristics, Class A Amplifier:		
Plate Voltage		75 volts
Grid No. 2 (Screen-Grid) Voltage		30 volts
Grid No. 1 (Control-Grid) Resistor		1 megohm
Plate Resistance (Approx.)		0.25 megohm
Transconductance		9000 μmhos
Plate Current		5 ma
Grid No. 2 Current		1.7 ma
Grid No. 1 Voltage (approx.) for plate current of 10μa		—3.5 volts
Maximum Ratings:		
PLATE VOLTAGE	250	max. volts
GRID NO. 2 VOLTAGE	100	max. volts
GRID NO. 1 VOLTAGE	—50	max. volts
PEAK POSITIVE GRID NO. 1 VOLTAGE	2	max. volts
GRID NO. 2 INPUT	0.3	max. watt
PLATE DISSIPATION	3	max. watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100	max. volts
Heater positive with respect to cathode	100	max. volts

PERFORMANCE

To date, the Electron Tube Division has demonstrated a developmental small-signal triode and a small-signal tetrode in the Nuvistor class. Work is currently being done on a beam power tube, and the application of the basic concept to other tube types is being investigated. Cross-sectional views of the tetrode and the proposed beam power tube are given in Fig. 3.

The triode in development is a general-purpose small-signal type suitable for use in applications such as radio-frequency amplifiers and local oscillators. Typical data for this type are given in Fig. 4. The developmental tetrode is suitable for small-signal applications including r-f and i-f amplifiers. Typical data for the tetrode are given in Fig. 5.

An experimental television-receiver tuner using these developments has been demonstrated. This tuner, shown in Fig. 6, has given superior performance to that of conventional tuners and yet operates with a plate voltage of only 40 volts. When the plate voltage was reduced to less than 10 volts, the tuner performance was still good. Ultimately, it is expected that a whole family of tubes can be developed to provide the advantages of small size, low-power requirements, high efficiency, and high reliability for many types of applications. In particular, the Nuvistor should be useful in television sets, communications receivers, high-speed data-processing equipment, and many types of compact electronic equipment for jets, guided missiles, and other military applications.

An engineering planning meeting at the Tube Division, Harrison (l to r)—D. K. Wilde, W. J. Helwig, D. W. Power, G. M. Rose (author), O. H. Schade, Sr., T. J. Henry, A. M. Seybold, and J. J. Thompson.

ACKNOWLEDGEMENTS

The success of the Nuvistor program has been made possible through the enthusiasm, cooperation, and persistence of many individuals in the Advanced Development Activity, the Chemical and Physical Laboratory, the Receiving Tube Development Activity, the Engineering Processes Activity, and the Equipment Design and Development Activity. Dr. O. H. Schade, Sr. and H. V. Knauf, in particular, should be credited for major contributions to this effort.

Fig. 6—Experimental "Nuvistorized" tuner capable of superior performance with plate voltage of 40 volts. Conventional tube used in present-day TV tuners is held in hand for comparison with thimble-size Nuvistor.

GEORGE M. ROSE received the B.S. degree in electrical engineering from the University of North Carolina in 1928, and remained there as a Teaching Fellow until 1929. From 1929 until 1931 he was an engineer in the Vacuum Tube Engineering Department of the General Electric Company at Schenectady. In 1931 he joined the Tube Department of the RCA Manufacturing Company at Harrison, N. J. as a member of the Tube Research Group. He later transferred to the Advanced Development Group and has been Manager of this Group since 1941. He received the Modern Pioneer Award from the National Association of Manufacturers in 1940. Mr. Rose is a member of Tau Beta Pi and a Fellow of the Institute of Radio Engineers.

ENGINEERING A MAJOR ROLE IN 1958 STOCKHOLDER'S REPORT

RCA's ANNUAL REPORT to stockholders was released February 27 by Brig. General David Sarnoff. Chairman of the Board. and John L. Burns. President of RCA.

In a letter to shareholders, General Sarnoff and Mr. Burns said:

"Sales of products and services of RCA were $1.176.094.000 in 1958. For the fourth successive year sales exceeded one billion dollars. During the latter months of the year both sales and earnings exceeding the corresponding period of the previous year. reflecting general improvement in the national economy, a higher volume of Government business and the introduction of new products and services.

"Net profit. before Federal income taxes was $60.442.000. and after taxes. $30,942.000. Earnings per share of common stock were $2.01 in 1958 compared with $2.55 in 1957.

"Federal income taxes, social security taxes, property taxes and other state and local taxes paid by the Corporation in 1958 totaled $47.319.000. In addition. excise taxes amounted to $28.275.000. making RCA's total tax bill for 1958 an aggregate of $75.594.000, equal to $5.46 per common share.

"In the last quarter of the year an extra dividend of fifty cents per share was declared on the common stock. the same as in the past three years. This was in addition to the regular quarterly payments of twenty-five cents per share.

"Dividends totaling $23.886.000 were declared by RCA in 1958. This included $3.50 per share on the preferred stock. and $1.50 per share on the common stock, the same as in 1957.

"Sales to the Government totaled approximately $300,000.000, an increase of 14 per cent over 1957. The backlog of Government orders at year-end was about $300,000,000. an increase of $50.-000.000 during 1958.

"Expansion and realignment of RCA's organization and manufacturing facilities have prepared the Corporation to take advantage of new opportunities for growth and service in the years ahead. Twelve important new operational units have been created to accelerate progress in areas of potential growth such as missiles, satellites and space vehicles. automation, electronic data processing and atomic energy.

"The Space Age has inaugurated a new era in radio communications. and is dependent in many ways upon electronics. Intent upon a role of leadership. RCA in May 1958 established an Astro-Electronic Products Division to consolidate its technological activity related to national security and explorations in space.

"As a further step, a new RCA missile and radar plant is being built at Van Nuys, California, with completion of the initial phase of construction scheduled by the end of 1959.

"Paralleling the defense demands are those of industrial and nuclear electronics, a new area in which RCA scientists and engineers are actively engaged with the objective of developing thermonuclear fusion power for peacetime purposes.

"Applications of electronics for the performance of business and industrial tasks are opening new fields of opportunity for business computers and automation. Recently a completely transistorized, general purpose, electronic data handling system. known as RCA 501. was introduced to the market.

"A new products campaign conducted by RCA throughout 1958 led to a variety of new developments for use in business. industry and national defense as well as in schools and the home. The sustained upswing in the popularity of color television and enthusiastic public acceptance of stereophonic sound promise increased activity in these fields in 1959.

"RCA entered its 40th year in 1959. At its inception. RCA gave the United States pre-eminence in international communications, free of alien control. Since that time scientists and engineers of RCA have made numerous inventions and have developed completely new electronic systems; they have discovered basic principles and new knowledge that have enlarged the Corporation's firm foundation for growth in service to national defense and to the American people.

"In electronic entertainment NBC has an outstanding record in all phases of radio and television broadcasting and is pre-eminent in color TV.

"In manufacturing RCA has produced billions of electron tubes and transistors, and many millions of radio instruments, 'Victrola' phonographs and records. Recently its 10 millionth TV set came off the line.

"We are planning ahead in the ever-broadening field of electronics, which is now a $14 billion a year industry. We look forward to continued progress in all of our operations which, within the next ten years, should make RCA's Fiftieth Anniversary a memorable milestone in the history of industrial America."

FINANCIAL HIGHLIGHTS OF THE ANNUAL REPORT

	1958	1957
Products and Services Sold	$1,176,094,000	$1,176,277,000
Profit before Federal Taxes on Income	60,442,000	77,049,000
Per cent to products and services sold	5.1%	6.5%
Federal Taxes on Income	29,500,000	38,500,000
Per cent to profit before Federal Taxes on income	49%	50%
Net Profit	30,942,000	38,549,000
Per cent to products and services sold	2.6%	3.2%
Per common share	2.01	2.55
Preferred Dividends Declared	3,153,000	3,153,000
Per share	3.50	3.50
Common Dividends Declared	20,733,000	20,756,000
Per share	1.50	1.50
Total Dividends Declared	23,886,000	23,909,000
Reinvested Earnings at Year End	243,783,000	236,727,000
Shareholders' Equity at Year End	295,439,000	288,382,000
Long Term Debt at Year End	249,995,000	249,995,000
Working Capital at Year End	307,983,000	305,583,000
Ratio of current assets to current liabilities	2.8 to 1	2.8 to 1
Additions to Plant and Equipment	24,817,000	35,593,000
Depreciation of Plant and Equipment	21,825,000	23,524,000
Net Plant and Equipment at Year End	196,609,000	199,581,000
Number of Employes at Close of Year	78,000	78,000

AMPLIFIED R-F DISTRIBUTION SYSTEMS FOR TELEVISION RECEPTION

by **STEVEN WLASUK**
Engineering
RCA Service Company
Cherry Hill, N. J.

