The pattern reproduced on the front cover results when light from a gas laser is projected through a series of lenses between which the aperture shown at the left has been placed. The experiments were performed by R. E. Hopkins, D. Dutton, and M. P. Givens of the Institute of Optics, University of Rochester, and described in their 1963 NEREM paper. For a detailed description of some other work in coherent light diffraction, see the article by W. H. Huntley, Jr., in this issue, page 114.

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

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New end-seal design makes possible two tiny sizes (.085" dia. x .250" long, and .127" dia. x .375" long) for “cordwood” packaging to supplement standard-sized Type 150D ratings in case size “A”.

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LTV ALTEC DIVISION • LTV ASTRONAUTICS DIVISION • LTV CONTINENTAL ELECTRONICS DIVISION • LTV LING ELECTRONICS DIVISION • LTV MICHIGAN DIVISION • LTV MILITARY ELECTRONICS DIVISION • LTV RANGE SYSTEMS DIVISION • LTV RESEARCH CENTER • LTV TEMCO AEROSYSTEMS DIVISION • LTV UNIVERSITY DIVISION • LTV VOUGHT AERONAUTICS DIVISION.

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*Kentron Hawaii, Ltd., and the Friedrich companies retain their identities as LTV subsidiaries.

**LTV**

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High-efficiency radiation shielding

Isotope container made of Mallory 1000.

Mallory makes a line of high density materials which have excellent radiation shielding characteristics. You may find them just what you require in designs for nuclear instruments, compact reactors or isotope containers.

These materials are powder metallurgy products based on tungsten. Mallory 1000 has about 70% of the tenth-layer thickness of lead, and is about twice as strong as low carbon steel. Its density is about 17 gm/cc. Even better shielding is possible with Mallory 2000 (density 18.0 gm/cc) and Mallory 2960A (density 18.5 gm/cc). And we have even newer experimental materials with densities of 19 gm/cc, approaching that of pure tungsten. Where both neutron and gamma shielding are needed, we can introduce boron-10 into the base material.

Technical data and consultation are available on request.

FOR DATA USE READER SERVICE CARD

New aluminum electrolytic has high reliability at moderate cost

Next time you need extra capacitor reliability without premium price, take a look at the Mallory Type TPG. It's a new kind of aluminum electrolytic, with exceptional stability and life expectancy. On tests that have run several thousand hours, the TPG shows retention of initial values of capacitance, DC leakage and equivalent series resistance that you may not have thought possible in a compact-sized aluminum tubular unit. We have run over a million piece-hours of certification testing with only one electrical failure. (Test conditions—rated voltage and 85°C.)

The TPG has all-welded construction. The positive lead tab is both mechanically locked and welded, to give double assurance of lead strength. Temperature rating is -40 to +85°C. Values range from 20 mfd., 150 volts to 450 mfd., 3 volts. Size: 5/8" diameter by 1 5/6" to 1 5/6" long. Evaluate this new capacitor in circuits where you may have been planning to use tantalum. You may be able to make real economies.

FOR DATA USE READER SERVICE CARD

Need an encapsulated control?

Some of our customers occasionally need a wire-wound control that is sealed against dust and humidity. For these applications, we have developed techniques of encapsulation that give protection against severe environments.

First, we use an epoxy encapsulation that surrounds the entire ease of the control. Then, we build in a dual O-ring seal, one on the shaft and another between the control bushing and the mounting panel.

The picture shows how this construction looks on our Type SC 5-watt control.

FOR DATA USE READER SERVICE CARD
Using Resonant Reed Relays in sequential code tone signalling

Our original self-holding resonant reed relay has such unusual characteristics as a simple tone-actuated remote switch, that we have engineered some additional functions into a model called the RRB relay.

In the RRB relay, two resonant reeds, which respond only to proper audio tones, are arranged to actuate telephone-type contact stacks. This permits many switching combinations to respond to a single tone signal.

The relay provides for an optional mechanical latching arrangement so that the signal may be removed from the carrier channel after achieving the desired switching. An auxiliary reed—tuned to a different frequency—releases the mechanical latch to restore the circuits to normal.

Additional option is provided in a sequencing mechanism. If the two working reeds are tuned to respond to tones A and B, for example, a circuit may be arranged to close only if tone A is transmitted before tone B. Two such relays may be operated selectively to call any 1 of 108 different stations by transmitting 4 proper tones in a required sequence. Each station (see diagram below) would have 2 of the relays with selected tone-sequence responses.

This basic system can be expanded by using additional tones or decoding relays. If 8 tones are used with three decoding relays at each station, any 1 of 134,456 stations may be selected by a proper sequence of a six tone code.

And that's not all. By reversing the sequencing mechanism of the relay, we can provide a unit which will "lock out" the system if a wrong sequence is transmitted. This permits the use of these relays in electrical lock circuits of extremely high security. The security code can be changed in seconds by simply plugging in different relays. You may find interesting possibilities in this concept for garage door openers, telemetering controls, selective calling systems, and security systems.

FOR DATA USE READER SERVICE CARD

REMOTE SWITCHING BY SEQUENTIAL CODED TONE SIGNALS

<table>
<thead>
<tr>
<th>Amplifier or Transmitter</th>
<th>Carrier (wire line, radio, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four tone generator ABCD</td>
<td>Mallory sequential relays Type RRB</td>
</tr>
<tr>
<td>AB</td>
<td>CD</td>
</tr>
<tr>
<td>Station 1</td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>BA</td>
</tr>
<tr>
<td>Station 2</td>
<td></td>
</tr>
</tbody>
</table>

Activation of station may close communication channel or initiate any electrical switching function.

When you need a lot of microfarads...

Occasionally, when you're working out a prototype, you may run into a circuit that needs microfarads by the thousands. How do you get what you need, in compact size, at compact price?

The answer is a Mallory Computer Grade (Type CG) capacitor. They were originally developed for use in computer power supplies, but you don't need to be designing computers to use them. They're made of materials—foil, separator, electrolyte—that meet highest specifications for purity. And they are assembled with extra care, in a construction which gives unusual reliability.

Their life is exceptional. We have tested them for the equivalent of 20 years service at room temperature without failure. Equivalent series resistance and DC leakage are remarkably low and stable.

In a single case (largest size 3" dia. x 5 5/8") you can get up to 115,000 mfd. at 3 volts, or 2000 mfd. at 350 volts...at a cost considerably less than that of conventional electrolytics paralleled together.

FOR DATA USE READER SERVICE CARD
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1. **ENGINEERING**—The nation's top engineering talent backed by over thirty years of knowledge and experience create UTC designs. All designs are fully laboratory proven before being released for production.

2. **MATERIALS AND LIFE TESTING**—The UTC Material and Chemical Laboratories fully analyze and evaluate the materials employed in UTC products. Special processes are introduced as required by material characteristics. Finished units, as well as insulation systems, are constantly undergoing life tests to provide guides for present and future designs and manufacturing processes to produce greatest reliability. The purpose of these tests is to extend the life of each design to the absolute maximum—usually far beyond the present state of the art.

3. **QUALITY CONTROL**—The Quality Control Division at UTC coordinates all statistics relating to materials and processes. All incoming materials are subjected to exhaustive testing, with individual lots of materials separately isolated and linked to their test reports in order to afford adequate material control throughout production. Continual surveillance is conducted to assure conformance of products to all applicable requirements. If discrepancies are found or anticipated, corrective action is immediately instituted. Parts made within the UTC plant, such as drawn cans, stamped laminations, etc., are inspected and treated as though they were provided by an outside vendor.

4. **PRODUCT TESTING**—Each individual transformer or filter produced by UTC is tested for its performance three times during successive stages of manufacture. In addition to this, a substantial sampling of each day's production is put through extensive humidity, vibration, thermal shock, and overload testing to assure exact performance and reliability.

5. **THE END RESULT**—UTC's level of quality and reliability is unmatched in the industry... twenty times better than the industry average, based on available information. For every phase of the art of iron core inductance devices, UTC is the first source for the highest reliability, the most varied types and the most sophisticated and advanced designs in the industry.

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to update older Type 580-series oscilloscopes

DC-to-80 MC at 10 mv/cm
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Type 82 plug-in unit adds new convenience to display and measurement of high-sensitivity, wide-band, dual-trace presentations on the Type 580-Series Oscilloscopes.

Characteristics

- **DUAL-TRACE OPERATION** with 4 operating modes and independent controls for each channel—for individual attenuation, positioning, inversion, and ac or dc coupling as desired.
- **PASSBAND** typically DC-TO-85 MC (3-db down) at 100 mv/cm (12-db down at 150 Mc), and typically DC-TO-80 MC (3-db down) at 10 mv/cm.
- **CALIBRATED SENSITIVITY** in 9 steps from 100 mv/cm to 60 v/cm, and in 10X Amplifier Mode, from 10 mv/cm to 5 v/cm, variable between steps.

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- **SUPPLIED SMALL SIZE PASSIVE PROBES** to simplify probe connection to signal-source points. Probes increase input R to 10 megohms and decrease input C to approximately 7 pf, with risetime (of probe, plug-in unit, oscilloscope) at over-all sensitivity of 100 mv/cm at approximately 4½ nsec.

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Some early Type 580-Series Oscilloscopes must be modified to accept the new Type 82 Dual-Trace Unit or the new Type 81 Single-Trace Unit. After modification, these oscilloscopes—with serial numbers below No. 970 for Type 581's and below No. 2585 for Type 585's—will have improved and standardized transient response (and improved performance with the Type 80/P80 combination).

To determine whether your particular instrument needs this modification, please call your Tektronix Field Engineer.

Modification Kit (Part Number 040-275) . . . . . . $25

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IEEE spectrum JANUARY 1964
The Power Division of IEEE is sponsoring the first Winter Power Meeting at the Statler Hilton Hotel in New York, February 2-7.

The technical program will consist of 48 sessions. Topics will include insulated conductors, power generation, power system communications, power system engineering, protective devices, relays, rotating machinery, substations, switchgear, transformers, transmission and distribution, residential wiring, electric heating, and electrical insulation.

Registration will begin on Sunday afternoon, February 2. At 4:00 p.m., a reception and tea will be held at the hotel for the early registrants. On Monday, February 3, a Special Awards luncheon is scheduled for 12:15 p.m., at which the Habirshaw Medal will be presented to former AIEE Vice-President L. M. Robertson. A nationally known speaker, to be announced, will address the luncheon. Tickets will be $6.50 per person.

Registration fees are as follows: Members, $10; nonmembers, $12; ladies, $2; and guests and students, no fee.

An open forum for all interested IEEE members to discuss plans for the inauguration of a Professional Technical Group on Power (PTG-P) will be held Monday, February 3, at 2:30 p.m., after the luncheon and General Session, in the ballroom of the Statler Hilton Hotel. Each Section is invited to have at least one representative present. All past and present Power Division Technical Committee members and Division Members are urged to attend. The Initial Ad Com, appointed by the IEEE Executive Committee, will present the program by which it is planned to open the activities of the Power Division for general membership participation through the PTG format. Plans for organization, publications, and activities will be open for review and discussion in this forum before submission to the IEEE Executive Committee for final approval.

Also on Monday, the ladies’ activities program will be launched at 4:00 p.m. with a get-together tea in the Statler Hilton’s Penn-Top. The major social event of the Winter Power Meeting will be on Tuesday, February 4. At 7:30 p.m. there will be a dinner, floor show, and dance in the Statler Hilton’s main ballroom. Dress is informal, and the charge is $15 per person. Visits to the Museum of the City of New York and the Metropolitan Museum of Art are planned for Tuesday afternoon. Luncheon facilities will be available at the Metropolitan. Two other events for the women visitors will be a Wednesday morning wig fashion show presented by Joyce Christopher at the Statler, and a Thursday luncheon at the Top of the Fair Restaurant at the World’s Fair grounds, at which the delegates will also be welcomed. For the latter event, the tickets are $6.50. Transportation and door prizes will be provided. At 9:00 a.m. daily, there will be a coffee hour in the ladies’ headquarters at the Statler Hilton Hotel.

Inspection trips arranged. A program of inspection tours to the following places is planned:

New York Stock Exchange, New York, N.Y. (Tuesday Morning) From a sightseeing bus passengers will view Washington Square, the “Village,” the Bowery, Chinatown, City Hall, and Lower Broadway. Visitors will be shown how transactions are made; the trip will include a visit to the gallery overlooking the trading floor in action.

After the tour, instructions will be provided on other outstanding sightseeing trips in lower Manhattan: American Stock Exchange, Battery Park, Staten Island Ferry ride, Trinity Church, and Federal Building. Instructions will be given on how to get back to the hotel by subway. Several famous luncheon restaurants in the area will be pointed out.

The New York Times, New York, N.Y. (Tuesday Afternoon) A visit to the Times will include a view of various de-

Consolidated Edison’s Ravenswood Generating Station in Long Island City will be visited Wednesday afternoon during the Winter Power Meeting.
vices in the communications room, a demonstration of how the news is edited, the mechanical operations required to put the paper on the street, and look at the composing room.

*Consolidated Edison System Operations Center, New York, N.Y. (Tuesday Afternoon, Thursday Afternoon)* This trip will consist of a tour through Con Edison’s new System Operations Center. The Center will be viewed from a special area constructed for that purpose and the instruments and operations will be seen at close range on a closed-circuit television set.

*Radio City Music Hall, New York, N.Y. (Wednesday Morning)* Backstage facilities, revolving sectionalized stage, elevating orchestra pit, motorized curtains, and the electric and mechanical controls for stage and lighting effects will be inspected. No women or children are permitted.

*Holophane Light and Vision Institute, New York, N.Y. (Wednesday Afternoon)* At the newly revised Institute, demonstrations will be given showing effects of quantity of light; light control to reveal depth and texture; how photometric curves are made; and other details. Refreshments will be served.

*Ravenswood Generating Station, Con Edison, New York, N.Y. (Wednesday Afternoon)* The two Con Edison units at Ravenswood Station in Long Island City, each with a name-plate rating of 363 mw and operating capability up to 425 mw, will be open for inspection.

*Digital Computer Control Center, Philadelphia Electric Co., Philadelphia, Pa. (Thursday Morning)* Inspection will be made of a system of completely solid-state design that uses no motors, servos, slidewires, or vacuum tubes.

*Site of 1964 World’s Fair, Flushing Meadow, N.Y. (Thursday Afternoon)* A preview model of the Fair, scheduled to open in April 1964, will be viewed and the facilities under construction may be toured. The electrical distribution system designed and developed specifically for the Fair will be explained.

A special feature of this year’s Winter Power Meeting will be a students’ session scheduled for Monday afternoon, February 3. A program has been arranged for the student engineers on the so-called glamor area of computer applications, control and communications, atomic and MHD energy conversion, and system planning. Speakers will be young engineers, no more than ten years out of college. Student participation in the discussion will be encouraged.

Tickets for all events, including the ladies’ activities, will be available at the registration desk, but the Hospitality Committee is inviting advance registrations for all social activities.

Advance registrations may be obtained by writing to Julius Bleweis, *Electrical World*, 330 West 42 St., New York, N.Y. Checks for all social functions may be made payable to William West, Treasurer.

Delegates are urged to make room reservations for the Winter Power Meeting as early as possible. Requests for reservations should be addressed to Philip Roberg, Reservations Manager, Statler Hilton Hotel, Seventh Ave. at 33 St., New York, N.Y. 1001. Room rates are as follows: Single room $10 to $18; Double room $14 to $22; Twin-bedroom $18 to $25.

The members of the Winter Power Meeting Committee are: J. H. Kinghorn, general chairman; E. J. Merrell, vice-chairman; C. Dorsa, secretary; E. C. Day, Headquarters representative; W. West, treasurer; C. A. Woodrow, representative, Power Division; S. H. Grim, representative, New York Section; J. C. Derse, local arrangements; D. T. Braymer, publicity; R. T. Weil student activities; A. P. Fugill, technical program; C. T. Hatcher and D. M. Quick, Members-at-Large.

**Technical program given.** The tentative technical program for the Winter Power Meeting follows:

**MONDAY, FEBRUARY 3**

9:30 a.m. Sessions
- Insulated Conductors—1
- Status and Potential of Energy Conversion Devices for Power Application
- Transformer-Arrestor Applications and Proposed Standards
- Transformers—1
- H. V. Systems
- Switchgear—1
- Student—Faculty

**TUESDAY, FEBRUARY 4**

9:30 a.m. Sessions
- Foreign Practices
- Switchgear—2
- Transformers—2
- EHV Line Design
- Electric Space Heating and Air Conditioning—1
- Insulated Conductors—3

2:00 p.m. Sessions
- Large Turbogenerator Application Problems
- Induction Machines
- Switchgear—3
- Transformers—3
- 500 kV Line Design
- Electric Space Heating and Air Conditioning—2

**WEDNESDAY, FEBRUARY 5**

9:30 a.m. Sessions
- Forces Affecting Power Engineering Relays
- Synchronous Machines
- Switchgear—4
- High-Voltage Phenomena
- Conductor Vibration

2:00 p.m. Sessions
- Power Plant Design
- Cables for Communication and Coupling Capacitor Potential Devices
- System Capacitor Applications and Planning
- Synchronous Machines and Inductor Machines
- Residential Wiring
- Student—Faculty

**THURSDAY, FEBRUARY 6**

9:30 a.m. Sessions
- Insulated Static Wires and Microwave for Communication
- Outage Data Analysis for Transmission and Distribution System Planning
- Panel Discussion
- General Rotating Machine Theory
- Substation Design Standardization Methods and Techniques—1
- Switchgear—1
- H. V. Corona and Radio Noise
- Corona and Breakdown Phenomena

2:00 p.m. Sessions
- Power Plant Control and Protection
- Computer Applications to Network Analysis Solutions
- D-C Machinery
- Substation Design Standardization Methods and Techniques—2
- Panel Discussion: Substation Design Standardization Methods and Techniques
- Switchgear—2
- Test Methods for Thermal Evaluation and Quality Control of Electrical Insulation

**FRIDAY, FEBRUARY 7**

9:30 a.m. Sessions
- Application of Probability Methods
- Fractional Horsepower Motors
- Capacitors
- Towers, Poles and Conductors
- Substations

The February 6 banquet speaker will be Maj. Gen. F. H. Britton, director of research and development, U.S. Army Materiel Command. The February 5 luncheon speaker is to be announced.

**Opening panel described.** The February 5 opening panel for the convention will discuss some aspects of the theme._5th National Winter Convention on Military Electronics due in February_ The 5th National Winter Convention on Military Electronics will be held February 5-7 in Los Angeles, Calif., at the Ambassador Hotel. The convention is sponsored by the IEEE Professional Technical Group on Military Electronics and the Los Angeles District of IEEE. The classified sessions of the convention are sponsored by the U.S. Air Force Systems Command._
“Weapons Systems Procurement,” with Dr. Eugene Fubini as chairman and moderator. Dr. Fubini is a deputy director for research and engineering, Office, Assistant Secretary of Defense.


Registration fees are $10.00 for Members of IEEE and $12.00 for nonmembers of IEEE. Registration fees include one copy of the Convention Proceedings. Military and Civil Service employees may register for $3.00 (this does not include a copy of the Proceedings). There is no charge for Military and Civil Service employees to attend the exhibits.

Additional copies of the Proceedings will be sold at the convention for the price of $7.00.


The general chairman of the convention is C. D. Perrine, Jr., executive vice-president, General Dynamics-Pomona. The vice-chairman is H. J. Delaney, Filtron Co., Inc., and the Technical Program chairman, Dr. N. A. Begovich, vice-president, Hughes Aircraft Ground Systems.


The usual cocktail reception before the banquet and the full ladies’ program are planned.

Registration materials may be obtained by writing the Los Angeles District IEEE Office, Suite 1920, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

Program sessions listed. The tentative technical program for the convention follows:

**WEDNESDAY, FEBRUARY 5**
2:00 p.m. Sessions
Command and Control (unclassified)
Microelectronics (unclassified)
Anti-Submarine (confidential)
Air Defense (secret)

**THURSDAY, FEBRUARY 6**
9:00 a.m. Sessions
Radar Technology (unclassified)
Guidance & Control (unclassified)
Nuclear Radiation Effects (unclassified)
Space and Communications (secret)
2:00 p.m. Sessions
Reconnaissance (unclassified)
Reliability and Maintainability (unclassified)
Ballistic Missiles (secret)

**FRIDAY, FEBRUARY 7**
9:00 a.m. Sessions
Program Management, Control & Evaluation (unclassified)
Radiation Effects (secret)
Displays and Human Factors (unclassified)
2:00 p.m. Sessions
Communications (unclassified)
Air and Ballistic Missile Defense (unclassified)
Radar (secret)

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**National Convention on Military Electronics features discussion on human and computer intelligence**

During the recent National Convention on Military Electronics in Washington, D.C., a panel discussion on “Human and Computer Intelligence” was held. The following report is a condensed and edited version of that discussion. Formal remarks of the panelists are immediately followed by an open discussion.

**David Mck. Riech, M.D.**
Director, Division of Neuropsychiatry, Walter Reed Army Institute of Research

In this most interesting period in which to live, we all assume that we know what human intelligence is but few of us feel that we know what computer intelligence is.

Computer intelligence is an area of considerable anxiety for some people; they tend to deal with it by saying: “They have machines that they say are intelligent, but I don’t believe it. They don’t feel.” Others think: “Now the millenium is about to arrive because we can develop machines that think.” Either of these attitudes brushes aside the even more fundamental problem that we still cannot adequately define human intelligence.

In any event, we’re moving rapidly into a new era. We feel threatened by this situation and need greater clarification of what machines can and cannot do, how we can control them, how we can use them adequately, and what changes we ourselves may have to undergo to live with them.

The primary difference between computer progress and anything else we care to call progress is that the computer has the ability to do some planning. Unfortunately, however, we don’t yet know how to put many planning problems into the computer. This is because we don’t have an adequate idea of what much of the human thinking process is in terms that would help us to program the computer.

**J. Prosper Eckert, Vice President, UNIVAC, Division of Sperry Rand Corp.**

After 17 years, I’ve finally been forced to adopt the definition that thinking is that which a computer cannot do. This definition is very workable since it
"We deliver the following quality products from stock: bench instruments; closed-circuit television systems (environmental, miniaturized, industrial); DC data amplifiers (wideband, narrowband, differential, solid state); DC preamplifiers; digital comparators; digital programers, digital translators; digital voltmeters (solid state, mercury-wetted, Zener reference, stepping switch); meter calibrators; power supplies; ratiometers; thermal transfer standards, and voltage standards (AC, DC, DC programable)."
changes from year to year as computer progress is made.

For example, one of the things a computer cannot do well at present is to recognize patterns no matter whether these patterns are in the form of handwriting, numbers, letters, mountaintops, or submarine periscopes.

On the other hand, computers have shown themselves to be very efficient at solving problems of complexity if we have some of the formulas. But the problem of getting the formula—the problem of perplexity—has not received much attention. Most of the formulas and ideas we’re using now are over 100 years old. Others, such as linear programming, were invented about 20 years ago but were not used until recently.

A human brain is believed to contain about 10 billion cells. We don’t know whether these cells are all logic elements, or partly logic and partly memory elements.

The largest computers built so far have only about 100,000 logic elements. Most computers have only about 10,000. The largest have no more than a few million bits of fast memory.

By any criterion, computers fall far short of the capacity the human brain apparently has at its disposal to solve problems. Therefore, we can safely assume that at present computers cannot provide sufficient complexity to solve the problem even if we know the formulas.

The matter of speed seems to offer promise. We can build computer elements which can work in a few nanoseconds. The elements in the human brain work in a few milliseconds at best. Compared to the human brain, computers are something of the order of one million or more times faster but about the same order of magnitude short on the number of elements needed.

What we seem to need is a general theorem for exchanging speed with complexity. As yet nobody has discovered any general theorem for doing so, although there are certain techniques such as breaking complex problems into a series of less complex steps that are sometimes useful. But most problems such as pattern recognition do not allow this technique to be used. Instead, we need some sort of time-sharing mechanism in which this is possible.

Suppose, for example, we want a system containing two million logic elements and for convenience we divide these elements into two fields each containing one million elements. Two fields will enable us to bounce information back and forth between them, making a logical transformation each time.

Let us suppose that each of these fields is made up of an array of 1000 by 1000 inexpensive elements. One economical approach might be the use of a sheet of material containing an array of one million optical elements. Each optical element would give no response when hit by one element of light but would respond when hit by two or more. These elements are also assumed to be capable of electric readout by a simple conductive grid of 1000 by 1000 conductors.

Assume we arrange the electro-optical elements in a rectangular array so that they are at the intersections of a 1000 by 1000 array of conductors. Assume that time pulses can activate one edge of the array, a conductor at a time in sequence, and cause information to be read out in groups containing up to 1000 impulses at a time from the conductors making up the other dimension of the array.

Thus far, I have described only a memory threshold device, activated by light, and capable of being read out in a serial parallel fashion. We now need a means for obtaining a logical transformation.

This can be done by taking the 1000 signals from the array and using them to drive 1000 small light projectors—each of which contains a lens and a negative or pattern which excites certain selected spots in the other array field of a million elements. A second set of 1000 time-sequencing light projectors will select those spots which are to be affected at a particular time in coincidence with light from the first set of projectors. In the second projector set, just one will be turned on at a time (in contrast to the first set of projectors in which many may be turned on at any given time) to control the time-sharing logic sequence of the information transformation.

The mechanism by which the coincidences of light from the two sets of projectors control a particular electrical optical element can be based on a threshold effect or an effect which requires two different frequencies or colors of light to cause its operation. With coherent light it might even depend upon the phase relation of the light from the different sets of projectors. Electric signals applied to the time-sequences of projectors (one edge) of the first array cause it to transmit information through the first set of light projectors to the second array and, in a 1000-step sequence, determine which elements of the second array are to be affected at any one time. Thus, a complex and highly flexible logic transformation, similar to that performed between clock phases of a conventional computer in one time period, will be performed—but it will require 1000 time periods. The payoff is that economically it may be many times more complex.

Normally there will be one spot in an array for each diode or similar logical “input” element being replaced in a present-day logic structure. The optical flexibility of this system allows complete freedom as to how a spot in one area affects spots in the other array without the inflexibility of a maze of semiconductors and wires. In fact, a few photographic negative plates placed in the optical projector system of this device completely describes the logical system. The rest of the optical and electrical system is, in itself, a repetitious mechanism having no specialized logical properties.

A complete system might contain just two electro-optical arrays or sheets and an associated timing circuit for activating 2000 conductors in simple sequence and 4000 light projectors, 2000 in each array, with their associated negatives. Such a system would replace over 2 million semiconductors and their mass of interconnecting wire. An element like this would greatly enhance our ability to build an artificial intelligence, since it provides the means to exchange some of the speed we have now for a degree of complexity which we cannot achieve economically at present.

Winston E. Kock, Director, Research, The Bendix Corp.

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It could indicate the presence of a very weak signal frequency in the noise.

Human memory is apparently a result of nerve loops comparable to tape loops. The neurons cause the memorized information to circulate continuously and repetitively. We tap this loop whenever we wish to recall information. The deltaic computer element is comparable to the memory loop. Here, a digitalized signal is inserted in a quartz delay line which closes back on itself; and the signal, if not altered, circulates continuously around the loop. The process involves changing periodically so that a new signal is inserted into the loop, then analyzed.

The electronicists have combined two human abilities—the ear’s analysis process and the eye’s integration ability.

If we replace the eye with an electronic integration system, we should have not only the capability of the ear in the original analysis procedure, but also the ability of the eye in integration.

I have been trying to get computers to do things previously done only by people. There are two sets of studies on artificial intelligence. One set attempts to understand how people do things and to use computers to implement this understanding. The second approach is to have computers do these things irrespective of whether or not they are done in the same way as people, from the viewpoint of developing useful tools.

My interest has been in this second area.

The brain seems to be composed of neurons. The brain can do the complicated process of studying their properties. Therefore, if we build a simulated brain, we shall achieve a device that can do the same things as the brain.

In another approach, we can analyze the problems that the brain solves—irrespective of the way it solves them.

There’s a trite analogy to these two different approaches. In the early history of aircraft development, people tried to simulate the flight of birds. They said: “A bird can fly; therefore, let’s build a mechanical bird, and it will fly.” But, it was not until people started the study of aerodynamics that we were able to develop airplanes. Now we have made studies on the aerodynamic aspects of a bird’s flight. We have discovered that there are many things birds know—and we don’t.

**Arthur L. Samuel, Research Consultant, International Business Machines Corp.**

Consider a typical problem the brain does well and machines do very poorly.

In the game of checkers there is no known algorithm or formula by which you can get a computer to follow a system of rules to win. People also don’t know such rules, yet they play the game very well. How is this done? We believe people do it through heuristic procedures. These are “rule-of-thumb” procedures, which apparently work. If we want computers to do these tasks, we must develop techniques of solving these heuristic approaches to problems.

The first is the problem of immensity. Any strategic problem in chess or checkers is so complicated that if we attempt it by the “exhaustion” process of looking back from the end of the game, considering every possible first play and every counter replay, we find that the number of possible moves becomes astronomical toward the conclusion of the game. To solve for the first move in checkers by this procedure would require more time than the total history of the universe for the fastest conceivable computer! Yet, people can do these things very well by the use of the “three Is”—intuition, imagination, and instinct.

The next problem is that of the “gestalt”—or ability. The gestalt is evident in the pattern recognition problem. Infants develop abilities to recognize patterns. They can distinguish people from inanimate objects. Nobody tells them there are two classes of things, yet they quickly form this concept. All the tasks that we want computers to do involve the formation of concepts. People seem to have this ability, but we do not know how to get computers to acquire it.

The problem of locating memory information is another thing that retards
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us in getting computers to do complicated human tasks. People have an associative memory; computers have an addressable memory. One must know where a particular bit of information is stored in order to retrieve it. There are many designs for the creation of associative memories, but all of these suggested devices are primitive compared to the ability of the human brain in recalling information. For instance, when you attempt to recall a name, the oddest bits of analog information assist you.

When we want computers to do human tasks, we find that the limitations are in people’s abilities to understand what they’re asking the computer to do, and to express what they want done in imperative statements. The computer is a “giant moron” rather than a “giant brain.” It has two characteristics not shared by people—fantastic speed and accuracy—and that’s all.

Computer programs are composed of simple imperative statements. We’re trying to replace a complicated preliminary programming process by a sequence of these statements. If we want computers to be more clever than humans, and to do things that we cannot do, some of us will have to be more clever than average in order to write such computer programs.

**Norman Zachery, Director of Systems Engineering, Space and Information Systems Division, North American Aviation**

My background is in the so-called software area of computing, particularly mathematics and programming. Since it is difficult, if not impossible, for anyone with this background to give a short dissertation on such a subject as human and computer intelligence, I will confine my remarks to some aspects of management problems in the computer field. I have no difficulty at all in summarizing my knowledge of management theory in less than 10 minutes.

In keeping with the general nature of our topic, I will attempt to keep my discussion of management problems equally “sweeping”; hence, I will not comment on specifics, but only on broad generalities.

Time and again the disparity between the fantastic growth rate in the speed of computers and the very limited growth of our ability to develop a theory for use in the computer has been demonstrated. To examine this statement more closely, let us look at the various functions we have asked the computer to perform in respect to human intelligence. These functions fall into three basic classifications. The computer can assist, cooperate with, or replace human intelligence. To date, the computer has been successful in only the first of these three. Our ability to compute, to undertake numerical approximations, and to store and recall information has literally exploded. In reference to the third classification, it is important to remember that in any part of the advance publicity given to computers’ “thinking,” it is not clear that any real success in this area is or ever will be possible.

From the first and third areas, let us go to a discussion of the second area—the area of human and computer intelligence working together (i.e., of the man-machine complex). Perhaps the most critical function performed by man in any man-machine complex is that of management. If the argument for the use of the computer as an aid to intelligence has any basic premise, it is as an attempt to reduce intelligence to a set of rules which can be placed on a computer. If management philosophy has a basic tenet, it is that the core of the manager’s job is not reducible to a set of rules. The man-machine complex then is an attempt to combine the ability of a computer, in handling those aspects of a problem which can be reduced to rules, with the ability of man to cope with the problems that are not reducible to rules. Viewed in this light, it is apparent that the closest possible cooperation between the inanimate computer and the (presumably) animate manager must be established in a successful man-machine operation.

In order, therefore, to develop this concept of the man-machine function, managers must take a more active part in the design of the basic systems. As of today, management in general has not been so involved. For example, in the military field, there is an application which goes by the name of “command and control.” Up to now, the basic conceptual developments in this field has come primarily from the technicians rather than from the military managers; yet the command and control problem is one of the most difficult facing us today, and one which can be resolved, in my opinion, only by a joint approach with computer systems designers and top-echelon military officers working together.

There are two conclusions which I would like to draw:

1. Further development in the field of computer intelligence hinges more on the education of various management levels than on improvement in computer hardware and software techniques.

2. To be optimistic about developments in the field of computer intelligence, because I believe that management generally is becoming more aware of its role and is willing to act intelligently in using computer intelligence.

**Panel Discussion**

**DR. RIOCH:** Mr. Eckert mentioned the problem of complexity in getting enough units into a computer. The whale has a brain several times larger than a man’s, but the whale is not considered to be as intelligent. Here, the number of units is not the important thing.

**MR. ECKERT:** I’m sure you know two people who have the same size brains but are not equally capable. One of them is not “programmed” as well as the other. A computer and a brain seem to be different qualitatively and quantitatively. Thus, we must appreciate both these problems.

**DR. RIOCH:** Dr. Samuel, would you develop playing games more completely? I understand you had two machines that played checkers with each other.

**DR. SAMUEL:** I have succeeded in getting a computer to play checkers and, with time, to improve its playing. The program is good enough to beat most amateur checker players—and it has won a game against a professional. This was the first game he’d lost in eight years.

This program does not generate concepts. I had to give the computer the concepts. It exploits and explores them in future depth many times further than the human can do normally. The computer substitutes its tremendous speed.
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and accuracy for people's "gestalt" ability. As a result, it plays a mediocre game of checkers.

**DR. RIOCH:** Dr. Kock, is there available data comparing the diagnostic ability of computers and doctors?

**DR. KOCA:** In the memory situation, the doctor's experience is so important that one must always have on file a huge store of memory and experience for the computer diagnosing any illness. How to retrieve this memory and diagnostic ability without such a quick access or large memory storage is still the problem.

**DR. RIOCH:** What is the future development of computer software likely to be?

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**New Fellow awards announced by IEEE Board of Directors**

One hundred and eighteen leading IEEE members from the United States and six other countries were named Fellows of the IEEE by the Board of Directors at its meeting on October 30, 1963, in Chicago. The grade of Fellow is the highest membership grade offered by the IEEE and is bestowed on those who have made outstanding contributions to electrical engineering, electronics, and allied branches of engineering and science.

Presentation of the awards will be made by local Sections. Recognition of the awards will be made by the President of the IEEE at the Annual Banquet on March 25, 1964, at the New York Hilton Hotel during the 1964 International Convention.

The recipients of the Fellow award and their citations are as follows:

**George Abraham**
For research on solid-state phenomena and for contributions to graduate engineering education

**J. T. Bangert**
For contributions to the advancement of network design through the use of computers

**R. A. Baudry**
For contributions to the mechanical development and design of large rotating machines

**R. C. Benoit, Jr.**
For contributions in the field of military electronics

**R. B. Blackman**
For contributions to circuit theory and data processing

**F. H. Blecher**
For contributions to the design of solid-state circuits and their application to communication systems

**J. P. Blettet**
For contributions in the field of high-energy particle accelerators

**Nicolaas Bloem Bergen**
For fundamental contributions to masers and lasers

**L. R. Bloom**
For contributions to the development and design of microwave and millimeter-wave tubes

**R. H. Bolt**
For contributions to the field of acoustics through research and teaching

**Nathaniel Braverman**
For contributions to planning, development, and application of air navigation systems and techniques

**G. M. Brunzell**
For outstanding engineering proficiency, leadership, and administrative attainments

**J. C. Cacheris**
For contributions to advancement of microwave technology, particularly in the application of microwave ferrites

**J. H. Chapman**
For leadership in space research and scientific achievement in upper atmospheric radio physics

**A. A. Cohen**
For pioneering achievement on computers and storage devices and sustained service to the profession in this field

**G. C. Dacey**
For contributions in the field of solid-state devices and in research management

**C. A. Desoer**
For contributions to control theory, circuit theory, and engineering education

**W. L. Doxey**
For leadership in research and development of electronic materials and devices

**H. W. Dudley**
For contributions to the fields of speech theory, speech signal processing, and speech synthesis

**A. J. Eaves**
For pioneering developments of telegraph transmission systems, radio transmitters, and sound amplifying systems

**K. R. Eldredge**
For contributions to pattern recognition and magnetic character reading systems

**R. G. Elliott**
For contributions to communications services and as an engineering manager

**Herbert Estrada**
For contributions to the design and operation of interconnected power generating stations and systems

**W. E. Evans, Jr.**
For contributions to applications of video techniques and video systems

**R. L. Frank**
For contributions to radio navigation and the development of instrumentation for the Loran-C System

**K. J. Germershausen**
For contributions to the technology of gaseous discharge flash lamps and stroboscopic lighting equipment

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For an accounting article in order to pick up an accounting article in order to encounter a heading such as: "How We Converted Our Payroll to a Computer," despite the fact that this type of operation has been known for a decade. I think we need more people who are able not only to compute answers to immediate problems but also who are willing to contemplate longer periods of time and the significance of the presently developing techniques for our way of life.