Editor's Note: This article represents RCA Service Company's continuing contribution to the practical development and design of amplified distribution systems for commercial television reception.

These distribution systems, called "Master Tenna," pose a rather particular engineering problem. In a field that is highly competitive, with no one installation which can be called standard, engineering design, sales, installation and maintenance are so interwoven as to be inseparable. Equipments are "installation engineered" to provide the ultimate in reliability and versatility with minimum of inventory, at low cost to the customer.

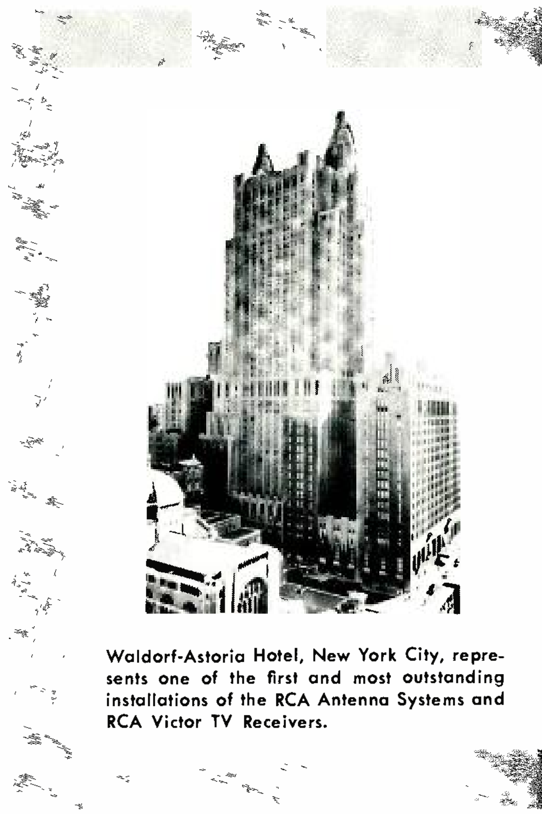
Testimony to RCA Service Company's growth and leadership in this field are the many "package" installations where the customers have equipped all their units with RCA receivers, fed by Master Tenna systems.

About eight years ago the RCA Service Company undertook a program to develop high-performance, low-cost r-f distribution systems for commercial television and frequency modulation band signals. The basic requirement for such systems is to supply signals to more than one receiver, each of standard design, from one antenna or group of antennas. The equipment designs and distribution materials described here are specifically for hotel, apartment and similar domestic applications, and are not intended for military, industrial or community antenna system television applications.

A Master-Tenna system generally consists of centrally located antenna complex, "head end" equipment—consisting of channel converters, antenna mixers, preamplifiers, and the main broadband or channelized amplifiers, the distribution medium (a high quality TV coaxial cable), and wall outlets (arranged as near as possible to the a-c wall outlets in the rooms where the TV or radio receivers are to be located).

The "head end" equipment is generally located near the antennas in an electrical closet on the top floor, an elevator penthouse, or in the radio room of a large hotel. Signals are divided at the main distribution amplifier and channelled throughout the building by main trunk lines, called "risers," and room connections branch off from the risers.

Fig. 1 shows a typical Master-Tenna layout indicating how the four main parts of the system tie in with each other. The system sketched is a "bleeder" system of receiver tap connections which has proven to be the most popular because of its economy in the use of cable and ease of installation. In this "bleeder" system, a small portion of the cable signal is diverted to each of the receivers. The amount of diverted signal is between 12 and 30 DB below the cable signal



Waldorf-Astoria Hotel, New York City, represents one of the first and most outstanding installations of the RCA Antenna Systems and RCA Victor TV Receivers.

—the exact "tap isolation" is determined by the configuration and electrical values of the tapping device. Of course, each receiver tap constitutes a power loss to the signal going through the tap, and each "tap loss" ranges from 0.2 db to 2.0 db, depending on the tapping device used. All cabling and accessories throughout are standardized at 75 ohms.

DETERMINATION OF SYSTEM REQUIREMENTS

To determine the amplifier requirements, total signal losses in a system are calculated to include distribution transformer "loss," cable loss, tap-off isolation loss, and tap loss. As an example, a typical 40-outlet system loss would amount to about 30 db. The gain that would be necessary to provide satisfactory performance in this typical installation would be 33 db, regardless of signal conditions, if the noise figure of the amplifier is at

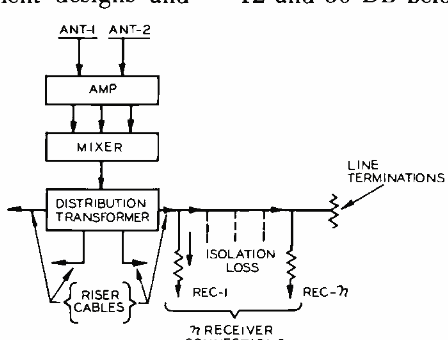


Fig. 1—A typical "Master-Tenna" layout.

least as good as the best receiver connected to the system. Note that the gain exceeds the loss by 3 db. If the amplifier noise figure is the same as the receiver noise figure, the over-all noise figure would be degraded by about 1 db, but since the antenna performance is generally better (because of type and location) for the system than it would be for the receiver, the over-all performance is generally superior. As the available signal increases, the need for amplifier gain decreases, but the need for greater voltage output takes over because the receivers and the cable are not totally immune to direct signal pickup (stray signal present around the receivers or cable). The voltage delivered to the receiver inputs from the system must be high enough to mask the direct pick-up signal.

TYPICAL INSTALLATIONS

of RCA Service Company amplified distribution systems with RCA Victor television receivers

Sheraton-Dallas Hotel......Dallas, Tex.

Thunderbird Hotel.........Miami, Fla.

Monmouth Hospital........Ft. Monmouth, N. J.

Sheraton-Plaza ....Boston, Mass.

Knickerbocker Hotel ......Chicago, Ill.

Howard Johnson Motor Lodge..........St. Louis, Mo.

Battle House.............Mobile, Ala.

Edgewater Hotel....Minneapolis, Minn.

Ambassador Hotel...Los Angeles, Calif.

Antenna System only:

Parkchester-Stuyvesant Town—Riverton Apartments, New York City, N. Y. (largest apartment project in the world)

"HEAD END" EQUIPMENT

The product line of Master-Tenna amplifiers is diversified enough to allow for selection of the proper amplifier to do a particular job.

In selecting the proper amplifier for an application, three factors are important: 1) Output voltage, 2) gain, and 3) noise figure.

Chart I
MAXIMUM SYSTEM LOSS (IN DB)

Amplifier Output Voltage	.1v	.2v	.3v	1.0v	2.0v	6.0v
Minimum Outlet Signal—1000 uv	40	46	49.5	60	66	75.5
Minimum Outlet Signal—3000 uv	30.5	36.5	40	50.5	56.5	66

(levels shown are all at 75 ohm impedance)

The output voltage of the amplifier will determine the number of outlets that an amplifier will operate in normal- to strong-signal areas. This is related to the system loss from the amplifier to the last outlet. In primary signal areas, an outlet signal of 3 millivolts is desirable. In medium signal areas, an outlet signal of 1 millivolt is satisfactory. Chart I shows the maximum system loss allowable for various output voltages.

The second step in the choice of the proper amplifier is to determine the required amplifier gain.

In the case of broadband amplifiers, the strongest signal is used in determining the amplifier gain required, as this signal will determine the overload point. Where separate antennas for each channel are used, all channels can be made equal by the proper use of attenuator pads. Additional gain can be obtained by the use of pre-amplifiers or by cascading amplifiers. However, where amplifiers are cascaded, the amplifier must be intended for this purpose and adequate isolation is required between amplifiers.

In weak signal areas, the noise figure of the amplifier becomes important. The amount of noise in the picture is mostly due to thermal agitation in the input tube of the amplifier and the receiver. A quality receiver will have a noise figure of about 6-11 db over the VHF range. To produce a completely satisfactory picture as far as noise through a system, the amplifier must have more gain than the system loss, and a noise figure equal to, or better than, the best receiver connected to the system. As a rule, the amplifier gain should be 3 db more than the system loss.

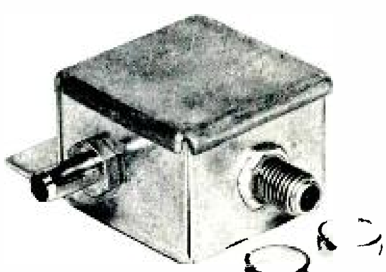
RECEIVER TAPPING DEVICES

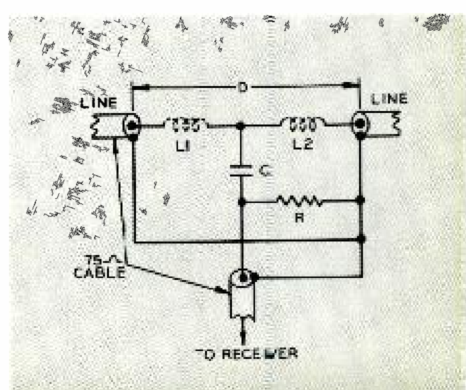
Fig. 2 shows one of the most popular tapping devices available in the Master-Tenna line. A schematic of Fig. 2 is shown in Fig. 2(b).

Spacing D [Fig. 2(b)] forms a planned discontinuity in the signal path that is inductive, as shown by L1 and L2. Capacitor C is small but sufficient to remove the inductive effects of L1 and L2 over at least a large part of the television/FM frequency spectrum. It does this by positioning L1 and L2 in a low pass filter configuration with a cut-off frequency above Channel 13 (216 mc). Most of the energy that is supplied by capacitive reactance is available to the receiver via a 75 ohm cable. Resistor R damps any standing wave excursions that may occur in the receiver cable due to receiver mis-match.

With this type of "tap off" an isolation loss of 14 db and a tap loss of 0.5 db is normal for a Channel 13 signal. The isolation loss rises and the tap loss falls as the frequency is reduced. The amount of isolation loss increase is off-set by a decrease in cable loss so that the over-all attenuation remains fairly constant from Channel 13 to Channel 2 for a typical installation.

Fig. 2—(a) Solderless tap-off outlet. (b) Schematic diagram of Fig. 2(a).





STEVEN WLASUK attended Drexel Institute of Technology. Subsequent additional curricular activities included student engineering courses at Brown Instrument Company, and University of Pennsylvania.

His Navy record from 1944 to 1946 evidences a series of self-initiated design improvements on electronic equipments used at training schools and throughout the fleet.

He joined the RCA Service Company in September, 1946 as a TV Technician in the Albany, New York Branch, and advanced to Manager of the Bronxville TV Branch in 1948. In 1949, he joined the Consumer Products Engineering Group, advancing to Manager of the development phase of this activity in 1953.

For his test equipment designs in color and UHF, and new product designs contributing to additional sales and profits for the Company, Mr. Wlasuk received the Award of Merit the same year, 1953.

The photograph of Fig. 2(a) shows a new type of fitting that is used to connect the riser line. This connector was designed to eliminate soldering, to decrease cost and, at the same time, provide a positive, easy to make connection.

In relatively high signal strength areas, the room outlets should supply a minimum of 3 millivolts across 75 ohms input impedance to the receiver. Various types of amplifiers have been included in the Master-Tenna line to accommodate different requirements. There are amplifiers for systems as small as two receivers, and for as large as 2,000 receivers.

RELIABILITY A DESIGN FACTOR

All possible precautions have been designed into the complete line of amplifiers to assure maximum reliability, quality and low noise. Tubes are operated at approximately 50% rated anode dissipations — with special heat dissipating tube shields. Tubes and component parts are placed for maximum ventilation and a minimum of complex wiring. Capacitors and resistors are operated at only a fraction of their specified maximum ratings. Transformers, fuses and heat transfer comply with Underwriter's Laboratories' specifications. Design considerations included gain, noise, overload, cross modulation, simplification of alignment, accessibility for maintenance, and standardization of components.

AN EXPANDED PRODUCT LINE

General applications of the line offer complete product flexibility ranging from the second or third receiver in the home to the largest hotel installation. Color, too, was given careful consideration in these designs. Broadband amplifiers are flat within 2 db across the television band. Channelized amplifiers are flat across any channel within 1 db.

Recently, a series of VHF converters have been added to the Master-Tenna line also. These converters have been designed to permit conversion of any VHF channel to any other non-adjacent VHF channel, through the proper choice of two of the four units available.

Converters may be used in distribution systems in many ways. Probably the most widely used objective is that of taking advantage of the lower cable transmission losses of the low-band channels. Thus, converters are employed to convert high-band channels (7-13) to low-band channels (2-6) which are then distributed over the system.

Another frequent use of converters is that of avoiding or eliminating direct pick-up problems on a distribution system. By moving the distributed signal to another channel through the use of a converter, the receiver is then able to divorce one signal from the other and thus eliminate the problem. Converters have been added to the line where it is desirable to convert from a UHF channel to a VHF channel to reduce system losses at UHF. Another flexibility is provided where it might be advantageous to move an existing channel within the system to eliminate direct pick-up, co-channel interference, or adjacent channel interference. An AM/FM amplifier is available to boost signals at the head end of the system where AM/FM is to be distributed with TV.

CONSIDERATIONS FOR THE FUTURE

Considerable work has been done already on re-designs of some of these equipments which incorporate some rather startling new approaches. It appears that within the year, RCA will be able to offer designs even simpler and more compact, with greater performance and output-handling capabilities, using transistors, newer tube types, etc., at a cost hitherto considered impossible. The market for such systems is a very competitive one, and any measure of success requires constant research and re-design.

Author checking his designs at year-end review.

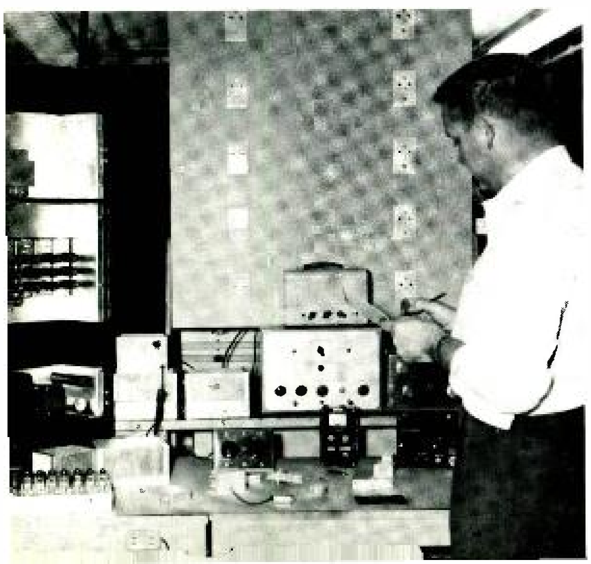
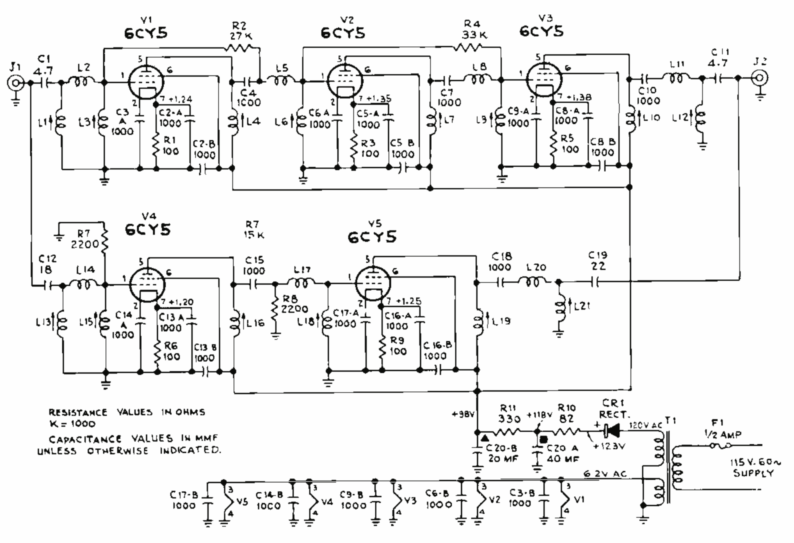


Fig. 3—Schematic diagram of a type 5BB amplifier. Frequency response is within 2.0 db over the VHF TV range, with nominal gain of 34 db on channels 7-13, 27 db gain on channels 2-6.



Patents Granted

TO RCA ENGINEERS

Based on Summaries Received over a period of about two months

DEFENSE ELECTRONIC PRODUCTS

Moorestown, N. J.

Four Terminal Waveguide Network
Pat. No. 2,867,773—granted Jan. 6, 1959 to N. I. Korman.