**DR. RIOCH:** Let me conclude this discussion with the observation that we don't spend enough time in the human mind in deciding upon the things we should really think about. We tend to take the current popular bandwagon, even if it may be heading for disaster.
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R. P. Gifford
For leadership in communications techniques and practice

G. M. Glasford
For contributions to engineering education and leadership in engineering activities

Janusz Groszkowski
For contributions in the field of frequency stability and electronic technology, and leadership in engineering education and research

E. W. Guernsey
For contributions to generation, transmission, and distribution of electric power

F. A. Gunther
For contributions to the fields of UHF and VHF communication and leadership in communications practice

F. E. Hanson
For contributions to manufacturing, engineering, and administration in the field of electron devices

E. O. Hartig
For contributions to the field of coherent high-resolution radar

O. C. Haycock
For contributions to research on the upper atmosphere and to engineering education

W. H. Hayt, Jr.
For contributions to electrical engineering education

G. E. Heberlein
For creative leadership in the switchgear field

Frank Herman
For contributions in the field of the energy band structure of solids

E. A. Hobart
For contributions in the fields of battery charging and welding

D. B. Holmes
For contributions to electronic early warning systems and leadership of manned space flight programs

R. R. Hough
For leadership in military electronics development associated with guided missiles

E. D. Huntley
For contributions to the design of large turbine generators

D. L. Jaffe
For contributions to the development of microwave electronic equipment

J. L. Jatlow
For contributions in the fields of FM carrier telegraphy and tropospheric scatter communication systems

P. H. Jeynes
For contributions to the economic analysis of power distribution
L. R. Kahn
For contributions to single sideband transmitting and receiving systems
S. F. Kaisel
For contributions to the development of traveling-wave tubes
R. E. Kalman
For contributions to the theory of system control
J. W. Kearney
For contributions to the development of electronic reconnaissance systems and to student activities
W. H. Kim
For contributions to network theory, particularly network topology
L. R. Kirkwood
For contributions to color television receiver design
V. A. Kotelnikov
For contributions to the theory and practice of radio communications and radar astronomy
R. J. Kuhn
For contributions in the fields of corrosion and cathodic protection
P. M. Lapostolle
For contributions in the fields of electron optics, traveling-wave tubes, and particle acceleration
R. F. Lawrence
For contributions in the field of power transmission and distribution
M. T. Lebenbaum
For contributions and leadership in the development and design of low-noise amplifiers
G. J. Lehmann
For his origination and development of techniques and theory in the fields of communication, radio navigation, radar, and engineering education
B. E. Lenehan
For contributions in the field of electrical instruments and measurements
I. A. Lesk
For contributions to the advancement of semiconductor technology and device development
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For contributions in the fields of linear accelerators and high-power microwave sources

P. H. McAuley
For contributions to the development, evaluation, and standardization of high-voltage insulation

W. S. McCulloch
For researches into the information-handling processes of the nervous system

K. G. McKay
For fundamental advances in the physics and engineering of solid-state devices

H. F. Meyer
For contributions to the development of advanced communication systems for the Armed Services

T. G. Mihran
For contributions to the theory of wave phenomena in electron beams

Fumio Minozuma
For research in radio wave propagation and radio noise interference, and leadership in the Radio Regulatory Bureau of Japan

Newton Monk
For contributions to mobile radio telephone systems for railroads

C. D. Morrill
For contributions to the development of electronic analog computing techniques

W. C. Morrison
For significant contributions to the fields of VHF, UHF, and color television

O. J. Murphy
For contributions to the art of communication system signaling and switching control

Kanichi Ohashi
For contributions to electrical communications and leadership in the theoretical, developmental, and manufacturing fields

E. C. Okress
For contributions to microwave magnetron design

C. N. Ostergren
For contributions to engineering economics in public utilities

G. L. Pearson
For contributions to semiconductor physics and to the development of the silicon solar cell

D. O. Pederson
For contributions to circuit theory and engineering education

R. L. Petritz
For contributions to semiconductor physics, fluctuation phenomena, and surface physics

P. J. Pontecorvo
For contributions to microwave communications systems

A. H. Powell
For development of high-power switching equipment and advancement of high-voltage power systems

Zvi Prihar
For contributions to communications systems, and for applications of operations analysis to communications networks

E. S. Purington
For contributions to circuit design, radio control, and communication systems

T. R. Rhea
For contributions to the electrification of industry, and to the teaching and training of engineers

L. W. Roberts
For contributions and administrative leadership in the field of microwave tubes

F. H. Rogers
For contributions to the planning, engineering, and management of electric utility operations

T. F. Rogers
For research on scatter propagation and for contributions to military communication systems

J. H. Rubel
For contributions to the management of research and engineering

H. A. Samulon
For contributions to color television and electronic equipment for space vehicle guidance

A. L. Schawlow
For contributions to the achievement of coherent light and the concept of the optical maser

C. E. Schooley
For contributions to ground, underwater, radio, and satellite communication systems

A. H. Scott
For contributions to precision electrical measurements, particularly in the field of dielectrics

N. R. Scott
For contributions to engineering education and to analog and digital computer technology

H. T. Seeley
For contributions to the design and application of relays for power system protection

Mark Shepherd, Jr.
For contributions to the evolution of the semiconductor art and the growth of the semiconductor industry

E. B. Shew
For contributions to the development of oilless circuit breakers and for leadership in the standardization of metal-clad switchgear

R. M. Showers
For leadership in engineering education and contributions to radio-frequency interference research

W. M. Siebert
For contributions to the theory and application of signal detection methods

K. M. Siegel
For contributions in the field of scattering of electromagnetic waves by complex targets

E. P. Smith
For contributions to the development of large direct-current machinery for industrial, marine, and excitation applications

E. D. Sunde
For contributions to knowledge of earth conduction effects

J. J. Suran
For contributions to the field of solid-state devices and circuits

R. L. Tanner
For contributions leading to the elimination of precipitation static on aircraft

A. H. Toepfer
For his contributions to atomic reactors

J. T. Tykociner
For his pioneering contributions to radio science

Lucio Vallese
For contributions to the theory and
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A. P. Walker
For contributions to the concepts of integrated electronic devices and field-effect transistors

H. G. Weiss
For contributions to the development of high-power radar

G. E. White
For contributions to radar systems and physical instrumentation

W. P. Wills
For contributions to the field of instrumentation, particularly recorders and controllers

W. R. Young, Jr.
For contributions to mobile radio and data communication systems

J. R. Zacharias
For contributions to defense systems, atomic frequency standards, and education

National conference on telemetering is scheduled

The National Telemetering Conference will be held June 2-4 at the Biltmore Hotel in Los Angeles, Calif.

Planning for NTC 64 is well under way. The Working Committee is as follows: General Chairman—Fred Ridge, California Institute of Technology; Program Chairman—W. S. Pope, North American Aviation; Finance—William Leffing, Jet Propulsion Lab.; Hospitality—H. G. Beenken, University of Southern California; Registration—Peter Van Deloo, Pacific Telephone Co.; Housing & Accommodations—D. W. Lang, Nortonics; Publicity—Charles Jeffress, ASW & Oceanographic Sys., Lockheed; Equipment & Supplies—Arthur Klopfenstein, Southern California Edison; Exhibits—Nathan Silk, Aerospace Corp.; Communications—John Mumma, TRW Space Technology Labs., Inc.; Allocation & Acceptance—Hugh Press, Telemetering Corp. of America; and Professional Exhibits manager—F. G. McGavock, F. G. McGavock Associates.
Suggestions and offers of support will be welcomed by the Working Committee chairman.

AIAA to be host for 1964. Host for 1964 is the American Institute of Aeronautics and Astronautics, IEEE and ISA are cosponsors.

Tentative subscription has been made for all of the exhibit space for NTC 64. The Biltmore Hotel facilities provide room for 95 exhibit booths. Interested potential exhibitors are encouraged to make application through F. G. McGavock Associates, the professional exhibits manager for NTC 64, or through the chairman at P.O. Box 3065, Pasadena, Calif.

The Telemetering Standards Coordinating Committee activity report for the last year is contained in the proceedings of the 1963 National Telemetering Conference.

Proceedings are available. NTC 63 Proceedings can be obtained through IEEE, Box A, Lenox Hill Station, New York 21, N.Y., by enclosing a check for $6.00 ($5.00 for the Proceedings; $1.00 for mailing).

Wescon is scheduled
August 25–28 in Los Angeles

Technical papers are invited for the Western Electronic Show and Convention (Wescon) to be held August 25–28 in Los Angeles, Calif.

The IEEE Summer General Meeting will be held simultaneously and in conjunction with this West Coast conference. Authors desiring to have papers considered for inclusion on the program of technical sessions should submit the following material by April 15:

1. Three copies of a 100–200 work abstract, including title of the paper, name, company affiliation, and address of the author.
2. Three copies of a 500–1000 word summary of the paper which identifies the related work and extent of new contributions in the field.
3. Indication of the technical category in which the paper falls.

Papers in all electrical and electronics fields will be considered for the 1964 Wescon program.

Any necessary military or company clearance of papers must be granted before submission of the abstracts. All materials should be addressed to Dr. R. R. Bennett, Technical Program Chairman, 1964 Wescon, Suite 1920, 3600 Wilshire Boulevard, Los Angeles, Calif. 90005.
BUSS: 1914-1964, Fifty years of Pioneering

1964 IEEE Convention to feature expanded program

New York City will be the focal point of the electrical and electronics engineering world on March 23 when the 1964 IEEE International Convention opens its doors for a four-day program of technical papers, engineering exhibits, and social events. An attendance of 75,000 engineers and scientists from 40 countries is expected.

This year's convention will feature several important changes. Convention headquarters will be in a new location, the recently completed New York Hilton Hotel, situated a convenient six blocks from the New York Coliseum. Both the technical papers program and the exhibits have been expanded approximately 20 per cent to encompass for the first time the full scope of IEEE technical interests.

A comprehensive program of 320 papers, covering the latest developments in every area of electrical and electronics engineering, will be presented in 64 technical sessions at the Hilton and the Coliseum. The high point of the program will be a special additional highlight panel of five foremost leaders from industry who will discuss the subject "Modular Magic" on Tuesday evening, March 24. The complete program will be announced in the March issue of IEEE Spectrum.

More than 1,000 exhibitors will participate in the IEEE Show, displaying some $20 million worth of the latest electrical and electronic equipment, most of it for the first time. This year's Show will be in two locations, with electrical equipment on display at the Hilton and electronic exhibits housed in the Coliseum.

The social events will include a get-together cocktail party Monday evening and the annual IEEE banquet Wednesday evening, both at the New York Hilton. The banquet will feature the presentation of major IEEE awards. Members are urged to place their banquet reservations with IEEE Headquarters as early as possible. The price of banquet tickets will be $15 each.

An entertaining program of tours, fashion shows, and matinees is being arranged for wives of visitors.

Organization of PTG on Power to be studied at Winter Meeting

An open forum for all IEEE members interested in the future of the power component of IEEE's technical organization will be held on Monday, February 3, at the Statler Hilton Hotel in New York. This forum will be one of the features of the IEEE Winter Power Meeting scheduled for February 3-6.

The subject for discussion at the forum will be the organization of a Professional Technical Group on Power (PTG-P) to become operative on July 1.

Plans for the new PTG-P have been under way since the merger of AIEE and IRE in January 1963. The Power Division of AIEE came into IEEE with its organization of 2400 committee members, its functions, and its publications essentially unchanged. It will continue so to operate until June 30. A petition to convert the Power Division to the PTG-P was approved by the IEEE Executive Committee on August 22, 1963.

The Initial Administrative Committee, approved by the IEEE Executive Committee, is developing detailed plans for...
the organization and activities of the new PTG-P. These will be placed before the power-oriented members of IEEE at the February forum. After this public review and discussion, the Constitution and Bylaws of the PTG-P will be completed and submitted to the IEEE Executive Committee for approval.

As planned, the PTG-P will be composed of all IEEE members who assert their interest in any phase of the generation, transmission, distribution, and utilization of electric energy and the apparatus involved therein and who pay the annual fee of $6.00. PTG-P Chapters will be organized in the Sections. A number of Chapters have already begun to form in anticipation of the formal beginning of the Group. All Chapters will be represented on the governing body of the PTG-P, the Council.

The government planned for the PTG-P will be an innovation in that a Council composed of Chapter, Region, and committee representatives will elect the officers and set the policies to be followed by the Administrative Committee. It is expected that the February forum will be attended by representatives from most of the IEEE Sections. The forum will therefore serve as an informal preview of a meeting of the PTG-P Council.

The bimonthly transactions, IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS, will become the monthly publication of the PTG-P. The transition to a monthly will begin with the January 1964 issue. Changes in format and content will take place progressively during the first year. However, PA&S will be, as it has been, the publication medium for transaction papers in the power field. Present subscribers who become members of PTG-P will continue to receive PA&S, but twice as often as at present.

IEEE approves policy of open attendance at meetings

A policy concerning open attendance at all IEEE meetings was approved by the Executive Committee of IEEE at a recent meeting.

In line with this policy, IEEE will not sponsor a meeting which is subject to security clearance. However, a classified session may be held in conjunction with an IEEE meeting, although the classified session has another sponsor. A statement of the policy follows:

"All IEEE members, irrespective of grade, shall be admitted (upon payment of the appropriate registration fee, if any) to any and all meetings, conferences, conventions, discussion groups, lecture series, or other assemblages of which the IEEE is sponsor or co-sponsor. In furtherance of the policy, the IEEE will not act as sponsor or co-sponsor of any assemblage, participation in which is subject to security clearance. In the event that another organization sponsors an assemblage requiring security clearance for admission, at a time and place which coincides with a meeting of which IEEE is sponsor or co-sponsor, notice of such classified sessions may be published in the program of the IEEE meeting, provided that such notice identifies the sponsor of the classified sessions and states that IEEE does not sponsor such sessions."

New Developments in Electrical Protection

**World's Tallest Hotel**

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TO KEEP PACE ELECTRICALLY with Safety

Standing majestically in mid-Manhattan is the recently completed 50-story, multi-million dollar Americana Hotel.

Most of the comforts enjoyed by guests are electrically controlled. This necessitates an electrical system of tremendous capacity. Available fault current at the three electrical service entrances is estimated at 125,000 amps.

To obtain safest, most dependable protection, BUSS Hi-Cap and BUSS Low-Peak fuses were selected for the mains and BUSS Low-Peak fuses for feeder circuits.

And growth of the system presents no problem since the interrupting rating of BUSS Hi-Cap and BUSS Low-Peak fuses is 200,000 amps, rms symmetrical.

The BUSS fuses installed at the Americana will remain just as safe and accurate as on the day installed—even if not called upon to protect for 25 years or more.

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Alfred J. Kleinberger New York City  
ELECTRICAL CONTRACTOR:  
Zwicker Electric Company New York City

Conference papers open for discussion

Conference papers listed below have been accepted by IEEE TRANSACTIONS and will be open for written discussion until January 24. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, IEEE, Box A, Lenox Hill Station, New York 21, N. Y., on or before January 24.

63-138 Designing Sample-Data Control Systems by Linear Programming K. A. Fegley
63-145 Power Spectrum Identification for Adaptive Systems Kenneth Stieglitz
63-518* Subjective Effects of Sidetone During Telephone Conversation A. M. Noll
63-562 A New Artificial Cable Kit R. W. DeMonte, F. Spadafino, T. J. Talley
63-91 A Program System for the Automatic Issue and Revision of Illustrated Parts Catalogs W. H. Maurer, M. L. Reynolds
63-1058 System Design Parameters for Electronic Exchange K. K. Spellnes
63-1059 Switching Units and Trunking for Electronic Automatic Exchange W. B. Klee, F. B. Sikorski
63-1060 Switching Unit Markers for Electronic Automatic Exchange A. S. Cochran, M. Levine, J. R. Vander Wege
63-1061 Register Sender Capabilities for Electronic Automatic Exchange K. E. Preacher, B. Sherstik, H. L. Wirsing
63-1062 Translation with Magnetic Drum in Electronic Automatic Exchange M. A. Langowski, J. R. Maneschi, W. C. Miller
63-1063 Control Center for Electronic Automatic Exchange W. R. Wedmore
63-1089 Stability Analysis of Incremental Servos J. M. Holtzman, A. I. Rue
63-1151* Recent Developments in Bell System Relays—Particularly Sealed Contact and Miniature Relays A. C. Keller
PPI*† Cable Installation Methods T. O. Swartt, John Tesoriero
JACC*† Optimized Feedback Control of Dead-Time Plants by Complementary Feedback W. Giloi
NMC*† Thin Tapes of High-Purity Silicon-Iron for Magnetic Amplifiers J. L. Walter
Presented at the 1963 International Nonlinear Magnetics Conference:* Two Heavy-Duty Transducers—The Pressductor and the Torductor—Based on Magnetic Stress Sensitivity Orvar Dahlle
Signal Switching with Magnetic Elements H. D. Crane, W. K. English
The Anisotropy Fields and Angular Dispersion of Permalloy Films H. J. Kump
Low-Power Thin-Film Memory C. J. Kriessman, T. J. Matcovich, W. E. Flannery
The Second-Harmonic Magnetic Modulator Using Ferrite Core Materials R. C. Foss
State of Art of Magnetic Amplifiers in Japan J. Yamaguchi
Magnetic-Tape Recording Materials C. D. Mee
Read-Write NDRO Memory D. L. Wile, R. D. Pierce

*Preprints not available.
†Published in the PROCEEDINGS of the following conferences: PPI—Ninth Annual Conference on Electrical Engineering in the Pulp and Paper Industry; JACC—1963 Joint Automatic Control Conference; NMC—1961 Nonlinear Magnetics Conference. Preprints may be purchased at 60 cents to members, $1.00 to nonmembers, if accompanied by remittance. Please order by number and send remittance to: IEEE Order Department, Box A, Lenox Hill Station, New York 21, N. Y.

Original papers invited on electromagnetic compatibility

Papers are invited for the 6th National Symposium on ElectroMagnetic Compatibility, formerly RFI, to be held June 23–25 in the Los Angeles area. The theme of the conference will be "Down-to-Earth EMC in the Space Age."

Original papers are solicited on these subjects: (1) New instrumentation and measurement techniques in EMC, (2) The contribution of EMC to system effectiveness, (3) Microminiaturization and EMC, (4) Logic technology and EMC, (5) EMC program management, (6) EMC and the space environment, (7) EMC and the nuclear environment, (8) The EMC semantic problem, (9) Pencil and slide rule EMI analysis, (10) Preventive techniques and design concepts, (11) EMI and the average citizen, and (12) The experience and educational requirements for EMC engineers.

Authors should submit completed papers by February 15 on one of the subjects listed. Papers should be submitted to J. A. Eckert, Technical Program chairman, Dept. 3441/32, Northrop-Norair, 3901 W. Broadway, Hawthorne, Calif.

The conference is sponsored by the Professional Technical Group on Electromagnetic Compatibility and the Los Angeles District of IEEE.

Papers sought for '64 Region 6 Conference

The Region 6 Annual Conference will be held April 29–May 1, in Salt Lake City, Utah.

This conference combines the functions of the former IRE 7th Region Technical Conference and the AIEE Pacific General Meeting. The Instrument Society of America is a co-sponsor.

Twenty technical sessions of five papers each are planned to serve the needs of former members of AIEE and IRE. In addition, at least two sessions will be devoted to instrumentation.

Papers are invited in the following and related fields:
1. Instrumentation. All areas of operation served by ISA.
2. Electrical Power. Systems, atomic reactors for power, communications for control, power for aircraft and spacecraft, energy conversion.
The tape with the built-in duster!

1000 times greater conductivity than ordinary tapes! That's how “Scotch” brand Heavy Duty Tapes drain off static charges before they can attract dust. That's the built-in duster that flicks away the growing danger of dust-caused dropout errors ... a danger greater than ever as higher and higher recorder speeds and tape tensions generate more and more static.

Electrical resistance of the oxide coating of “Scotch” Heavy Duty tapes is 50 megohms per square or less. The resulting conductivity, unusual in magnetic tape, not only avoids dust contamination, it minimizes such other static problems as tape drag and skew, noise induced by arcing.

Heavy duty formulation of binder and high potency oxides withstands temperatures from -40 to as high as +250°F to conquer high head heat, assures tapes that outlast standard tapes by at least 15 times. Exclusive Silicone lubrication reduces recorder head and tape wear. And “Scotch” Heavy Duty Tapes are offered for all high-speed applications, even for extreme high frequency and short wavelength requirements. 16 different constructions include a variety of backing and coating thicknesses.

TECHNICAL TALK Bulletin No. 4 provides detailed discussion of the effects of static electricity on instrumentation recording, offers helpful information in solving static-caused problems. It's free. Write 3M Magnetic Products Division, Dept. MEC-14, St. Paul 19, Minn.
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SWITCH TECHNOLOGY IS THIS
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- Impedance, 50 ohms
- Frequency to 7 GC
- VSWR 1.25 @ 4 GC
- Insertion loss 0.25 db @ 4 GC
- Crosstalk 30 db @ 4 GC, 45 db
- @ 2 GC
- Operating time 25 ms max
- Contacts, break-before-make
- Temperature, — 65°C to + 250°C
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- Actuator power, 0.5 amps @ 28 VDC
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Transco designs and manufactures Airborne, Spacecraft and Ground Antennas; Microwave Switches, Components and Systems; Subfractional Horsepower Motors; Electromechanical Devices; and Airborne Transponders. We invite resumes from qualified engineers.

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Automatic controls, electron devices, semiconductor circuitry, circuit theory, high speed data by wire, advances in telephone techniques, military electronics, satellite relays, communications systems, medical electronics, nuclear reactor instrumentation, audio, data processing, pattern recognition.

Abstracts of approximately 200 words are to be submitted by January 15, 1964, to the Technical Program chairman, Prof. Clayton Clark, Electrical Engineering Dept., Utah State University, Logan, Utah.

**Conference scheduled on broadcast and TV receivers**

The 1964 Chicago Spring Conference will be held at the O'Hare Inn, Des Plaines, Ill., on June 15–16. Papers are sought that would be contributions of significant interest to the home entertainment radio and television industry. Special consideration will be given to papers dealing with new concepts or new techniques associated with new or improved product design.

The deadline for receipt of papers is February 17. Potential authors are asked to submit, in triplicate, a summary of 50 to 100 words, including paper title, author(s), company affiliation, and position. Papers should be limited to 2500 words, and presentation to 20 minutes.

Papers should be submitted to F. H. Hilbert, Papers Committee, Motorola Inc., 9401 W. Grand Ave., Franklin Park, Ill.

**Special issue of PROCEEDINGS on microelectronics planned**

A forthcoming special issue of the PROCEEDINGS OF THE IEEE will be devoted to the field of microelectronics (integrated electronics) and is planned for the late Fall of 1964. Outstanding papers covering the state of the art and the most significant recent contributions in the field of microelectronics are sought for this special publication.

Papers pertaining to the following categories are requested:

1. Survey papers on broad, major aspects of microelectronics (e.g., economics; major technologies; philosophy of application; history; etc.)

2. Original papers on:
   a. Microelectronic devices and structures (e.g., semiconductor struc-
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First and foremost, Allen-Bradley's exclusive hot molding provides a uniformity that cannot be matched by any other resistors on the market—a fact with which hundreds of Allen-Bradley customers have become acquainted through their experience for over 30 years. Such history of uniformity in physical dimensions and electrical properties from one resistor to the next...from one order to the next...has been demonstrated in the production of more than ten billion resistors.

In addition, with their stable characteristics and conservative ratings providing an extra margin of safety, you can accurately predict long term resistor performance under various circuit conditions—and at all times be certain of complete freedom from catastrophic failures.

A unique manufacturing method is the key which makes all this possible. Allen-Bradley's hot molding technique is unlike anything in the industry, because both the process and the automatic machines—with built-in precision control—were developed and perfected by Allen-Bradley. Here, the resistance material, insulation material, and lead wires are hot molded into one solid integral structure that's mechanically strong—completely free of cracks which might admit moisture. There are additional reasons why more and more leading electronic manufacturers are standardizing on Allen-Bradley hot molded resistors. Complete specifications are furnished in Technical Bulletin 5050. Please send for your copy, today: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.
Brush uses Allen-Bradley Hot Molded Resistors because their reliability is established by years of experience.

To insure consistently accurate readout of their recorder, Brush insists upon the ultimate in component reliability. For this reason, Allen-Bradley hot molded resistors are their standard for their direct writing recording system.

The complete reliability of A-B hot molded resistors is proved by an "in service" record of more than ten billion resistors without a single instance of catastrophic failure. This has been made possible through Allen-Bradley's exclusive hot molding process that results in such complete uniformity—from one billion resistance units to the next—that long term resistor performance can be accurately predicted. Their stable characteristics and conservative ratings are your assurance of faultless performance even in super-critical applications.

Performance experience is the reason for the constantly growing family of electronic engineers who have standardized on A-B hot molded resistors. You can only benefit by following such qualified leaders. Publication 6024 gives detailed information on these and other A-B quality electronic components. So please write: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario.

*At NASA, a Brush Recorder was used to design a control system which would bypass the pilot and project the plane into prolonged zero gravity flight.

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HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, plus extended ranges below and above standard limits.
tures; thin-film resistive, capacitive, magnetic, etc., structures; optoelectronic structures; etc.)

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c. Interconnections and packaging

d. Circuit concepts and techniques using microelectronic structures (digital, linear; trade-offs; isolation, coupling; margins; frequency; power)

e. System aspects (e.g., trade-offs, system design using microelectronic devices; etc.)

f. Concepts, design, and performance of electronic equipments using microelectronic devices (military and industrial)

g. Reliability of microelectronic devices and equipments

h. Special topics (e.g., compatibility, hybrid structures and systems, etc.)

Two kinds of papers will be considered for publication:

1. Contributions of reasonably broad impact described in full length papers.

2. Contributions of limited impact described in brief monographs not exceeding 2000 words (corresponding approximately to two pages of the Proceeedings). Expanded versions of such monographs can be recommended for publication in the Transactions of appropriate Professional Technical Groups.

To facilitate the organization of the special issue, prospective authors are requested to inform the undersigned at their earliest convenience of their intention to submit a paper, indicating the subject and probable length of their contributions. Complete manuscripts should be submitted as soon as they are available. The tentative deadline for receipt of complete manuscripts is May 15, 1964. A small extension of time may be granted for work in progress if a suitable detailed abstract is received.

Three copies of each paper and of all illustrations pertaining to the paper should be submitted to: A. P. Stern, Editor, Microelectronics Issue of Proceedings of the IEEE, Martin Co., Electronic Systems & Products Div., Baltimore, Md. 21203. Attn: Mail No. 3031. The submission should include one original typed copy with one set of reproducible illustrations. A photograph and a biography of the author should be attached.

Further inquiry may also be directed to E. K. Gannett, Managing Editor, Proceedings of the IEEE, Box A, Lenox Hill Station, New York 21, N.Y.

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Price Electric Series 1000 Relays Now Feature . . .

- Sensitive Operation
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These versatile sensitive relays are designed for applications where available coil power is limited. They retain all the basic features, such as small size, light weight and low cost, that makes the Series 1000 General-Purpose Relays pace setters in their field.

**TYPICAL APPLICATIONS**

Remote TV tuning, control circuits for commercial appliances (including plate-circuit applications), auto headlight dimming, etc.

**GENERAL CHARACTERISTICS**

**Standard Operating Current:**
1 to 7 milliamps DC at 20 milliwatt sensitivity

**Maximum Coil Resistance:** 16,000 ohms

**Sensitivity:**
20 milliwatts at standard contact rating; 75 milliwatts at maximum contact rating. Maximum coil power dissipation 1.5 watts.

**Contact Combination:** SPDT

**Contact Ratings:**
- Standard 1 amp; optional ratings, with special construction, to 3 amps. Ratings apply to resistive loads to 26.5 VDC or 115 VAC.
- Mechanical Life Expectancy:
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Some customers really challenge us

Take the case of the commercial airlines. They needed a transducer that would accurately measure jet engine vibration in flight—yet would not disintegrate from the vibration as well as the searing heat.

Since CEC had pioneered and perfected vibration transducers for reciprocating engines, we believed we could do the same for jets. Result: CEC's first models successfully passed every ground and laboratory test. But when they took to the air it was another story. Failure followed failure. The airlines began to wonder if the answer could be found. And so did we.

That was six years and hundreds of experiments ago. Today the engine nacelles of increasing numbers of jet airliners carry pairs of tiny CEC 4-125 Vibration Transducers. Some of these 4-125s have already logged more than 3,600 hours—all are still functioning—and that's a record no other manufacturer has approached.

This is another case in point why CEC's leadership in the development and production of all phases of data recording has been advanced by troublemakers we're proud to call customers.

And it's why CEC has established a network of 22 sales and service offices throughout the nation. To expedite application engineering. To help train customer personnel in the use of advanced instrumentation. To find positive answers to evasive problems.
International conference on solid-state circuits slated for February 19–21

Recent advances in solid-state circuitry and applications will be covered at the International Solid-State Circuits Conference, February 19–21, in Philadelphia, Pa., at the University of Pennsylvania and the Sheraton Hotel.

Fifty papers—contributed, tutorial, and invited—will be presented by more than 80 industry scientists, engineers, and educators. In 38 contributed papers, speakers will cover system realization and interconnection; microwave circuits; device characterization and analysis; linear and digital integrated circuits; optical circuit techniques; transducers and display devices; and memories. Invited and tutorial reports will discuss all-magnetic digital circuits; circuit reliability, redundancy, and adaptability, and circuit noise.

Contributed papers will be presented during nine day sessions. Two sessions will be devoted to tutorials and one to invited papers.

Ten topical subject areas have been selected for informal evening discussions at the Sheraton Hotel on Wednesday and Thursday evenings. More than 50 panelists from here and abroad will participate. Discussions will cover microwave solid-state techniques, digital considerations of optical techniques, radiation resistance, threshold detection circuits, field-effect transistor applications, integrated digital logic, adaptive and self-repairing circuits, minimum power devices and circuits, optical modulators and detectors, and multi-octave high-frequency power sources.

The winners of plaques for outstanding papers delivered at ISSCC 63 will be announced at a special presentation ceremony during a formal opening session on Wednesday, February 19.

Another feature of this session will be a keynote address by H. B. G. Casimir, director of research, Philips Research Labs., Eindhoven, Netherlands. In a talk titled "Physical Phenomena and New Devices," he will survey discoveries made during academic research that have led to new circuit and device developments and stimulated study in university, industry, and government laboratories.

All registrants will receive, at no additional cost, a copy of a 120-page letterpress conference report book featuring condensations of every paper, including the keynote, tutorial, and invited talks, supplemented by more than 300 diagrams and photographs.

Post-conference copies of the Digest will be available from the University of Pennsylvania at $5.00 per copy.

Irvine Auditorium and the University Museum, where all of the day meetings will be held, are on the campus of the University. The informal Wednesday–Thursday evening discussion sessions will be held in the Sheraton Hotel.

Daily luncheons will be served to a limited number on Wednesday, Thursday, and Friday, November 19–21 in the University Museum.

Advance and at-conference fees are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Advance Before Feb. 14</th>
<th>At Conference, or after Feb. 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>Member IEEE: $10.00</td>
<td>$12.00</td>
</tr>
<tr>
<td></td>
<td>Non-Member: 12.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Wednesday Lunch:</td>
<td>3.00</td>
<td>3.50</td>
</tr>
<tr>
<td>Thursday Lunch:</td>
<td>3.00</td>
<td>3.50</td>
</tr>
<tr>
<td>Friday</td>
<td>3.00</td>
<td>3.50</td>
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</tbody>
</table>

Full-time students will be registered free of charge for technical sessions.

To avoid delays in registration and to assist the local arrangements committee, advance reservations, registrations, and luncheon ticket purchases are recommended.

E. O. Johnson of RCA is general chairman, and P. B. Myers, Martin Marietta, program chairman.

The tentative technical program for the conference follows:

**WEDNESDAY, FEBRUARY 19**

9:00 a.m.
Session 1. System Realization and Interconnection
University of Pennsylvania—Irvine Auditorium
Session 2. Tutorial: All-Magnetic Digital Circuits
University of Pennsylvania—University Museum
12:00 noon Lunch
University Museum
1:45 p.m.
Formal Opening of Conference
Irvine Auditorium
Introductory Comments
E. O. Johnson, RCA, chairman of conference
Welcoming Remarks
D. R. Goddard, Provost, Univ. of Penna.
1963 Conference Awards
F. H. Blecher, Bell Tel. Labs., chairman, 1963 conference
Invited Address
Physical Phenomena and New Devices
H. B. G. Casimir, Philips Res. Labs., Eindhoven, Netherlands
2:50 p.m.
Session 3. Microwave Circuits
Irvine Auditorium
3:00 p.m.
Session 4. Design Applications
University Museum
GLOBECOM VI seeks
technical papers for symposium

A call for papers has been issued for an International Symposium on Global Communications—GLOBECOM VI—to be held in Philadelphia June 2-4 at the University of Pennsylvania and the Sheraton Hotel.

Original papers (not previously published or presented) on communications and computer research, development, application, and operation—system-oriented—are invited. Suggested topics are traffic analysis and systems simulation; terrestrial radio transmission; communication, coding and modulation theory; economic factors in systems design; data transmission systems; computer control of communications; commercial satellite communications; military satellite communications; input-output technology; deep space communications; communications data handling and processing; military command and control systems; cable transmission; switching systems; and industrial communication and control.

Prospective speakers should submit both a 35-word abstract and a 300-500 word summary of the paper. The summary should define the nature of the effort's contribution to the art and should include theoretical and experimental results, when available, as well as key illustrations.

The abstract, suitable for publication in an advance program, should be typed in triplicate, on separate sheets and include title of paper, author's name, affiliation, return address, and telephone.

Summaries should also be submitted in triplicate and in single-side, black-on-white, double-spaced typewritten form, suitable for immediate reproduction and subsequent screening. The author's name, affiliation, address, and telephone number must appear on the first page, and the author's name and abbreviated paper title on each subsequent page. On papers with multiple authorship, the name of the speaker who will deliver the paper should be noted.

Deadline for abstracts is February 28.

Both the abstract and summary should be forwarded on or before February 28 to Richard Guenther, GLOBECOM VI Program Chairman, RCA Communications Systems Div., Bldg. 1-3-1, Camden, N.J. 08102.

Recognition Awards given by IEEE during National Electronics Conference

Four of five awards administered by the IEEE Recognition Awards Committee were presented on October 30 during the National Electronics Conference in Chicago.

W. G. Dow, medalist in Electrical Engineering Education, is a professor of electrical engineering at the University of Michigan. Dr. W. L. Everitt, Mervin J. Kelly Award recipient, is dean of engineering at the University of Illinois. Dr. F. B. Silsbee, Morris E. Leeds Award recipient, is a consultant to the National Bureau of Standards. Dr. R. N. Hall, David Sarnoff Award recipient, is a physicist at the General Electric Research Lab.

The William M. Habirshaw Award will be presented February 3 at the Winter Power Meeting to Dr. L. M. Robertson, manager of engineering, Public Service Co. of Colorado, on February 3 at the Winter Power Meeting.