Step-Wave Generator with Means to Adjust and Measure Height of Any Step
Pat. No. 2,874,280—granted Feb. 17, 1959 to J. M. McCulley.

Microwave Switching Device
Pat. No. 2,880,397—granted Mar. 31. 1959 to R. W. Howery.

Camden, N. J.

Commutatorless Electric Motor
Pat. No. 2,867,762—granted Jan. 6, 1959 to J. N. Lehman and J. B. Theiss.

Geneva Movement
Pat. No. 2,870,647—granted Jan. 27, 1959 to C. Lauxen.

Color-Correction Systems
Pat. No. 2,872,508—granted Feb. 3, 1959 to H. E. Rose.

Television Display Sweep Linearization
Pat. No. 2,879,448—granted Mar. 17, 1959 to F. L. Putzrath.

Los Angeles, Calif.

Mechanism for Rotating Electrical Units
Pat. No. 2,867,489—granted Jan. 6, 1959 to J. Medow.

ELECTRON TUBE DIVISION

Harrison, N. J.

Getter Structure
Pat. No. 2,869,014—granted Jan. 13, 1959 to H. E. Natalis.

Electron Tube Structure
Pat. No. 2,871,391—granted Jan. 27, 1959 to O. H. Schade.

Getter Structure
Pat. No. 2,872,028—granted Feb. 3, 1959 to E. S. Thall.

Lead Wire Feeding Device
Pat. No. 2,873,835—granted Feb. 17, 1959 to P. W. Maurer and H. L. Blust.

Notching Roller Assembly for Grid Winding Machine
Pat. No. 2,877,065—granted Mar. 10, 1959 to J. A. Chase.

Lancaster, Pa.

Photoconducting Devices
Pat. No. 2,866,878—granted Dec. 30, 1958 to G. S. Briggs and R. W. Christensen.

Electron Tube
Pat. No. 2,869,009—granted Jan. 13, 1959 to M. B. Shrader.

Electron Beam Convergence Apparatus
Pat. No. 2,875,374—granted Feb. 24, 1959 to J. C. Cooper and R. W. Hagmann.

Glass Sealing
Pat. No. 2,876,596—granted Mar. 10, 1959 to S. W. Kessler.

Marion, Ind.

Electrode Assembly
Pat. No. 2,877,370—granted Mar. 10, 1959 to E. O. Hanson.

RADIO & "VICTROLA" DIVISION

Cherry Hill, N. J.

Phonograph Pickup
Pat. No. 2,866,857—granted Dec. 30, 1958 to D. R. Andrews.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

Signal Processing Circuits
Pat. No. 2,867,751—granted Jan. 6, 1959 to S. I. Tourshou, E. B. Smith and G. E. Skorup.

Adjustable Voltage Supplies
Pat. No. 2,867,750—granted Jan. 6, 1959 to B. V. Vonderschmitt.

Deflection Circuits
Pat. No. 2,869,030—granted Jan. 13, 1959 to B. V. Vonderschmitt and M. Deranian no longer with RCA.

Cathode Ray Beam Deflection Apparatus
Pat. No. 2,869,029—granted Jan. 13, 1959 to L. Dietch.

Deflection Systems
Pat. No. 2,870,373—granted Jan. 20, 1959 to F. E. Brooks.

Transistor Reactance Circuit
Pat. No. 2,870,421—granted Jan. 20, 1959 to H. C. Goodrich.

Stabilized AGC System
Pat. No. 2,871,288—granted Jan. 27, 1959 to L. P. Thomas.

Raster Centering Control
Pat. No. 2,871,405—granted Jan. 27, 1959 to B. V. Vonderschmitt.

Negative Resistance Oscillator
Pat. No. 2,872,580—granted Feb. 3, 1959 to L. A. Horowitz and R. W. Sonnenfeldt, IEP, Camden, N. J.

RCA SERVICE COMPANY

Cherry Hill, N. J.

Modulator Circuit
Pat. No. 2,875,414—granted Feb. 24, 1959 to S. Wlasuk.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Antenna Array and Feed System Therefor
Pat. No. 2,867,804—granted Jan. 6, 1959 to H. E. Gihring.

Negative Resistance Oscillator
Pat. No. 2,872,580—granted Feb. 3, 1959 to R. W. Sonnenfeldt and L. A. Horowitz, Television Div., Cherry Hill, N. J.

Controllable Transistor Clipping Circuit
Pat. No. 2,873,387—granted Feb. 10, 1959 to M. C. Kidd.

Color Television Synchronization
Pat. No. 2,873,311—granted Feb. 10, 1959 to R. W. Sonnenfeldt.

Generator of Color Images from Monochrome Television Signals
Pat. No. 2,874,212—granted Feb. 17, 1959 to F. L. Bechley.

Microwave Bypass Capacitor
Pat. No. 2,875,386—granted Feb. 24, 1959 to R. H. Fricke and J. A. Liggett.

Stabilized Clipper and Clamp Circuits
Pat. No. 2,875,332—granted Feb. 24, 1959 to A. C. Luther, Jr.

Synchronized Vibrator System
Pat. No. 2,875,397—granted Feb. 24, 1959 to N. S. Parks.

Oscillator Control System
Pat. No. 2,875,337—granted Feb. 24, 1959 to H. A. Robinson.

Color Television
Pat. No. 2,876,347—granted Mar. 3, 1959 to J. W. Wentworth.

NATIONAL BROADCASTING CO.

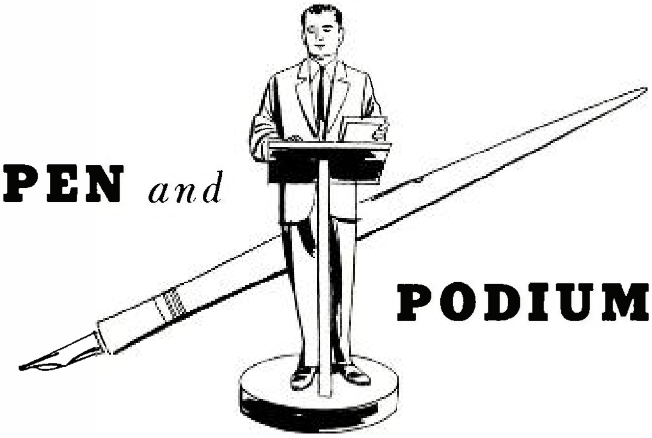
New York, N. Y.

Phase Synchronizing Systems
Pat. No. 2,879,384—granted Mar. 24, 1959 to N. E. Sprecher.

RCA STAFF

Camden, N. J.

Multiplex Transmission
Pat. No. 2,874,213—granted Feb. 17, 1958 to G. L. Beers.



PEN and PODIUM

BASED ON REPORTS RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

DEFENSE ELECTRONIC PRODUCTS

Camden, N. J.

Printed Circuit Connectors
By H. R. Sutton: Presented at the EIA Third Reliability Conference on Electrical Connections, Dallas, Texas, Dec. 2, 1958. The materials and design factors affecting the performance of electrical connectors are considered.

Analysis of an Air Traffic Control Data Link System
By A. B. Glenn: Presented at the National Global Communications, St. Petersburg, Florida, Dec. 4, 1958. This paper deals with the modulation and detection characteristics of a radio link.

Low Noise Microwave Amplifiers
By H. J. Woll. Presented at the Armed Forces Communications and Electronics Association, Colorado Springs, Colo., Jan. 28, 1959. The continuing need for low noise amplifiers was discussed. Illustrations of where such amplifiers are currently needed were given.

Effects of Space Environments on Plastics
By J. J. Lamb: Presented at the 15th Annual Meeting of Society of Plastics Engineers at Hotel Commodore, New York City, Jan. 30, 1959. Space environments, such as vacuum, ozone, ultraviolet light, and ionization, were described and related to their causes.

A Technique for Drift Reduction in Semiconductor D-C Amplifiers
By T. B. Martin and J. E. Lindsay: Presented at the AIEE Mid-Winter General Meeting, New York City, Feb. 4, 1959. This paper describes a technique for the reduction of thermal drift caused by changes in the d-c conductance of silicon diodes.

Ferrite Apertured Plate Memories
By C. S. Warren: Presented at the Solid State Conf., Philadelphia, Pa., Feb. 12, 1959. Ferrite Apertured Plates as applied to coincident current random access memories were described.

Maintenance Key to Useability
By D. B. Dobson: Presented at the National Convention on Aero. Electronics, Dayton, Ohio, May 1959. Various areas of Maintenance Engineering Responsibility are: Spare Parts, Field Tools and Test Equipment, Personnel, Training, and Overhaul.

Recent Advances in Micro-Module Techniques
By H. J. Laiming and D. Mackey: Presented at the Electric Components Conference, Benjamin Franklin Hotel, Philadelphia, Pa., May 1959. This paper covers the background, approach accomplishments and future plans on a program initiated April 1, 1958 under Army contract.

Moorestown, N. J.

Progress in Reliability
By R. M. Jacobs: Published in the *Electronic Equipment Engineering* Magazine, Jan. 1959 issue. This report summarized the accomplishments of the professional societies, the military educational institutions, and the electronics industry in furthering an awareness of reliability requirements.

A Multiload Transfluxor Memory
By W. L. Morgan, D. G. Hammel and R. D. Sidnam: Presented at the Western Joint Computer Conference, Mar. 1959. The multiload transfluxor memory system is described as being well suited to serve conventional computer systems more efficiently.

C-Band Radar Observations of Sputnik II
By D. K. Barton: Presented at the 15th session of the IRE Convention, Mar. 24, 1959. The AN/FPS-16 radar on Grand Bahama Island obtained two extended tracks on Sputnik II during Feb. 1958. Observed signal strength and details of the signal strength and servo error signal records are believed to establish facts as to structure and placement of corner reflectors.

A Survey of Analog-Digital Conversion Techniques for the Analog Computer
By V. Coates: Presented at the bi-monthly meeting of the Eastern Simulation Council, held at RCA, Moorestown, N. J., Dec. 15, 1958. The processes of "Sample & Hold" and "Quantilization" are discussed and methods of simulating them on the Analog Computor are presented.

Analog Study of F.M. Discriminator
By E. A. Sevian and O. J. Palumbo: Presented at the bi-monthly meeting of the Eastern Simulation Council, held at RCA, Moorestown, N. J., Dec. 15, 1958. This paper presents a new approach in employing the analog computer to design a frequency discriminator centered about 200 Kilocycles per second.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

A Broad Band Microwave Relay Antenna
By R. F. Privett: Presented at the combined meeting of IRE Professional Groups; PGMTT and PGAP of Philadelphia Chapter, RCA, Camden, N. J. A new antenna concept was explained and a description given of a radio relay antenna of high efficiency (64%), low VSWR (1.06 average) and large bandwidth (± 15%).

Quartz Crystals in Frequency Control
By R. R. Bigler: Presented at the Moorestown Radio Club Meeting, Feb. 6, 1959. A brief description of the possibilities of accurate frequency control using quartz crystals was given.

The Characteristics and Properties of an EDP Language
By J. S. Mamelak: Presented at the Delaware Chapter of the ACM, Jan. 21, 1959. This talk deals with the questions related to the construction of programming language more complex than the usual assembler-compiler pseudolanguages available.

High Power Transmitter Design Considerations
By T. J. Boerner: Presented at the Twin Cities IRE Professional Group, Broadcast Transmission Systems, Minneapolis, Minn., Jan. 21, 1959. A combination of Jim Creek high-power transmitter techniques and ampliphase circuitry is developed in a conceptual design of a 750 KW standard band broadcast transmitter.

Transistorized Video Switching
By J. Wentworth, A. C. Luther and C. R. Monro: Presented at the IRE Convention, Mar. 1959. The RCA TS-40 Switching Equipment employs diode switching elements, controlled by transistorized flip-flops. The equipment is adaptable to a wide variety of television switching applications.

The Computing Machine-Slave Labor in a Free Society?
By H. M. Elliott: Presented at the Western Joint Computer Conference, San Francisco, Calif., Mar. 1959. This paper illustrates how the computing machine is an economic servant.

The RCA 501 Automatic Assembly System
By T. M. Hurewitz: Presented at the WESCON Convention, San Francisco, Calif., Mar. 3, 1959. The RCA 501 Automatic Assembly System presents a powerful tool for reduction of both programming costs and time.

A New Approach to Low Distortion in a Transistor Power Amplifier
By H. J. Paz: Presented at the IRE National Convention, New York City, Mar. 24, 1959. The new approach described here takes into account the limitations of presently available power transistors in designing a low-distortion high-fidelity transistor power amplifier without need of special selection.

A Minimum Distortion Tapered-Transmission Line Transformer for Pulse Application
By H. Amemiya: Presented at the IRE National Convention, New York City, Mar. 26, 1959. The paper presents a mathematical derivation to show that, when handling pulses, a tapered-transmission-line transformer gives minimum distortion.

Industrial Electronics—The Growing Servant of Mankind
By T. A. Smith, Exec. Vice Pres., Industrial Electronics Products: Presented at the IRE National Convention, Mar. 26, 1959, New York City. A presentation and panel discussion dealing with the social, commercial and technical aspects of the industrial electronics field.

RCA RADIO & "VICTROLA" DIVISION

Cherry Hill, N. J.

A High Quality Stereophonic Pickup for Mass Production
By D. Laux and J. Tourtellot: Presented at the AES Convention, Los Angeles, Calif. A technical description of the new stereophonic pickup, its performance capability and life testing results are given.

A New Magnetic Recording System
By A. D. Burt and D. R. Andrews: Presented at the IEE Convention, London, England, Mar. 18, 1959. This paper describes a new magnetic tape recording system that provides the consumer all the same desirable features of dish methods.

Automatic Handling of Magnetic Tape
By A. D. Burt and D. R. Andrews: Presented at the AES Convention, Los Angeles, Calif., Feb. 17, 1959. A new approach toward handling magnetic tape in a cartridge is combined with an automatic machine to provide up to two full hours of unattended recording or reproduction.

The Design of a Mechanism to Handle Tape in a Cartridge
By A. D. Burt and D. R. Andrews: Presented at the AIEE Convention, New York City, Feb. 2, 1959. A tape transport mechanism has been designed which handles tape in a cartridge. Automatic stopping is provided by a mechanical trip at the end of the tape.

A High Resolution Stereo Magnetic Head for Four Track Applications
By A. Sariti: Presented at the Sixth Annual Western Convention and Exhibit of the Audio Engineering Society, Los Angeles, Calif., Feb. 17, 1959. Design criteria for slow speed narrow gap in line stereo head for cartridge application is discussed.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

Transients in Bandpass Systems
By M. S. Corrington: Presented at the Philadelphia Section IRE and Philadelphia Chapter Prof. Group on Circuit Theory, Univ. of Pennsylvania, Nov. 24, 1958. The paper described the response of single-tuned, stagger-tuned pairs, and flat-staggered triple-tuned circuits to suddenly-applied sine waves.

NATIONAL BROADCASTING COMPANY, INC.

New York, N. Y.

Television Control Room Human Engineering Problems
By E. B. Pores: Published in the October 1958 issue of the SMPTE Journal, Volume 67. This paper describes the design of a technical director's operating console used to assemble and control a TV film coordinating studio.

A Basis for Loudness-Judgments
By E. B. Pores, NBC, and R. M. Warren and E. A. Sersen, New York University: Published in the Dec. 1958 issue of the American Journal of Psychology. This paper describes tests and studies of theory that judgements of loudness are based on experience with the manner in which sound changes with distance.

CORPORATE STAFF

Camden, N. J.

Here's How Standards Make Money for My Company
By S. H. Watson: Presented at the Ninth Nat'l. Conf. on Standards, New York City, Nov. 19, 1958. The vital role of standards in modern day electronic equipment, and in the possibilities of standardization in diversified industrial operations were discussed.

RCA ASTRO-ELECTRONIC PRODUCTS DIVISION

Princeton, N. J.

High Definition T.V. Systems for Space Applications
By J. Staniszewski, P. Werenfels and M. Mesner: Presented at the annual meeting of the American Astronautical Society, Dec. 30, 1958. Television cameras can be used to photograph the earth, the planets, and stars from space vehicles, and men, animals, and instruments within such vehicles. Design considerations for low power radio transmitters were described.

Space Vehicle Attitude Problems
By H. Perkel: Presented at the annual meeting of the American Astronautical Society, Dec. 29, 1958. The motion of an orbital vehicle about a coordinate system located at the center of gravity of the body is discussed, and the attitude of an axis fixed in the body and its response to disturbances given.

ELECTRON TUBE DIVISION

Harrison, N. J.

Method for Determining Specific Cooling Rates of Electron-Tube Anode Materials in Vacuum
By C. W. Horsting, I. S. Solet, T. A. Sternberg, and P. Avakian: Published in IRE TRANSACTIONS on Electron Devices, January 1959: This paper describes a simple and convenient measurement technique which quickly provides quantitative data on heat-radiating abilities of plate materials.