Dr. J. G. Brainerd (left), chairman of the Recognition Awards Committee, appears with the award winners: (from his left) R. N. Hall, W. L. Everitt, W. G. Dow, and F. B. Silsbee. IEEE President Ernst Weber (right) made the presentations.
Now...one new EH swept signal generator gives you continuous coverage from 1 to 40 KMC

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### Specifications

<table>
<thead>
<tr>
<th>Frequency Control</th>
<th>Continuously adjustable with direct calibrated dial, accurate to ±1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweep Selector</td>
<td>Internal (recurrant), Single, CW, External, and Symmetrical</td>
</tr>
<tr>
<td>Symmetrical Sweep</td>
<td>Zero to 1% around any center frequency</td>
</tr>
<tr>
<td>Single Sweep Triggering</td>
<td>Front panel push-button triggers sweep</td>
</tr>
<tr>
<td>Leveling</td>
<td>Less than ±1 db to 18 Gc</td>
</tr>
<tr>
<td>Sweep Width</td>
<td>Continuously adjustable from 0 to any part of the entire frequency band</td>
</tr>
<tr>
<td>Time (Frequency)</td>
<td>0.001 to 100 seconds</td>
</tr>
<tr>
<td>Monitor Output</td>
<td>20V linear triangle</td>
</tr>
<tr>
<td>Frequency Markers</td>
<td>Three internal markers, 25 volts in amplitude, continuously adjustable in width from 0.1 to 1%, accurate to 1%</td>
</tr>
<tr>
<td>Amplitude Modulation</td>
<td>800-1200 CPS square wave; other frequencies available</td>
</tr>
<tr>
<td>External Sweep</td>
<td>20 volts gives full sweep. Negative voltage frequency</td>
</tr>
<tr>
<td>Price: Model 560 supply section only: $1,275</td>
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</table>

**NOTE:** All rf Generator Heads listed below are completely interchangeable. Add price of those desired to price of Model 560 Supply Section when ordering

<table>
<thead>
<tr>
<th>RF Generator Head</th>
<th>Model 561</th>
<th>Model 562</th>
<th>Model 563</th>
<th>Model 564</th>
<th>Model 564-1</th>
<th>Model 565</th>
<th>Model 566</th>
<th>Model 567</th>
</tr>
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<tr>
<td>Frequency</td>
<td>Gc</td>
<td>Gc</td>
<td>Gc</td>
<td>8.2-12.4</td>
<td>7-12.4</td>
<td>12.4-18</td>
<td>18-26.5</td>
<td>26.5-40</td>
</tr>
<tr>
<td>Price</td>
<td>$2300</td>
<td>$2300</td>
<td>$2300</td>
<td>$2300</td>
<td>$2500</td>
<td>$2850</td>
<td>$3500</td>
<td>$5800</td>
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</table>

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IEEE spectrum JANUARY 1964
Two-day seminar to discuss writing-improvement programs

Arrangements have been completed for the Seminar on Writing-Improvement Programs for Engineers, to be held February 24–25 at the Hotel Delmonico in New York City.

Dr. James Hillier, vice-president, Radio Corp. of America Labs., Princeton, N.J., will address the seminar at a banquet. His subject will be "Engineering Writing: The Larger View of Management."

The seminar is cosponsored by the Professional Technical Group on Engineering Writing and Speech and the Professional Technical Group on Education. The program will start on Monday, February 24, at 9:00 a.m., with a welcome and keynote speech by the seminar chairman, C. A. Meyer, RCA. Four discussion periods will follow, led off by brief talks by panels of specialists in the particular fields.

The Monday morning session on "Specific Needs of Engineers for Writing Improvement" will include as panel members J. N. Shive of Bell Telephone Labs., P. K. Furney of the Ohio Society of Professional Engineers, E. E. Grauda of Hayden Publishing Co., and G. Kiessling of RCA. The session moderator will be W. J. Underwood of RCA. The panel for the afternoon session on "Course Content of Writing-Improvement Programs" will include R. R. Rathbone of the Massachusetts Institute of Technology, E. Ehrlich of Columbia University, A. Mansfield of the Atomic Power Development Assoc., and S. Wilcox of Arizona State University. The moderator will be C. W. Sall of RCA. The afternoon session will be followed by a reception and banquet on Monday evening.

The program will continue on Tuesday morning with a session on "Program Administration." Panel members will include J. A. Miller of Bell Telephone Labs., J. R. Gould of Rensselaer Polytechnic Institute, C. H. Stephens of the Newark College of Engineering, and R. Rolff of MIT Research and Engineering. The session moderator will be E. M. McElwee of RCA. The final session on Tuesday afternoon will consist of an "Evaluation" by H. Orel of the University of Kansas, followed by some "Recommendations for the Future" by T. Farrell of Michigan State University, and W. C. Praeger of RCA. The moderator for the final session will be J. D. Chapline of Philec. A registration fee of $30 will cover...
participation in the four discussion sessions and attendance at the banquet. Advance registrations may be sent to the seminar chairman, C. A. Meyer, RCA, Harrison, N.J.

First RUD exposition will take place April 21–23

The first residential underground distribution exposition ever to be held has been announced by its sponsors, the Insulated Conductor and the Transmission and Distribution Committees of IEEE.

This combined special technical conference and exposition, to be devoted solely to residential underground distribution, will take place at the Chase Park Plaza Hotel, St. Louis, Mo., April 21–23.

The program will consist of utility-sponsored technical papers, IEEE subcommittee-sponsored technical papers, and 60 manufacturers' exhibit booths for the display of all types of residential underground equipment.

The event will provide a meeting ground where utility executives, distribution engineers, manufacturers, and others interested can meet to exchange ideas, and to discuss methods, materials, and equipment.

Technical program planned. Acceptances have been received for presentation of almost all of the papers to be delivered at the conference.

The initial session will be devoted to a review and discussion of about 15 utility papers from different sections of the country. These will include all the big users of RUD.


The third session will discuss: (1) Lightning protection. (2) Fault protection and sectionalizing. (3) Transformer equipment. (4) Grounding protection.

Conference committee named. E. C. DeBaene, Detroit Edison Co. engineer, is general chairman of the conference. The Technical Program Committee chairman is R. C. Graham of the Rome Cable Div. of Alcoa, Rome, N.Y. The vice general chairman is R. F. Lawrence, Westinghouse Electric Corp.
Calendar

For additional information on any of the IEEE meetings listed on the following pages, write either to the person designated for that meeting or to the following address: Meetings Inquiries, Institute of Electrical and Electronics Engineers, Inc., Box A, Lenox Hill Station, New York 21, N.Y.

IEEE-AAA-MIT 5th Symposium on Engineering Aspects of Magnetoohydrodynamics
April 1–2, 1964
Massachusetts Institute of Technology
Cambridge, Mass.
(Final date for TP—Jan. 2, CP Syn—Jan. 12, CPMs—Jan. 27)
§Dr. G. S. Janes, Arco Everett Research Labs.,
2385 Revere Beach Parkway, Everett 49, Mass.

Rubber & Plastic Industries Conference
April 6–7, 1964
Sheraton-Mayflower Hotel
Akron, Ohio
(Final date for TP—Jan. 7, CP Syn—Jan. 17, CPMs—Jan. 31)
§D. J. Burton, Ohio Edison Co., Akron, Ohio

International Conference on Nonlinear Magnetics (INTERMAG)
April 8–10, 1964
Sheraton Hotel
Washington, D.C.
§R. C. Baker, Dept. of Engineering and Applied Science, Yale Univ.,
Dunham Lab., New Haven, Conn.

3rd Symposium on Micro-Electronics
April 13–15, 1964
Chase-Park Plaza Hotel
St. Louis, Mo.
§T. F. Muirha, P.O. Box 4104, St. Louis, Mo.
63118

IEEE-ASME Railroad Conference
April 14–15, 1964
Pick Carter Hotel and Cleveland Engineering
and Scientific Center
Cleveland, Ohio
(Final date for TP—Jan. 15, CP Syn—Jan. 24, CPMs—Feb. 7)

IEEE-Illinois Institute of Technology
American Power Conference
April 14–16, 1964
Sherman Hotel
Chicago, Ill.
(Final date for TP—Jan. 15, CP Syn—Jan. 25, CPMs—Feb. 7)
§W. A. Lewis, Illinois Institute of Technology,
Chicago, Ill.
UNMATCHED VERSATILITY  By utilizing a basic Panoramic spectrum analyzer and selecting from several standard compatible accessory units, "customized" equipment is available with varying capability—ranging from portable analyzers for the field to highly versatile laboratory systems like the SY-1 shown above.  ■ Hundreds of Panoramic LP-1aZ spectrum analyzers are in use today. This is the basic unit of the system above, and may combine with many accessories to greatly extend its capability: the C-2 for additional range resolution and sweep widths; RC-3b chart recorder for special inputs and high resolution; PDA-1 spectral density analyzer for statistical plots of random information; TFA-1 time-frequency analyzer for intensity-modulated raster analyses like those often used for speech; G-2a sweep generator for response curves; PA-1 phase and amplitude response plotter; TW-1a triangular wave generator for long scans; and the SW-1 signal alternator for simultaneous CRT display of two signals. All fit standard 19" rack or cabinets.  ■ Additional capability may be had with the LF-2b which covers the 0.5-2500 cps subsonic region; and the TA-2 covering 20-35,000 cps—a compact, portable, battery-operated unit. Plug-in units extend range to 25 mc. Higher frequencies are also available.

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Sixty electric utility chief executives have expressed overwhelming endorsement for General Electric's $10-million investment in extra-high-voltage transmission research. And they frankly state that the cost should be recovered in the price of products we sell. However, General Electric faces a practical business decision: Should this kind of research investment be continued when actual utility purchasing practice gives scant recognition to R&D as a competitive evaluation factor? General Electric strongly wishes to continue R&D on many fronts vital to electric industry growth. But we must receive your votes in the only form recognizable to our profit and loss computers—dollar evaluations for R&D on your purchase orders. I'll welcome your further comments.

M. F. Kent
Vice President and General Manager, Electric Utility Sales Operation
Cement Industry Technical Conference
April 14–16, 1964
Huntington-Sheraton Hotel
Pasadena, Calif.
(Final date for TP—Jan. 15, CP Syn—Jan. 24,
CPMs—Feb. 7)
§D. B. Carson, General Electric Co., P.O. Box
2830, Terminal Annex, Los Angeles 24, Calif.

International Conference and Exhibit on Aero-
space Electro-Technology‡
April 19–25, 1964
Westward-Ho Hotel
Phoenix, Ariz.
§A. A. Sorensen, Mail 3016, Martin Co., Balti-
more 3, Md.

Reliability Training Course
April 20–24, 1964
Westbury Hotel
Toronto, Canada

AFIPS Spring Joint Computer Conference
April 21–23, 1964
Sheraton Park Hotel
Washington, D.C.
(Final date for TP—Jan. 22, CP Syn—Feb. 1,
CPMs—Feb. 14)
§Jack Roseman, 2313 Coleridge Dr., Silver
Spring, Md.

Underground Residential Distribution Con-
ference
April 21–23, 1964
Chase Park Plaza Hotel
St. Louis, Mo.
(Final date for submitting papers—Feb. 1)
§R. C. Graham, Rome Cable Div., Alcoa,
Rome, N. Y.

Southwestern IEEE Conference and Electronics
Show
April 22–24, 1964
Dallas Memorial Auditorium
Dallas, Tex.
§R. A. Arnett, Texas Instruments, Inc., P.O.
Box 35084, Dallas 35, Tex.

IEEE Region 6 Annual Conference
April 29–May 1, 1964
Salt Lake City, Utah

Packaging Industry Conference
May 4–6, 1964
Nassau Inn
Princeton, N.J.
(TP—Feb. 4, CPMs—Feb. 28)
§E. W. Macoy, American Can Co., 100 Park
Ave., New York 17, N. Y.

5th Symposium on Human Factors in Elec-
tronics
May 5–6, 1964
San Diego, Calif.
§Dr. Mel Freitag, 1910 Shire Drive, El Cajon,
Calif.

IEEE-EIA Electronic Components Conference‡
May 5–7, 1964
Marriott Twin Bridges Motor Hotel
Washington, D.C.
§John Bohrer, IRC, 401 N. Broad St., Phila-
delphia 8, Pa.

Southeastern Textile Industry Conference
May 7–8, 1964
Atlanta, Ga.
(Final date for TP—Feb. 7, CP Syn—Feb. 17,
CPMs—Mar. 4)
§Ben Thompson, Russell Manufacturing Co.,
Alexander City, Ala.

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IEEE-AIAA National Aerospace Electronics Conference
May 11–13, 1964
Biltmore Hotel
Dayton, Ohio
§IEEE Dayton Office, 1414 E. 3rd St., Dayton, Ohio

15th Annual Appliance Technical Conference
May 19–20, 1964
Ben Franklin Hotel
(Final date for TP—Feb. 19, CP Syn—Feb. 28, CPMs—Mar. 13)

International Symposium on Microwave Theory and Techniques
May 19–21, 1964
International Inn, International Airport
Idledwld, N.Y.
§Dr. Leonard Swern, Sperry Gyroscope Co., J7105, Great Neck, N.Y.

10th Annual Pulp and Paper Industry Conference
May 20–22, 1964
Netherlands Hilton Hotel
Cincinnati, Ohio
(Final date for TP—Feb. 20, CP Syn—Feb. 28, CPMs—Mar. 16)

IEEE-ISA-AIAA National Telemetering Conference
June 2–4, 1964
Biltmore Hotel
Los Angeles, Calif.
(Deadline for papers—Jan. 1)
§H. S. Pope, North American Aviation, Downey, Calif.

International Symposium on Global Communications (GLOBECOM VI)
June 2–4, 1964
University of Pennsylvania
and Sheraton Hotel
(Deadline for submission of abstracts—Feb. 28)
§Richard Gaenther, GLOBECOM VI Program Chairman, RCA Communications System Div., Bldg. 1-3-1, Camden, N.J. 08102

IEEE-PB Symposium on Quasi-Optics
June 8–10, 1964
Statler Hilton Hotel
New York, N.Y.
§Prof. L. Felsen, Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.

6th National Symposium on Electromagnetic Compatibility
June 9–11, 1964
Los Angeles, Calif.

Chicago Spring Conference on Broadcast and Television Receivers
June 15–16, 1964
O’Hare Inn
Chicago, Ill.

IEEE-U.S. Nav. Hosp. San Diego Symposium for Biomedical Engineering
June 23–25, 1964
Ocean House
San Diego, Calif.
(Final date for TP—Mar. 25, CP Syn—Apr. 9, CPMs—Apr. 17)
§Dr. L. Franklin, director, Scripps Clinic & Research Foundation, La Jolla, Calif.

IEEE-NBS International Conference on Precision Electromagnetic Measurements
June 23–25, 1964
Boulder, Colo.
Author’s Deadline—Mar. 15
§C. F. Henbestead, Bell Telephone Labs., Inc., Murray Hill, N.J.

IEEE-AICHE-ASME-ISA Joint Automatic Control Conference
June 24–26, 1964
Stanford University
Stanford, Calif.
§L. A. Zadeh, University of California, Berkeley, Calif.

Wescon Show and Summer General Meeting
August 25–28, 1964
Los Angeles, Calif.
(Deadline for abstract and summary—April 15)
§Dr. R. R. Bennett, Suite 1920, 3600 Wilshire Blvd., Los Angeles 5, Calif.

Petroleum Industry Conference
August 24–26, 1964
St. Francis Hotel
San Francisco, Calif.
(Final date for TP—June 26, CP Syn—June 5, CPMs—June 19)

IECE International Conference on Microwave, Circuit Theory, and Information Theory
September 7–11, 1964
Tokyo, Japan

8th Convention on Military Electronics (MILECON)
September 14–16, 1964
Washington Hilton Hotel
Washington, D.C.

IEEE-ASME-AIE-ASCE 12th Annual Engineering Management Conference
September 17–18, 1964
Pick-Carter Hotel
Cleveland, Ohio
(Final date for TP—June 19, CP Syn—June 29, CPMs—July 14)

PTG on Antennas and Propagation Symposium
September 22–24, 1964
International Airport
Idledwld, N.Y.
(Deadline for submission of abstracts—Mar. 1)
§Henry Jasik, Philco Corp., 100 Shames Br., Westbury, N.Y.

3rd Canadian Symposium on Communications
September 25–26, 1964
Montreal, Canada
(Final date for TP—June 26, CP Syn—July 7, CPMs—July 22)

IEEE-ASME National Power Conference
September 27–October 1, 1964
Mayo Hotel
Tulsa, Okla.
(Final date for TP—June 29, CP Syn—July 9, CPMs—July 24)

Symposium on Space Electronics
October 4–9, 1964
Dunes Hotel
Las Vegas, Nev.
§C. H. Doersams, Jr., Instruments for Industry, Hicksville, N.Y.
Ed Cabrera Speaks Out On Low-Cost Balanced Mixers

"Competitive market conditions, together with multi-channel system concepts such as phased-array radar, are making the microwave industry increasingly conscious of the high cost of mixing. Manufacturers have been hard-pressed to reduce component cost without sacrificing performance. Particular emphasis is being placed on mixers, since they have such a major effect on system sensitivity. Whether your mixer needs number in the tens or thousands, I believe you'll share our excitement over SAGELABS' new TRIMODE™ Balanced Mixers. Model 28453 shown here, for example, costs only $75 in small quantities, yet it provides a maximum noise figure of 7.0 DB from 5.8-6.6 GC using 1N23E/ER diodes and an IF noise figure of 1.5 DB. Maximum signal VSWR is only 1.8. Maximum LO VSWR is 2.5, while minimum LO-signal isolation is 18 DB. The mixer is a very rugged lightweight package measuring only 2" in body diameter by 0.75" in body depth. All this for only $75, including crystals! As they would say in my native Colombia, "Caramba!", which is roughly equivalent to "Wow!"

Eduardo Cabrera/Microwave Engineer

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Société Européenne d'Electronique
123, Rue de Silly • Boulogne-Billancourt (Seine)
Téléphone: VAL. 62-83.

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The world's most advanced camera, the Polaroid Land Automatic 100, contains a most advanced photoconductive cell by Clairex capable of high speed operation over a ratio of light levels greater than 10,000:1. This cell is a key component—a "light valve"—in the new camera's electronic shutter which permits perfect exposures in both color and black and white under all conditions, including flash operation. Precisely controlled characteristics, as well as speed and reliability, prompted Polaroid to rely on Clairex photoconductive cells for such an important task...a second time!

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Over four years ago, Polaroid Corporation came to Clairex and asked it to supply the critical photoconductive cell component for its "Microeye" exposure control device, a "first" for still cameras!

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10th Communications Symposium
October 5-7, 1964
Utica, N.Y.

1st Annual Conference on Industrial and Commercial Power Systems
October 6-8, 1964
Marriott Motor Hotel
§A. M. Killin, Union Carbide Metals Co., division of Union Carbide Corp., Ashtabula, Ohio 44-4

National Electronics Conference
October 19-21, 1964
McCormick Place
Chicago, III.
(Final date for TP—July 21, CP Syn—July 31, CP/MS—Aug. 14)
§National Electronics Conference, 228 N. LaSalle St., Chicago, Ill.

East Coast Conference on Aerospace and Navig. Electronics (ECCANE)
October 21-23, 1964
Baltimore, Md.

Western Technical Appliance Conference
October 26, 1964
(Final date for TP—July 28, CP Syn—Aug. 7, CP/MS—Aug. 20)

AFIPS Fall Joint Computer Conference
October 27-29, 1964
Civic Center, Brooks Hall, and St. Francis Hotel
San Francisco, Calif.
(Final date for TP—July 29, CP Syn—Aug. 7, CP/MS—Aug. 21)

Symposium on Space and Laboratory and PTG-NS 11th Anniversary Meeting
October 27-29, 1964

Electron Devices Meeting
October 29-30, 1964
Sheraton-Park Hotel
Washington, D.C.

Northeast Research and Engineering Meeting
November 4-6, 1964
Boston, Mass.

IEEE-EIA Radio Fall Meeting
November 9-11, 1964
Hotel Syracuse
Syracuse, N.Y.
§V. M. Graham, Electronic Industries Assn. Engineering Dept., 11 W. 42 St., New York, N. Y.

15th Annual Machine Tools Industry Conference
November 16-18, 1964
Stauffer Hilton Hotel
Hartford, Conn.
(Final date for TP—Aug. 18, CP Syn—Aug. 28, CP/MS—Sept. 11)
§Lee Musser, Bendix Industrial Controls, 998 Farmington Ave., West Hartford, Conn.

IEEE-AIP 10th Conference on Magnetism and Magnetic Materials
November 16-19, 1964
Radisson Hotel
Minneapolis, Minn.
(Final date for TP—Aug. 18, CP Syn—Aug. 28, CP/MS—Sept. 11)
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People

Dr. Sinclair is elected president of General Radio

D. B. Sinclair (F '43), formerly executive vice-president of General Radio Co., was elected president at a meeting of the directors on October 18.

Dr. Sinclair leaves the post of executive vice-president and technical director that he has held for the past two years. He joined General Radio in 1936 and subsequently became chief engineer. In 1955, he was appointed vice-president for engineering and in 1956 was elected a director.

He was born in 1910 in Winnipeg, Canada. From 1926 to 1929 he attended the University of Manitoba, and then transferred to the Massachusetts Institute of Technology where he received the degrees of B.S. in 1931, M.S. in 1932, and D.Sc. in 1935. At this time, he was enrolled in a cooperative course in electrical engineering with several branches of the Bell System. While studying for his doctorate he was a research assistant in the Dept. of Electrical Engineering at MIT and spent one year working on his dissertation at General Radio. He remained at MIT as a research assistant for one year after receiving his degree, and next became associated with General Radio.

During World War II, Dr. Sinclair was in charge of the search-receiver work for radar countermeasures at the Radio Research Lab. at Harvard University. He was also a member of Division Five of the National Defense Research Committee in Guided Missiles. For his work on countermeasures and guided missiles he received the President's Certificate of Merit in 1948. From 1954 to 1958 he was a member of the Technical Advisory Panel on Electronics of the Depart. of Defense.

Dr. Sinclair, now a member of the IEEE Editorial Board, was President of IRE in 1952 and served a term as Treasurer from 1949 to 1950. He was a member of the Executive Committee of IRE in the years 1948-1950 and 1952-1953, and was on the Board of Directors from 1945 to 1954 and in 1958.

EIA plaque presented to R. L. Pritchard of Motorola

R. L. Pritchard (F '60), director of engineering at Motorola Inc.'s Semiconductor Products Div., has been given the Radio Fall Meeting Plaque presented annually by the Electronic Industries Association for significant technical contributions to the electronic industries.

The award, presented at the EIA Radio Fall Meeting held recently in Rochester, N.Y., cited Dr. Pritchard for his "many contributions to national and international standardization of semiconductor devices through active participation in the International Electro-technical Commission, the Institute of Electrical and Electronics Engineers, and the Joint Electron Device Engineering Council."

Dr. Pritchard has been a member of the U.S. delegation to the IEC's Technical Committee TC-47 on Semiconductor Devices since 1958 and currently is chief U.S. delegate to that committee. He has served as chairman of the JEDEC Committee on Industrial Transistors.

He joined Motorola's Semiconductor Products Div. in 1963 with responsibility for director of all engineering activities, budgetary control, overall engineering projects, initiating and terminating projects, and recommending when and how new devices resulting from engineering projects should be placed in production.

Before moving to Motorola, Dr. Pritchard was staff director of engineering for the Semiconductor-Components Div. of Texas Instruments Inc.

Dr. J. R. Wait appointed NBS Senior Research Fellow

Dr. J. R. Wait (F '62), authority in the field of radio propagation, has been appointed a Senior Research Fellow at the National Bureau of Standards, U.S. Dept. of Commerce. Dr. Wait has been on the staff of NBS Boulder (Colo.) Labs. since 1955, and will
DATA PROCESSING SYSTEMS FOR SPACE

Advanced STL digital telemetry units, decoders, and command distribution assemblies are now being used on NASA's OGO and Pioneer, and the Air Force's Nuclear Test Detection spacecraft. STL hardware and experience with on-board data processing equipment is being applied in the development of new systems which will perform checkout and maintenance functions in space. This advanced technology requires circuit designers, logic designers, and digital systems engineers. For Southern California or Cape Canaveral opportunities, write Professional Placement, One Space Park, Dept.IS-1, Redondo Beach, California, or P.O. Box 4277, Patrick AFB, Florida. STL is an equal opportunity employer.
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Fewer accessories needed, hence less error from associated equipment.

Over 100 synchro/resolver test instruments are available from Gertsch — synchro standards, resolver standards, synchro bridges, resolver bridges. In addition to conventional, manually-operated units, all standards and bridges can be supplied as rotary solenoid, relay (programmable), and decade (.001° resolution) instruments.

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Complete information on all Gertsch synchro/resolver test instruments in catalog #11 — 40 pages of technical information, specifications, theory, application data and engineering bulletins. A valuable reference source for design and test engineers.

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continue to serve as consultant to Dr. C. G. Little, chief of the Central Radio Propagation Lab. at Boulder.

Dr. Wait is a 1959 recipient of the Dept. of Commerce Gold Medal for highly distinguished authorship in the field of radio propagation. He has to his credit two books and more than 200 other technical publications. In 1960, he received the Boulder Scientist Award from the Research Society of America. In 1962, he was one of three Bureau staff members who received the new Samuel Wesley Stratton Award established by NBS to recognize outstanding contributions by Bureau scientists.

He was born in Ottawa, Canada. He entered the radio propagation field as an Army radar technician during World War II. After the war he received three degrees from the University of Toronto, a B.A.Sc. in engineering physics in 1948, an M.A.Sc. in the same field in 1949, and a Ph.D. in electromagnetic theory in 1951. During this time, he was associated with Newmont Exploration, Ltd., of New York and Jerome, Ariz. From 1952 to 1955, he was a section leader in the Defence Research Telecommunications Establishment in Ottawa and was primarily concerned with electromagnetic problems. Since joining NBS in 1955, Dr. Wait has concentrated on the theoretical aspects of radio propagation. He was the first editor of the Radio Propagation Section of the NBS Journal of Research (1959–1961), soon to be published monthly under the title Radio Science.

Dr. Wait is a past president of the Boulder Chapter of the Research Society of America. He is a member of the U.S. National Committee of the International Scientific Radio Union and the Administrative Committee of the Professional Group on Antennas and Propagation of IEEE. In 1961 he was appointed Professor (adjoint) of the Electrical Engineering Dept. of the University of Colorado. In 1960, he was a visiting research fellow at the Technical University of Denmark, in Copenhagen.

Dr. Coolidge honored at 90 with Rontgen Medal

W. D. Coolidge (F ’55, Life Member) was honored on his 90th birthday, October 23, by the presentation of the Röntgen Medal, in recognition of his scientific achievements in the field of X rays.

The medal was presented by Dr. Richard Seifert on behalf of the city of
**NEW HIGHER RATINGS ON D/B MODULAR DC POWER SUPPLIES**

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- **ITS PERFORMANCE**
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- **ITS RELIABILITY**
  - Temperature: Operating: -54°C to 110°C
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  - 2" x ½" x ½"... occupies ½ cu. in., weighs only 2.3 ounces

This switch can be used in virtually any application requiring a high performance C-Band Switch, military or commercial.

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The presentation of the Röntgen Medal to Dr. W. D. Coolidge (center) was made by Dr. Richard Seifert (right). Looking on is (left) Dr. Guy Suits (F '47), General Electric, vice-president and director of research.

Renscheid-Lennep, West Germany birthplace of Röntgen, who discovered the X ray. The presentation was made at the General Electric Research Lab. in Schenectady, N.Y., of which Dr. Coolidge was director for 22 years before his retirement in 1945.

Dr. Coolidge, inventor of the X-ray tube that bears his name, played a leading role in the development of X-ray technology for both medical and industrial applications. Prior to his retirement, he had been vice-president and director of research for the General Electric Co.

In 1932, Dr. Coolidge received the Washington Award, and in 1927 the Edison Medal. He became the third citizen of the United States to receive the Röntgen Medal.

**Philip Ryan retires from top Cutler-Hammer post**

Philip Ryan (F '59, Life Member), president of Cutler-Hammer, Inc., Milwaukee, Wis., for the last eight years, retired December 31 from that position.

Mr. Ryan is a veteran of 43 years with Cutler-Hammer. He is a native of Helena, Mont. He joined the company he eventually headed in 1920 as a student engineer following graduation from Cornell University.

Prior to being named manager of the firm's New York Works in 1931, Mr. Ryan held various engineering and purchasing posts. He became works
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IEEE spectrum JANUARY 1964
manager of the Milwaukee plants in 1934. He was subsequently made vice-
product—manufacturing, in 1945. In 1951, he assumed the additional
responsibility of directing development engineering and at the same time he
became executive vice-president. He was elected president in 1956. He has been a
director of the company since 1949 and will continue to serve in that capacity
after his retirement from the presidency.

A. L. Aden (SM '57) has joined the staff of Electro-Optical Systems, Inc., Pas-
dena, Calif., as a corporate vice-president and associate technical director. Dr.
Aden was formerly a vice-president of Motorola Instrumentation and Control,
Inc., in Phoenix, Ariz.

M. M. Brandon (F '44), president, Underwriters' Labs., Inc., Chicago, Ill., is
the recipient of the 1963 Award for Meritoriuous Service in the Field of Standardi-
ization, presented by the Standards Engi-
neers Society and the American Society
for Testing and Materials Award.

C. I. Cummings (SM '54), former Lunar
Program director of Caltech's Jet Pro-
pulsion Lab., has joined the staff of Elec-
 tro-Optical Systems, Inc., as manager of
the Advanced Systems Development Op-
erations.

Jim Fitzpatrick (M '61) has been ap-
pointed microwave project engineer of
Budelman Electronics Corp., Stamford,
Conn., a unit of General Signal Corp.
He was previously employed by Western
Union Telegraph Co., as design engi-
neer in the Radio Research Div.

International Resistance Co. has ap-
pointed C. R. Gray (M '59), as manager,
Microcircuit Application Development, and C. I. Swanson (A '54) as manager,
Microcircuit Customer Services.

Both men were formerly affiliated with the Lansdale Div. of Philco Corp., as
manager of commercial engineering and manager of customer engineering ser-
vice, respectively.

R. J. Greenway (SM '59) has been ap-
nointed to the newly established position
doctor of program operations at Moto-
rola's Chicago Military Electronics
Center. Mr. Greenway has been in engi-
neering management with Motorola
since 1958 in the undersuse electronics,
microwave, and radar laboratories.

J. F. Hirlinger (SM '43) retired on Oc-
tober 31 as administrator, Technical Per-
sonnel Programs, for the Radio Corp. of
America Electronic Components and
Devices at Harrison, N.J. Mr. Hirlinger
served in a similar capacity with the
RCA Electron Tube Div., which was re-
aligned to become the Electronic Com-
ponents and Devices organization.

H. F. Ivey (SM '51), formerly research
and engineering consultant at the West-
inghouse lamp division, Bloomfield,
N. J., has been named advisory scientist
at the Westinghouse Research Labs.

George Kende (SM '51) has been ap-
nointed chief engineer, Process Develop-
ment, for Bausch & Lomb Inc., Ro-
chester, N.Y. Mr. Kende was formerly
plant manager for the Wollensak Div. of
Minnesota Mining & Manufacturing
Co., Rochester.

J. M. Kranz (M '62) has been appointed
assistant sales manager for Semiconduc-
tor and IR devices, Micro State Elec-
tronics Corp., Murray Hill, N.J. Prior to
joining Micro State, Mr. Kranz was with
Barnes Engineering Co.

W. C. Morrison (SM '49) has been ap-
nointed chief engineer, Radio Corp. of
America's Broadcast and Communica-
tions Products Div. He was formerly as-
sistant to the chief defense engineer.

Walter Morton (SM '61) has been ap-
nointed technical director of Dynamics
Instrumentation Co., Monterey Park,
Calif. Mr. Morton was previously a con-
sulting engineer in the field of data acquisi-
tion systems and instruments.

W. M. Pease (SM '57) has been ap-
nointed director of special projects for
Raytheon Co.'s Space and Information
Systems Div. Prior to joining Raytheon,
he was president of Aracan Labs.,
Concord, Mass.

E. R. Piore (F '50), vice-president of In-
ternational Business Machines Corp., has
become a group ex-
ecutive with respon-
sibility for the Ad-
vanced Systems De-
vices and IBM Re-
search, which now becomes the Research
Div. Dr. Piore was formerly vice-presi-
dent, research and engineering.

H. W. Pollack (SM '58) of Polarad Elec-
tronics Corp., Long Island City, N.Y.,
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For research, development, production Temperatures to 1650° C. Solid state Sensitronic device features current proportioning control.

Model K-36 (1300° C.) The Despatch Model K-36 provides a 12” uniform zone that is primarily designed for the semiconductor industry or other areas where extremely close tolerance temperatures must be maintained. As in other “R” model ovens by Despatch, the unit is controlled by the solid state Sensitronic In-po-trol which proportion the AC voltage from the power line to the heater in response to a low level control signal.

Model K-38A (1300° C.) The Model K-38A provides a 22” long, uniform zone with cool surface temperatures, excellent serviceability. The Model K-38A is designed for semiconductor diffusion and other areas where 1/8” C. temperatures are required in range 600° C. to 1300° C. Heavy gauge Kanthal A-1 elements with proportioning Sensitronic In-po-trol.

write for Bulletin 206-5-6X or call 112-612-331-1873.

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BRIGHT LITTLE BRAIN FROM IEE DECODES, DISPLAYS, REMEMBERS
IEE Bina-View® takes any binary code up to six bits □ translates it quietly □ displays it in bright, readable alpha-numeric characters □ and then remembers what it last translated.

Bina-View is a binary input, self-decoding readout with a complete alpha-numeric capability. Decoding is entirely self-contained; no translators, relays or diodes are required. Its 41-message capacity permits additional display of colors, symbols, words. Floating decimal points are available from a separate lamp circuit.

Bina-View also provides automatic memory and retains the last message displayed after signal and set-pulse power have been removed. As an optional feature, Bina-View may also be used for check-back to verify input signals and to transmit input signals back into source equipment.

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Ideal for Remote Operation. In-line assembly of four alpha-numeric displays operates from single 12-wire cable. Each additional Bina-View requires only one extra wire. Contact your local IEE engineering representative or write to IEE for information on remote applications.

Your inquiry will bring complete information on Bina-View plus the new “Readout Display Selector Guide” covering the entire IEE line of display devices.

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Model K-38A (1300° C.) The Model K-38A provides a 22" long, uniform zone with cool surface temperatures, excellent serviceability. The Model K-38A is designed for semiconductor diffusion and other areas where 1/8" C. temperatures are required in range 600° C. to 1300° C. Heavy gauge Kanthal A-1 elements with proportioning Sensitronic In-po-trol.

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BRIGHT LITTLE BRAIN FROM IEE DECODES, DISPLAYS, REMEMBERS
IEE Bina-View® takes any binary code up to six bits □ translates it quietly □ displays it in bright, readable alpha-numeric characters □ and then remembers what it last translated.

Bina-View is a binary input, self-decoding readout with a complete alpha-numeric capability. Decoding is entirely self-contained; no translators, relays or diodes are required. Its 41-message capacity permits additional display of colors, symbols, words. Floating decimal points are available from a separate lamp circuit.

Bina-View also provides automatic memory and retains the last message displayed after signal and set-pulse power have been removed. As an optional feature, Bina-View may also be used for check-back to verify input signals and to transmit input signals back into source equipment.

OTHER MAJOR FEATURES:

Long Unit Life. Certified for 20,000,000 operations. Uses new extra-brightness lamp that is replaceable in 30 sec. □
Low Power. Requires only 100 mw per bit; only four watts for set-up □ Quiet Operation. Bina-View’s electro-magnetic operation is barely audible □ Bright, Readable Characters. Lucite one-plane viewing screen displays characters up to 1¾” in height.

Ideal for Remote Operation. In-line assembly of four alpha-numeric displays operates from single 12-wire cable. Each additional Bina-View requires only one extra wire. Contact your local IEE engineering representative or write to IEE for information on remote applications.

Your inquiry will bring complete information on Bina-View plus the new “Readout Display Selector Guide” covering the entire IEE line of display devices.

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**SPECIFICATIONS**

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- **Size:** 6 7/8" x 6 7/8" x 6"
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- **3 1/2" Rack Mount Available**

**MINIATURE NOISE SOURCE**

The Allison 655 has characteristics and range similar to 650.

1" x 1 3/4" x 1 1/8", 2 1/2 oz.

$60.00 for single units, down to $36.00 in 100 lots.

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has been elected a vice-president of the corporation and a member of the Board of Directors. Mr. Pollack will continue to function as president of the Polaroid Electronic Instruments Div.

William Shockley (F '55) of Los Altos, Calif., inventor of the junction transistor, is the recipient of the Holley Medal, given by ASME for unique engineering genius. Dr. Shockley was cited “for outstanding discovery, invention and leadership in bringing the transistor into existence and into the service of humanity.”

Dr. Shockley was recently named the first Alexander M. Poniatoff Professor of Engineering Sciences at Stanford University. He is a consultant for Clevite Corp., Palo Alto, Calif.

G. L. Smith (SM '53) has been made assistant power pool manager, Southern Services, Inc., Birmingham, Ala. Mr. Smith joined the System Planning Section of Southern Services in 1947 and was transferred to the power pool in 1951. He is chairman of the Southeastern Electric Exchange Power Coordinating Committee.

R. O. Usry (SM '62) has been made power pool engineer, replacing Mr. Smith. He joined Southern Services in 1953 and is the Southeast Regional representative on the Interconnected Systems Group Test Committee.

R. A. Soderman (SM '46) has been appointed engineering manager of General Radio Co.'s new plant in Bolton, Mass., scheduled to open early in 1964. Mr. Soderman has been with General Radio since 1945, most recently as administrative engineer and leader of the Impedance Group.

John Szogyen-Delmar (M '59) has been appointed manager of manufacturing, Electro Dynamic Div. of General Dynamics Corp., Avenel, N.J. Mr. Szogyen joined Electro Dynamic in 1962 as chief electrical engineer and later was named assistant to the general sales manager.

B. R. Teare, Jr. (F '42), dean of engineering and science at the Carnegie Institute of Technology, is a member of a five-man committee named by the National Aeronautics and Space Administration to study possible locations for its proposed multimillion-dollar electronics research center.

Dr. Teare served as AIEE President (1962), District 2 Vice-President (1957-59), and Director-at-Large (1961-62).
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• Non-Polar series added to Dickson line offering 6 through 100V in standard sizes.

DICKSON TANTALUM CAPACITOR AVAILABILITY INDEX

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FOR COMPLETE TECHNICAL INFORMATION on Dickson Tantalum Capacitors, wire or write Dickson Electronics, P.O. Box 1387, Scottsdale, Arizona . . . or phone code 602, 947-5751.

DICKSON ELECTRONICS CORPORATION
310 Wells Fargo Avenue, Scottsdale, Ariz.
R. F. Tullius (M '54) has been named engineering supervisor for Continental Electronics Products Co., subsidiary of Long-Temco-Vought, Inc., Dallas, Tex. Mr. Tullius was with the General Electric Co. for 12 years, most of the time based in Dallas.

Howard Vollum (F '55), president of Tektronix Inc., Beaverton, Oreg., has been named to a four-year term on the board of trustees of the Western Electronic Education Fund.

Obituaries

E. S. Fields is deceased; past AIEE Vice-President

Ernest S. Fields (M '20, SM '26, F '29, Life Member) of the Cincinnati Gas & Electric Co., Cincinnati, Ohio, died recently. Mr. Fields was a Vice-President of AIEE for the term 1945-47.

Mr. Fields was born in Bracken County, Ky., on August 27, 1897. In 1918, he was employed by the Union Gas & Electric Co., Cincinnati, as maintenance electrician and operator. He subsequently became chief electrician and assistant engineer. After two years with the Columbia Engineering and Management Corp., Cincinnati, he returned to the Union Gas & Electric Co. in 1929 as manager.

Mr. Fields joined the staff of the Cincinnati Gas & Electric Co. as manager in 1936 and was made vice-president in 1943.

He was a charter member of the Cincinnati Section of AIEE when it was organized in 1920, secretary of the Section in 1924-25, and chairman in 1931.

A. H. Grimsley dies; retired from FPC in 1949

Andrew H. Grimsley (M '16, SM '21, F '49, Life Member), retired, of Shav-ville, Va., died recently. Mr. Grimsley was chief of the consolidation section, Federal Power Commission, Washington, D.C., at his retirement in 1949 after 15 years' service with that organization.

From 1908, he also held the positions of superintendent of the Kanawa Water & Light Dept., Charleston, W. Va.; vice-president and general manager, Virginia-Western Power Co., Clifton Forge, Va.; vice-president and general manager, Virginia Public Service Co., Charlottesville, and vice-president of the General Engineering & Management Co., New York City.

J. J. Wall, Jr. (M '50) has been elected vice-president in charge of sales for the Electric Machinery Manufacturing Co., Minneapolis, Minn. He was formerly general sales manager.

J. W. Yetter (SM '52) has been appointed chief electrical engineer of Stone & Webster Engineering Corp. in Boston. Mr. Yetter was formerly a senior engineer for General Electric Co. in the Electric Utility Engineering Operation, Schenectady.

David W. McLenegan of General Electric Co.


Mr. McLenegan was born in Milwaukee, Wis., June 30, 1900, and was graduated from the University of Wisconsin in 1921 with the B.S. degree in mechanical engineering.

After teaching for a year, he joined the General Electric Co. in Schenectady, N.Y., as a research assistant and, later, as an application engineer, Industrial Engineering Dept. When the Air Conditioning Dept. was formed in 1932, he joined it as assistant commercial engineer.

In 1948, he became manager of technical personnel and education for the Nucleonics Div., Richland, responsible for appraisal of all scientific and engineering personnel needs, selection, and recruitment; the development and conduct of graduate-level program of scientific and engineering education.

George D. O'Neill, 63, GT&E Labs. employee

George D. O'Neill (A '28, SM '46, F '49), manager and consultant on technical publications at General Telephone & Electronics Labs. Inc., Bay-
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side, N.Y., died November 13 at the age of 65.

He was a native of Montclair, N.J., and a graduate of the University of Michigan with a B.S. degree in chemistry.

In 1928, he joined the engineering staff of Sylvania Electric Products Inc. in Salem, Mass. His work there on electron tube design resulted in the development of the low voltage-drop rectifier tube and the indirectly heated power output tube.

Mr. O'Neill was transferred in 1942 to Sylvania's receiving tube plant in Emporium, Pa., where he served as engineering consultant on design and production of receiving, radar, cathode ray, and proximity fuze tubes.

In 1943, he was transferred to the Sylvania Research Labs. in Bayside which later became the GT&E Labs. He was the founder and editor of The Sylvania Technologist, a magazine concerning technical developments published by the laboratories. He later served as manager of technical publications.

Mr. O'Neill was the founder and first chairman of the IEEE Professional Group on Electron Devices.

Emmett D. Talbot

Emmett D. Talbot (M '09, SM '25, F '36, Life Member) of Rochester, N.Y., died recently.

During his career, Mr. Talbot was employed as a consulting telephone engineer in Rochester and as a staff member of The J. G. White Engineering Corp. of New York, in their Djarkarta, Indonesia, Dept. In Indonesia, he served as a communication consultant to the government's Telegraph and Telephone Dept.

Retired associate editor of Electrical Engineering dies

G. C. Baxter Rowe (SM '50), associate editor of Electrical Engineering until his retirement on March 1, 1962, died November 14 of a heart attack. He was 66 years old.

Following his retirement, Mr. Rowe was associated with R. C. Mayer Associates in New York City as an editorial consultant.

Mr. Rowe was a staff member of Electrical Engineering for 12 years. He was previously associate editor on Radio News, managing editor of Radio Engineering, and an editor for John F. Rider, publisher. He was also employed
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(g) are produced in ample supply by a large, modern, technically staffed plant

### DATA TABLE

| MAPICO PRODUCTS | COMPOSITION | PARTICLE SHAPE | PARTICLE SIZE (Micron) | Apparent Density | % Fe₂O₃ | % SiO₂ | % Al₂O₃ | % CaO | % MgO | % H₂O | % LOSS ON IGNITION | % WATERS OR AQUEOUS EXTRACT | % SO₂ | % SO₃ | % P₂O₅ | % PAN | % AL₂O₃ | % SiO₂ | % Fe₂O₃ | % Water | % H₂O
|------------------|-------------|----------------|------------------------|------------------|--------|-------|--------|------|------|------|-------------------|-----------------------------|-------|-------|-------|------|--------|--------|---------|---------|--------|--------
| Yellow Light Lemon 100 | ferric oxide hydrate | acicular | 0.4-0.8 | 22.4 | .14 | .35 | 98.8 | 99.2 | .30 | .50 | 11.5 | 12.0 | .04 | .05 | .02 | .04 | .004 | .002 | .01 | .01 |   
| EG-1 * | magnesium ferrite | acicular | 0.4-1.2 | 4.7 | .18 | .40 | 99.3 | 99.6 | .10 | .10 | 39.0 | 45.0 | .40 | .10 | .02 | .04 | .004 | .004 | .01 | .01 |   
| EG-2 ** | zinc ferrite | acicular | 0.4-1.2 | 3.5 | .27 | .59 | 99.7 | 99.9 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| EG-3 | gamma ferric oxide | cubical | 0.3-1.2 | 8.7 | .39 | .71 | 98.0 | 98.0 | .10 | .10 | 11.0 | 15.0 | .01 | .04 | .01 | .04 | .004 | .004 | .01 | .01 |   
| Red 110-2 | alpha ferric oxide | cubical | 0.3-1.1 | 5.4 | .33 | .67 | 99.5 | 99.7 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| EG-60 | alpha ferric oxide | cubical | 2.0-4.0 | 2.8 | .45 | 1.00 | 99.5 | 99.9 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red H.P. | alpha ferric oxide | cubical | 2.0-4.0 | 2.8 | .45 | 1.00 | 99.7 | 99.1 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| EG-80 | alpha ferric oxide | cubical | 3.8-5.9 | 1.3 | .85 | 1.74 | 99.4 | 99.7 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 297 | alpha ferric oxide | spheroidal | 0.3-0.8 | 8.4 | .30 | .59 | 99.5 | 99.6 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 347 | alpha ferric oxide | spheroidal | 0.3-0.9 | 7.4 | .32 | .61 | 99.5 | 99.7 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 387 | alpha ferric oxide | spheroidal | 0.3-1.1 | 6.5 | .33 | .69 | 99.5 | 99.7 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 477 | alpha ferric oxide | spheroidal | 0.4-2.0 | 5.9 | .36 | .74 | 99.5 | 99.8 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 657 | alpha ferric oxide | spheroidal | 0.4-2.6 | 4.9 | .37 | .74 | 99.5 | 99.8 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 617 | alpha ferric oxide | spheroidal | 0.4-3.7 | 3.9 | .39 | .74 | 99.5 | 99.8 | .10 | .10 | .15 | .20 | .02 | .04 | .01 | .04 | .002 | .002 | .01 | .01 |   
| Red 516-M | alpha ferric oxide | acicular | 0.3-1.0 | 26.4 | .14 | .32 | 97.0 | 98.3 | .10 | .10 | .10 | .10 | .02 | .02 | .01 | .01 | .004 | .004 | .001 | .01 |   
| Black† | synthetic magnetite | cubical | 0.2-0.8 | 6.7 | .34 | .71 | 99.7 | 99.2 | .20 | .20 | .30 | .30 | .02 | .04 | .02 | .04 | .002 | .002 | .001 | .01 |   

*Fe₂O₃ (as Fe₂O₃) 21-22% (U.S. Patent 2,502,130)
**ZnO (as ZnO, Fe₂O₃) 32.5-32.9% (U.S. Patent 2,904,393)
***As determined by nitrogen adsorption

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IEEE Spectrum January 1964

Mr. Rowe was a graduate of Union College, Schenectady, from which he received a B.S. degree in 1920.

During World War I, he served in the U.S. Naval Reserve. In World War II, he was editor of radar texts at Camp Murphy, Fla., U.S. Signal Corps. While there, he enlisted in the U.S. Coast Guard Auxiliary Reserve, and later transferred to Brooklyn, N.Y.

Bernhardt Skrotzki, associate editor of Power

Bernhardt G. A. Skrotzki (SM '45), associate editor of Power, a McGraw-Hill publication, died November 11 in St. Louis. He was 56 years old.

He had been in St. Louis attending a conference on energy transportation. He was found dead in his room at the Chase Hotel, apparently of natural causes.

Mr. Skrotzki was associated with Power since 1945. He was with Brooklyn Edison Co. and Consolidated Edison Co. for 22 years before joining Power.

He was the author of nine textbooks for advanced engineering students. His special areas were in gas and steam turbines and nuclear energy.

Mr. Skrotzki served as director of the AIEE Professional Development and Recognition Dept. (1960–62).

Death Notices

Harry A. Appleby (M ’25, SM ’40, Life Member), on October 14, signal engineer, Atchison, Topeka & Santa Fe Railway Co., Amarillo, Tex.

Philippe A. Arvisais (S ’60, M ’63), Ottawa, Ont., Canada, on September 30.

H. D. Baldwin (M ’23, SM ’29, Life Member) of Upper Darby, Pa., on February 25.

B. S. Barrell (A ’62) of Chicago, Ill.,

Richard J. Biagiotti (S ’52, A ’54, M ’60) of Millis, Mass.

George H. Bogart (M ’22, Life Member), of Jamaica, N.Y.

Lester H. Britton (SM ’40) of Basking Ridge, N.J.

IEEE spectrum JANUARY 1964
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Glenn H. Ciapp (M '51, SM '58) of Williamsville, N.Y.

Edward Carlson (M '26, SM '34, Life Member) of Lexington, Mass., on May 15.

Thornton A. Church (A '51) of Lindenhurst, N.Y., on October 7.

Leland Ediger (S '59, M '61) of St. Paul, Minn.

J. Finkel (M '59, SM '62) of Buffalo, N.Y., on August 10.

H. T. Hayden, Jr. (M '23, SM '30, Life Member) of New York City, on October 28.

Mrs. E. M. Heyer (A '54, M '60) of Mt. Holly, N.J.

Oswald N. Jones (M '36, SM '45) of Tryon, N.C., on October 17 at the age of 72. He was president and owner of the former Ambos Jones Co. until his retirement in 1960.

E. M. Kickler (A '47) of Charlotte, N.C., on October 1.


J. D. Lockwood, Jr. (M '42) of New Orleans, La.

Richard O. Luke (S '49, A '52, M '54) of Southampton, N.Y.

John Magee (M '15, SM '43) of Baltimore, Md.

Donald W. McMartin (M '52) of Islington, Ont., Canada, on September 30. He was associated with Silvercel Canada, Ltd., of Toronto, Ont.

R. F. Modnosky (S '54, M '60) of Mountain View, Calif.

William L. Muir (M '39) of Tulsa, Okla.


Antoni Reimann (M '53) of Cedar Grove, N.J., on September 27.

H. Skootsky (M '39) of Daly City, Calif., on September 2.

Walter E. Spurling (M '23, SM '30, Life Member) of Pembroke, Bermuda, on September 28.

Mrs. Doris M. Wills (M '62) of Havertown, Pa., on March 18.
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4. ESTABLISHED RELIABILITY  Inquire about special screening test methods developed for Titan and Polaris programs.

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75 years ago

**The Future.** "The work of the electrical engineer is in a field of constant expansion; much work has been done, far more remains to be done. It is difficult for those unacquainted with the nature of the problems presented in a field so new to realize to the full, the hard-fought battle with difficulties and against obstacles resulting in the victories thus far achieved. It has been required of the electrical engineer that he unite the qualities of the mechanician, the chemist, the physicist and general technologist, with those of patience and tenacity of purpose. He has been, as it were, a pioneer in a new country with rocks and fallen trees lying in his path. The materials of construction alone, with whose properties he must be acquainted, cover a vast range of available substances and manufactures. For confirmation of this, all that is required is to inspect the stock rooms of our largest electrical manufactories. Many materials before unknown to the trade have been demanded in the work. The field of operation is wide. Electric metallurgy, telegraphy, telephony, arc lighting, incandescent lighting, motive power transmission and electric railways, electric welding, soldering and metal working, electric tanning, besides a host of other operations in which electricity plays a chief part, now afford scope for the activities of the electric engineer. Who is to say where the growth and development will stop? Will we not light our houses by electricity, giving light without heat? Shall not the time come when we may burn our coal, produce electricity in efficient amount therefrom, and thus supplant steam engines for motive power, and dynamos for electrical work? Shall not the great water powers be turned to account to propel our railway trains, to do our metal work, to light our streets and buildings, to run our factories, and to effect our chemical operations such as bleaching, tanning, and others? Shall not we even store up power in substances possessing high chemical affinities, which power may be let out or recovered at any time hereafter for the uses to which electricity is now applied? Shall we even dare to hope that electrical communication on the Atlantic may be maintained with our friends and dear ones ashore? I believe that these things and more lie in the path which the electrical engineer of today has but begun to tread." (Elihu Thomson, Trans. AIEE, vol. VI, Nov. 1888–Nov. 1889, pp. 483–484.)

**Edison Chemical Meter.** "I can endorse the meter for two reasons. It is the friend of the poor man as well as the company for the following reasons: It gets action on the hungry-handed son of toil this way. Our contract price for lighting houses for five lights is $4.25 per month or $51.00 a year. Now there are lots of customers who cannot afford to pay that, but can afford to have five lights installed and use the meter, which will probably not average over $2.50 per month or $30.00 for the year. At the same time if they should contract for $4.25 per month, and then run till 12 o'clock for a month, they would consume $13.50 per month (if measured by the meter), but we would only get $4.25. If all did this our load would overrun our capacity, but thanks to the little box—he holds her down. It produces the same effect with business houses. Our contract price with this class is $1.50 per month (all my figures are based on 16-candle lamps). Houses having 25 lights would be $37.50 monthly; by meter we would realize $29.10 average for year, our lighting being 6 till 9. You see we get $29.10 for 3 hours light, while with contract they could burn till 12 for $37.50 or six hours light. The meter holds the load down for families when they use only one or two lights a night, but if contracted they would 'turn her loose, Murphy,' in order to play even. It is our experience that the people always manifest a desire to play even with a light company if possible, and if they can't get action one way they will another." (Trans. AIEE, vol. VI, Nov. 1888–Nov. 1889, p. 53.)

50 years ago

**Progress.** "What would have been said twenty years ago if a man had stated he could connect one end of a conductor to earth, hold the insulated end 800 feet in the air, put 100 K.W. in that conductor, and use that arrangement for telegraphing 4,000 miles?" (Robert H. Marriott, Proc. IRE, p. 93, Mar. 1914.)

**TREASURER'S REPORT**

Statement of Receipts and Disbursements
From February 6 To December 31, 1913

**Receipts**

Amount turned over by former Treasurer of Institute of Radio Engineers, February 6, 1913 .................... $150.97
Amount received from J. L. Hogan, Jr., account balance Society of Wireless Telegraph Engineers .................... 50.00
Dues .................... 476.75
Gift—Dr. A. N. Goldsmith .................... 50.00
Anonymous Gift through Dr. A. N. Goldsmith .................... 100.00
Sale of Proceedings .................... 23.21
$850.93

**Disbursements**

Printing Proceedings of Institute .................... $647.25
Swastika Office Equipment Co., for duplicating letters, addressing, etc. .................... 68.69
Postage, typewriting, stationery, etc. .................... 67.56
Fayerweather Hall—Janitorial service .................... 16.00
Coal & Iron National Bank, check book and charges for handling account .................... 7.00
Fees for incorporating Institute, exchange and miscellaneous charges .................... 20.00
$826.50
Cash on hand in bank .................... 24.43
$850.93

(1914 IRE Yearbook.)
Six 1.5-mc Mincom CM-100 Recorder/Reproducers form the backbone of an extremely complex tape copy station delivered to the Atlantic Missile Range. This station makes possible for the first time as many as five first-generation copies of prime data tapes in one operation. In addition to the six CM-100's, it also includes two 600-kc Mincom G-100's, two degaussers, and an advanced monitor alarm system policing forty-two 1.5-mc channels. The station is the result of Mincom's long experience with frequency responses of better than 1 mc—an outstanding reliability record since 1955.
In the production of precision gyros for aircraft guidance, the Water Welder is an extremely useful instrument. Because heat is localized, less solder is used, pins in headers are not burned, and glass observation windows are hermetically sealed without breakage. A bonus feature is that leaks can be repaired without even damaging the paint on a unit. Sperry Phoenix Company is one of the major gyro producers for whom Water Welder is doing an excellent job.

- Model "M" illustrated has a BTU output 500% greater than Model "S".
- Generates its own gas
- Fuses wires from .0005" diameter up to 3/16".
- Butt-welds sheet metal from a few thousands up to 16 gauge
- Anneals spot weld joints
- Flame polishes glass and acrylic
- Silver solders and brazes to precision
- Gives you any temp. up to 6000 F. thru hypo needle torch
- Plugs into any 110-120 Volt A.C. outlet
- You can dial the flame size you want with Model "M"

Write, wire or phone for the new Model "M" Price $625.

**HENES MANUFACTURING CO.**
4323 East Madison, Phoenix, Ariz.
**Trademark**

IN CANADA — CANADIAN CURTIS-WRIGHT, LTD., TORONTO, ONTARIO

---

**Printing Telegraph System.** "The method employed is direct throughout and the transmitting and recording parts are capable of such adjustment that the speed of operation is limited only by the speed of the line. The mode of operation is as follows:

"By means of a punch which is connected to a commercial typewriter a half-in. (.127-cm.) strip of paper is punched with a series of groupings of holes distinctively spaced in five rows, each row representing a letter. The punched strip of paper is then sent through the transmitter so that the holes pass under five wire brushes. Batteries of either polarity are thereby connected between the earth and either one of a pair of conductors. Batteries of different potential can also be used, and in one case that is done, making five different transmitting impulses. Fig. 1 shows the wiring connections, a representative piece of transmitting tape, the printing elements and a section of the record.

"At the receiver there are five elements which are separately controlled, except that No. 3, which needs only the normal current, also operates when the strong current needed to operate No. 5 is received.

"The printing is accomplished by subdividing the alphabet into four independent elements and a fifth which, whenever used, accompanies one of the others. These elements then make an autographic record, by means of a local battery, on a moving sensitized paper whenever they touch the surface. It is merely necessary to have them operated in the proper sequence and with the desired interval in order to obtain any letter or figure of the alphabet." (Carl Kinsley, "A High-Speed Printing Telegraph System," Trans. AIEE, vol. XXXIII, pt. II, 1914, pp. 1245-1246.)

**Interference.** "This is a subject which has been given but little attention, although the problem is a very important one. Nearby telephone and telegraph lines are sometimes made inoperative when any disturbance exists on the transmission line.

"A good part of the trouble of the telephone service is due to insufficient insulation. Some of the lines, before long-distance transmission was inaugurated, ran through and touched the branches of tree tops, which caused leakage in wet weather, and hence unbalanced the wires.

"With the troubles due to poor insulation overcome and the transmission line well balanced, no further trouble was encountered except at times of disturbance or interruption on the transmission line. With grounded systems this resulted in the burning out of telephone relays and blowing fuses on the telephone.

"A much more difficult matter to deal with is the making of the transmission company's own private telephone to operate at all times. Usually the telephone line is needed the most at times of trouble and this is just the time when it is out of service, having been put out of commission by the trouble itself.

"When providing protection for a recent telephone line paralleling a high-voltage system for a distance of some 300 miles (482.8 km.), it was found that there is no protective apparatus on the market capable of handling the large induced currents which are always present on such lines.

"Thus the apparatus had to be built, and was of a very substantial character. The basic principle which was worked upon was to make the line subject, in the first place, to as little trouble as possible by carefully insulating and balancing it with respect to the transmission line circuits. This meant that transpositions had to be placed at frequent intervals. Furthermore, no twigs or other objects were allowed to come into contact with the wire. The usual grounding coils, but designed specially for this purpose, were cut in at each station. By these means alone the line was rendered quiet, even though within 60 ft. (18.2 m.) of the high-voltage wires, and conversations could be carried on over a distance of 125 miles (201 km.) with greater satisfaction than over the paralleling commercial circuits. Much heavier fuses were used, for it was not permissible to have them blow out when the circuits were needed most. Discharge gaps were provided, some of these being in vacuum, which gave very good results. The other protection consisted of condensers and choke coils for absorbing the smaller disturbances which would make conversation more or less unsatis-
A few examples of the best U band oscillator capability in the industry

These families of Sperry tubes are representative of the most complete selection of U band klystron oscillators available anywhere.

Four tuning arrangements—fixed-tuned, gap-tuned, trim-tuned, and dielectric-tuned—enable the designer to select the U band klystron with the exact combination of operating characteristics required by his system.

Since Sperry's line of U band klystrons is already in the hardware stage, you get fast delivery and low prices. For complete information, contact your Cain & Co. Sales Engineer, or write Sperry, Gainesville, Florida. In Europe, contact Sperry Europe Continental, Paris.

<table>
<thead>
<tr>
<th>For High Power Output</th>
<th>For Extreme Mechanical Stability</th>
<th>For Low Voltage Operation</th>
<th>For Wide Tuning Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric-tuned Reflex Klystrons (SRU-4480 Series, in development)</td>
<td>Dielectric-tuned Reflex Klystrons (SRU-4480 Series, in development)</td>
<td>Dielectric-tuned Reflex Klystrons (SRU-4480 Series, in development)</td>
<td></td>
</tr>
</tbody>
</table>
PRECISE CONTROL OF TIMING STANDARDS

with VLFC-1
FREQUENCY STANDARD COMPARISON SYSTEM
OPERATING OVER THE 10 KC TO 30 KC VLF RANGE

- 10 channels for world wide coverage
- Instantaneous direct frequency comparison in parts in 10⁻⁴
- Corrected standard output frequencies in parts in 10⁻⁴
- Instantaneous "No-Break" battery supply
- Doppler correction for mobile use
- Complete coverage frequency synthesized in 1 cps steps

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MOST RUGGED DIODES: Even if glass is broken, characteristics of diode remain intact.

Prices: from $1.25 Delivery: from stock


Super-fast switching transistors now in the development stage.

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TELEPHONE: 201-432-7151

factory. It must not be understood, however, that any or all of these means can be guaranteed to produce a quiet working line, for each case must be studied by itself and methods adopted to meet the conditions." (Trans. AIEE, vol. XXXIII, pt. I, 1914, pp. 117-118.)

25 years ago

Basement Radio. "When the need for aeronautical ground radio stations arose in 1928, the greatest amount of radio voice-communication equipment in use was for broadcast purposes. There were some stations used for commercial telephony but, as far as can be determined, there were no extensive radiotelephone circuits in use at that time. It was not surprising then, that the equipment designed for the aeronautical station was patterned after broadcast equipment and differed only from such equipment in its somewhat narrower audio-frequency response band. After this first equipment had been in operation for some time, various problems of aeronautical communications, which had not been foreseen at the time of design, presented themselves, and these were dealt with by a certain amount of minor redesign. It is believed that the stage has now been reached where these problems may be reviewed and certain standards set down for the guidance of future builders or buyers of aeronautical ground-radio-station equipment. . . .

"Fig. 1 shows a map of the Chicago Municipal Airport. The problem here is typical of that encountered at all of the major airports in the United States. This map shows that 11 transmitters are located within an area of less than one-
Anything that can be drawn in line can be reproduced on glass or in metal. Sizes up to 20 feet have been produced to tolerances of ±0.015. Small quantities are practical at moderate cost because no dies are required.

**GLASS ETCHING DATA**

Calibrated dials, straight and cross line rulings, scales, special purpose reticles and prisms suggest a few of the items produced. Glass may be coated or lines filled permanently with a choice of compounds.

<table>
<thead>
<tr>
<th>DESIGN</th>
<th>GLASS TYPES</th>
<th>LINEAR &amp; ANGULAR TOLERANCES</th>
<th>LINE WIDTH TOLERANCES</th>
<th>FILLING MEDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Control Reticles</td>
<td>Polished Ordinental Plate</td>
<td>Up to 3&quot; ±.0005</td>
<td>±.0001</td>
<td>Titanium Dioxide</td>
</tr>
<tr>
<td>Test Fitted Reticles</td>
<td>Water White Plate</td>
<td>Up to 6&quot; ±.0005</td>
<td>±.0001</td>
<td>Ferric Oxide Black</td>
</tr>
<tr>
<td>Concave or Convex Reticles</td>
<td>Optical Crown</td>
<td>Up to 12&quot; ±.0005</td>
<td>±.0001</td>
<td>Ferric Oxide Red</td>
</tr>
<tr>
<td>Reticle for Guidance Systems</td>
<td>Boro-Silicate Crown</td>
<td>Up to 24&quot; ±.0005</td>
<td>±.0001</td>
<td>Ferric Oxide Yellow</td>
</tr>
<tr>
<td>Calibrated Dials</td>
<td>Pyrex</td>
<td>Angles 0° to 30°</td>
<td>±.010 to ±.0001</td>
<td>Conductive Metallic Silver</td>
</tr>
<tr>
<td>Light Copper Dies</td>
<td></td>
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</tr>
</tbody>
</table>

**METAL ETCHING DATA**

Etching does not change the molecular structure, leaves no burrs to remove. Round, square, oval or slotted holes may be etched. Patterns are etched through metal of these thicknesses: Copper to .030, nickel and alloys to .020, stainless steel to .025, molybdenum to .010. Surface etching on any thickness.

<table>
<thead>
<tr>
<th>DESIGN TYPES</th>
<th>METALS</th>
<th>DIMENSIONAL TOLERANCES</th>
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</thead>
<tbody>
<tr>
<td>Fire Control Reticles</td>
<td>Copper and Copper Alloys</td>
<td>Linear to 3&quot; ±.0002</td>
</tr>
<tr>
<td>Reticle for Optical Instruments</td>
<td>Nickel and Nickel Alloys</td>
<td>Linear to 12&quot; ±.0001</td>
</tr>
<tr>
<td>Scale</td>
<td>Cupro Nickel</td>
<td>Linear to 24&quot; ±.0003</td>
</tr>
<tr>
<td>Calibrated Dials</td>
<td>Spring Steel</td>
<td>Angular ±.0° to 30°</td>
</tr>
<tr>
<td>Reticle for Guidance Systems</td>
<td>Stainless Steel</td>
<td>Line Widths ±.0002</td>
</tr>
<tr>
<td>Micro Component Parts for Control Systems</td>
<td>Aluminum</td>
<td>Line Widths ±.0005</td>
</tr>
<tr>
<td>Curved Surface Etched Parts</td>
<td>Gold Plated Steel</td>
<td>Line Widths ±.010</td>
</tr>
<tr>
<td>Cylindrical Surface Etching</td>
<td>Molybdenum</td>
<td>Line Widths over .010 15% of Metal Thickness</td>
</tr>
<tr>
<td>Mechanical Parts Too Complicated for Die Stamping</td>
<td>Tungsten, Lead, Insuals</td>
<td></td>
</tr>
</tbody>
</table>

**ELECTROFORMED MESH LIST MAX. TRANS.**

Evaporation masks in miniature and subminiature sizes. Micro-mesh sieves and screens from 5 to 150 microns are standard. For all work a special ruling engine draws up to 2,000 lines per inch (straight or cross line, calibrated dials, scales and reticles), to linear and concentric circle accuracies of ±.000039.
half square mile. Omitting the airport transmitter which is on 278 Kilocycles and the army transmitter which operates only at irregular intervals, . . . there are stations near 5600 Kilocycles which have frequency separations of only 20 kilocycles, or 0.36 per cent. The minimum frequency separation in the broadcast band is 10 kilocycles, or 0.67 per cent, and the separation for broadcast stations in a common area somewhat equivalent to the close association of the stations at the airport is several times greater than 10 kilocycles.

"Another feature of this problem is that the maximum air-line distance between any two stations is only 3850 feet. Each station has a transmitter with an output of 400 watts and a receiver on which signals having a field strength of only 10 microvolts per meter are being received. When one remembers that early receivers consisted only of several tuned-radio-frequency stages, it can be seen that the conditions present make for very unsatisfactory radio operation.

"The method for obtaining aeronautical radio reception in common use today consists in finding an interference-free location in a suburb near the airport by a series of listening tests. The receiver (only) is moved to the garage or basement of some resident at this location. A line rented from the telephone company serves to bring the output of the receiver to the airport, where the radio operator and the transmitter are located. An audio-frequency tone put into the line at the airport and interrupted by means of a telephone dial serves to control the gain and frequency of the receiver. While these remotely located receivers are in general use, and will probably remain in use regardless of additional developments, there are factors which show that further developments are in order. Whenever a tube fails, a fuse blows, or the local power fails, it is necessary for a radio serviceman to leave the airport and travel several miles in order to examine the receiver and make the necessary repairs. During the time that the remote receiver is out of repair, radio watch is maintained by means of a local receiver, and, to be effective, the local receiver should be free of adjacent-channel interference. It often happens that the airport is an excellent receiving location were it not for the interference from the other air lines on the airport. These factors definitely call for effective local receivers."  


Technological Unemployment. "In recent years much discussion has centered around technological unemployment—the loss of work due to obsolescence of an industry or use of machines to replace workmen or increase their per capita production. Are machines the genii which spring from the Aladdin's lamp of science to supply every need and desire of man, or are they Frankenstein monsters which will destroy man who created them? Startling examples of both viewpoints can be given.

"If we look at industry as a whole, without inquiring into particular cases, we would conclude that technological unemployment is a myth, because statistics show no decrease in the fraction of our population gainfully employed during the last few generations in which machine production has become important. This is because technology has created so many new industries and has so greatly increased the market for many commodities by lowering the cost of production to make a price within reach of large masses of purchasers.

"In individual instances, however, technological unemployment may be a very serious social problem, as in a town whose mill has had to shut down, or in a craft which has been superseded by a new art. Here the fact that technological unemployment does not exist as measured by over-all statistics is of small comfort to the families whose wage earners have lost their jobs.

"I believe that two principles should guide us in these matters. Improved products and services should be made available to the public, and not forcibly estopped to protect any entrenched business or any group of workers who would be thrown out of jobs by the change, but with this proviso: The change should be made in a manner to afford generous protection to the workers affected by it. This is a definite job for management, in which efficiency should be tempered by humane considerations (an attitude which, I believe, makes for real efficiency in the long run). . . .

"In any case, I believe that the fundamental criterion for good management in this matter, as in every other, is that the predominant motive must not be quick profits, but best ultimate service to the public." (Karl T. Compton, "Technical Progress and Social Development," Electrical Engineering, vol. 59, Jan. 1939, pp. 12-13.)

Transatlantic TV. (It is reported that English, French and German television
**Designed for Application**

**INSTRUMENTATION OSCILLOSCOPE**

One Inch
Miniaturized basic packaged panel mounting Cathode Ray Oscilloscope for instrumentation use replacing "Painter Type" meters. Panel bezel matches 2" square meter. No. 90901 uses ICP1 tube. No. 90911 uses IEPI tube. Power supply No. 90202 available where application requires.

**FREE WALL CHART**

dielectric materials

Over 200 materials are displayed on this full color wall chart—24" x 36". Each material is located with respect to dielectric constant and dissipation factor. Many physical properties are given. Foams, solids—plastics, ceramics—low loss, high loss dielectrics—all are included. This valuable reference chart is yours. Write or use the Reader Service Card.

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Canton, Mass. • 604 W. 182nd St. Gardena, Calif.

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Breakdown Testers

Make faster, safer AC dielectric strength tests of electronic parts and components, small tools, appliances, motors, transformers, etc.


Visual Indicator Models

Have neon "breakdown" light for breakdown, corona or arcing indication . . . and separate neon "leakage" light for leakage indication. 5 models from 0-1500 to 0-10,000 volts output. Priced from $137.50 to $199.50. Model 411 shown.

Automatic "Squawker" Models

Provide audible and visual test indications. 4 models from 0-1500 to 0-6000 volts output. Priced from $255 to $290.

Get all facts . . . write for Bulletin 4-1.3

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Signals have been observed in the U.S.A. at Riverhead, L.I., N.Y., during the winter of 1937-1938."

The English transmitters located at Alexandra Palace, London, operated on 41.5 megacycles for the sound channel and 45 megacycles for the picture channel. The frequency of the French sound transmitter at the Eiffel Tower was 42 megacycles and the Berlin sound-transmitter frequency was 42.5 megacycles.

"A rhombic antenna 45 feet above ground and directed towards London was used at Riverhead for these measurements. Its length was 400 feet per side and it was arranged so that the dimensions of the major and minor diagonals could be readily changed. This was done so as to facilitate matching the antenna to the vertical arrival angle of the signal. The effective height of the antenna system was about 20 meters..."

"Fig. 1 shows the receiving equipment used. In the foreground is a television receiver with a small camera mounted over the oscilloscope. Only the video-frequency amplifier and Kinescope controls were used as it was thought desirable for these experiments to have available greater flexibility than the radio circuits of this set provided. Therefore, the receiver standing to the left of the one just described was designed by Bertram Trevor of this department. This set provided automatic or manual volume control, a minimum noise equivalent of about 30 microcycles, with a band width somewhat less than 5 megacycles, and two diode outputs, one giving a (positive) and one a (negative) image. On the bench is the signal generator and receiving equipment used for signal-strength measurements."

"Most of the observations took place between 9:45 A.M. and 11:30 A.M. E.S.T., as that appeared to correspond approximately to the afternoon schedules of all three countries..."