Design of Traveling-Wave Tubes for Airborne Applications
By M. Nowogrodzki: Presented at AIEE Winter General Meeting, New York City, February 3, 1959. This paper reviews the development of traveling-wave tubes from laboratory novelties to modern airborne systems components, and describes a few of the solutions to the problems of ruggedization and miniaturization.

Development of a Front-End Tube Having Reduced Crossmodulation and Noise
By A. A. Jalajas and K. W. Uhler: Presented at AIEE Winter General Meeting, New York City, February 3, 1959. This paper outlines a general theory of distortion and crossmodulation, and presents a graphical method for approximating crossmodulation directly.

Long-Life Characteristics of Traveling-Wave Tubes and Magnetrons
By E. W. Kinaman and R. W. Kissinger: Presented at AIEE Winter General Meeting, New York City, February 3, 1959. This paper describes the design considerations involved in producing magnetrons and traveling-wave tubes for long-life applications.

The RCA-7111, a Very-High-Performance Tunable Magnetron
By V. J. Stein: Presented at AIEE Winter General Meeting, New York City, February 3, 1959. This paper describes a pulsed X-band magnetron tuned by coupled cavities which was developed for operation in modern radar systems.

Periodically Focused Traveling-Wave Tubes for Operation Under Extreme Environmental Conditions
By E. E. Bliss: Presented at AIEE Winter General Meeting, New York City, February 3, 1959. This paper describes the design features incorporated in traveling-wave tubes to satisfy the requirements of temperature stability and resistance to vibration.

Density Effects of Additives
By W. C. Allen: Presented at New York Section of American Ceramic Society, Newark, N. J., February 27, 1959. This paper discusses the effects of various types and amounts of additives on the density of pressed ceramic parts.

The Weekend Special
By L. W. Aurick: Published in HAM TIPS, February 1959. This paper describes the design of a portable 40-meter cw station which can be carried in a portable typewriter case and yet provides a high degree of operating convenience and efficiency.

Performance of Low-Plate-Potential Tubes at Mobile-Communications Frequencies
By R. J. Nelson and C. Gonzalez: Presented at IRE National Convention, New York City, March 23, 1959. This paper analyzes the performance of low-plate-potential tubes at frequencies above 2 megacycles, and discusses performance requirements.

Development of Automatic Machinery for Making Electron-Tube Stems
By M. M. Bell: Presented at IRE National Convention, New York City, March 23, 1959. This paper discusses some of the problems peculiar to the manufacture of electron-tube stems and the development of machinery.

Selective Signal Suppression and Limiting in Traveling-Wave-Tube Amplifiers
By H. J. Wolkstein and E. W. Kinaman: Presented at IRE National Convention, New York City, March 24, 1959. This paper describes saturation characteristics of traveling-wave tubes in the presence of overdriving signals and the effects on gain and power output.

Talk and Demonstration on Stereophonic Sound
By C. A. West: Presented to 3rd Presbyterian Church Couples Club, Elizabeth, N. J., March 28, 1959. This paper discusses the arrangement of recording equipment for stereophonic sound, the use of two receiver (AM-FM) arrangement from studio to living room, and a stereo setup in the home.

Shifts in Work Functions and Surface Characteristics of Some Receiving-Tube Grids
By E. R. Schrader and D. A. Yanchusk: Presented at MIT Electronics Conference, Mass., March 27, 1959. This paper discusses the variation of work function and emission of receiving-tube grid surfaces and the effects of various processing techniques.

SEMICONDUCTOR AND MATERIALS DIVISION

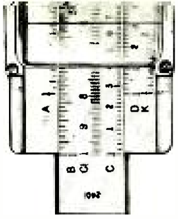
Somerville, N. J.

Application of RCA Drift Transistors to FM Receivers
By J. W. Englund and H. Thanos: Published in IRE TRANSACTIONS on Broadcast and Television Receivers, January 1959. This paper discusses the application considerations involved in the use of drift transistors in the rf amplifier, oscillator, and if amplifier stages of battery-operated FM receivers.

A Simple and Flexible Method of Fabricating Diffused N-P-N Silicon Power Transistors
By L. D. Armstrong and H. D. Harmon: Presented at IRE National Convention, New York City, March 23, 1959. This paper describes the unique diffusion and contacting operations used in a method of fabricating diffused n-p-n silicon junction transistors.

A Five-Transistor Automobile Receiver Employing Drift Transistors
By R. A. Santilli and C. F. Wheatley: Presented at IRE National Convention, New York City, March 25, 1959. This paper describes a high-performance, low-cost, five-transistor automobile receiver employing a new line of RCA drift transistors developed specifically for this application.

Improvements in Detection, Gain-Control, and Audio-Driver Circuits of Transistorized Broadcast-Band Receivers
By R. V. Fournier and D. Thorne: Presented at IRE National Convention, New York City, March 25, 1959. This paper describes the uses of a developmental diode-triode transistor to improve detection, automatic gain control, and audio amplification in transistorized broadcast-band receivers.

Engineering  NEWS *and* HIGHLIGHTS

O. B. HANSON RETIRES; DR. G. H. BROWN ELECTED VICE PRESIDENT, ENGINEERING

Dr. G. H. Brown was elected Vice President, Engineering, succeeding O. B. Hanson who recently retired. He will be responsible for the direction of the Corporate engineering staff including Operations Engineering, Product Engineering, and the RCA Frequency Bureau. He will report to Dr. D. H. Ewing, Vice President, Research and Engineering.

Since January, 1957, Dr. Brown has served as Chief Engineer of IEP. A 25-year veteran of RCA engineering activities, he has made major contributions to radio and television broadcast communications, particularly in the fields of antenna design and UHF transmission.

O. B. Hanson, pioneer radio and television broadcasting engineer, retired early in March as Vice President, Engineering Services, RCA. He will continue to serve the Corporation as a consultant.

Mr. Hanson has been associated with RCA, NBC and predecessor companies for thirty-six years. Prior to joining RCA's engineering staff five years ago, he had served for seventeen years as Vice President and Chief Engineer of NBC, and for ten years before that as NBC's Chief Engineer. He made major contributions to both radio and television, directing the establishment of the first radio network, and designing the studios for WRCA-TV, formerly WNBT, first commercially licensed TV station to go on the air.

RCA HONORS SCIENTIST AND ENGINEER

Armstrong

Lindenblad

A scientist who has pioneered in research on electronic cooling and an engineer who has made basic contributions to transistor design and production techniques have been named as the 1958 recipients of the David Sarnoff Outstanding Achievement Awards in Science and Engineering.

The two recipients are Nils E. Lindenblad, a Fellow of the RCA Laboratories technical staff at Princeton and Dr. Lorne D. Armstrong, a Senior Engineer in Advanced Development at the RCA Semiconductor and Materials Division, Somerville.

The awards, established in 1956 to commemorate the fiftieth anniversary in radio of Brig. General David Sarnoff, are presented annually by the corporation to honor outstanding achievement by a scientist and an engineer of RCA. Each award carries a gold medal and a citation.

The awards will be presented formally at a later date.

Mr. Lindenblad joined RCA in 1920. As a member of the RCA technical staff at Rocky Point and Riverhead, Long Island, during the following two decades, he made many basic contributions in radio communications research, including pioneering studies in the generation and use of centimeter waves and discovery of the principles of the traveling wave tube. During the 1930's, Mr. Lindenblad was responsible for major advances in antenna theory and applications, including the development of the first television antennas employed on the Empire State Building.

After his transfer to the RCA Laboratories staff at Princeton in 1950, Mr. Lindenblad was selected to head a new research activity on electronic cooling systems, subsequently developing the first full-size electronic refrigerator and a pioneer working model of an electronic room air-conditioning system. A Fellow of the IRE and a member of Sigma Xi, Mr. Lindenblad has been issued about 250 patents.

Dr. Armstrong has been with RCA since 1949, when he went to work at the RCA Laboratories in Princeton. During the next five years, he was active in semiconductor research, making major contributions to the development of alloy junction transistors. In 1954, he was transferred to the Semiconductor Engineering Department of the RCA Tube Division at Harrison, N. J., where he remained until moving with the operation to Somerville in 1956.

POSITION OF 'FELLOW' CREATED BY RCA LABORATORIES

A new position carrying the title of Fellow, Technical Staff, has been established by RCA Laboratories to recognize continued outstanding individual achievement in the field of research, Dr. Irving Wolff, Vice President, Research.

"We consider this appointment a badge of high technical achievement. We hope and expect that the title of Fellow will confer the same recognition as that of Associate Laboratory Director and Laboratory Director. The difference will be mainly one of personal volition: the Fellow desiring to make continued personal technical contributions, and the Associate Laboratory Director and Laboratory Director electing to contribute through leadership in group administration."

The eight RCA Laboratories scientists designated as Fellows are A. V. Bedford, Herbert Belar, C. W. Hansell, R. D. Kell, N. E. Lindenblad, D. O. North, E. G. Ramberg, and Albert Rose. The three new Associate Laboratary Directors are Harwick Johnson, L. S. Nergaard, and J. A. Rajchman.

HAVE YOU MAILED YOUR SURVEY?

Be sure to send in your survey, mailed to you with the last issue. If you've misplaced the form, contact your Editorial Representative (inside back cover) or call or write the Editors.

ENGINEERS IN NEW POSTS

With Dr. Brown's move to RCA Staff, **Wendell C. Morrison,** recently of Dr. Brown's IEP staff, has been appointed Mgr., Engineering Plans and Services, reporting to **J. J. Graham,** Gen'l Mgr., Communications and IEP Operations Division . . . **G. A. Olive** becomes Staff Engineer to Morrison . . . **J. W. Leas,** Ch. Eng. of IEP's EDP appoints **R. E. Wallace** Mgr. Custom Projects . . . in EDP, **H. Kleinberg** becomes Mgr. Computer Devices Eng. and **R. E. Montijo** appointed Mgr. Special Data Processing Equip. Eng. (West Coast).

In DEP, **John B. Coleman** becomes Administrator, High-Power Transmitters for **A. L. Malcarney,** coordinating R&D in DEP, appraising future defense needs and serving as liaison with other divisions. **D. Brainerd Holmes** takes Mr. Coleman's place as BMEWS Mgr. . . . **C. A. Gunther,** Ch. Defense Eng., appoints **E. S. Lowry** as Staff Engineer.

W. C. Morrison

H. K. Jenny

F. E. Vinal

In the Tube Division, **E. E. Patella** becomes Resident Engineer at Cincinnati Plant for R. C. Fortin . . . in Microwave Operations, Microwave Engineering Mgr. **H. K. Jenny** announces his staff: **W. R. Beam** Mgr. Advanced Devel.; **M. Nowogrodzki** Design & Devel. Mgr.; **R. G. Talpey** Systems & Applications Mgr.; **G. G. Carne** Tube Processing Systems Devel.; and **P. Wakefield** Services & Admin.

In Semiconductor & Materials Div., **F. E. Vinal,** as Mgr. Needham Materials Lab. announces the following managers as his staff: **J. H. McCusker,** Adv. Development; **T. A. Richard** Laboratory Services; **J. J. Sacco** Ferrite Product Devel.; **L. B. Smith** Methods & Process Devel.; **J. R. Wagenseller** Product Planning & Marketing Services; and **L. A. Wood** New Product Eng.

DR. ENGSTROM RECEIVES AIEE 'BEST PAPER' AWARD

Dr. E. W. Engstrom, Senior Executive Vice President, RCA, was awarded the annual prize for Articles in Electrical Engineering by the American Institute of Electrical Engineers.

The cash award and certificate were presented to Dr. Engstrom at the General Session of the AIEE Winter General Meeting, February 2, 1959, Hotel Statler, N.Y. for his paper, "Science and Technology in a Changing Environment," delivering before the Eta Kappa Nu Award Recognition Dinner in February 1958. The paper was subsequently published in the April 1958 issue of *Electrical Engineering*, the AIEE journal.

Dr. Engstrom delivered the paper on the occasion of the Eta Kappa Nu "Outstanding Young Electrical Engineer" Honorable Mention Award to W. R. Beam, Electron Tube Division engineer at Princeton.

MEETINGS, COURSES AND SEMINARS

'JOE BERG' FOUNDATION ACTIVE AT HADDONFIELD HIGH SCHOOL

RCA engineers are active in the recently inaugurated segment of the 'Joe Berg' Foundation at Haddonfield High School.

The Foundation was established about 2 years ago by Chicago industrialist Joe Berg for the furtherance of secondary school education in science and mathematics on a nation-wide scale. Courses are conducted voluntarily by prominent men of local industry in after-hour classes once a week during the school year. Exceptional students from all secondary school grades are eligible in schools accepting the program.

The following are instructors for the current semester at Haddonfield: From RCA, H. N. Crooks (Director of Program), M. S. Corrington, D. J. Parker, L. T. Sachtleben, R. W. Sonnefeldt, J. H. Reisner, Dr. A. H. Benner, and D. R. Crosby. There are one each instructors from DuPont, Socony-Mobile, Jefferson Medical School, and two from Campbell's Soup.

There will be more to follow on this program in a later issue.

Microwave Seminar

J. B. Bullock, TV Broadcast Equipment Engineering, IEP, conducted a microwave seminar for Bell Telephone Company operating engineers in St. Louis, February 25 and 26. Discussion and demonstration stressed operational features of TVM-1A TV Microwave Equipment and the use of test equipment in its maintenance.

—*J. H. Roe*

MICROWAVE LECTURE SERIES

The Microwave Subcommittee of the Engineering Education Committee at Harrison, N. J. has announced a new series of lectures on microwave tubes. The purpose is to give to all microwave engineers a better understanding of principles and operation of microwave devices.

The series consists of sixteen lectures, with seven already delivered during March and April. A schedule of the last nine for May and June is given below.

Secondary School Talks

W. N. Parker, Staff Engineer, Lancaster Industrial Tube Products, addressed the Mathematics and science teachers of the Manheim, Pa. Central School District of the subject, "How Schools May Better Meet the Needs of the Science Age." After Mr. Parker's talk, there was an open discussion on curriculum changes which might attract more students and prepare them better for college science training. This is part of a broad plan of cooperation between industry and the secondary schools of the Lancaster area.—*H. S. Lovatt*

Program of Lecture Series on Microwave Tubes

No.	*Date*	*Title*	*Speaker*
8	5-5-59	Magnetics	M. Schindler
9	5-12-59	Electrostatic Focusing	F. Vaccaro
10	5-19-59	High Power Slow Wave Structures	E. Belohoubek
11	5-26-59	High Power TWT and Klystrons	W. Siekanowicz
12	6-2-59	Electron Motion in Crossed Fields	
13	6-9-59	Crossed Field Devices	V. Stein
14	6-16-59	Magnetrons	D. Nelson
15	6-23-59	Bandwidth Wave Tubes	R. Johnson
16	6-30-59	Traveling Wave Tube Noise	E. Kinaman

—*H. J. Wolkstein*

Creativity

C. M. Sinnett, Mgr. of Advanced Development Engineering, Television Division, Cherry Hill, gave the following talks on Creativity: "The Importance of Creativity in Engineering," March 5 at the Pennsylvania Institute of Technology; "Creativity: Motivating the Engineer," April 9 at the A.M.A. Seminar on Managing & Measuring Engineering Effort, New York; "Creativity Should Be Taught in College" before the American Society of Inventors, to be presented May 12.—*D. J. Carlson*

WILL YOUR KEY UNLOCK THIS DOOR?

Although the third and final installment of the series on Creativity was published in Vol. 4 No. 4, the following was submitted too late to be included, but too good to pass up.

PRACTICAL ESSENTIALS FOR CREATIVE ENGINEERING

By

Joel Morris

Surface Communications DEP, Camden, N. J.

Creativity means money in your pocket and profits to the Company.

Creativity is preceded by a thorough analysis of apparent and real "causes and effects" of the subject matter under consideration. It stems from a genuine or imagined application of the product or concept. It requires confidence in yourself to find a solution to the given problem.

Creativity is the ability to think out of the ordinary. It is the capacity to look and think of traditional products and concepts in the converse, reverse, obverse, adverse, and traverse. It consists of letting your uninhibited imagination search and float freely over associated ideas.

Creativity is best produced in an environment that eagerly awaits and accepts your ideas—an environment in which people are dependent upon your creativity, be they your family or work associates.

Creativity requires courage. Prime criteria are that you exercise your creativity, that you are not ashamed to present new and totally different ideas to supervisors, that you are not negatively affected by the criticism of others who do not appreciate your ideas.

NEW EDITORIAL REPRESENTATIVES APPOINTED

Three new Editorial Representatives have been appointed in DEP. John F. Biewener replaces T. P. Canavan in Airborne Fire Control Engineering, Airborne Systems Department, Dr. A. H. Benner replaces R. D. Lending in Airborne Systems Engineering, and F. W. Whittier replaces L. M. Seeberger in Development Engineering.

The Editors wish to thank Messrs. Canavan, Lending, and Seeberger for their long-standing and helpful cooperation on the RCA ENGINEER.