"These European television signals
NEW! BALLANTINE SENSITIVE DC VOLT/AMMETER

MODEL 365

Measures
1 µV to 1,000 V dc
0.001 µA to 1 A dc

EXTREMELY WIDE VOLTAGE AND CURRENT RANGE

UNMATCHED ACCURACY FOR ALL INDICATIONS

BUILT-IN CALIBRATION STANDARD

Price $650

DC voltages with the extremely wide voltage range of 1 µV to 1 kV and currents from 1 nA to 1 A can now be displayed on an analog indicator and measured with unmatched accuracy. The Ballantine Model 365 Sensitive DC Volt/Ammeter, with a single logarithmic scale and range selector, will measure voltages above 1 mV with a constant accuracy of 1% of indication. Currents above 0.1 µA are measured with an accuracy of 2% of indication.

The accuracy of the Model 365 is supported by a high order of stability gained by both ac and dc feedback techniques and conservative operation of all components. For further assurance of accuracy, a simple and reliable internal standard is available to check calibration accuracy and panel controls can correct the calibration, if necessary, in seconds.

Signal-ground isolation allows floating measurements to 500 volts above panel ground, and ac rejection is provided to reduce the effects of common-mode signals.

The new 365 is available in both portable and rack versions.

PARTIAL SPECIFICATIONS

Voltage .......................... 1 µV — 1 kV
Current ............................ 1 nA — 1 A

Accuracy .... 1% of indication above 1 mV
Impedance ............... 1 MΩ above 1 µV;
5 MΩ above 0.1 mV; 10 MΩ above 0.1 V

Impedance Between Signal and Panel Grounds: R > 100 MΩ, C = 0.1 µF, 500 V Peak Max
Usable as DC Amplifier: 100 db max gain, 0.1 to 1 V output for each decade input range

Write for brochures giving many more details

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IEEE spectrum JANUARY 1964
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**Resistivity 80 Ω/CM**
Temperature Coefficient of Resistance .00065
Tensile Strength 160,000 psi
LR Potentiometer Wire Brochure sent on request.
SIGMUND COHN Corp.
121 So. Columbus Avenue, Mount Vernon, N.Y.

ALL-SILICON SOLID STATE
FREQUENCY STANDARDS

<table>
<thead>
<tr>
<th>MODEL 2.5</th>
<th>MODEL 5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Output</td>
</tr>
<tr>
<td>1 volt to 50 ohm load at 3.5 Mc, 1 Mc and 100 Kc</td>
<td>1 volt to 50 ohm load at 5 Mc, 1 Mc and 100 Kc</td>
</tr>
<tr>
<td>Stability</td>
<td>Stability</td>
</tr>
<tr>
<td>1 x 10^{-10} or better over 24 hours</td>
<td>5 x 10^{-10} or better over 24 hours</td>
</tr>
<tr>
<td>over ambient temperature range -10 to +35</td>
<td>over ambient temperature range -10 to +35</td>
</tr>
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<td>degrees C</td>
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<td>for load variation ±20%</td>
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Front Panel Frequency Control
-linear, with range of 100 x 10^{-5} sensitivity of 5 x 10^{-11} per division

Standby power supply Model 5P (10 hours battery)
-for use with either unit. 4½"x4½"x11¾" for shelf, bulkhead or rack mounting

Other products by
SULZER include:
- Frequency dividers
- Frequency multipliers
- Frequency comparators
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have been reported heard on a number of occasions from as far west as Phoenix, Arizona. Clyde Criswell, located near Phoenix, has reported hearing all the aforementioned signals during the winters of 1936–1937 and 1937–1938. G. W. Kenrick at San Juan, Puerto Rico, reported hearing the French, German, and English voice channels several times during the past winter. On most of these occasions the signals were also heard at Riverhead.

"On one occasion the rhombic antenna used for these observations gave a very much weaker signal than a standard short-wave fishbone antenna directed towards London. Usually the rhombic antenna gave several times the signal strength observed on these fishbone antennas. This condition lasted from about 10:30 to 11:00 A.M. on February 15. This condition may have been due to the signal arriving over a path other than the great-circle path from London. A deviation of but a few degrees from this path would considerably reduce the voltage picked up by the rhombic antenna while it would have slight effect on the fishbone antennas as they were not designed for these frequencies. Criswell reported observing variations in horizontal arrival angle with his rotatable Reinarz beam antenna. He also reported usually obtaining a stronger signal from a south-easterly direction during times of weak signals from London. This same condition was observed at Riverhead during the winter of 1936–1937. In this connection it might be mentioned that an amateur at Peekskill, N.Y., operating on the 28-megacycle band was observed to have "around the world" echo. This occurred on December 12 at about 10:45 A.M., Eastern Standard Time. A few minutes later an amateur in Holland was heard calling the operator at Peekskill. At about the same time of the morning of February 17 "around the world" echo was heard on the second harmonic (37.8 megacycles) of a Rocky Point, L.I., N.Y. transmitter operating on 18.9 megacycles.

"Before closing, mention should be made of the results obtained with the Kinescope shown in Fig. I. On February 18 the English video-frequency channel became strong enough to synchronize the Kinescope sweep circuits and allow glimpses of the picture being transmitted. Usually these pictures consisted of numerous images superimposed one on another indicating two or more paths of propagation. The path conditions were continually changing and
AT ANY MOMENT, A MESSAGE WILL BE SENT

It may be in London or Paris, Hong Kong or Singapore, Bogota or Lima, or perhaps in Washington, D.C. It may be sent in Anchorage on the coldest day of the year, or in Cairo on the hottest day. But hot or cold, day or night, there's a good chance that the message will be sent on an E.S. Message Switching System. Why? Because industry, commerce and government around the world, realize the important advantages this communication system has to offer. The Norelco Electronic Storage Message Switching System gives you high speed telecommunications combined with lower message unit cost. It gives you simplicity of operation, error-free reliability and the flexibility which modern business demands. Your organization can save time and increase operating efficiency with this system. Therein lies its greatest value.

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how to measure in-phase, quadrature and angle while sweeping frequency to 100 kc

North Atlantic's latest addition to the PAV line of Phase Angle Voltmeters* enables you to make measurements while frequency is varying over half-decades without recalibration. The VM-301 Broadband Phase Angle Voltmeter* provides complete coverage from 10 cps to 100 kc, and incorporates plug-in filters to reduce the effects of harmonics in the range of 50 cps to 10 kc with only 16 sets of filters. Vibration analysis and servo analysis are only two of the many applications for this unit. Abridged specifications are listed below:

<table>
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<th>Specification</th>
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<tr>
<td>Voltage Range</td>
<td>1 mv to 300 volts full scale</td>
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<tr>
<td>Voltage Accuracy</td>
<td>2% full scale</td>
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<td>Phase Dial Range</td>
<td>0° to 90° with 0.1° resolution (plus 4 quadrants)</td>
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<tr>
<td>Phase Accuracy</td>
<td>0.25°</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>10 megohms, 30μµf for all ranges (signal and reference inputs)</td>
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<td>Reference Level Range</td>
<td>0.15 to 130 volts</td>
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<td>Harmonic Rejection</td>
<td>50 db</td>
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<tr>
<td>Nulling Sensitivity</td>
<td>less than 2 microvolts</td>
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<tr>
<td>Size</td>
<td>19&quot; x 7&quot; x 10&quot; deep</td>
</tr>
<tr>
<td>Price</td>
<td>$1990.00 plus $160.00 per set of filters</td>
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</table>

North Atlantic's sales representative in your area can tell you all about this unit as well as other Phase Angle Voltmeters* for both production test and ground support applications. Send for our data sheet today.

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Fig. 5. Photograph of television image received at Riverhead from London showing displacement due to multipath propagation occasionally a single picture would appear quite plainly and with good detail. Fig. 5 shows an attempt to photograph this multipath phenomenon. It shows the front view of a man's head and shoulders. As can be seen there are two images and computation shows that the horizontal displacement represents a time delay of about 3.5 microseconds which corresponds to a difference in total length of the two paths from London of something less than 3000 feet.” (D. R. Goddard, “Observations on Sky-Wave Transmission on Frequencies Above 40 Megacycles.” Proc. IRE, Jan. 1939.)

Control of Interference. “The system of friendly co-operation has been remarkably successful in the great majority of cases and the Department proposes to continue this system wherever it can be successfully applied. There are, however, the few cases where individuals and companies have refused to give the necessary co-operation to reduce interference. One example is that of a manufacturer of household appliances who paid a few cents each for capacitors for the suppression of interference and installed these capacitors in apparatus made for export to New Zealand. In order to save this small additional cost he omitted to put the interference suppressors in the apparatus intended for the Canadian market and, thus, hundreds of household devices which will cause interference to radio reception are being installed in our own country.

“Occasionally, a householder will tell the Department’s inspectors, ‘I know my vacuum cleaner causes interference but I turn my radio off when the vacuum cleaner is in use.’” (H. O. Merriman and F. G. Nixon, “Radio Interference—Investigation, Suppression, and Control.” Proc. IRE, Jan. 1939, p. 19.)

IEEE spectrum JANUARY 1964
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The Syntron Company has recently made available to the industry a complete line of Avalanche Silicon Power Rectifiers at prices equal to or less than those being currently charged for conventional units. Because this is a new and distinct generation of semiconductors and a major accomplishment in development and production, Syntron has registered these diodes under new JEDEC numbers.

Now you can order Syntron Avalanche Silicon Power Rectifiers by JEDEC Numbers.

<table>
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Data subject to change without notice. Prices f. o. b. factory.

HEWLETT PACKARD COMPANY

Greetings! With the birth of IEEE Spectrum comes the opportunity through this page, appropriately entitled "Spectral Lines," for the Editor to speak each month to the membership. It is the intent of the Editorial Board that our new journal provide as much personal contact as possible with the members, that it bring news of the organization and of the profession, and that it encourage education in the basic areas as well as in the results of recent research. Thus some of its "news" may actually be found in its editorial content rather than in its departments.

While limited in space, it is proposed that this page provide the Editor with an opportunity to also provide such personal contact. It is hoped that the topics discussed here will encompass a spectrum as broad as the IEEE technical interests, and as diverse as is the spectrum of membership functions. Your comments on matters discussed here will always be appreciated, and when appropriate may appear as letters in the "Correspondence" section.

Chicago and NEC. The National Electronics Conference, a yearly Chicago function since 1944, this year also included many activities and much program that might have been associated with the former AIEE Fall Meeting. Upon invitation the Board of Directors held its fourth meeting of the year at the NEC, and also met informally with the officers of NEC, attended a Chicago Section meeting, and heard Dean W. L. Everit address an NEC luncheon on problems in continued education.

The Board received reports from its Awards Board concerning those to be honored at events in the next year, discussed continuing problems arising from Section and Region merger, and heard from the IEEE Treasurer of the efforts to contain the expected and occurring first-year-of-merger deficit. Other items included a discussion of plans to acquire a new computer for processing of membership and financial data, accounting, and other data-processing functions. It is expected that the computer will be available to the other professional organizations housed in the United Engineering Center, as well as performing an indispensable service for our headquarters.

In general, the Regional Directors reported completion of merger at the Section level, and that those organizations were now functioning at high efficiency. Some concern was reported from the Student Branch area, where it was felt that in several Regions the merger activity had not advanced the program. Further action can be expected along this line, especially as several Regions develop more complete cooperation with their Regional Education Committees and other groups within the Region.

News of the formation of the Professional Technical Group on Power, and of the merger of several Professional Technical Groups and appropriate Technical Committees was greeted warmly. With the approval previously given to standards activities by the PTG's, it now seems to us that a PTG organization has all the opportunity formerly given to a Technical Committee, plus a closer association with an identified group of the membership, plus greater opportunity to serve that membership through directed programs and symposia, including exhibits, plus greater freedom in serving this membership through selective publication. We hope for continued study of the problems of duplication of effort existing in our organization, and for broad and impersonal thinking which will always emphasize the question "How best do we serve the needs of the membership?"

The Board also discussed the position of the Institute in intersociety relations, particularly with respect to member interests in professional, legal, and civic areas. Clearly, from this discussion, the Board believes that IEEE, because of its great diversity in interest and viewpoint, cannot accept responsibility for representing the opinions of individual members on such professional topics; it was suggested that when members desire such representation they consult other organizations.

The second day of the Board of Directors meeting at Chicago was reserved for further discussion of editorial policy. Looking to this, the Editorial Board had spent many hours on the preparation of a statement of editorial objectives, additive to the proposal adopted in June 1963, which led to the establishment of IEEE Spectrum. After considerable discussion in Committee of the Whole, the Board adopted a slightly modified version of the Editorial Board proposal. The statement defines the IEEE publication objectives as two-pronged—to provide for rapid dissemination of research results important to our field, and to furnish a means for furthering the education and technical abilities of our members. The Editorial Board will have coordinating powers over all of our publications, in order to ensure that basic policies are carried out, and to determine that appropriate standards are being maintained. It is hoped that a more detailed report of the genesis of our editorial policies can be presented in an early issue of this journal.

J. D. Ryder
The view from the starship bridge
and other observations

A theoretical journey into space
three light years from earth and back
brings into play several interesting
concepts, including optical Doppler
shift and aberration, relativity,
and time dilation

B. M. Oliver Hewlett-Packard Company
In alluding to the appearance of the sky as seen from a fast-moving spaceship, writers of science fiction (and scientific fact) often mention the reddening of stars astern and the bluing of those ahead. Occasionally tribute is paid to Lorenz and Fitzgerald and, as the ship approaches optic velocity, the universe is described as foreshortened in the direction of motion. The color changes are quite correct, but no one who had stood on the bridge of a fast starship would ever make the second statement. The changes in appearance are completely described by relativistic Doppler and by relativistic aberration, both first-order effects in \( v/c \), where \( v \) is the velocity of the ship relative to the source and \( c \) is the velocity of light.

Nonrelativistic Doppler is familiar to all of us in the form of the increased pitch of the approaching whistle or siren and the drop in pitch as it passes. Nonrelativistic aberration can be observed in a calm rain. If we stand still the drops appear to fall vertically, but if we run in any direction the drops appear to come from that direction. If we want them to fall straight down a tube we must tip the tube forward. So it is with photons and telescopes. In 1727, Bradley noticed that the stars as a group, particularly those near the normal to the ecliptic, execute an annual circular motion—the displacement of the star from its mean position being in the direction of the earth's orbital motion.

The exact expressions for optical Doppler shift and aberration can be computed from the theory of relativity. The Doppler shift is given by

\[
\nu = \frac{\sqrt{1-v^2/c^2}}{1-(v/c)\cos\theta}
\]  

(1)

and the aberration by

\[
\tan\theta = \frac{\sqrt{1-v^2/c^2}\sin\theta}{c \sin\theta + v\cos\theta}
\]  

(2)

where

\( \nu \) = observed frequency of light

\( \theta \) = apparent angle of source with respect to ship's velocity vector (heading)

and the subscript zero indicates the quantity as observed with \( v = 0 \).

For sources dead astern \( \theta = \pi \) and (1) gives

\[
\frac{\nu}{\nu_0} = \frac{1 + v/c}{\sqrt{1 - v/c}}
\]

while for those dead astern \( \theta = \pi \) and

\[
\frac{\nu}{\nu_0} = \frac{1 - v/c}{\sqrt{1 + v/c}}
\]

For sources (apparently) directly to the side, \( \theta = \pi/2 \) and

\[
\frac{\nu}{\nu_0} = \sqrt{1-v^2/c^2}
\]

This last expression is the so-called transverse Doppler effect and shows the retardation of moving clocks.

Turning to Eq. (2), we see that for \( v > 0, \theta < \theta_0 \) unless \( \theta_0 = 0, \pi \). All sources appear to be swept forward as shown in Fig. 1, except for any already directly ahead or directly astern. The universe appears to reddish and thin out to the stern and to become blue and denser astern. As \( v/c \to 1 \), the entire universe, save for the stern point, appears to concentrate in front of the ship.

Either by going through the algebra, or by noting that we may interchange \( \theta \) and \( \theta_0 \) provided we reverse the sign of \( v \), we may rewrite (2) as

\[
\tan\theta = \frac{\sqrt{1-v^2/c^2}\sin\theta}{\cos\theta - v/c}
\]

(3)

or (since, if \( \tan x = a/b \), \( \sin x = a/\sqrt{a^2 + b^2} \) as

\[
\sin\theta = \frac{\sqrt{1-v^2/c^2}}{\cos\theta - (v/c)}
\]

(4)

Finally, we can differentiate (3) to obtain

\[
\frac{d\theta}{d\theta_0} = \frac{1-v^2/c^2}{\sqrt{1-v^2/c^2}}
\]

(5)

Comparing (1), (4), and (5) we note that the right sides are identical—a fact of some significance, as we hope to show.

All sources that lie within the angular annulus of width \( d\theta_0 \) are shifted forward and lie within the annulus of width \( d\theta \), as shown in Fig. 2. Thus the size of objects in the \( \theta \) direction changes by the factor \( d\theta/d\theta_0 \). Since the circumference of the annulus changes by the factor \( \sin\theta \sin\theta_0 \), distances measured along the circumference change by the same factor. Small constellations will thus appear unchanged in shape. Finally, since \( \lambda = c/\nu_0 \) we may take (1) to be a measure of \( \lambda_0 \lambda \) or \( dr_0/dr \), so radial distances appear to change by the same factor. To sum up,

\[
\frac{dr}{dr_0} = \frac{\sin\theta \sin\theta_0}{\sin\theta_0 \sin\theta} \frac{1-(v/c)\cos\theta}{\sqrt{1-v^2/c^2}}
\]

where says that all apparent dimensions of small solid objects change by the same ratio, and thus their apparent shape is unchanged. By more elegant methods it has been shown that a sphere of any apparent size remains spherical.

We stress the word “apparent” because computation would show the radial and lateral dimensions to have changed differently; that is,

\[
\frac{r \sin \phi}{r_0 \sin \phi_0} = \frac{r \sin \theta \sin \phi_0}{r_0 \sin \theta_0 \sin \phi_0} = \left(\frac{dr}{dr_0}\right)^2
\]

(7)

When we are viewing stars, it is convenient to speak of densities. These vary inversely with size and hence the factors are given directly by (1), (4), or (5). The apparent linear density is the original density times \( f(\theta) \), where
that equal in the ration. Stars Fig. proportional in motion.

Fig. 2. Conformal mapping property of aberration. Stars lying between the cones \( \theta \) and \( \theta + d\theta \), with the ship at rest appear to lie between the cones \( \theta \) and \( \theta + d\theta \) when the ship is in motion. Circumference of annulus is proportional to \( \sin \theta \). Transformation is such that \( d\theta /d\theta_0 = \sin \theta /\sin \theta_0 \), so compression is equal in the \( \theta \) and \( \phi \) directions.

\[
T(\theta) = \frac{\sqrt{1 - v^2/c^2}}{1 - (v/c)\cos \theta}
\]

(8)

This is the equation of a prolate spheroid with one focus at the origin and the other lying on the axis \( \theta = 0 \). Figure 3 shows a plot of (8) for \( v/c = 0.6 \). Directly ahead the densities are doubled; directly to the rear they are halved.

To verify our interpretation of (1) as a measure of radial density let us consider a distance measurement made by a ship. Assume that a series of corner reflectors is distributed along a straight line in space at intervals of one light year and that a space ship is traveling along this line at a velocity \( 0.6c \). In coordinates fixed with respect to the reflectors, the trajectory of the ship, which moves three light years to the right in five years' time, is shown by the heavy line \( OMP \) in Fig. 4. Since the reflectors move in coordinate time but not coordinate space, their trajectories are vertical lines. Events on the line \( OMP \) are seen by the ship at the same place (the ship) but at different times, so the trajectory \( OMP \) is the ship's time axis. According to relativity theory the ship's clock runs at \( \sqrt{1 - (0.6)^2} \), or 0.8 the rate of the coordinate clocks, and therefore it records four years in five coordinate years, and the trajectory is so marked. Let us call the coordinate time \( t \) and ship's time \( t' \). At \( t = t' = 0 \), The ship is at \( O \) and sends out a light pulse, which propagates along the 45-degree dashed lines at one light year per year.

After \( t = 2 \) years (at \( S \)) the reflections from reflectors \( R_1 \) and \( R_2 \) return to the point of origin in the coordinate system. They are received simultaneously and the

Fig. 3. Effect of velocity on apparent density. If the sky were uniformly besprinkled with stars the apparent density with the ship at rest plots as a sphere; that is, the radius (proportional to density) is independent of direction. With the ship in motion this plot becomes a prolate spheroid with the ship at one focus, Angular and radial densities change by the same factor \( f(\theta) \), increasing ahead and decreasing astern.

Fig. 4 (right). Radar measurement of densities. Corner reflectors are strewn along a line at intervals of one light year. A ship moving along this line with \( v = 0.6c \) sends out a radar pulse at \( O \). The ship gets a return every year from those ahead, indicating a one-half light-year spacing; and every four years from those astern, indicating a two light-year spacing. These are the apparent densities predicted by \( f(\theta) \). Here and in Fig. 5 the items in color pertain to the ship's frame of reference, rather than the earth's.
operator there is gratified to learn that \( R_{1A} \) and \( R_A \) are each a light year away; or rather that they were at that time \( t = 1 \) when he assumes the reflection took place—as indeed it did, in his time.

After four years of ship's time the reflections from \( R_{1A} \) and \( R_A \) are received simultaneously by the ship. The ship's operator therefore concludes that \( R_{1A} \) and \( R_A \) were both two light years from him at \( M \), or the time \( t' = 2 \) when he assumes the reflections took place. In effect he measures distance parallel to the dashed line \( R_{1A}R_A \), which he calls four light years long. Events on any line parallel to \( R_{1A}R_A \) he calls simultaneous.

Notice that from the reflectors that were ahead of him at \( t' = 0 \), he receives an echo every year and he concludes that they are one-half light year apart. Also, since it takes four years per echo from those astern, he concludes that their spacing is two light years. His measurements, which show twice the density in front and one half the density behind (as compared with the coordinate observer), are in complete accord with (1) and (8).

A pulse emitted by the ship after two years of ship time is received by the coordinate observer after four years of coordinate time, as shown by the line \( MQ \). Similarly, a pulse emitted by the coordinate observer after two years of coordinate time is received after four years of ship time as shown by the line \( SP \). Thus both observers receive half frequency from the other as required by (1). This symmetry would not exist if we had assumed five years' ship time between \( O \) and \( P \) rather than four.

As long as we are on the subject we may as well discuss the clock paradox. This is not the fact that the twin who has taken the journey ends up the younger, though this seems strange to many people. Rather it is a logical impasse that arises in the following example. Two clocks, one in a spaceship, the other in an internal frame, are synchronized. The spaceship then makes its trip to a distant point and returns. It is then incorrectly argued that "since each sees the other's clock running slow while the relative motion exists (which, in the limit, is all the time), each clock will be ahead of the other when the ship returns"—clearly an impossibility. The student concludes that either he is out of his mind (which is distressing) or Einstein was (which is irreverent, but less distressing). In this way much skepticism of relativity develops. To see what really happens all we need to do is draw a diagram like Fig. 4 (a Minkowski diagram) for the entire trip. This we have done in Fig. 5.

The ship, at \( v = 0.6c \), takes five earth years to travel to a point three light years away and five more earth years to return. Each year, by their own clocks, earth and ship send each other a light pulse, as shown by the 45-degree dotted lines, so \( 2v_0 = 1 \) pulse per year. During the time either thinks the other is receding, the received frequency of pulses is \( 2v_0 = 2 \), as required by (1); and when either thinks the other is approaching, the received frequency is \( 2v_0 \), again as required by (1). But the ship realizes it is returning as soon as it accelerates at \( t' = 4 \) years. Earth, on the other hand, has to wait for a light signal to communicate this fact at \( t = 8 \) years. So the earth receives the lower frequency for a longer time, and gets fewer total pulses from the ship than the ship gets.
Fig. 5. How to keep from growing old. Less time elapses in the spaceship than on earth. So long as both earth and ship are unaccelerated and agree on each other's velocity, symmetry exists and each sees the other's clock running slow. Acceleration of ship at destination causes earth and ship to disagree on velocity for just long enough to eliminate any logical paradox. Any measurements made by the ship that include acceleration period will show the earth's clock to be racing ahead.
from the earth. Thus, even though symmetry exists while each thinks the other has the same velocity, earth and ship disagree on the relative velocity long enough to eliminate any paradox.

To estimate the other's clock rate, correction must be made for propagation times. Thus the earth can consider the pulse received at \( t = 4 \) years to be a radar return of the one sent at \( t = 1 \). Reasoning that the light took the same time to go and return, the earth concludes that the reflection (or the transmission) from the ship took place at \( t_2 = (1 + 4) \cdot 2 = 2.5 \) years. But, being the second one received, the pulse must have been sent at \( t' = 2 \) years. Earth thus concludes the ship's clock is running at

\[
\frac{t'}{t} = \frac{2}{2.5} = 0.8 = \sqrt{1 - \frac{v^2}{c^2}}
\]

times earth rate. In the same way the times \( t_1 \ldots t_{10} \) may be determined and all show the ship's clock to be running at the same slow rate; that is, \( dt'/dt = 0.8 \). Note that simultaneous events in the earth's frame always lie on horizontal lines.

In exactly the same way the ship regards the signal received at \( t' = 4 \) to be a radar return of the one sent by the ship at \( t' = 1 \) and concludes it was reflected (or sent by earth) at \( t' = 2.5 \). Again it is the second pulse received, so it was sent at \( t = 2 \) years. Thus up to this point the ship also sees the earth's clock running at 0.8 ship's rate. The situation is symmetrical, as required by special relativity, because up to this point both frames have been inertial—that is, unaccelerated. As soon as the ship accelerates (at \( t' = 4 \)), interpreting each received signal as a radar return and splitting the time between ship's transmission and reception to find the time of earth reflection yield the times \( t'_1 \ldots t'_6 \). During this period, in retrospect, the earth's clock appears to have been running at twice ship rate. Finally from \( t'_6 \) to \( t'_w \), with the acceleration period excluded once more, the earth's clock (now ahead) appears to revert to 0.8 of ship rate. Thus the average rate is

\[
0.8 \times 2 \text{ years} + 2 \times 3 \text{ years} + 0.8 \times 2.5 \text{ years} = 1.25
\]

or the reciprocal of the ship clock rate as determined by earth. Note that simultaneous events in the ship's frame lie on sloping lines. The two clocks do not agree upon the ship's return, but this is no logical paradox. It is plain time dilation and is as real as (and no more mysterious than) \( E = mc^2 \), which most people believe today.

Using the Mossbauer effect, one can detect the time dilation produced by modest velocities and gravitational potentials. Cobalt-57 decays to excited-state iron-57. The excited \( ^{57}\text{Fe}^0 \) then emits a photon (a 14.4-kv gamma ray) that can be absorbed and reradiated by other \( ^{57}\text{Fe} \).

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Fig. 6. Doppler detection using Mossbauer effect. Radioactive source A emits very monochromatic radiation. By absorption and re-emission highly resonant absorber B scatters radiation in all directions, thus shading detector C. The slightest frequency shift prevents scattering and increases the output of the detector.
nuclei. Thus the intensity at the detector in Fig. 6 is reduced by the absorber, which scatters the incident radiation in all directions. However, the radiation of the Fe source is extremely monochromatic and the absorber is extremely frequency selective; in fact the \( Q \) is about \( 1.6 \times 10^{12} \). This is like having an X-band receiver with a bandwidth of about 1000 MHz. As a result the absorption is extremely sensitive to frequency shifts. The Doppler shift caused by a radial velocity \( v_r \) of only one foot per hour will cause a significant decrease in scattering and so increase the detector flux. Likewise, a transverse velocity \( v_t \) of 400 feet per second produces a detectable relativistic transverse Doppler shift. The frequency emitted by the moving atoms drops. This frequency drop also occurs as the result of rms thermal velocity of the nuclei if the source is heated with respect to the absorber.

With a receiver 74 feet below the source, Pound and Rebka were able to measure the blue shift of the falling photons. Thus the atomic clocks at a higher gravitational potential appear to run fast.

All such measurements have been in agreement with the theory of relativity, which says that

\[
\frac{d\tau}{dt} = \left( 1 + \frac{2\chi}{c^2} - \frac{\chi^2}{c^4} \right)^{1/2}
\]

where \( d\tau \) is the increment of time measured by a clock at a gravitational potential \( \chi \) and moving at a velocity \( v \) with respect to the coordinate clock, which measures \( dt \).

As the moving, elevated clock describes its trajectory, the total time dilation is

\[
\Delta t = \int dt - \int d\tau = \int \left[ 1 - \left( 1 + \frac{2\chi}{c^2} - \frac{\chi^2}{c^4} \right)^{1/2} \right] dt
\]

For ordinary potentials and velocities such that

\[
\frac{2\chi}{c^2} \quad \text{and} \quad \frac{\chi^2}{c^4} \ll 1
\]

\[
\Delta t = \frac{1}{c^2} \int \left( \frac{\chi^2}{2 - \chi} \right) dt = \frac{1}{mc^2} \int (T - V) dt
\]

where

\( T = \frac{1}{2} mv^2 \) = kinetic energy of body
\( V = mc^2 \) = potential energy of body

The time dilation for a free body executing a trajectory at nonrelativistic speeds and potentials is the integral of the Lagrangian \( L = T - V \), divided by the rest energy, \( mc^2 \). In other words, the difference in clock rates is proportional to the excess of kinetic energy over potential energy.

Hamilton's principle of least action states that if a free body the path is such that \( J^L dt \) is least (or takes an extreme value). From the foregoing we see that this is the same as requiring that the time dilation be least (or stationary), and represents the nonrelativistic approximation of the principle that, for a geodesic, \( J^L dt \) is an extremum.

We normally think of electrons as indivisible particles. Just as Young's experiment in optics established the wave nature of light, electron diffraction (Fig. 7) forces us to assign wave properties to matter. Some years ago Feynman showed that, at least in the nonrelativistic case, the diffraction and interference of particles (for example, electrons) was consistent with the concept that all possible trajectories contributed equally to each arrival. To each possible trajectory is assigned a (complex) probability amplitude with a phase \( \theta = (2\pi/h) J^L dt \). For each of the possible end points all probability amplitudes are added to give a complex number whose magnitude squared is the probability of detecting an arrival at that point. If a large number of paths contribute in nearly the same phase, the probability will be large. If the phases cause the amplitudes to cancel, the probability of arrival is zero.

From the foregoing we see that \( \theta \) is the phase shift \( 2\pi/\Delta t \) that would occur in an oscillator of the Compton frequency \( f = mc^2/h \) as a result of the time difference

\[
\Delta t = \frac{1}{mc^2} \int L \, dt
\]

Is time dilation, then, an intrinsic ingredient of all motion, determining it as much as being determined by it? Or have our fancies led us astray?

Perhaps it is time to turn our gaze back to the stars. They seem to be in their proper places once more, for we have come to the end of our flight. Does anyone feel younger?

REFERENCES

High-power solid-state devices

Advances in process technology are giving rise to the appearance on the market of an increasingly large number and variety of economical high-power semiconductor devices

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In any "state of the art" discussion, particularly when the field is as broad as that of solid-state devices, it is important at the outset to define the basic area to be covered. For the purpose of this article, solid-state devices will be restricted to those utilizing p-n junctions in single-crystal semiconductor material. From the standpoint of practical usefulness and availability, we are then further restricted to the consideration of silicon and germanium p-n junction devices, limiting our discussion to those capable of handling a high power. Other high-power solid-state devices—many of them utilizing a semiconductor material—include resistors, capacitors, transformers, thermoelectric generators, barrier-layer rectifiers, crystal lasers, piezoelectric and magnetostrictive transducers, photoresistors, positive thermal coefficient thermistors, and varistors.

What differentiates a high-power from a low-power device has not been universally established. Moreover, a power that is considered high at microwave frequencies may be relatively low in the audio range. In addition, the mode of operation, such as amplification (in various classes) or switching, makes a big difference in how much power the device handles. We shall use as an approximate definition of high-power devices those capable of dissipating more than one watt, and exhibiting useful characteristics under this condition.

High-power semiconductor p-n junction devices are large (active dimension generally in the range 0.05 to 1 inch) compared to signal devices (0.001 to 0.05 inch). Hence, they are still much more difficult to manufacture free from catastrophic defects than are low-power components. However, advances in process technology (including, for example, epitaxy, diffusion, crystal growing, alloying), along with a continually improving understanding of the physics of device operation and failure, are giving rise to the appearance on the market of an increasingly large number and variety of economical high-power semiconductor devices. The future should witness a continuation of this trend, so that five years from now most of the high-power semiconductor p-n junction devices on the market will be made of silicon, of the types described in this article, but extending to higher power ranges. A large number of germanium power alloy transistors will probably still be used, and perhaps power varactors using gallium arsenide will appear.

Basic power considerations

The power level to which a device can be driven depends upon operational, reliability, and thermal limitations. Operational limitations refer either to those that physically prevent the voltage or current level from ex-
ceeding a certain value, or reduce the efficiency of operation to a useless value even though higher voltages or currents could be achieved. Operational limitations are discussed separately for the case of each device.

Reliability limitations refer to changes that high temperature, voltage, and current (in various combinations) can cause in the characteristics of devices after long periods of application. The failure rate generally increases at higher powers, and can be a factor that limits the operating power level of a device for ultrareliable applications. Failures of this type are surface induced, and are the subject of intensive research at present. As reliability is increased, even better results will be obtainable at lower power levels. For most applications, the major power limitations are operational and thermal, so reliability limitations need not be discussed here further. It should be noted, however, that hermetically sealed packages are necessary for the present high level of reliability that is obtained (failure rates of \( \approx 0.001 \) per cent per 1000 hours under operating conditions).

Thermal limitations are those that prevent operation of the device at a higher power level in a specified heat flow configuration, even though it could operate efficiently at higher power in a more efficient thermal environment. The more important thermal limitations common to all semiconductor devices are discussed in this section.

The \( V-I \) characteristics of a p-n junction are shown in idealized form in Fig. 1. In the forward direction (p-type region positive) the current increases in an exponential manner with voltage. On a linear scale, this closely resembles a region of very low resistance offset by a voltage \( V_f \) (about 1 volt for silicon, 0.5 volt for germanium) from the current axis. In the reverse direction, a very-high-resistance region limits current \( I_L \) to the approximate ranges of 1 nanoampere to 1 microampere for silicon and 1 microampere to 1 milliampere for germanium. This high-resistance region is abruptly terminated in a very-low-resistance region beginning at the avalanche breakdown voltage \( V_{br} \).

Thermal limitations on the power level to which a p-n junction device may be operated are almost always caused by the extreme temperature sensitivity of the reverse leakage current \( I_L \).

To a first approximation

\[
I_L \propto e^{-qV_0/kT} \tag{1}
\]

where

\( V_0 = \) semiconductor band gap, about 1.1 volts for silicon and 0.7 volt for germanium at room temperature

\( T = \) temperature in °K

\( kT/q \approx 26 \text{ mV} \text{ at } 27^\circ \text{C (300°K)} \)

The rate of change of \( I_L \) with temperature

\[
\frac{dI_L}{dT} \approx \frac{qV_0}{kT^2} I_L \tag{2}
\]

An approximation sufficiently accurate for many calculations over the normal range of operation of most silicon and germanium p-n junction devices (−50 to +150°C) is

\[
\frac{dI_L}{dT} \approx 0.1 I_L \tag{3}
\]

This approximates an increase in \( I_L \) by a factor of two for each 10°C rise in temperature and by a factor of ten for each 50°C temperature rise. If \( I_L \) is increased because of surface (or other) defects, its rate of increase with temperature can be less than the rate that is given by (3). At some elevated temperature, however, the faster rising term given by relation (3) will emerge as dominant.

In the forward bias direction, over an appreciable current range, \( V_f \) decreases about 1 mV for each 1°C temperature increase.

Figure 2 illustrates schematically a practical high-power-device mounting scheme. The pellet (silicon for this example) contains one or more p-n junctions, the temperature at a given junction being designated \( T_J \). The device is bonded to the bottom of its case, only one section of which is shown in Fig. 2. The case temperature is \( T_C \). In use, the case (package) is mounted on a heat sink, a portion of which is shown in Fig. 2. \( T_C \) is the heat sink temperature.

Heat is generated at the p-n junction, and is dissipated through the pellet and case to the heat sink. For linear heat conduction

\[
\frac{dQ}{dt} = \frac{KA}{L} \Delta T \tag{4}
\]

where

\( Q = \) quantity of heat (energy)

\( K = \) thermal conductivity

\( A/L = \) area-to-length ratio of specimen through which heat is flowing

\( \Delta T = \) temperature difference

By analogy to electric-current flow,

\[
\frac{dq}{dt} = I = \frac{\sigma A}{L} \Delta V \tag{5}
\]

where

\( \sigma = \) electrical conductivity

\( \Delta V = \) potential difference

\( q = \) electronic charge
and also $R = \text{resistance} = \frac{L}{\sigma A}$. We can define a thermal resistance

$$\theta = \frac{L}{KA} \quad (6)$$

and

$$\frac{dQ}{dt} = \frac{\Delta T}{\theta} \quad (7)$$

Practical units for $\theta$ are °C per watt. An important difference between the thermal and electrical situations is that, since $Q$ represents an energy, $dQ/dt$ is a power, and can be equated to an electric power. For the case of a p-n junction under steady-state bias

$$V/I_j = \frac{\Delta T}{\theta} \quad (8)$$

There are various thermal resistances that are specified. For example, from junction to case

$$V_jI_j = \frac{T_j - T_c}{\theta_{jc}} \quad (9)$$

From junction to heat sink

$$V_jI_j = \frac{T_j - T_s}{\theta_{js}} \quad (10)$$

From the nature of Eq. (4)—and perhaps more simply by analogy to electric circuits—thermal resistances in series can be added. For example,

$$\theta_{js} = \theta_{jc} + \theta_{is} \quad (11)$$

This is really an approximation because the regions (Fig. 2) are not isothermal, and heat flow is not linear. Separate thermal resistances can be calculated for each region from a knowledge of $K$ for that material and the heat generation pattern of the junctions. The latter is often difficult to ascertain. Interfaces between regions may also add significant thermal resistances, and so must be taken into account in an equation like (11). A thin layer of silicone grease is often inserted between the case and heat sink before they are bolted together to improve conduction between the metal surfaces, which are not perfectly flat. Heat is transferred from the heat sink to an ambient by convection (free air) or by conduction to a stream of forced air or water. The latter technique employs water flowing through a tube brazed to the heat sink.

Electrical isolation of system parts is often necessary and the use of isolated heat sinks is generally impossible. Instead, a separate layer is provided between the case and heat sink during mounting, between two metal parts.
of the case, or between the pellet and the case. A thin piece of mica (and silicone grease) is generally used between the case and heat sink, adding a thermal resistance in the range 0.2 to 0.5°C per watt. The other isolation schemes use thin metallized ceramic disks, generally of aluminum oxide. Recently beryllium oxide ceramics, which have much higher $K$ values than aluminum oxide, have become available. Thermal resistances added by the ceramics are higher than that of mica because they are thicker; and, since heat flows in a spreading fashion from junction to heat sink, they have effectively smaller areas. For example, an alumina disk 0.1 inch in diameter and 0.02 inch thick has $\theta = 10^\circ$C per watt from top to bottom (assuming uniform heat flow). Beryllia would have $\theta \approx 1^\circ$C per watt, about twice the value of an equivalent piece of copper.

To illustrate thermal limitations in a simple manner, consider a p-n junction rectifier to be biased into the avalanche breakdown region, as shown by the points in Fig. 3 (axes shifted from Fig. 1). Power generated is then simply $V_n I_n$. Power dissipated is $(T_j - T_e)/\theta_{jn}$, and equals the power generated for steady-state conditions. Three operating points—$P_n$, $P'_n$, and $P'_e$—are shown in Fig. 3. Shown dotted are the junction leakage currents, larger for the higher power conditions due to junction temperature rise. $P_n'$, $P'_n$, and $P'_e$ are the values of power generated at the three operating points as the result of leakage current flow. Figure 4 represents these effects graphically.

The straight line plots total power $P = T_j/T_e = V_n I_n$. The exponentially increasing line represents uncontrolled power, $V_n I_n$, a power that cannot be utilized. The difference between the two curves is controlled (useful) power. At $P_e$, the total power is uncontrolled. For the given $\theta_{jn}$, points beyond $P_e$ (Fig. 3) are not attainable because if we were to attempt to increase $I_n$ the consequent temperature rise would increase $I_n$ to a still higher value. This is called thermal runaway, which, if not safely limited, results in catastrophic burnout of the device. A stable power limitation point is $P_b$, where (Fig. 4) the rates of increase of the total ($P_n$) and uncontrolled ($P_n'$) powers with temperature are the same. Below $T_b$, an increase in power dissipation within the device will result in a greater increase in heat flow to the heat sink than in uncontrolled power. By differentiating (10) with respect to $T_j$, assuming $T_i$ constant,

$$V_n \frac{d I_n}{d T_j} = \frac{1}{\theta_{jn}}$$

(12)

From Eq. (3),

$$0.1 V_n I_n \approx \frac{1}{\theta_{jn}}$$

(15)

Hence, for absolute stability,

$$V_n I_n < \frac{10}{\theta_{jn}}$$

(14)

Although (14) was obtained for a simple case (Fig. 3), it applies to any operating mode of a device, where $I_n$ is a leakage current.

Semiconductor p-n junction devices operate well at high power densities, and can fail so quickly as the result of thermal (or other) runaway that they are difficult to protect. Structures designed specifically for high-frequency operation are forced to operate at high power densities to minimize parasitic electrical effects. Hence, lowering thermal resistance is a major design consideration. Figure 5 illustrates the basic problem for a device with small junction area (approximated by a conductive hemisphere of diameter $d$). The spreading thermal resistance (from $d$ to infinity) is $\theta_{es} = 1/\pi K d$. The thermal resistance from $d$ to $D$, with $D = 2d$, is $\theta_{es} = 1/2 \pi K d$, or

Fig. 7. Schematic illustration of distribution of p-n junction structure, giving lower value of $\theta$

Fig. 8. Schematic illustration of large-area p-n junction device designed for operation at high currents

Fig. 9. Schematic illustration of two devices connected in parallel in one package

Fig. 10. Schematic illustration of two separately packaged devices connected in parallel on a heat-sink member, thus forming a new, large package
Fig. 7

Fig. 8

Fig. 9

Fig. 10
half the value of θ₂. To a first approximation for small geometries, θ₂ may be taken as the sum of θ₂ and θ from 
D = 2d to the case; see Fig. 6. For heat flow from an 
area of width D and unit length to one of width D + S

\[
\theta = \frac{L}{KS} \ln \left( 1 + \frac{S}{D} \right) \tag{15}
\]

\[
\theta_{2=0} = \frac{L}{KD} \tag{16}
\]

\[
\frac{\theta_{2=0}}{\theta_{2=10d}} = 4 \tag{17}
\]

Hence, lateral spread of heat flow is important in lowering θ. Figure 7 depicts schematically a device in 
which the junction geometry is split into two equal 
parallel parts for better electrical performance or lower 
thermal resistance. To take full advantage of heat-flow 
spending, the two sections are not brought closer 
together than approximately the thickness of the pellet.

For operation at very high currents, devices having 
large areas are required, as shown schematically in 
Fig. 8. Since the largest crystals of silicon or germanium 
that can be grown conveniently are about 1.5 inches in 
diameter, a device that requires a larger size than this 
must be built in several parallel-connected parts. Also, 
from a practical standpoint, it is more difficult to make 
large-area p-n junction structures at a high yield than 
small ones, because of crystal defects and process 
limitations. Another limitation on the size of a single 
structure that may be built is thermal expansion coefficient 
mismatch between the silicon and its large-area metal 
contacts. If a hard solder connection is used, the silicon 

pellet may be strained, or may shatter upon cooling down 
from the bonding temperature. If a soft solder con-
nection is used, the solder may rupture upon repeated 
temperature cycling (thermal fatigue). To solve these 
problems, smaller devices can be connected in parallel 
in a package (Fig. 9), or perhaps connected in parallel on 
a heat-sinking member and then perhaps repackaged for 
mounting on a larger heat sink (Fig. 10). These multiple-
device arrangements permit selection and matching of 
units before interconnection.

**Power rectifiers**

Solid-state power rectifiers are single p-n junction 
devices, made according to either of the geometries 
illustrated in Fig. 11, where p⁺ and n⁺ are very-low-
resistivity p-type and n-type regions, respectively. The 

power rating of a rectifier is increased by increasing its 
reverse avalanche breakdown voltage and current-
handling capacity, consistent with packaging to provide 
adequate thermal dissipation. The reverse breakdown 
voltage of a single silicon cell is limited to about 2 kV 
for practical reasons, and most rectifiers have absolute 
maximum peak reverse voltage ratings of under 1 kV. 
As cell size increases, so do the difficulties in producing 
cells that are free from defects, and hence, the voltage 
rating decreases. Reverse voltage can be increased by 
stacking two or more silicon pellets on top of one another; 
see Fig. 12. This method is not in common use, however, 
because the forward voltage drop is doubled and, even 

worse, the thermal resistance of the top cell is increased 
by a large factor. High-voltage cells generally have their 

p-n junctions covered with silicon varnish, and may be 
packaged with a gas under pressure, to prevent arcing 
across the p-n junction in the package.

If a reverse line transient drives a rectifier into its 
reverse avalanche breakdown region, the device should 
recover provided the average power is not sufficient to 
produce thermal runaway. It can happen, however, that 
reverse avalanche breakdown occurs first in a localized 
region, generally at the surface. Appreciable current (at 
high voltage) flowing through such a localized region can 
result in a local thermal runaway, which destroys this 
part of the cell and, as a consequence, generally makes its 

overall characteristic unusable. Hence, the cell must be 
protected from receiving reverse transient pulses by 
various means. To prevent surface breakdown from 
occuring before bulk breakdown, various schemes for 

lowering the surface electric field are being used. Figure 
13 illustrates one of these schemes—that of shaping the 

pellet surface. By this technique, 1000-volt rectifiers have 
been made that can be pulse nondestructively to 100 
amperes in the reverse avalanche region, giving a peak 

power of 100 kW.

In the forward direction, single-junction rectifiers are 
rated to average currents of about 500 amperes, with 
peak surge current ratings (1/120 second) of twenty times 
this value. Pulsed operation takes advantage of the 

extremely high instantaneous thermal gradient (and 
hence, large heat flow) produced by fast heating of a 
junction in contact with the relatively cool body of the 
adjacent semiconductor. Junction defects are not so 
important under forward bias, because they generally 
result in regions of low current density and, hence, low 

power. Adjacent normal areas heat the defect areas by 
conduction through the silicon, making them more
efficient, thus tending to make current flow more uniform. The forward current carried by a p-n junction cell of a given size is limited by the increase in forward voltage drop that takes place at high currents due to its very small, but finite, series resistance. This additional voltage drop reduces circuit efficiency and increases power generation. Germanium rectifiers are used primarily in a few selective applications that take advantage of their very low (<0.5 volt) forward drop. For example, in electrochemical refining, where enormous currents are used, the high forward efficiency results in a considerable savings in power.

Until \( T_j \) becomes appreciable, almost all the power generated in a rectifier is under forward bias. Hence, forward current must be derated at elevated case temperatures. As shown in Fig. 14, for a 35-ampere stud-mounted rectifier having \( \theta_{jc} \approx 1^\circ C \) per watt, no derating is necessary until a case temperature of 150\(^\circ\)C is reached. Although most rectifiers operate at line-power frequencies, some have been designed for higher-frequency use and fast switching. For example, 30-ampere rectifiers are available that have 99 percent rectification efficiencies to beyond 150 kc/s and recovery times, from forward operation to a high reverse resistance, of less than 0.2 \( \mu s \).

Very-high-current rectifiers are being made by the paralleling concept illustrated in Fig. 10. Individual cells are selected for forward match to within 1 per cent before assembly, and are aided to some extent in uniform current distribution by thermal flow from the heat sink to cooler-running (higher forward voltage) cells. A further advantage of this type of construction (rather than a single, hermetically sealed package) for very-high-current rectifiers is that a very large, current-carrying hermetically sealed member is not required. A seal that is large in area and that will withstand stresses caused by thermal cycling is extremely difficult to make.

Fig. 16. Power-temperature derating curve for a zener diode having a power dissipation of 50 watts

![Power-temperature derating curve](image-url)
Rectifier stacks are assemblies of separately heatsunk rectifiers to perform specific functions. One type of small stack is shown in Fig. 15. A great many series, parallel, and bridge arrangements are possible.

**Power zener diodes**

The zener diode is a regulator utilizing the almost constant-voltage region following reverse avalanche breakdown of a p-n junction ($V_a$ in Fig. 1).

Although the term “diode” is generally reserved for low-power units and the term “rectifier” for high-power units, common usage is such that “zener diode” refers to all power levels of this device. Zener diodes with dissipations up to 50 watts are available, covering (in the high-power region) voltages from 6.8 to 200. A typical derating curve is shown in Fig. 16. The major effect of a rise in $T_j$ is to increase the avalanche voltage. Temperature coefficients of zener diode avalanche voltage range from 0.1 per cent per °C for 200-volt units down to 0.04 per cent per °C for the 6.8-volt device. A 50-watt zener diode is packaged like a stud rectifier, or in a single-ended case.

**Power transistors**

There are several generic types of power transistors in common use: germanium alloy, germanium mesa, silicon alloy, and silicon diffused. Each type has several modifications, a few of which are sketched in cross section in Fig. 17. Like the rectifier cell, the transistor is limited in voltage operation to the breakdown potential of a single p-n junction and, although limited in current density by some basic considerations, can be extended to higher current levels by an increase in area.

Both n-p-n and p-n-p transistors can be made in silicon or germanium by each of the processes used, although in some cases one type has emerged as predominant. Hence, almost all germanium power alloy and mesa transistors are p-n-p, and most silicon power alloy and diffused units n-p-n. For some applications, matched n-p-n and p-n-p types can lead to circuit simplification. A rather close
match can be obtained in some cases (such as silicon diffused base), but tight matching, particularly at high frequencies, is difficult because of inherent differences in device physics of the two types.

Transistors can be utilized in circuits in three different configurations: common base, common emitter, and common collector. Since the common-emitter configuration is by far the most frequently employed, and also best exhibits the use and limitations of power transistors, it will be the only type discussed. The emitter is common to input and output characteristics, the input is between base and emitter \((I_b, V_{be})\), and the output is between collector and emitter \((I_c, V_{ce})\).

Historically, the germanium alloy power transistor was the first power transistor worthy of the name. These transistors are generally made as shown in Fig. 17(A), although many modifications, such as the diffused-base type, are used. For these devices, \(\theta_{ja} \approx 0.5^\circ C/\text{patt}\), so with a mica isolator, \(\theta_{ja} < 1^\circ C/\text{patt}\). When mounting is on a convection-cooled heat sink, \(\theta_{ja}\) can be as low as \(3^\circ C/\text{patt}\).

Some power transistor limitations can be visualized by considering the common-emitter characteristics of a germanium alloy unit, such as shown in Fig. 18. Operational limitations for this type of unit are now imposed by \(BV_{CEO}\) (collector-emitter breakdown voltage with open base) values generally less than 200 volts. The value of \(BV_{CEO}\) is determined by reverse avalanche breakdown of the collector junction, and is often lower than this (see Fig. 18) as the result of current gain and surface effects. Since high current gain (at low currents) tends to reduce \(BV_{CEO}\), it is doubtful that the present limit will be extended very much. Laboratory structures with high gain to 400 amperes have been made, but the marketing potential has not warranted their appearance as a product. Germanium alloy power transistors have very low values of \(V_{CEsat}\), 50 mV at 50 amperes being attainable. Although this does not represent a very large power (2.5 watts), it is not negligible. The low \(V_{CEsat}\) value attainable with these units makes possible efficient operation with low-voltage sources such as thermoelectric generators, solar cells, fuel cells, and sea-water batteries. Because of their wide bases and high \(h_{f(e)}\), germanium alloy power transistors generally have serious gain fall-off above 10 kc/s. Diffused-base types are usable in the radio-frequency range and as high-current switches, with fall times under a microsecond.

Germanium alloy power transistors are rated to power levels of just under 200 watts at a 25°C case temperature. With \(\theta_{ja} \approx 0.5^\circ C/\text{patt}\), these units are linearly derated to zero power at 110°C. A constant-power curve is shown in Fig. 18. For a given thermal environment, a curve of this type then defines the limit of dc operation, even though useful transistor characteristics extend beyond the curve and could be utilized in a more efficient thermal environment. For an amplifier application, the average power generated must be considered. This will vary tremendously depending on whether class A, B, or C is used. For a switch application, not only must the power generated in the off and on positions be considered, but also the power generated during switching. The latter is a function of switching speed and load-line shape, which may be far from linear for reactive loads. For fast switching, the transistor may safely traverse extremely high power regions. Thermal time constants
are in the range of 50 ms for these transistors, so during each switching pulse the time spent in high-generation regions must be considerably less than this to utilize powers higher than the dc rating.

Silicon n-p-n alloy power transistors are limited to about 30 amperes, but are rated up to 250 watts, 250 volts $BV_{CEO}$ and can operate to $175^\circ$C. They have much lower current gains (about 20) and much larger values of $V_{CE(on)}$ than germanium units of similar geometry (well over 1 volt at rated current). Silicon diffused transistors of similar geometry, Fig. 17(B), are available in ratings up to 300 watts, with a minimum $h_{FE}$ of 10 at 50 amperes and $BV_{CEO}$ of 150 volts, and are derated to zero power at a case temperature of 200°C.

Power transistor operation would be relatively simple if the only operational and power limitations were those already discussed. Unfortunately, there are several complicating factors. These are illustrated in Fig. 19, which shows only the curves limiting the area of operation of a transistor. The $V_{CE(on)}$ curve OA is similar to that in Fig. 18. Figure 19 shows a $BV_{CEO}$ value equal to the collector-base junction breakdown voltage. This is the case where the transistor is free from punchthrough (collector junction depletion region reaching the emitter junction) and surface breakdown (caused by surface impurities and imperfections), and has a low value of leakage current. Leakage current $I_{CEO}$ along OB is not differentiated from the $V_{CE}$ axis because of its small value. As the transistor is driven beyond breakdown (base open), the characteristic follows along the curve $BDGE$. From B to D, collector-emitter voltage drops as current increases. This part of the characteristic is determined by the equation $M_0 = 1$, where $M$ is the avalanche multiplication coefficient (a function that increases with voltage) and $\alpha$ is the low-voltage common-base current gain. As collector current is drawn beyond $BV_{CEO}$, $\alpha$ increases, so $M$ must decrease to keep $M_0 = 1$. Hence, collector voltage decreases. At higher currents, $h_{FE}$ stops rising, so the negative-resistance region terminates (point $D$) in a low-value positive-resistance region $DGE$ at a voltage $LV_{CEO}$. The avalanche switchback from $BV_{CEO}$ to $LV_{CEO}$ is approximately 50 per cent for germanium p-n-p and n-p-n as well as silicon n-p-n transistors but, due to a lower avalanche coefficient, is only about 20 per cent in silicon p-n-p transistors. To the right of $BDGE$, between $LV_{CEO}$ and $BV_{CEO}$, the common-base current gain $h_{FE} = M_{0X}$ is greater than unity. Operation in this region in the common-base configuration is possible, as long as the circuit is properly designed to accommodate the greater-than-unity current gain. The region $DG$ can be shifted to voltages higher than $LV_{CEO}$ by reverse biasing the emitter-base junction and, in some cases, can approach $BV_{CEO}$.

At point $G$ in Fig. 19, a secondary breakdown region $GF$ is indicated. Secondary breakdown is a phenomenon that appears to occur in all transistors, although in low-power types it is often entirely beyond the rated power and, in such cases, can be neglected. In high-power transistors, it is a major problem and can restrict the operating range far below the limitations produced by ordinary thermal considerations.

Several mechanisms are recognized as being capable of causing secondary breakdown, and they often act in combination. One is caused by defects that concentrate current in small areas. These defects may be regions of higher current gain due to localized, thin base sections. The local power density becomes very large, and local thermal runaway occurs. Another mechanism involves a greater temperature rise at the middle of a large structure (see Fig. 6) than at the edges, since the edge regions take advantage of thermal spreading. A defect near the center of a large structure will invoke both mechanisms.

Transistors having high-resistivity base regions, so that uniform punchthrough can easily occur, display a third type of secondary breakdown. This is caused by conduction of emitter current to a small region near its center as the result of biasing by radial base current flow. This effect is particularly active along $DGE$, Fig. 19, in which region a large majority current flows from collector to base. Here an emitter-collector voltage drop from $G$ to $F$ (secondary breakdown) can occur with no requirement for temperature rise, although the conduction of current to a small region often produces one. The secondary breakdown condition is made worse (that is, $I_c$ is lowered) if the emitter-base junction is reverse biased; or improved (that is, $I_c$ is raised) for forward emitter-base bias. Here, also, defects complicate the picture.

A fourth secondary breakdown mechanism appears when the contact to the collector region is injecting, and may be caused by a nonintentional, perhaps not even continuous, p-n junction, or a tunneling process. The transistor (from emitter to collector) assumes a p-n-p-n appearance (like a silicon controlled rectifier). This type of structure is regenerative, and switches to a lower voltage at the current $I_c$. If the undesired injecting structure is nonuniform, current can be localized. Secondary breakdown is often destructive because of current (and hence, power) concentration that can cause local thermal runaway.

For purposes of amplification, transistor operation is
limited (Fig. 19) to the region enclosed by $OBDGFO$, with the additional limitation that power generated must be within the rated limit. This region, called the safe area, is specified for a given transistor as shown in Fig. 20. An amplifier load line will be entirely within the safe area. For switching applications, since we are concerned only with the end points and not with the linearity of characteristics in between, the load line may violate all limiting curves as shown by $JK$ in Fig. 19.

One item of concern in this case is the power generated during switching, which must be kept below the power that results in thermal runaway in any of the violated regions. The faster the switching, the less the power generation, so safe-area curves may be extended (Fig. 20). Another item of concern is latch-up at point $L$ in Fig. 19. Since $L$ represents a stable operating point, the transistor can end up there during the turnoff cycle instead of returning to point $J$. If the power generation at point $L$ is beyond the transistor rating, it will undergo thermal runaway. It is necessary, then, that the turnoff pulse be not only sufficiently fast to avoid thermal problems, but sufficiently strong to carry the transistor back to point $J$.

The germanium mesa transistor has a diffused base region and alloy emitter, as shown in Fig. 17(C). It derives its name from the shape of the active area that is formed by etching down the remainder of the original pellet surface. Although originally designed for low-power high-frequency operation, larger-area versions mounted in packages designed for better thermal dissipation are useful into the range of several watts. Germanium power mesa transistors are usually limited to a $BV_{CEO}$ of 25 volts and collector current of $\frac{1}{2}$ ampere. Usable to about 250 Mc/s for communication applications, they provide, for example, about $\frac{3}{4}$ watt output RF power at 160 Mc/s with greater than 50 per cent efficiency.

Silicon diffused-base power transistors are almost

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Fig. 21. High-power silicon interdigitated epitaxial annular transistor pellet. Size is approximately 0.5 inch square. Tapered emitter (center) fingers can be used to reduce emitter area because current decreases down a finger due to its distributed flow into the base.
always made using masked diffusions for base and emitter, giving structures like those shown in Fig. 17 (D) and (E). This type of construction (as does the germanium mesa) allows the formation of extremely thin bases, less than 0.5 micron in many cases. Since the transport time of minority carriers across the base region is inversely proportional to the square of the base width, frequency response of these units can be very high. A narrow base creates an additional problem, however, in that the sheet resistance of the base region becomes very high. Base current flowing laterally between emitter and collector creates an electric field in such a direction (for \(h_{FB} < 1\)) that a somewhat higher emitter junction forward bias is produced at its periphery than toward its center. Since current injected from emitter to base is an exponential function of junction voltage, a small potential difference leads to a high degree of emitter current crowding toward the periphery. Hence, the central parts of the emitter carry little current, but do add a large parasitic junction capacitance. The obvious result has been to utilize geometries that concentrate on "line" emitters, such as a narrow stripe or ring. Where larger current capability is desired, geometries are used that effectively place many line segments in parallel, such as an interdigitated structure; see Figs. 21 and 17(E).

The structure shown in Fig. 17(D) will have a relatively high value of \(V_{CE(sat)}\) due to the ohmic drop caused by collector current flowing through the rather high resistivity (of the order of 1 ohm-cm) collector region. As the geometry is made more "linear," electrical and thermal spreading resistance become important, particularly since current flow through the base and into the collector is constricted to a path about the size of the emitter. The electrical (but not the thermal) resistance can be very much reduced by utilizing a collector that has a thin (generally 10–50 micron) high-resistivity region (so that a high collector-junction breakdown voltage may be achieved) backed up by a very low resistivity region (generally 100–250 microns); see Fig. 17(E). Thickness of the high-resistivity region is greater the higher the breakdown voltage. A much thinner pellet with just the high-resistivity region would work even better, but breakage in processing would be excessive. It is important, however, from the thermal standpoint, to keep the pellet as thin as practically feasible. Two-layer collector structures (n-n+ or p-p+) are produced primarily by the epitaxial process, wherein the high-resistivity layer is grown on the low-resistivity substrate. Epitaxial growth and localized (masked) diffusion are the two "breakthroughs" without which silicon high-frequency power transistor technology would be far below its present level of perfection.

Base transport time (base width) is not the only factor determining speed of a transistor. The other major limiting factors are controlled by junction capacitance and diffusion capacitance (charge storage) effects. Each p-n junction behaves very much like a capacitor in parallel with the mechanism producing nonlinear \(V-I\) characteristics (Fig. 1). These parasitic capacitances degrade performance of high-frequency amplifiers by virtue of the resulting \(RC\) time constants. If the emitter junction is made as narrow as possible, its capacitance is reduced. The collector junction is also kept as small as possible for the same reason. Practical process limitations impose restrictions on how fine a structure can be made. Lateral spacings and line widths in the 5-to-10-micron range are handled reasonably well at present. Collector capacitance can be reduced by raising collector resistivity. At high current densities, however, this permits the effective base width to increase, and hence the frequency response is lowered by virtue of a longer base transport time. This technique limits the power handling capability of the transistor, but is very useful in automatic-gain-control applications.

The gain–bandwidth product of a transistor \(f_T = \sqrt{f_I} \cdot f_v\) is a measure of how fast a signal can travel from emitter to collector, and includes emitter and collector junction capacitance charging times (\(RC\) products), base transport time, and collector depletion layer transit time. At \(f_T, h_{FB} = 1\), but power gain exists because of impedance transformation. In Fig. 22, \(f_T\) is plotted versus collector current for a 10-ampere silicon diffused-base transistor (Fig. 21). The drop-off at low currents is due to
increasing emitter junction time constant since emitter junction resistance \( R_e = 1/(dI_e/dV_e) \) is inversely proportional to \( I_e \). The drop-off at high currents is due primarily to effective base widening, and is much more severe for the higher voltage (higher collector resistivity) unit.

Although \( f_T \) is an important measure of the ability of a transistor to amplify at high frequencies, a more important figure of merit for amplifier use is the maximum frequency of oscillation

\[
\tau_{\text{max}} \approx \frac{1}{5} \sqrt{\frac{f_T}{r_e'C_e}} \quad \text{if} \quad f_{\text{max}} \gg f_T \quad (18)
\]

As base width is reduced to increase \( f_T \), \( r_e' \) increases because of inherent process limitations, and \( f_{\text{max}} \) may actually drop. Hence, for amplifiers, \( f_T \) is often lowered so that \( f_{\text{max}} \), and hence, amplifier performance, is optimized.

The present status of silicon high-frequency power transistor amplifiers is illustrated in Fig. 23. The shaded curve represents upper limits of powers attainable with usable efficiencies. The lower part of the shaded area depicts transistors that can be made with reasonable yield and the upper part indicates transistors that have been demonstrated as laboratory models. Because of thermal limitations imposed by the fine geometrical designs, above approximately 100 Mc/s these transistors are generally distributed over the surface of a larger silicon pellet. The parts are made as separate low-current transistors (see Fig. 7) and then interconnected in parallel by metalizing. Conducting paths then form over the surface of the silicon dioxide passivating glass, approximately 1 micron thick, that covers the silicon. Contact to appropriate silicon regions is made by cutting holes in the glass. Metalized paths drop down from the outer oxide surface and alloy to the silicon in these regions. Although some (or all) of the interconnections could be made by connecting p-n junction geometries, over-the-oxide interconnections have lower parasitic capacitance and, hence, are essential for the ultimate in transistor high-frequency performance.

High-frequency transistors are often used in parallel (see Fig. 10) to increase power output. High-frequency power silicon transistors are often difficult to use in low-frequency applications because of their tendency to oscillate in practical circuits. If the base is widened to lower the frequency response, current gain drops because minority carrier lifetime in the low-resistivity base regions produced by this type of process tends to be low. Diffused-base transistors in the 10-ampere 100-volt range have been successfully made with \( f_T \) values as low as 10 Mc/s. Lower than this, geometries such as that shown in Fig. 17(B) are used.

The current gain–bandwidth product \( f_T \) is a good indicator of how fast a transistor can be switched on. To turn it off, however, requires removal of the minority carriers stored in the base and collector regions while in the (saturated) "on" condition. Fastest switching is accomplished by lowering minority carrier lifetime (by gold diffusion) to a very small value so that the injected minority-carrier stored charge will quickly recombine once turnoff is started. Transistor design to minimize stored charge is also important. Very low lifetimes indicate very thin bases, so that a reasonable

![Fig. 24. Safe-area curves for a typical high-power diffused-base silicon transistor with various switching times](image)

![Fig. 25. Junction structures in the two SCR polarity types](image)
current gain will be preserved. At present, transistors are available with switching times of approximately 10 nanoseconds for currents in the low ampere range.

Thermal limitations for diffusion-base power transistors are similar to those for other transistors, and safe-area curves are necessary (Fig. 24). Because of the very thin bases of these structures, large-area versions are prone to be limited by defect-induced secondary breakdown.

Silicon controlled rectifiers

The silicon controlled rectifier (abbreviated SCR) is a four-layer device utilizing three p-n junctions for its operation. Like the transistor, two polarity versions are possible, as shown in Fig. 25, the most commonly used version being shown at the top. The SCR is used as a three-terminal switch, such that anode-to-cathode switching from a high voltage–low current (off) state to a high current–low voltage (on) state is triggered by a small gate signal. In order to return the SCR to its high-impedance state, the anode-to-cathode current is reduced below a critical hold current $I_h$. Figure 26 illustrates the $V-I$ characteristic of an SCR. As voltage is increased in the positive direction (center junction reverse biased) a small leakage current flows until the avalanche breakdown voltage $V_{BO}$ of the center junction is reached (or until surface breakdown occurs). Past this point, appreciable current can flow. As with the transistor, the $V-I$ characteristic from $V_{BO}$ to $I_h$ is governed by the equation $M = 1$, except that since now there are two transistors, each utilizing the reverse-biased center junction for a collector, the equation in this case is approximated by $M(\alpha_{anp} + \alpha_{pno}) = 1$. As the current increases, $\alpha_{anp}$ and/or $\alpha_{pno}$ increases, so the voltage drops to reduce $M$. Whereas in the case of a transistor this avalanche switchback is undesirable, in the case of an SCR we wish to maximize it. The current gain sum $\alpha_{anp} + \alpha_{pno}$ rises quickly with current, permitting efficient switchback to a low voltage at a low current $I_g$. At this point, and for all higher currents, all three p-n junctions are forward biased, with the outside two of polarity opposite to the center junction. Hence, the total voltage drop across the device is approximately that of a single forward-biased silicon p-n junction, about 1 volt. Hold current $I_h$ is typically in the range of 1 to 50 mA. For currents larger than $I_h$, the multiplication factor $M$ is equal to unity because of the low voltage, so the equation describing this region is $\alpha_{anp} + \alpha_{pno} = 1$.

The short section of the SCR $V-I$ characteristic extending vertically from $V_{BO}$, Fig. 26, is present on some types made utilizing a “short-circuited junction” geometry—for example, in Fig. 25 (top), if the cathode contact were to extend a short distance farther to the right, it would short-circuit a section of the upper p-n junction on the surface. As $V_{BO}$ is exceeded, appreciable avalanche current from the center junction flows through the short-circuited region into the cathode instead of having to flow through the upper p-n junction. Hence, the effective emitter efficiency of the upper (n-p-n) transistor is zero. As current is increased, however, lateral current flow through the upper p-type region, Fig. 25 (top), produces a transverse voltage drop there, causing the left section of the upper p-n junction to receive a forward bias. This triggers the main p-n-p-n anode-to-cathode breakdown, which occurs somewhat away from the short-circuited region. The short-circuited junction geometry is built into an SCR structure to promote temperature stability of $V_{BO}$. An effect of this type may be obtained on nonshort-circuited units by attaching a resistor between gate and cathode; see Fig. 25 (top).

If the gate is given a small bias in a direction so that the upper p-n junction is forward biased, the upper three junctions behave as a transistor, and current flows. The current flow increases $\alpha_{anp}$ or $\alpha_{pno}$ or both, and, if it is large enough (that is, of the order of $I_g$), the high-impedance region (Fig. 26) disappears. The characteristic then follows the short dashed curve from the origin to $I_h$. Hence, switching from A to B is accomplished by the application of sufficient gate current that the high impedance region is eliminated (or very much reduced) and point B becomes the only stable operating point available for the circuit. The device will stay at point B when the gate signal is removed.

For an anode-cathode potential of the opposite polarity, the two outer p-n junctions are reverse biased. Switching action does not occur in this case and the SCR behaves like two reverse-biased junctions in series and undergoes avalanche breakdown at the sum of their individual breakdown voltages. Silicon controlled rectifiers are generally rated (at 125°C) with the same values of forward and reverse breakdown voltages.

The silicon controlled rectifier has an advantage over power transistors when used for off-on switching. Since the action is regenerative and has two stable points (without the need for gate current), current flow is uniform over the area of the device, except for small perturbations in short-circuited junction structures. No crowding toward a junction periphery takes place. Hence, simple large-area geometries suffice for very-high-current operation.

Gate-firing characteristics for an SCR must be well specified to make sure that all units of a given type will turn on if a gate pulse beyond a given current threshold is applied. Also, since the gate region—and usually the gate lead, too—is small compared to the anode and cathode, applied gate power must be limited.
The highest-current SCRs are rated up to 400 volts and lower-current units are generally rated in the 600–800 volt range. Newer devices show promise up to 1500 volts. The power controllable by a 400-volt 300-ampere unit approaches 100 kW, and can be reliably switched by the expenditure of as little as 1 watt. Thermal resistance from junction to case (stud) of a power SCR runs from 0.1 to 1°C per watt. Since the SCR is often used for controlled rectification, wherein the device is triggered to start conduction at a particular phase angle of a sinusoidal or square-wave power voltage, the units are generally graphically rated for the convenience of the user, so permissible average forward current is specified as a function of conduction angle. Most silicon controlled rectifiers are rated for operation up to 125°C.

If the duration of a high-power pulse is short compared to the thermal time constant of the heat-removal system, the user can take advantage of a much lower thermal resistance, since thermal gradients are higher. Thus, \( L \) in Eq. (4) is effectively shortened. Turn-on times for an SCR are short because of the regenerative nature of their switching. Even the larger units turn on in about 1 \( \mu s \). If anode–cathode voltage is applied too quickly (for example, when controlling conduction in a square-wave system), however, the value of \( V_{BO} \) may be lowered. This \( \text{dv/dt} \) effect occurs if the charge released from the center junction when it is quickly reverse biased is sufficient to charge up the bases of n-p-n and p-n-p component transistors. The effect is most severe if the central n-type and p-type regions are thin. High-power SCRs have relatively thick regions, however, and voltage application rates of greater than 10 volts per \( \mu s \) are generally permitted without lowering \( V_{BO} \).

The turnoff time of an SCR is much slower than the turn-on time, and is circuit dependent. Most devices are rated through 400 c/s sinusoidal and square-wave operation, with newer (medium current) SCRs operable above 10 kc/s. Turnoff is quickened if reverse anode–cathode voltage is applied. Even though the anode–cathode current has dropped to a value below \( I_{th} \), the SCR may refire at a voltage below \( V_{BO} \) if sufficient time has not been allowed for recombination of charge stored deep within the device. Hence, turnoff time must be measured by determining how long a time must elapse before a voltage of \( V_{BO} \) is required to fire the unit.

For certain pulse applications, switching is entirely within the first quadrant (Fig. 26). A high reverse-voltage rating is not required. Silicon controlled rectifiers of this type are rated to close to 1000 volts \( V_{BO} \), 100 amperes repetitive (10 \( \mu s \)) pulse current. Turn-on times are in the range of 250 nanoseconds. Turnoff times (with 10 amperes reverse current) are several microseconds. Forward-voltage application rates exceed 50 volts per \( \mu s \).