Biewener

Benner

Whittier

Dr. A. H. Benner received a BS in EE in 1944 from the University of Kansas and a PhD in EE from Pennsylvania State College in 1951. From 1946 to 1949 he was an electronic design engineer at the Ordnance Research Laboratory in State College, Pa. From 1949 through 1950 he was a project engineer at the Ionosphere Research Laboratory. He has been with RCA since 1950 in the Airborne Systems Dep't., DEP, in charge of such projects as modulation studies, filter research, and communication systems error analysis.

He is a member of Sigma Xi, Tau Beta Pi, and a Senior Member of the IRE.

J. F. Biewener received the BS in EE from Carnegie Institute of Technology in 1950 and joined RCA the same year in the Engineering Reports Group of EPD General Engineering Development. In December 1954 he transferred to Aviation Systems Development at Moorestown on the Black Cat Project. He left RCA in 1955 to enter a printing association in Philadelphia, returning to RCA in 1957 as Manager, Engineering Reports and Publications, Airborne Systems Department.

He is a member of Eta Kappa Nu and Tau Beta Pi.

F. W. Whittier received the BS in ME from Cornell University in 1944 and the MS in ME from Lehigh in 1949. A succession of positions from 1943 to 1958 lead him from Army Ordnance work at Frankford Arsenal to include instructing Mechanical Engineering at Lehigh, production engineering at Western Electric Co., assembly supervision at Warren Webster Co., Camden, to Senior Research Engineer at Franklin Institute Laboratories. At Franklin Institute he became Manager, Report Services, before coming to RCA in 1958 as Publications Engineer.

NEW EDITION OF "RCA RECEIVING TUBE MANUAL" PUBLISHED

A new revised edition of the "RCA Receiving Tube Manual" has been announced by the Electron Tube Division.

"The Manual in eight editions has sold more than 3½ million copies since 1933," according to Robert S. Burnap, Manager, Commercial Engineering. He added that the book is recognized as the most authoritative and comprehensive tube manual in the industry.

DINO L. CURTI

It came as a harsh shock to realize that the collision in front of the Moorestown plant on January 29 had taken the life of one of our friends, Dino Louis Curti.

Born in 1936, Mr. Curti graduated from Villanova University, where he earned his BEE. He made the Dean's list every semester and finished fourth in his class, while earning all his expenses and helping support his mother and younger brother and sister. He was always interested in the welfare of others. When one of his friends was bedridden for three months, Dino kept him so well instructed that he was able to graduate with the rest of his class; and with Dino's inspiration and help, both his brother and sister expect to finish college.

Although he had offers from the University of Notre Dame and Massachusetts Institute of Technology, Mr. Curti chose, in June of 1958, to join RCA's effort on BMEWS. Working in the field of display control, he soon earned a reputation for careful, thorough investigation, and his first six months' work led to a circuit advance that will be used in the Nation's defense. His passing has lost the Company a very promising talent.

Dino's quiet manner could not hide a warm and responsive nature; he brought to his daily contacts the sympathy, sincerity, and generosity which cement acquaintance into friendship. There are many of us who will long feel a sense of deep personal loss.—*A. C. Stocker*

RCA ENGINEERS ACTIVE AT IRE CONVENTION

RCA engineers presented seventeen papers at the technical sessions of the IRE national Convention, held during the week of March 23, 1959. Five RCA engineers were chairmen of various technical sessions.

COMMITTEES

IEP Camden

F. J. Herrmann, Mgr. Scientific Instruments, IEP, has been elected Vice President of the Philadelphia Alumni Chapter of Eta Kappa Nu.—*C. W. Sall*

Industrial Tube Products, Lancaster

Miss Betty J. Bell, Quality Control Coordinator, has been elected secretary of the Harrisburg Section, American Society for Quality Control. **H. W. Metcalf,** Quality Control Engineer, has been made Chairman of the Membership Committee.

C. W. Weineke, Standardizing, has been appointed to the A.S.T.M. Committee F1 on Materials and also to the Subcommittee V, Section A on Materials for Glass Sealing.

J. M. Forman, Life Test and Data, has been appointed to the Instrumentation Subcommittee of the Institute of Environmental Engineers.

J. K. Glover, Mgr. Standardizing, has been appointed consultant on the JETEC Packaging Committee JTC 10.—*H. S. Lovatt*

Kinescope Engineering, Lancaster

G. G. Thomas has been appointed Chairman of the Engineering Education Committee succeeding Dr. L. B. Headrick, who has transferred to C Stellarator Associates at Princeton.—*D. G. Garvin*

Airborne Systems, DEP Camden

F. F. Martin, Engineering Systems Projects, was appointed National Secretary of the American Astronautical Society, and has also been selected as Chairman of the National Membership Committee of the same Society.—*J. F. Biewener*

NEW SYSTEMS LAB NEAR TUCSON, ARIZ.

RCA will establish new quarters for its Surface Com. Systems Lab., at a site 20 miles southeast of the present Tucson location.

In its evaluation work on current and advanced military systems, the RCA Systems Laboratory works closely with the U. S. Army Electronic Proving Ground at nearby Fort Huachuca. For the past three and a half years the Laboratory has been concentrating on a study contract from the Signal Corps group at Huachuca to analyze and develop recommendations for a complete area communications system.

Allen M. Creighton will be Manager of the new RCA Systems Laboratory facility. A native of Phoenix, where his family has lived for three generations, he received his BS in EE from the U. of Arizona.

A. M. Creighton

W. L. Oates

Architects' sketch of new RCA Surface Communications Systems Laboratory which will provide 12,000 sq. feet of space and be completed about Aug. 1, 1959.

ACKNOWLEDGMENT

RCA's new Automatic Soldering System for Printed Circuit Boards, as described under the heading "Detroit Story" in our last issue, owes much to Equipment Development Engineering, Camden.

Equipment Development was part of the Components Division when given the opportunity of developing the system for D.E.P. Mechanization and Methods.

William L. Oates was the Equipment Development Engineer in charge of the project and he conceived the idea of the Cascade Multi-Wave Solderer, and designed the unit which is the subject of a patent application in his name.

William L. Oates was born in London, England, and received his engineering training at Battersea and Northampton Polytechnics, London. He was with the Morgan Crucible Co. Ltd. London, for 11 years before emigrating to Canada, where he joined RCA Victor Co. Ltd., Montreal. He later came to live in the U. S. and joined International Resistance Co., Philadelphia, as Manufacturing Engineer, transferring to their Asheville Plant as Product Engineer.

He joined RCA Camden as Equipment Development Engineer in June 1956, and became an American Citizen May 1958.

Equipment Development is now part of Airborne Systems Department, D.E.P.

REGISTERED PROFESSIONAL ENGINEERS

Additions to the RCA ENGINEER list of registered professional engineers:

RCA Service Company	*State*	*Licensed As*	*License No.*
Francis L. Kelly	N. J.	Chief Eng.	B-30633
		Mech. Eng.	1207
David W. Honeycutt	N. C.	Land Sur.	
Elmer L. Brown	Calif.	Prof. Eng.	E. E. 3643
D. L. Klein	Virginia	Prof. Eng.	PE 3563 M
Otis W. Child	Illinois	Prof. Eng.	62-18130
William A. McLendon	Florida	Prof. Eng.	1839
George A. Kunz	Penna.	Eng. in Training	
RCA Victor Record Division			
William J. Tejral	N. J.	Prof. Eng.	10605
DEP Surface Communications, Camden			
R. W. Conner	Calif.	Elect. Eng.	2586
Tube Division, Harrison			
Constantino Formicola	N. Y.	Prof. Eng.	35120

PRINCETON SCIENTIST HONORED

Dr. Frank Herman, member of the technical staff, Physical and Chemical Research Laboratory, RCA Laboratories, was named one of New Jersey's Five Outstanding Young Men by the New Jersey Junior Chamber of Commerce recently. Dr. Herman and the four other recipients were honored at a dinner on Saturday evening, February 28, at which the Distinguished Service Awards were presented.

Dr. Herman's citation was as follows:

"Research Physicist, Consulting Scientist, he is Senior Member of the Technical Staff at one of the nation's leading research laboratories and a recognized authority in the field of theoretical solid state physics. A pioneer in his field who has often published the results of trailblazing basic research, he has contributed in great measure to the national defense, the standard of living, and man's understanding of the environment in which he exists."

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5 February-March 1959
6 April-May 1959

Occasionally an (ED) will be noted following an article title, with no page reference. This is an editorial on the inside front cover of the issue indicated.

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