The silicon gate-controlled switch (GCS) is an SCR in which the gate can be used to turn the unit off as well as on. Consider a controlled rectifier to be on (position B in Fig. 26). A reverse bias on the gate will change the characteristic to that shown by the long dashed line (if the SCR does not burn out first). The only stable point for the anode–cathode bias circuit is at \( A \), so the device must turn off. Gate control works by robbing the upper transistor of some of its minority-carrier base charge. Hence, a higher current is required to make \( \alpha_{on} \alpha_{off} = 1 \), and \( I_T \) moves up to \( I_T' \). The gate electrode must obtain at least partial control over the base region it contacts, and thus the situation is between that of an SCR and a transistor.

Silicon gate-controlled switches are rated up to 400 volts, 5 amperes. They turn on with forward gate currents similar to those of an equivalent SCR, but have less gain during turnoff. For example, turnoff from 5 amperes to 25 volts is accomplished with 500-mA reverse gate current, or a turnoff gain of 10. This is lowered at higher voltages and lower currents, as shown in Fig. 27. Ratings are for a 200-% pulse width. The GCS can simplify switching circuitry, as shown in Fig. 28, for an electronic ignition system.

The silicon GCS is a recent product innovation, and

![Image](image-url)
should witness rapid improvement in characteristics, particularly in current rating and turnoff gain. Other more complex structures have been demonstrated in the laboratory and should appear as products in the near future. These include a five-layer diode—that is, n-p-n-p-n with double short-circuited junctions—for symmetrical twoterminal switching, and a three-terminal five-layer device that is switched on for either polarity of anode-cathode potential by means of a pulse of either polarity applied to the gate. Fig. 29 (after F. E. Gentry, General Electric Company) illustrates the rather complex internal geometry of the latter device.

**Power varactors**

The varactor is a p-n junction rectifier designed to maximize junction capacitance variation with voltage and to minimize series resistance. For high power capability, high reverse breakdown is also necessary. Because of its nonlinear properties, the varactor is used to generate higher harmonics from a signal impressed across it. V-I characteristics of a varactor are like those for any p-n junction (Fig. 1).

The depletion region that defines the extent of a p-n junction is illustrated in Fig. 30. It is a region which, to a first approximation, contains no mobile charge, but contains a large fixed charge. Hence, its behavior is much like that of a parallel-plate capacitor, and

\[ C = \frac{\varepsilon}{w} \]  

(19)

where

- \( C \) = capacitance per unit area
- \( \varepsilon \) = dielectric constant (12 for silicon)
- \( w \) = width of depletion region

The value of \( w \) depends upon the total potential across the depletion region, increasing for reverse bias and approaching zero for large forward bias. An applied potential appears, to a first approximation, entirely across the depletion region, adding to (reverse bias) or subtracting from (forward bias) the built-in junction potential \( \Phi \)—in the range of 0.7 volt for many silicon p-n junctions.

For an abrupt p-n junction

\[ C_j \propto (\Phi - V)^{-1/2} \]  

(20)

For a linearly graded p-n junction

\[ C_j \propto (\Phi - V)^{-1/3} \]  

(21)

Powers from \(-1/2\) to \(-1/5\) are obtained in practice, depending in detail upon the impurity distribution in the structure. If the bottom edge of the depletion layer, Fig. 30, should reach the \( n^+ \) boundary before avalanche break-
down, the extent of the depletion region \( w \) from that voltage until breakdown is almost constant, and so the capacitance changes very little with voltage, as seen in (19). Operation of a varactor under reverse bias is limited by the avalanche breakdown voltage \( V_{\text{mb}} \), shown in Fig. 1.

Under forward bias, appreciable quantities of holes are injected into the p\textsuperscript{+} region into the n-type base (Fig. 30). These are neutralized by electrons, and can constitute a charge much greater than the free electron charge in the n-type material by itself. This charge lowers the effective resistivity of the n-type region, a fact that is responsible for the extremely high forward efficiency of a p-n junction rectifier. Since this large charge is stored by virtue of a forward junction voltage, it constitutes a capacitance called diffusion capacitance, in addition to and effectively in parallel with the junction depletion region capacitance. Hence, as the p-n junction goes into forward bias, its capacitance increases at an extremely fast rate because both the depletion capacitance—\( v = \Phi \) in Eq. (20)—and diffusion capacitance terms become large. A plot of total capacitance versus voltage for a p-n junction varactor is illustrated in Fig. 31.

A p-n junction varactor may be considered to be a nonlinear capacitor \( C(V) \) with a series resistance \( R_0 \). If a sinusoidal current is impressed upon a nonlinear capacitor, of the type indicated in (20) or (21), the voltage appearing across the capacitor will be nonsinusoidal. It will contain harmonics of the fundamental signal. In a practical case, the current, voltage, and stored charge will all be nonsinusoidal functions of time. When the nonlinear capacitor is placed in a circuit so that it is common to loops resonant at fundamental (input) and first-harmonic (output) frequencies, much of the input signal at frequency \( f \) is converted to frequency \( 2f \). Figure 32 shows a simple frequency-doubler circuit.

The efficiency of frequency conversion by a varactor is a function of the losses in the system. The circuit \( Q \), which is important, is controlled to a large extent by the quality factor \( Q \) of the varactor diode.

\[
Q = \frac{1}{2\pi f R_0 C} \tag{22}
\]

A diode cutoff frequency \( f_c \) is defined as the frequency at which \( Q = 1 \), so

\[
f_c = \frac{1}{2\pi R_0 C} \tag{23}
\]

\( R_0 \) and \( C \) both vary with voltage. For a good 25-watt silicon varactor, \( C \) will be in the range of 50 pF (measured at 6 volts reverse bias). \( R_0 \) climbs from about 0.5 ohm at 300 volts reverse bias to several ohms as zero bias is approached. This gives a device \( Q \) of well over 100 for most of this voltage range, and a cutoff frequency \( f_c \) at 300 volts approaching 50 Gc/s, and at 6 volts of about 2 Gc/s. Equations (22) and (23) are only partially realistic, however, since they do not take into account how much \( C \) varies with voltage.

Advantage can be taken of the very wide capacitance swing under forward bias at high frequencies by proper circuit biasing. If a diode is driven into forward bias under low-frequency conditions, current flows and \( Q \) is very much lowered. If the diode is driven into forward bias for part of a high-frequency cycle, however, the injected charge can be extracted as the junction swings quickly into reverse bias. Hence, there is little loss since almost no ohmic current flows. By the use of these techniques, as well as by careful circuit tuning, varactors are presently capable of accepting 50 watts input at 50 Mc/s and doubling frequency at greater than 80 per cent efficiency or quadrupling at over 40 per cent efficiency.

Strings of varactor multiplier circuits are used to take power from the 50-Mc/s range and convert it with reasonable efficiency to well beyond 10 Gc/s. Figure 23 shows how the use of varactors for frequency multiplication has extended the range of transistors. Because of the extremely nonlinear operation of varactors, their performance is very difficult to calculate and circuit tuning is extremely sensitive. Nevertheless, their use above 100 Mc/s is important at the present time and will continue to grow. From the device standpoint, decreasing \( R_0 \) is the most important problem. Linearly graded silicon structures offer an advantage in this respect. Also, germanium and gallium arsenide, because of their higher mobilities, may find widespread use above 1 Gc/s.
Eighty years ago a great society of electrical engineers was born. At that time its planners laid heavy emphasis on the communications aspects of electrical engineering. At first they stressed telegraphy, and later telephony as well. Then, with greatly expanded activities, the American Institute of Electrical Engineers took its place as a worthy representative and tool of the electrical branch of the engineering professions.

Twenty-eight years later there came into being another major engineering society specializing strongly in two particular divisions of electrical engineering—communications and electronics. This organization, The Institute of Radio Engineers, also prospered. And it too grew into a definite symbol and instrument of the professional engineering interests of its membership.

The coexistence of these two societies was, on the whole, gratifyingly dignified and peaceful. Yet it seemingly perpetuated an anomaly, which resulted from a partly artificial division of electrical engineering into two arbitrarily delimited sections. Although AIEE was also vigorously active in the electronics and communications field, IRE stressed comparatively few portions of most of the other divisions of electrical engineering. Inevitably there was undesirable duplication of effort by the two societies. And there was a corresponding partial waste of funds and, more important, of skilled and relatively scarce engineering manpower.

The problem of unity

Four decades ago the need for unity in the electrical engineering profession became increasingly evident, at least to some of us. But formidable obstacles loomed in the path to unification. These included the jealously guarded corporate standing of the societies, the personal pride or individual ambitions of important members, resistance to supposed subordination of one society or the other, outright conservatism, and normal competitive instincts. These factors and other all-too-human elements for many years were solid roadblocks in the path of the merger of the two Institutes.

Yet the wheel of time turned irresistibly from a partly
unsatisfying past toward a brighter and greater future. Increasing tolerance and understanding sprang up between the societies—first as tender shoots, then as massive-trunked and sheltering trees. Mutual understanding led to growing cooperation. The need for unification became ever clearer. Accordingly, when a comprehensive merger proposal, painstakingly developed, was submitted in 1962 to the AIEE and IRE memberships, it was accepted by an overwhelmingly favorable vote. And now we, the membership of the older societies, are The Institute of Electrical and Electronics Engineers, Inc. And we have in our hands all the responsibilities and challenging opportunities conferred in our new corporate charter.

Thus, with broad coverage of the entire electrical and electronics field within our scope, it is appropriate that IEEE should select as its unifying and “core” publication, reaching all its members, a new Journal born this month—fittingly termed IEEE Spectrum. Its novel designation was wisely and felicitously suggested by E. K. Gannett, in charge of IEEE Editorial Operations, and W. R. Crone, Consultant to the IEEE Student Journal.

It is anticipated that IEEE Spectrum will contain review and tutorial articles, and occasionally articles of broad and fundamental import. It will include articles of application and of economic significance. It will present news of the profession and of IEEE, announcements and reports of conferences and conventions, news of education, and letters to the editor on topics of broad concern as well as of general interest. Also included will be news of scientific and engineering advancement, items of political and social interest to the profession, and abstracts of or references to material in other IEEE publications. The technical level of IEEE Spectrum will be such that it will be a positive force in upgrading the level of membership ability and in fostering the development and expansion of the field encompassed by IEEE. It will inherently aim to be an agent for human progress through enhanced professional capabilities.

The title IEEE Spectrum is particularly appropriate in view of the unusually wide range of topics falling within the scope of IEEE. These subjects, at present, might include (merely as a small and typical sample): electrical applications of Boolean logic and algebra, error-correcting codes, magnetohydrodynamic power generators, peak-power storage in elevated water basins (tidal or artificial), helicopter placement of transmission-line towers, fuel cells as primary generators, magnetic memories of the ferrite-core or thin-sheet types, status of electronic prosthetic devices in medicine, plasma absorption of electromagnetic radiation from re-entering space vehicles, and space communication over tens or hundreds of megamiles. One might multiply this sample many hundredfold to acquire some concept of the breadth of knowledge that will necessarily be presented in IEEE Spectrum.

**Professionalism**

Yet, serving as a source of dependable and timely information on matters within the scope of IEEE, and thus keeping the membership of the Institute up to date in its fields, is only one of the purposes of IEEE Spectrum. Another primary aim of IEEE and its publications is to foster and strengthen the professional standing of its members and to promote and emphasize their professional accomplishments. It is appropriate here to consider briefly the nature of professionalism and the personal value and significance of the professional attitude among engineers. Our new publication, IEEE Spectrum, will appear in clear perspective if its aims are shown to be definitely identical with those of IEEE itself. Publisher and publication must be parts of the same consistent and coherent structure. Accordingly it is fitting here to consider the nature of the professional engineer and of his chosen implement, our Institute. Thus the services rendered by IEEE Spectrum will be clearly seen and justified.

There is of course a close professional kinship between electrical and electronics engineering and the older professional fields. Technically considered, the closest relationship is probably between the field of the IEEE and the civil and mechanical engineering fields. Ethically and socially, the field of IEEE perhaps seems closest to the field of medicine. Professional consulting engineering calls
for the solution of individual problems somewhat similar to those encountered in electrical and electronics engineering and involves the acceptance of similar ethical concepts. The legal profession is based on somewhat different fundamental needs and concepts. Yet it and the field encompassed by IEEE are slowly approaching similar common bases and modes of attack on problems.

Professionalism merits a clear definition. To avoid confusion, we should first consider some elements that, though not directly within the purview of a learned society such as IEEE, are self-evident requirements for the successful functioning of the professional man. To begin with, these are the establishment and maintenance of reasonably attractive working conditions and adequate remuneration for the engineer, permitting personal and family life at a cultural level. Included are due public and private recognition of the value of the work of the individual engineer (even though the engineer has not been notable as a seeker for fame through self-advertising which, in fact, is viewed with doubt or distaste by most ethical engineers). The preceding factors must be regarded as the necessary socioeconomic foundations of any healthy professionalism.

But at this point we must face a group of complex, knotty, and potentially controversial elements involved in professionalism. We must ask ourselves such questions as: What are the essential elements of a professional calling? How do they differ from those of a trade or a craft? What are the inherent obligations of a professional worker? How shall his fellow workers and the public recognize his unique characteristics and accomplishments?

The usual dictionary definitions are not particularly helpful in attempting to answer these questions. Thus, a profession is defined as “the occupation, if not commercial, mechanical, agricultural, or the like, to which one devotes oneself.” A craft is defined as “an occupation requiring art or skill.” The definition of a trade is, for example, “a means of livelihood” or, alternatively, “the act or business of exchanging commodities by barter or sale.”

Admittedly, different men might give diverse answers to the questions posed above. Yet it is believed that the nucleus of agreement, like the nucleus of the atom, is firmly knit and adequately definable. Here, then, are some proposed answers to these questions. The inherent factors in a professional occupation include the possession of a wide range of knowledge, both broad and detailed, of the chosen field. Also needed is much more than a smattering of its relation to society in general, implying as well a good understanding of the humanities. Other factors are the possession of unusual skills in applying the teachings of the field, a strong sense of responsibility and of personal dignity, and a measured pride of accomplishment in the field. These factors lead naturally not only to self-respect but also to respect for fellow workers. They require a firm refusal to engage in comment or conduct prejudicial to a comember in the field unless clear ethical considerations, violations of law, or obvious neglect of duties lead to a public controversy or a legal procedure in which professional men must be involved.

Thus the obligations of the professional worker flow naturally from his standing and privileges. His main objects in life are such as to emphasize and justify his special repute, his scientific and technical skill, his creativity, his social importance to humanity, his ethical guidance, and his intraprofessional relationships.

IEEE fits well into this matrix of purposes. Clearly one of its major functions is to nurture and preserve a precious dichotomy. This dualism involves the reconciliation and coexistence of the socioeconomic elements and the professional aspects of the electrical engineering profession. As has been stated, one part of the engineer’s life is not dissimilar to that of other men. It is obviously essential that the engineer and his family shall live an economically pleasing life free from harassment or distress arising from his daily needs and the development of his long-term security. An atmosphere of acceptable peace and modest plenty are rightfully needed. To these ends the engineer, as an economic unit, rightfully asks an adequate scale of remuneration and a congenial type of environment. Sometimes the engineer handles these matters directly through personal negotiations. And sometimes these factors are worked out by group association and large-scale negotiation. But, in any case, their handling is a necessary and normal part of the engineer’s life.

But man lives not by bread alone. The engineer is first and foremost a professional man. What then shall we seek as a primary function of IEEE? Clearly, one such aim must be firmly to establish and maintain professionalism under the guardianship of IEEE. If we succeed in building up IEEE as the vigilant and effective symbol of engineering professionalism—and we shall—all else may well be given to us.

Yet there are many matters of detail that must be considered. As influential and large an organization as the IEEE is justified in taking a “long, hard look” at its purposes, procedures, and accomplishments, and even at its daily activities. Great amounts of human effort, time, and devotion have gone and will go into IEEE. Correspondingly convincing and decisive reasons justifying its aims, its mode of operation, and its desired results can legitimately be sought and developed with utmost care.

Without any wish to be dogmatic or didactic, here are some personal concepts concerning this Institute, which belongs to all of us. Considering its specific aims, these concepts clearly include the orderly large-scale collection and dissemination of comprehensive and advanced information in the electrical and electronics field. This information should range from the most specific to the most general; from the longest-term historical data to the latest “news of the minute”; and from the most highly technical data through humanitarian aspects of public interest to the study of the particular needs and personal welfare of the members of our Institute. Every available and logical agency for the collection of information should be considered and, if found suitable, should be effectively utilized. And all available and powerful modes of dissemination of the gathered information should be used, including small specialized meetings, larger meetings, conventions, world conferences, publications, and wide distribution of films and tapes.

Since IEEE is a nonnational body, it must appropriately proceed on the valid basis that science and engineering know no frontiers. Truth has a scope as wide as the cosmos. To implement so broad a plan, great care must be taken to encourage and support activities of IEEE in every country of the world. The IEEE membership in each country must enjoy in equitable measure every opportunity and privilege granted to those in other
countries. Race, creed, and national origin are not relevant factors in the standing and advantages to be enjoyed by every member.

It follows naturally that each body of regional members shall have full opportunity to work out its problems, to exercise its organizational and administrative ingenuity, to expand its Sections and Chapters in healthy fashion, and to make its maximum contribution to the fulfillment of the general aims of IEEE.

Some interesting, difficult, and challenging problems are therefore encountered by a nonnational body like this Institute. One of these is the barrier of language differences. Here an early and complete solution may be economically impracticable. However, several steps toward making all technical material issued by IEEE equally available to all or most members (and readers) are possible. Various fields must be explored, open-mindedly. These include multilingual editions (or abstracts) and utilization of machine-translation facilities, with the resulting availability of printed, microfilm, or tape versions of basic material. The ultimate aim is to make every technical advance in the field of the Institute available to all.

**Members’ needs and obligations**

At all times, the needs of the membership and of the community should be kept in mind as guides to preferred procedures. These activities of the Institute, its Sections, Regions, Chapters, Professional Technical Groups, Committees, and other Divisions should be skillfully and painstakingly adapted, probably on a partially pragmatic or even empirical basis, to the needs of the membership and to the benefit of the public.

IEEE has acquired a rich heritage of accomplishments from its parent societies. The professional assets of IEEE represent in considerable measure the summation of the achievements of AIEE and IRE. These accomplishments are so outstanding and helpful to IEEE that nothing further need be said on the subject. As to the future, however, even more may confidently be expected from IEEE. It must be expected to accomplish many and more complex tasks. Scientific and technical progress in its field must be progressively and systematically promoted. The professional viewpoint and standing of the Institute and its membership must be jealously guarded. The public must ever be made aware that the engineer members of the Institute are not only the dependable custodians of profound knowledge, skill, and creativity but also the exponents of the high and demanding standards of professionalism. The dignity and importance of the electrical and electronics field must continually be explained and stressed.

In the light of these needs, it is seen that there are definite obligations involved in IEEE membership. Each member should feel a proper pride in his Institute and should do his utmost to enhance its standing. There is an urgent need for the maximum of “grass roots” activities. Only thus can the Institute continue to enjoy democratic regimes, consistent with firm and capable everyday administration. Each member may well have a group of unified loyalties, which are different aspects of the same basic identification of himself with his Institute. A man may be a dweller in his home town, a citizen of his local state or regime, and a citizen of a nation. So too an IEEE member may be a member of his local Section and Chapter, a member of his Professional Technical Groups, and a member of IEEE. These multiple affiliations are all different aspects of the same association. Together they form the strong bond between IEEE members, imbued with a common purpose, and their Institute.

Despite the most careful planning and an enthusiastic membership, the path of IEEE may nevertheless beset with pitfalls that must be carefully avoided. There may well arise a trend toward bureaucracy, with its cumbersome, costly, and time-consuming frustrations. Attempts at “empire building” may arise, with their corresponding animosities and political overtones. Ill-advised members of industry or government may attempt to wrest control of IEEE policies and procedures from the members of the Institute, with consequent damage to the professional spirit of the Institute. There may arise deviations from high professional ideals and methods. And, last but not least, the prolonged maintenance of vestigial and useless customs may perpetuate a tragic waste. The membership of the Institute and its elected representatives and headquarters staff must be ever on guard against these insidious weaknesses, which could be encountered in the future of IEEE.

Perhaps one of the best panaceas for these ailments is the avoidance of any freezing of the form and activities of the IEEE. A dynamic future must consistently be sought. At every step, careful judgment based on experience must be exercised. Viewpoints must be kept flexible, perhaps through an empirical approach to many problems. And there must be an open-minded readiness to try out new plans, and modifications of old plans, whenever inadequacies in current principles of operation become evident.

In brief, the future success of IEEE will rest on the enterprise, originality of thought, and the loyalty and professional pride of its membership and their representatives. And always the independence of the Institute must be sedulously guarded so that it may fulfill the purposes for which it was established.

**Prospects for the future**

On the basis of these guiding principles, we may speculate optimistically in to the future of our IEEE. We may anticipate that it will render many and valuable services to us, its members, and that it will make important contributions to human welfare. We are called on to retain our enthusiasm, our inspiration, and our willingness to render yeoman service to our Institute and thus to each other and to society. If we do, a bright vista of accomplishment is spread before us.

Never should it be forgotten that this IEEE is our Institute. It is no more and no less than a reflection of our hopes, our ideals, our professional dedication, and our sense of our value to each other and to the world. It is ours to mold, to change, to guide, and to re-create in an increasingly worthy form.

Each of us, therefore, is most fortunate in having the unique opportunity and the pleasant obligation of adding our quota to the integrated efforts of our IEEE membership. Thus our Institute will not be merely a large society; rather, it will be a great and admirable institution of social and professional worth. It will symbolize the professional aspirations and accomplishments of each of us, and of all of us together. And these, it is hoped and expected, will ever be ably reflected in our new journal, the IEEE Spectrum, which is now laid before us.
New coherent light diffraction techniques

Scattered coherent light exhibits a granular, sparkling appearance. Experiments described give an insight to this phenomenon. Diffraction techniques permit giant antenna scaling with desk-top scale models

Wright H. Huntley, Jr.  Stanford Electronics Laboratories
When continuous-wave gaseous lasers are operated in the visible portion of the spectrum, an unusual effect is apparent to the observer. Wherever the beam strikes a scattering surface, the illuminated spot exhibits an extraordinary granular, sparkling appearance.

When examined at close range, the illuminated spot appears like a richly detailed mosaic and the viewer's first impression is that the laser must be oscillating in thousands of modes. This impression is readily disproved, however, when the observer moves his head from side to side; for the granular pattern does not remain fixed with respect to the scattering surface as one would expect with multimoding. Instead, it sweeps across the field of view. The relative direction of motion depends on whether the eye is focused in front or behind the viewing surface.

The best explanation of this phenomenon was given by B. M. Oliver, who says that "...coherent light reflected by a diffusing surface produces a complex, random, but stationary diffraction pattern." He demonstrates that this pattern consists of a large number of needle-like beams which are essentially the lobes of the far-field radiation pattern of the scattering spot. Langmuir has indicated the similarity between this standing pattern and the familiar problem of radar clutter wherein the sea, chaff, or moving trees give a fluctuating return; yet a similar pattern is involved. The pattern is simply more stationary with coherent light scattering because individual scattering points tend to maintain a fixed relationship to each other.

It is interesting that most people experience an odd psychophysical reaction when attempting to look at the scattering spot. If the spot is small—2 mm in diameter—and the observer is more than a few centimeters from the scattering surface, it is quite difficult to focus the eyes on the plane of the scattering surface. As a result, printing on that surface disappears (also described by Oliver). The reason for this illusion is that the stationary diffraction pattern exhibits granularity that always seems in focus, no matter where the eye is actually focused. Figure 1 illustrates the effect on the eye—or other imaging system—in the far field. Each line represents the center of one of the needle-like random lobes.

Focusing on the scattering surface produces an image of minimum size and the granularity is crowded into a small area. If the eye is out of focus, the over-all image expands and the details of the granularity are enlarged. Most observers find that their eyes focus automatically at some average point which yields rich granular detail and sufficiently small image size to have moderate intensity in the individual grains. This arbitrary focal plane almost never will coincide with the scattering surface.

Another effect can be seen from Fig. 1. If an iris is
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The new hp 5100A-5110A Frequency Synthesizer offers pushbutton convenience for fast, accurate selection of frequencies from 0.01 cps to 50 mc in steps as fine as 0.01 cps. Remote programming in less than 1 millisecond may be accomplished by external electronic switching. The excellent spectral purity is evidenced by the fact that spurious components are more than 90 db down (including power line components) and signal to phase noise ratio is greater than 60 db.

The system consists of the 5100A Frequency Synthesizer and the 5110A Synthesizer Driver. The latter contains a 1 mc quartz crystal oscillator which has a long term stability of ± 3 parts in 10^6 per day. The design of the instrument allows for the use of an external 1 mc or 5 mc oscillator. In any case, the output frequencies retain the accuracy of the chosen driving standard. The 5110A Synthesizer Driver generates twenty-two discrete, spectrally pure signals from the single standard frequency. These fixed frequencies are then fed to as many as four 5100A's by means of rear panel BNC connectors.

Manual frequency selection is accomplished by means of ten columns of pushbuttons arranged in standard decimal notation. Remote programming connections are made through three 50-pin connectors located on the rear of the 5100A. Further versatility in control is added by the fact that it is possible to use a combination of local and remote programming.

Standard instrument design provides a search oscillator which may be used in any one of the eight least significant digit columns. This technique allows the output frequency to be varied smoothly over the range of frequencies covered by the substituted column, either manually or by applying an external voltage.

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**SPECFICATIONS**

<table>
<thead>
<tr>
<th>Output frequency:</th>
<th>0.01 cps to 50 mc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital frequency selection:</td>
<td>From 0.01 cps per step to 10 mc per step; selection is by front panel pushbutton or by remote contact closure</td>
</tr>
<tr>
<td>Spurious signals and harmonic distortion:</td>
<td>All non-harmonically related signals are more than 90 db below (including power line components) the selected frequency; harmonics are more than 30 db below the fundamental</td>
</tr>
<tr>
<td>Signal-to-phase-noise ratio:</td>
<td>More than 60 db down in a 3 kc band centered on the signal</td>
</tr>
<tr>
<td>Frequency stability and accuracy:</td>
<td>With internal standard, less than ± 3 parts in 10^6 per day; with external standard, same as external standard</td>
</tr>
<tr>
<td>Output voltage:</td>
<td>1 v rms ± 1 db from 100 kc to 50 mc; 1 v rms ± 2 db = 4 db from 50 cps to 100 kc into 50-ohm resistive load</td>
</tr>
<tr>
<td>Output impedance:</td>
<td>50 ohms nominal</td>
</tr>
</tbody>
</table>

**Search oscillator:**

Allows continuously variable frequency selection with an incremental range of 0.1 cps up to 1 mc, depending on the digit position being searched; dial accuracy is ± 3% of full scale; linearity with external voltage control is within ± 5% (-1 to +11 volts)

**External standard input:**

1 or 5 mc, 0.2 v rms minimum, 5 v maximum across 500 ohms; purity of output signal will be determined partially by purity of external standard

**Interference:**

Complies with MIL-I-16910A (SHIPS)

**Temperature range:**

0 to +55° C

**Dimensions:**

5100A, 10½" high, 16½" wide, 16½" deep behind panel; 5110A, 5½" high, 16½" wide, 16½" deep behind panel; hardware furnished for quick conversion to rack mount

**Weight:**

5100A, net 75 lbs.; 5110A, net 52 lbs.

**Price:**

5100A, $10,250; 5110A, $5,000

Data subject to change without notice. Prices f.o.b. factory.
placed ahead of the lens, the outermost lobes will be intercepted, the detail in the granularity will be reduced, and the eye will refocus to find a new brightness-detail balance. It is this automatic readjustment that causes the apparent increase in granule size when the scattering spot is viewed through a limiting iris. This effect is best examined on the ground-glass screen of a camera, where the aperture and the focus are independently controllable.

Observed effects and photographic investigation have all strongly established the validity of Oliver’s hypothesis. This unexpected effect may have a major influence upon systems design. We might ask: What happens if the detector of a coherent-light radar falls in a null of the scattered return? What happens if the target moves? Can this effect be utilized in a system design?

Because these questions seem to deserve early answers, an effort has been made to demonstrate conclusively the validity of Oliver’s hypothesis by repeating (with minor variations) his experiment and by devising new tests, and to extrapolate the results of this effort to indicate areas for future investigation and the application to possible systems.

**Random-scatter experiments**

Oliver’s original photograph (Fig. 2) was taken by exposing the film to the scattering spot without lens or limiting aperture. An earlier assumption, attributing the granularity entirely to diffraction limiting in the incident beam, caused some confusion.

The photograph, reproduced as Fig. 3, was made by exposing the film as in Oliver’s experiment but the spot was illuminated from behind the diffusing screen. That is, the laser beam illuminated the rear of a thick piece of white paper and the photograph is the result of the standing diffraction pattern produced after the light had diffused through to the surface nearest the film. However, the “diffraction-limited” argument is not entirely invalid. It merely tends to distract the casual reader from the more basic issue—that the source must be spatially stable for the diffraction pattern to “stand still.”

While this first experiment indicated clearly that there was a stationary, standing diffraction pattern in space, an additional test was made to demonstrate that the only effect of an iris is to restrict the amount of the pattern reaching the film.

Figure 4 shows the results obtained when limiting apertures of various sizes are placed between the scattering surface and the film. As in the first experiment, no lens was used and the granularity is caused by light passing directly from the white paper to the film. Note that there is no difference in the granularity between (A) and (B). Only close examination reveals the slight effect of edge smearing from diffraction around the border of the iris.

The energy in any major lobe (bright spot) of the standing diffraction pattern is dependent upon net phase addition from incremental scattering points across the entire illuminated surface of the spot. It would be reasonable to expect that slight motion of the scattering surface in the laser beam would cause bright spots to dim, while other areas previously dark would become bright as new scattering surface is illuminated. Thus, one might expect the entire complex pattern shown in Figs. 2 through 4 to “boil” as the scatterer moves through the laser beam.

To confirm that this effect actually takes place, the paper was mounted on the minute hand of a clock, and the pattern was observed on the ground glass of a camera with no lens. The expected “boiling” did occur, but it was accompanied by an additional effect which should have been predicted. As usual, hindsight is exceptionally keen!

The unexpected effect was a large transverse motion of the pattern with respect to the amount of boiling. Since a small motion of the paper with reference to the incident beam diameter removes and adds only small scattering areas, it is possible for a given lobe to retain its identity while being swept through an angle which is very large compared to its diameter. This “sweeping” effect of the pattern is illustrated by the streaked appearance evident in Fig. 5. The photograph reproduced in Fig. 5 was taken with the same arrangement used for Fig. 4, but the scattering paper was moved very slightly with respect to the incident light beam during the exposure. Although Fig. 5 does not illustrate adequately

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**Fig. 2.** B. M. Oliver's original photograph of the standing diffraction pattern

**Fig. 3.** Duplication of Oliver's photograph, except that transmission rather than scattering diffraction is used. (Difference in grain size is caused by dissimilar degree of enlargement)
the dynamic effect obtained by viewing the ground glass directly, it nevertheless does show the ease with which tangential motion of the scattering surface in the beam can be detected.

It appears from the results of this last experiment that the random scatter may have some useful applications. It was decided that the author's earlier assumption—that the granularity is always present in the image no matter where the optical system is focused (as indicated in Fig. 1)—should be verified.

Figures 6 (A) and 6 (B) were made with the use of a small telescope with a relatively large aperture in order to obtain sufficiently large images on the film. Figure 6 (A) shows the well-focused image of a 2-mm diameter scattering spot as seen from a distance of about 15 feet; (B) shows the same spot with the image strongly out of focus. The dark, center region is caused by the shadow of the small center mirror in the Cassegrainian telescope. Note that the total amount of granularity has changed very little, but the grains are larger and

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**Fig. 4.** A—Effect of an aperture between the scattering light and the film. B—Reduction of the aperture has no effect upon the granularity of the photograph image

**Fig. 5.** Streaking caused by motion of the scatterer in the laser beam is shown in this picture

**Fig. 6.** A—A 2-mm scattering spot taken at a distance of 15 feet by eyepiece projection with a focused Questar telescope. B—Photograph of spot taken under identical conditions, except that telescope is strongly out of focus. Note that the granularity remains whether or not the optical system is focused.
they are spread over a greater area, exactly as indicated in Fig. 1.

**Scaling antennas with coherent light**

Diffraction effects are not new to most engineers. The stubborn refusal of electromagnetic radiation to propagate in the nice straight lines of geometric optics is accepted as a "fact of life." While the antenna designer is concerned with directivity, main-lobe width, side-lobe amplitude (or null spacing) the lens designer must consider the effect of diffraction limits on the resolution of his optical system. And, where the antenna designer increases the diameter of his antenna to increase its directivity, the lens designer increases the diameter of his lens to improve its resolution. This parallel is more than coincidence; both are dealing with the same property of radiation, although in heretofore widely separated portions of the spectrum.

Recently, Skolnik\(^3\) borrowed the "slits and pinholes" of the classic physics demonstrations to suggest a novel way of making scale models of antenna arrays. He proposed the substitution of a hole in a conducting plate for each driven element in the array. By illuminating the "holey plate" with radiation of the appropriately scaled microwave frequency, a pattern can be generated on the other side of the plate that is the same as if each hole represented an active radiating element. If the array is not too large with respect to wavelength, this technique has tremendous advantages over assembling the array with waveguide or coaxial feed lines connected to each element.

But, unfortunately, recent systems require very large arrays for space tracking and radio astronomy. The increase in size and number of driven elements has compounded the difficulty of calculating the pattern or space factor and has emphasized the need for testing with scale models.

The following technique extends Skolnik's method to permit scaling antennas that are hundreds or even thousands of wavelengths in diameter on a measurement range that is little larger than the average laboratory workbench.

The emergence of the helium-neon cw laser as a readily available laboratory tool makes possible a great extension of the holey-plate technique by taking the "slits and pinholes" back into the optical region of the spectrum. When operated in the visible region (6328 Å), the laser beam provides a stable source of plane waves with a very large diameter in wavelengths—about 1580/\(\mu\)m. These plane waves are used to illuminate an opaque screen that has holes corresponding to the elements of the array being scaled. The size and shape of the holes and their relative spacing are scaled down by the ratio of the light to the microwave wavelength.

For example, to scale an array to be operated at 3 Gc for evaluation with the 6328-Å helium-neon laser, the dimensions of the holey plate are related to the dimensions of the 3 Gc array by

\[
\frac{\lambda_{\text{light}}}{\lambda_{\text{microwave}}} = \frac{6328 \times 10^{-10}}{10^{-4}} = 6.328 \times 10^{-6} \quad (1)
\]

**Fig. 7. Typical arrangement for simulating large antenna patterns with a laser.** Photograph shows a test aperture, "holey plate," and its location in the apparatus diagram. The square mesh is electroformed nickel with center-to-center hole spacing of 0.001 inch (40X). The overall array aperture is 0.020 inch (800X).
It is apparent that such an extreme scaling factor will tend to restrict the technique described to antennas whose dimensions are all relatively large with respect to wavelength.

Several methods are available for controlling the characteristics of the illuminating source. But, for the purpose of this discussion, let us assume that we are dealing with a simple linear array of similar sources with equal spacing. The resultant far-field pattern can be described by simply multiplying the patterns of an individual source and an array of isotropic point sources as

$$E = f(\theta, \phi) F(\theta, \phi) / [f_s(\theta, \phi) + F_s(\theta, \phi)]$$

where the first two terms are the field patterns of an individual source and an array of isotropic sources, and the last two terms are their respective phase patterns.

There are several constraints on Skolnik's holey-plate technique and its described extension when an array is scaled that differs substantially from the uniformly illuminated normal or broadside array. The use of lenses to create spherical phase fronts in the illuminating source, or tilting the holey plate to obtain linear phase differences between individual sources also influences the phase pattern $f_s(\theta, \phi)$ of the individual source. Since large individual sources have already been specified, this effect must not be ignored in attempts to scale steerable arrays where the phasing is adjusted for $E_{\text{max}}$ at angles other than 90 degrees to the linear array.

While phasing poses problems that have not been solved satisfactorily, polarization and amplitude distribution are more subject to control by the investigator. A "quarter-wave plate" gives circular polarization when the crystal axes are at 45 degrees to the polarization of the incident light, and other orientation angles provide all possible axial ratios of elliptical polarization.

It is often desirable to illuminate an array more strongly at the center and gradually taper the illumination to zero at the edges. The natural-mode patterns of the laser can be used quite effectively for approximating

---

**Fig. 8.** The resultant far-field pattern of the model array shown in Fig. 7. The two-dimensional surface of the picture represents the two spatial dimensions (E and H field) of the field pattern. This illustration does not show the last few nulls near the main lobes. These are clear in the negative
such tapered illumination. The TEM\textsubscript{00} modes, for instance, have a nearly Gaussian amplitude distribution, and it is necessary only to furnish the appropriate lenses to collimate the beam at the desired diameter ahead of the holey plate. Some of the same precautions mentioned in connection with phasing should be considered. However, smooth amplitude tapering should have small effect on the individual aperture field pattern \( f(\theta, \phi) \), if this aperture is small with respect to the aperture of the array.

Operation in the visible portion of the spectrum has an advantage over microwave scaling. The pattern can be recorded directly on photographic film. It is easy to convert the film record to more conventional plots by merely scanning the negative with a densitometer and, if necessary, applying corrections for nonlinearities in the film response.

A typical equipment arrangement is shown in Fig. 7. A hemispherical mirror configuration in the laser is desirable, for it can be aligned readily for a simple, strong TEM\textsubscript{00} mode, and the spherical wavefront (from the curved-mirror end) can be allowed to expand to the desired diameter before being collimated to obtain the plane wavefront.

Punching, etching, and electroforming are all useful techniques for producing the relatively small holey plates.

An interesting property of this scaling technique is that the experimenter can see the actual pattern distribution. Calculation of the range required for far-field pattern measurement \( 2D^2/\lambda \), where \( D \) is antenna diameter and \( \lambda \) is wavelength, is noteworthy because of the magnitudes involved, but quite unnecessary in practice. Merely moving a piece of white paper away from the holey plate quickly shows the rather abrupt transition from Fresnel to Fraunhofer regions—and at surprisingly short distances for most apertures.

Figure 7 also shows a typical aperture which was produced by sandwiching an electroformed, square nickel mesh and a thin sheet of phosphor-bronze with a single, punched hole. The mask was coated with carbon black to prevent distortions caused by edge effects. Figure 8 shows the resultant pattern. The wide range of intensities in the figure is greater than the dynamic range of conventional printing processes. This illustration does not show the last few nulls near the main lobes, but they are quite clear in the original negative. Special films are now available with over 60-dB dynamic range of intensity, so this is not a serious problem.

In Fig. 8, the two-dimensional surface of the picture represents the two spatial dimensions (\( E \) and \( H \) field) of the field pattern. Simple geometry will quickly convert the linear dimensions to angular values.

The differential density of the field \( (D_z - D_x) \) is directly related to the relative illuminating energy levels \((E_z/E_x)\) by

\[
D_z - D_x = \gamma \log \frac{E_z}{E_x}
\]  
(3)

where \( \gamma \) is the slope of the film’s characteristic curve. The use of this expression—if the film \( \gamma \) is known—will permit conversion of film density to a quantitative plot of the far-field pattern. This represents a salient advantage over the simple qualitative evaluation of the pattern that may be obtained by merely viewing the distribution of Fig. 8.

This optical scaling technique could be readily extended to provide realistic, laboratory-sized models of mountain-ridge diffraction paths and other configurations of difficult analysis that are large with respect to wavelength. The cw laser should prove to be a powerful experimental tool for investigators in these areas.

Conclusions

Two principal conclusions have been reached on the basis of all the diffraction experiments described.

The new relationship between the typical size of target-surface irregularities and wavelength will probably cause severe amplitude fluctuations at the detector in optical radars.

The same phenomenon gives high promise of providing rapid tracking capability by direct measurement of tangential target velocity.

It is evident from the previously described experiments that the spatial and even temporal coherence of the gaseous laser beam can produce most interesting scattering effects. These experiments also provide sufficient information to engage in some speculation about future optical electronic systems.

It is quite probable that the high directivity possible in this region of the spectrum will permit practical illumination of relatively small target areas at great range. If so, the detector used in such a system will have to operate in the sort of field pattern shown in Fig. 2. If the detector aperture is small and at great distance from the target, any tangential motion of the target with respect to the illuminating source can be expected to produce large fluctuations or scintillations in the detector output. Some initial investigation of metallic surfaces has shown the same random intensity patterns as the test paper, though polarization is not at random, as it is from the paper.

If an array of detectors (with proper correlative interconnection) or an imaging system is used to examine the target returns, a potentially annoying effect could be turned into a unique advantage. The sweeping motion of the random-field pattern is a direct function of the tangential-velocity vector of the target in the beam. Therefore, it should be possible to obtain angular tracking information on a nearly instantaneous basis. It is also possible to modulate the beam to obtain range and radial-velocity data. The additional information on relative tangential velocity is all that should be required to maintain continuous track on a target in three dimensions.

Proposed optical electronic systems will encounter monumental problems in acquisition—but the ability to establish rapid tracking of an acquired target could improve some proposed systems significantly.

REFERENCES


This article is based on a paper presented by the author at the 1963 Western Electronic Show and Convention at San Francisco, August 20–23.
EHV ac and dc transmission

EHV is used to move large blocks of power when distances between power source and load are great. On existing transmission structures, one 500-kV line could replace six 230-kV lines, as far as loading capability is concerned.

J. J. W. Brown, E. M. Hunter General Electric Company

As the electric utility industry enters the year 1964, the list of utilities in the United States with 500-kV projects under way and expected to be in service by the mid-1960s is most imposing: Virginia Electric Power Company; Pacific Gas and Electric Company; Southern California Edison Company; Pacific Power and Light Company; Bonneville Power Administration; South Central Electric Companies; Tennessee Valley Authority; Pennsylvania–New Jersey–Maryland (P-J-M) Utility Group; and Allegheny Power System, Inc. In addition, a large number of new 345-kV projects have been started. The July 8, 1963, issue of Electrical World estimates a total of 5450 circuit miles of EHV interconnections planned between 1964 and 1970. Of these, 2210 miles will be at 345 kV and 3230 miles at 500 kV and higher. Similar growth is also to be found in Canada and overseas and is, in fact, world-wide.

Extra-high-transmission voltages (EHVs) are defined at voltage levels above 230 kV. To put this expansion of system voltages in its proper perspective, let us briefly trace its growth. In the United States, 230 kV was first com-
missioned in 1923, 287 kV in 1936, and 345 kV in 1953. Today, 345 kV is the highest commercial voltage in the United States. Overseas, Sweden energized 400 kV in 1952; this voltage in the ensuing years has been adopted by Finland, West Germany, Austria, France, Italy, Great Britain, Spain, and Switzerland. In Africa, South America, and Australia 345 kV is being used but on a limited scale. At present, the line mileage outside the U.S.S.R. is estimated to be 4000 at 345 kV and 5000 at 400 kV.

The U.S.S.R. installed its first 400 kV line in 1954. East Germany, Czechoslovakia, Hungary, and Romania followed suit shortly thereafter. Then, in 1961, the U.S.S.R. found it expedient to raise the EHV level to 500 kV.

With regard to the future, there appears to be no contemplated 500-kV transmission expansion for western Europe. In Canada, however, as well as the United States, line construction is now under way and terminal equipment is on order for 500-kV projects that should be commissioned by the mid-1960s. Canada will also have a 700-kV project in partial service by 1965 and fully commissioned by 1967 or 1968. This is the first 700-kV project to be undertaken by any nation. (The U.S.S.R. reports studying 700 kV and plans for a network by 1969.)

The achievement of a heretofore unattained EHV level has moved from country to country. Some critics of the industry have used this as a criterion of progress. Far more significant criteria, however, are the proper voltage level and development and application of the new higher voltage in time to meet the needs of industry expansion.

## 1. Electric utility peak loads

<table>
<thead>
<tr>
<th>Companies</th>
<th>Winter Peak MW</th>
<th>Rank</th>
</tr>
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<tbody>
<tr>
<td>Tennessee Valley Authority (TVA)</td>
<td>12124</td>
<td>1</td>
</tr>
<tr>
<td>American Electric Power</td>
<td>638</td>
<td>2</td>
</tr>
<tr>
<td>Pacific Gas &amp; Electric</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>Commonwealth Edison</td>
<td>428</td>
<td>3</td>
</tr>
<tr>
<td>Consolidated Edison</td>
<td>4373</td>
<td>4</td>
</tr>
<tr>
<td>Southern California Edison</td>
<td>4157</td>
<td>5</td>
</tr>
<tr>
<td>Niagara Mohawk</td>
<td>3301</td>
<td>6</td>
</tr>
<tr>
<td>Duke Power</td>
<td>3192</td>
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<tr>
<td>The Detroit Edison</td>
<td>3119</td>
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<td>Public Service Electric &amp; Gas</td>
<td>2361</td>
<td>9</td>
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<td>Georgia Power</td>
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<td>General Public Utilities</td>
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<td>Florida Power &amp; Light</td>
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<td>Allegheny Power</td>
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<td>17</td>
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<td>City of Los Angeles</td>
<td>1840</td>
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<td>Union Electric</td>
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<td>New England Electric System</td>
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<td>Northern States Power</td>
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<td>Pennsylvania Power &amp; Light</td>
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<td>Houston Light &amp; Power</td>
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<td>Carolina Power &amp; Light</td>
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<td>Duquesne Light &amp; Power</td>
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<tr>
<td>Long Island Lighting</td>
<td>1206</td>
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</tr>
</tbody>
</table>

### Alternating voltage selection

In 1947 the International Electrotechnical Commission (IEC) selected 400 kV as an international standard. It was an increase of 173 per cent above 230 kV, the highest voltage then in use in Europe.

At about that time, 345 kV was selected in the United States as the overlay voltage for an existing 138-kV system. The 2.5 factor between the old and the new voltage was economically sound.

It is generally conceded that neither 345 nor 400 kV is a suitable voltage to superimpose on a 230-kV system, as neither is high enough.

An acceptable criterion in selecting a new voltage is to have a ratio of 2.0 to 2.5 between the superimposed and existing voltage. The IEC at its 1963 meeting in Venice, Italy, approved the addition of 500/525 kV and 700/750/-765 kV to its list of standard voltages.

ASA Sectional Committee C92 on Insulation Coordination and EHV's is contemplating changes to its Standard ASA C92.2 "EHVs" by changing 500/525 kV to 500/550 and 700/735 kV to 700/765. The change to 550-kV maximum voltage will support the practice on United States 500-kV systems and the 765-kV maximum is in accord with the IEC Standards.

These days, new voltage levels come to fruition much sooner than expected. However, in the United States, the prevailing opinion is that a 700-kV network will not be needed before the mid-1970s. However, while 700 kV could be accepted as a suitable overlay for 345 kV, it is not economically sound for 500 kV. Should there not be in the Standards a superposition voltage for 500 kV? It is suggested that 1000/1100 kV be considered for future studies and investigations. Before the end of the century, it might be needed.

### Why EHV?

Power losses in a transmission line are a function of the impedance and the square of the current; thus, raising the voltage lowers the current proportionately, which helps compensate for the increase in impedance with distance. Extra-high voltages, therefore, are economically applied when the distances are great between the power source and the load. Sweden, for example, is a country without known deposits of fossil fuels but with a substantial supply, in the northern part of the country, of potential hydro power. However, the load for the output of these plants is in the southern part of the country. The first 400-kV line in Sweden ran about 600 miles between the hydro site in the north to the load center (Stockholm) in the south. A similar load-generation distance situation exists in the U.S.S.R.

In Great Britain, on the other hand, these great distances are not encountered. However, with the high density of population and with the pressures to preserve the appearance of the countryside, transmission rights of way are very difficult to obtain and those at hand must be utilized to their full capability. The higher voltages in Great Britain are needed to load the rights of way.

In the United States, EHV transmission is used to move large blocks of power. While there is an extensive land mass in continental United States, about 10 per cent of it is underlain by coal deposits. These have wide geographic distribution. While there are a few remote coal fields and hydro sites yet to be developed, transmission lines longer than 150 to 200 miles are relatively rare because of the
relative proximity of fuel sources to load centers. However, new rights of way to some of our metropolitan centers of population are most difficult to come by; public opposition to overhead construction is growing, and use of public lands for this purpose is being hedged with restrictions, making it more and more necessary to utilize fully whatever is in place. The full significance of this statement is better appreciated when it is considered that one 500-kV line could replace six 230-kV lines as far as loading capability is concerned. (See the Appendix.)

Incentives for EHV transmission growth

The rate of growth of electric utilities is such that they must plan and construct a facility equal in size to the one in place on the average of every ten years. In 1962, the investor-owned electric utilities announced that they would spend $8 billion in the next eight years to expand their transmission networks. This amount, together with government expenditures (approximately 25 per cent of the total) is a sizable investment.

Furthermore, of the total investment in an electric utility system—generation, transmission, and distribution—expenditures for low-voltage transmission are approximately 20 per cent. EHV transmission expenditures, however, are closer to 25 per cent; thus, these latter expenditures play an important role in system financing.

Any one of several factors may be the deciding incentive for installing a new EHV line. The new line may be used for an overlay of existing transmission facilities to provide the backbone of the system of the future. However, EHV transmission can be used only by the larger systems because the economic loading capabilities are so great they cannot be fully utilized on smaller systems. Electrical World for March 18, 1963, alphabetically listed utility companies and their December 1962 peak loads. These data, listed in descending order of peak loads, are shown in Table I. One may readily observe that (1) only 17 companies have a peak load in excess of 2000 MW, which is about the surge impedance loading of a 700-kV line; (2) it would not be sound engineering to transport the total load of any company over one line; and (3) existing and planned EHV systems through 500 kV are sufficient for overlay purposes at present.

On the other hand, EHV transmission may be used to provide the grid to interconnect neighboring utilities whereby the individual companies can share economically the installation of relatively large generating plants and give and receive mutual support in times of emergencies. The pooling of resources through interties can support higher transmission voltages than could be justified by the individual member companies comprising the pool.

Last but not least, EHV transmission may be the prime factor in allowing a wider choice of sites for new generation facilities. Remote low-cost fuel plants at mine mouths where essential cooling water is available, or remote hydro sites that could be exploited, increase in economic attraction with increases in the higher voltage levels and the bulk power to be transmitted.

It should be noted that some or all of the above factors were compelling incentives for the 500-kV EHV projects enumerated at the beginning of this article.

A first attempt at appraisal of the economics of various means to move large blocks of power long distances is given in Fig. 1. It shows present-day energy transportation costs in mills per kWh as a function of distance, and compares EHV transmission costs with the cost of moving coal by rail. It should be recognized that the results presented must of necessity be average figures and specific studies might produce different break-even points.

EHV transmission techniques

Certain techniques, somewhat peculiar to EHV transmission, have been developed to reduce to acceptable standards some of the problems encountered to make the systems serviceable and economical.

EHV transmission systems may be subjected to dynamic overvoltages owing to the large charging kVA requirements. It is well known that the flow of reactive charging current through a reactance, such as is found in a power transformer, produces a rise in voltage. If, however, the line reactive current is compensated by shunt reactive current, the dynamic overvoltages can be controlled. Shunt reactors are available for this purpose. The application technology must be able to resolve whether the shunt reactors should be located on the high- or low-voltage systems, and when they should be switched in and out of the system.

Transient overvoltages from internal origin can increase system insulation requirements; hence there is considerable economic incentive to keep them to minimum levels. Fortunately, they are for the most part internally generated and therefore predictable and controllable. Most of these overvoltages result from switching operations. EHV circuit breakers have series resistors that can

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Fig. 1. Transmission costs based on optimum loading of two-circuit transmission from base-loaded station (90 per cent transmission load factor). Receiving system, 138 kV; 15 per cent annual carrying charge; average coal-by-rail costs based on 9000 Btu/kWh plant heat rate.
Define needs and list alternate system layouts

Preliminary line design

Set performance criteria and build weather model

Explore overvoltage levels on TNA

Load flow and stability study

Specification of apparatus

Purchase of apparatus

Installation and service

Fulfillment of power needs

Acquisition of right-of-way

Special design problems

Economic conductor solution

Radio noise analysis

Final line design

Optimize tower locations

Line construction

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be preinserted on closing operations, and are designed to prevent restriking on opening operations. With these measures, the switching overvoltages of 3.0 or higher formerly encountered may now be limited to the order of 2.0 times normal.

EHV transmission circuits may also require series compensation for the line's inductive reactance to improve either stability or load flow. The series capacitor with its protective gap is available as an aid in the moving of bulk power over great distances.

To improve stability for remote generating plants, dynamic braking resistors need to be considered. The resistors (electric brakes) are switched onto the system as overspeeding occurs to act as the load absorbing the input to the prime movers until adjustments can be made. The basic principles of application of series compensation and dynamic braking to achieve system stability are understood. In fact, they have been thoroughly studied by system planners for at least 30 years but only with EHV transmission have they received new impetus.

**EHV designs by the critical path method**

There are many technical decisions to be made during the design stages of an EHV project. They must come at the proper time and in orderly sequence because decisions in one area often hinge on conclusions in several others.

As an aid in thinking through one of these undertakings, a critical path diagram can be prepared similar to that shown in Fig. 2. Each numbered circle represents a decision point which may be either provisional, intermediate, or final. Each arrow connecting the circled decision points represents an activity.

The lower portion of the diagram embracing decision points 1 through 5 covers system performance and the specifications for the purchase and installation of substation terminal equipment. The upper portion involving decision points 6 through 13 involves the electrical and mechanical design of the transmission line and towers. Thus, this critical path diagram gives a bird's-eye view of what must be accomplished from the time the decision has been made to go ahead with the project to the fulfillment of the undertaking.

Many engineering tools are available that may be used in getting facts for decision making. Load flows and stability problems are studied by the well-known analog and digital computers. System overvoltage magnitude, if from internal origin, can be established on the Transient Network Analyzer (TNA) when the system is set up in equivalent miniature and tested. Lightning performance can also be predicted by geometric scale models. Full-scale tower tests using an impulse generator at the General Electric Company's Project EHV will give full assurance that the insulation used will develop the strength needed in service. Project EHV has also added much in the way of basic data and understanding in the areas of corona and RIV (radio noise influence voltage) which aids in the selection of the economic conductor size.

**Meteorological integrated forecasting**

Troubles on transmission lines and the attendant interruptions of service are, for the most part, oriented with adverse weather conditions. Hourly records of weather for periods up to 15 to 20 years are available from the United States Weather Bureau. Statistical models constructed from these data integrated into a computer program can be used to assess the lifetime performance of any particular line design. For example, the program can judge the possibility of the occurrence of maximum switching surges or maximum lightning voltages at a time when factors such as air density, humidity, precipitation (rain, snow, sleet), and wind (proximity of conductor to tower leg) are least favorable to the maintenance of insulation strength.

Two types of management decision questions that can be answered by the meteorological integrated forecasting (METIFOR) approach are:

1. Given a fixed line investment, what is the optimum allocation of expenditures to produce the maximum in service continuity?
2. Will increasing line investment produce a justifiable increase in performance or not?

**Power transmission with HVDC**

HVDC (high-voltage direct current) transmission is a scheme by which power can be rectified from 60-c/s current to direct current and transported to the load center where it is inverted from direct current to 60-c/s current for distribution and utilization by the ultimate consumer. It is a relatively new tool in power transmission.

The first commercial application in the world was placed in service in 1954 between the Swedish mainland and the island of Gotland. Twenty MW is delivered over
a 60-mile single-conductor cable at 100 kV. This application which was made by Allmanna Svenska Elektriska Aktiebolaget (ASEA) has provided experience and encouragement for additional undertakings.

The second application was the tie between France and England. This link through 40 miles of cable across the English Channel is suitable for transporting 160 MW at ±100 kV in either direction.

To date, outside of the U.S.S.R. contracts have been let for four other projects as listed in Table II. ASEA mercury-arc valves will be supplied in all of the new applications although the English Electric Company is supplying the other equipment on the Italy—Sardinia undertaking.

II. Summary of HVDC transmission systems

<table>
<thead>
<tr>
<th>Location</th>
<th>Installation Date</th>
<th>Rating (kV MW)</th>
<th>Type of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island of Gotland</td>
<td>1964</td>
<td>100 20</td>
<td>60-mile cable</td>
</tr>
<tr>
<td>English Channel</td>
<td>1961</td>
<td>±100 160</td>
<td>40-mile cable</td>
</tr>
<tr>
<td>Donbass—Volgograd (U.S.S.R.)</td>
<td>1964</td>
<td>±400 750</td>
<td>300-mile overhead</td>
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<tr>
<td>New Zealand</td>
<td>1965</td>
<td>±250 600</td>
<td>25-mile cable</td>
</tr>
<tr>
<td>Italy—Sardinia</td>
<td>1965</td>
<td>200 200</td>
<td>61-mile cable</td>
</tr>
<tr>
<td>Japan (50-60 c/s)</td>
<td>1965</td>
<td>±215 300</td>
<td>217-mile overhead</td>
</tr>
<tr>
<td>Konti-Skan (Denmark—Sweden)</td>
<td>1965</td>
<td>250 250</td>
<td>53-mile cable</td>
</tr>
</tbody>
</table>

View of GE 345-kV transformer rated FOA-T 200 MVA, showing three bushing-mounted load-tap changers on top and two Atmos seals oil expansion tanks on either side.

The U.S.S.R. scheme employs two valves in series for a 100-kV bridge and a basically different valve design. At the time of this writing, this project is reported to be operating at ±100 kV with the expectation that it will be at full voltage of ±400 kV in 1964.

Technical feasibility of HVDC transmission has been proved in the applications made to date. Economic feasibility needs to be studied on each application considered.

HVDC transmission has economic potential in bulk power transmission in four categories: (1) overhead remote source-to-load transmission; (2) underwater cable transmission; (3) underground cable to distribution networks in large cities; and (4) conversion tie between large networks of different frequencies.

These are all point-to-point applications. The future possible use of HVDC transmission in integrated networks will require a great deal of study, taking into consideration the high cost of terminal equipment and that the controls for multitapped lines will require attention.

As already mentioned, in this country power sources and load centers for the most part are geographically so situated that there has been little need for transmission lines over 150 to 200 miles in length. However, there are some remote coal fields in the western part of the United States and underdeveloped hydroelectric sites in Canada where the distances become much greater. Some of these remote power sites are being studied and comparisons of series and shunt-compensated ac lines have been made with HVDC. If the transmission route includes a section requiring cable, economics favor HVDC because of the higher permissible dc loadings of cable.

HVDC terminal equipment is more expensive than that required for ac transmission. On the other hand, HVDC transmission lines cost approximately 70 per cent of an equivalent ac line. On the French—English cross-channel application, roughly two thirds of the investment covers terminal equipment and the other one third goes for cable. If the application had been ac, these percentages would have been reversed; i.e., one third for terminal equipment and two thirds for cable. The economics of the application was such that the application was at the break-even point between ac and dc. The nonsynchronous features of the dc tie was one of the deciding factors in favor of HVDC.

With regard to the immediate future, the high cost of HVDC terminal equipment limits HVDC transmission to applications where large blocks of bulk power are to be transported on a point-to-point basis over great overhead or cable distances. There probably will be only a limited number of these applications in the next decade or so but each could be a massive undertaking.

APPENDIX

The surge impedance of a line may be expressed approximately as $C \times (kV)^2$, where $C$ equals 2.5 for single conductors and from 3.0 to 3.5 or greater for bundled conductors, depending on whether two or more conductors are in the bundle. The surge impedance loading (SIL) of 345 kV is on the order of 300 MW, 500 kV is 800 MW, and 700 kV is 1800 MW. The economic loading is often expressed in multiples of surge impedance loading and may vary from 1.0 SIL to 3.0 SIL, depending upon the transmission distance, series compensation used, number of circuits with intermediate switching stations, and stability of the system.

The surge impedance loading of a 220-kV line is equal to $2.5 \times 230^2 = 133$ MW. Similarly, for a 500-kV line, it is between $3.0 \times 500^2 = 750$ MW, and $3.5 \times 500^2 = 876$ MW. Thus, 750 divided by 133 is 5.62 and 876 by 133 is 6.57. Six lines is, therefore, a good approximation.
The U.S. basis of electromagnetic measurements

Whenever technology outstrips our ability to measure, the result is poor reliability, overdesign, and delays. Here is how a radio standard evolves, and how NBS is striving to shorten the standards time lag

John M. Richardson, James F. Brockman  National Bureau of Standards

The undersigned believe that the following material, describing the national basis of electromagnetic measurements, deserves the thoughtful consideration of all members of the IEEE, and we have recommended that it be brought to their attention through this publication.

The size and importance of the electrical and electronics industry is clear to all members of the IEEE without the need of statistics. What may not be so clear is that this whole industry must rest on a uniform base of accurate and precise measurement if it is to achieve in practice the results which physicists and engineers find possible in principle. That base can only be provided by the National Bureau of Standards. However, the provision of a uniform base of measurement is costly in manpower, laboratory space, equipment, and time because of the great scope of electromagnetic quantities in kind, frequency, magnitude, and accuracy.

There is a strong indication, from some of the material presented, that the provision of that base has not kept pace with the growth of the industry. We believe that the National Bureau of Standards is making strong efforts to discharge the task assigned to it by Congress, but we also believe that the importance and magnitude of the problem call for understanding and support from outside NBS. It is from this standpoint that we recommend to members of the profession the reading of this article.

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In 1911, J. V. L. Hogan, one of the founders of the IRE, asked the National Bureau of Standards to calibrate a wavemeter. The job was given to a young employee, J. Howard Dellinger, who, 50 years later, described the event as follows:

"I was working in the Inductance and Capacity Section, in part of a room in the South Building. I was taking a course in Maxwell and had been intensively studying high-frequency phenomena. So this job was handed to me. It had to be in the Inductance and Capacity Section, for how else could you make a frequency standard at radio frequencies than by setting up a resonating LC circuit? I had to improvise such a circuit which generated the current, and the crystal rectifier to detect resonance, all without vitiating the value of frequency calculated from the L and the C."

Thus was the first radio calibration made by the National Bureau of Standards. Apparently the work was satisfactory since Dellinger later became chief of the NBS Central Radio Propagation Laboratory and was elected president of IRE.

From one man, the Bureau's effort in radio standards has grown to a staff of 300 people, who form the Radio Standards Laboratory. The Laboratory's purpose is to provide the central basis for electromagnetic measurements in the United States and to assure their international coordination. Thus it provides the measurement foundation for the electronics industry—an industry that has multiplied about 35 times during the past 25 years while the gross national product has increased only by a factor of six.

Pressure from the research frontiers

Electronics' first big leap forward came with the widespread use of radar during World War II. NBS felt the impact through a request from the Joint Chiefs of Staff dated April 26, 1944:
"The Joint Communications Board has decided that there is a need by our Armed Forces for primary radio frequency standards for frequencies between 1,550 and 11,000 megacycles per second. These standards are necessary for the proper calibration of secondary standards by which the radio equipment of our Armed Forces can be calibrated in the field. No primary standards of frequency determination for use in the radio spectrum between 1,550 and 11,000 megacycles per second are now known to be available. . . ."

The need was clear-cut, the reasons behind it were well defined, and the need could be considered with little concern for large simultaneous improvements in other quantities. This was probably the last time that major measurement needs in the field could be so clearly and succinctly summarized.

Since 1944, electronics has enjoyed spectacular growth in both size and scope. Its importance in new, extreme, and complex environments means continual pressure for extending the useful range of electromagnetic energy. This in turn means continual and substantial pressure for improving the art of radio measurement—to higher frequencies, to different magnitudes (both high and low), and always with greater accuracies.

This pressure for the extension of radio measurements is augmented by the swift application of new discoveries. It is well known that the lag time between the discovery and application of major developments is swiftly decreasing; over 50 years for electric power generation, about 4 years for the transistor, about 19 months for the laser. A consequence of this acceleration is that new standards are desired barely moments after discovery.

**Effects of a measurement gap**

With the need for better standards, more standards, and the rapid development of standards, it is not surprising that technology sometimes outstrips the science of radio measurement. It should also come as no surprise that this lack of measurement creates spectacular problems. Usually, however, these problems are not recognized as being the result of inadequate measurement, for standards of measurement tend to remain hidden in the background.

Since 1960, NBS has been meeting with members of the Aerospace Industries Association to compare industry's measurement needs with the services offered by NBS. This has helped define the needs more precisely and has provided some measure of their relative urgency. The meetings have also uncovered many specific illustrations of how industry is affected when a standard of measurement does not exist—when there is a measurement gap. Some of the effects are:

- Disagreement between contractor and subcontractor as to whether a product meets specifications.
- Poor reliability.
- Excessive time required to produce equipment by trial and error since, if the component characteristics are unknown, it is impossible to predict performance accurately.
- Need to overdesign to be sure the product will do the job.
- Schedule delays caused by unacceptable components and systems.
- Duplication of effort.
The dramatic quality of our national defense and space programs, and the fact that most unsatisfied customers of the Radio Standards Laboratory are tied to these programs, may create the feeling that improved electromagnetic standards need only concern those whose work is related to the defense and space efforts. It should be apparent, however, that better measurement in these areas affects the entire national economy.

The National Aeronautics and Space Administration has estimated that about 90 per cent of space systems failures are electronic; it seems reasonable to assume that a portion of these are due to inadequate measurement.

While visiting our laboratory last year, H. L. Balderston of the Boeing Aircraft Corp. referred to the early (1952–1954) flights of the Bomarc missile which occurred before the Department of Defense was insisting that weapons systems be tested by instruments whose calibration was directly traceable to the U.S. standards at NBS. None of the first six test flights was completely successful. The next missile, thoroughly tested with measurement traceability, was the first Bomarc that accomplished all flight test objectives and marked the turning point in a successful flight test program.

Obviously it is important to both industry and the taxpayers that the expense of these programs be kept at a minimum by the very best measurements we are able to provide. And experience shows that meeting the extreme demands of advanced technologies often provides the ability to meet similar needs as they develop in such fields as telephone, radio, television, electric power, and industrial process control.

Fig. 1. Evolution of a national standard. Improvements in the accuracy of the U.S. national frequency standard (A). New cesium beam standard (also usable with thallium) was built and is now being evaluated by the NBS Radio Standards Laboratory (B). Its 18-foot length should reduce spectral line width to about 45 cycles as compared with 110 cycles in the previous 10-foot model, and should increase precision significantly. Improved frequency stability of WWV due to control by low-frequency broadcasts from WWVB and WWVL (C).

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<td>Fundamental relativistic experiments</td>
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<td>Deep space research and development</td>
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<td>National and international frequency standards</td>
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<td>National coordination of standards laboratories</td>
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<td>Aerospace research and development laboratories</td>
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<td>Automatically controlled clocks</td>
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How a national standard is developed

The pressure for new and more accurate standards of electromagnetic measurement means that the Radio Standards Laboratory is continually faced with requests for crash development. This pressure provides an exciting stimulus, but it has forced the staff to concentrate on developing calibration services at the expense of national standards of measurement.

A standard of measurement grows from fundamental research. It evolves through theoretical work that applies the fundamental principle to a particular measurement problem. It matures as the instrumentation and procedures that provide a standard, and finally a calibration service, are developed and evaluated.

Development of a national standard is illustrated by the evolution of the United States Frequency Standard, presently obtained from cesium atomic beams. The fundamental research on which these machines are founded was done by Rabi and his associates about 1940. NBS published early research results of the development of an atomic frequency standard in 1949, and the first machine began reliable operation in 1957. But this machine was not accepted as a standard until a second one was completed and independently evaluated.

The independent testing of each machine, together with a comparison of their frequencies over a period of three years, establishes our confidence in the quoted accuracy with respect to the idealized atomic transition frequency (about 1 part in $10^{13}$) and precision (about 2 parts in $10^{13}$ for a 12-hour averaging time). What these machines mean in the evolution of the U.S. Frequency Standards is shown in Fig. 1(A).

Now the staff is evaluating a new cesium beam, Fig. 1(B), which is longer and therefore should be more precise. They have also developed thallium beams to evaluate their potential as frequency standards, and are exploring the possibility of using lasers.

During development of the cesium beams, the staff was also concerned with making the frequency standard available to others. The instabilities of high-frequency propagation require averaging the signals from station WWV for a period of up to 30 days to achieve a precision of 1 part in $10^{10}$ (the usual, quite attainable precision is only about 1 part in $10^6$), and reliable reception is limited to a few thousand miles. In 1959, several major organizations, including NASA, requested much higher accuracies over most of the globe.

The Laboratory began an experimental broadcast at 60 kc/s, WWVB, in 1956. Although the radiated power was only 2 watts, this did meet the needs of some specialized users by offering higher precision over shorter measuring periods. For precise measurement, however, 60-kc/s transmission is effectively limited to the continental United States.

In April 1960, the Laboratory began broadcasting with another experimental station, WWVL, at 20 kc/s. WWVL was located in the mountains near Boulder, Colorado. With a radiated power of only 15 watts, it was received as far away as New Zealand and verified predictions of the NBS Central Radio Propagation Laboratory that 20 kc/s was suitable for stable global transmissions. Since 1961, WWVL and WWVB have been controlling WWV in Maryland and WWVH in Hawaii. The improvement this provided in the frequency control of WWV can be seen in Fig. 1(C).

In 1963, both the 60- and 20-kc/s stations began broadcasting with larger antennas and more powerful transmitters from a new site near Fort Collins, Colorado. The radiated power was increased to about 1 kW for WWVL and to about 7 kW for WWVB. The 60-kc/s transmission includes time signals that will offer a precision ranging from a ten-thousandth to a millionth of a second (depending on distance from the transmitter) which is 10 to 1000 times more stable than the signals from WWV. The WWVL 20-kc/s transmission is being used to extend experimental studies required to provide accurate time signals, clock synchronization, and frequency transmission with very narrow band signals over much of the globe.

Besides the creation and dissemination of standards, another major responsibility of the Radio Standards Laboratory is the international comparison of standards. In the area of frequency standards, this responsibility has been met by comparisons made through propagation data among the Bureau standards, four commercial cesium standards in the United States and one in France, the British standard at the National Physical Laboratory, the Canadian standard at the National Research Council, and the Swiss standard at Neuchâtel.

The performance of these various standards has led to international consideration of redefining the unit of time in terms of an atomic transition. The ephemeris second, the presently accepted astronomically based unit, is now recognized as inadequate for precision measurement, and a change to a definition of the second based on atomic properties will probably follow. The choice of a particular atom and a particular transition, the experimental conditions under which this transition is observed, and the assignment of a particular frequency to this transition, will be based on scientific results of the next few years.

The standard of frequency is unique in two ways: the unit of frequency is directly related to the unit defined for one of the six basic physical quantities (length, mass, time, current, temperature, and luminous intensity) in terms of which the units for all other physical quantities are defined; and it is the one standard disseminated by broadcast.

Usually, the chain of derivation extending from a basic physical quantity is quite lengthy and complex and requires meticulous care in analysis and, usually, dissemination is accomplished through the calibration of interlaboratory standards by the NBS Electronic Calibration Center. Otherwise, the various steps in the development of the atomic frequency standards are representative of the evolution of each national standard of measurement.

Dimensionality of radio measurements

Even those working in electronics seldom realize the number of national standards involved in electromagnetic measurements. Figure 2 illustrates three “dimensions” of this work. The front plane shows the variety of standards required to measure power at various frequencies and magnitudes. Succeeding planes show the various quantities of electromagnetic measurement—each requiring an entirely new family of standards.

One must imagine a fourth dimension to this graph to indicate the various activities required in the development of each standard—research, development, and distribution. Finally, a fifth dimension is involved in that the equipment sometimes must operate in a variety of tem-
peratures, applied fields, or other environmental parameters.

The scope of this multidimensional space is obviously so big that the Laboratory cannot hope to fill the entire volume. We therefore do our best to recognize key anchor points, and upon these to erect a network to span the various areas to a suitable degree.

Suppose, for example, that we decide that power shall be standardized only at an anchor point near one milliwatt. By standardizing attenuation for all ranges, any value of power can be referred to the one-milliwatt level with a standard attenuator. Thus the need for power standards at all other levels is eliminated.

The general areas of research and engineering at the Radio Standards Laboratory are the development and distribution of frequency standards; studies in the areas of radio and microwave materials, radio plasmas, and microwave physics; the development of high-frequency and microwave standards; and the development and calibration work of the Electronic Calibration Center. A look at work under way and at some of the services available gives an idea of the present status of radio measurement.

**Studying basic materials**

Materials research at the Laboratory is designed to acquire an understanding of the magnetic (primarily ferrimagnetic), dielectric, and conductive behavior of materials at radio and microwave frequencies, in terms of the atomic constitution and structure of matter. For example, magnetic resonance studies are being conducted to determine the magnetic energy levels, relaxation times, and transition probabilities in paramagnetic and antiferromagnetic crystals.

Specific tools and techniques are developed, such as the RF permittimeter which makes dielectric measurements without electrodes, thus avoiding dielectric and electrode interaction problems and errors.

**Probing radio plasmas**

Plasma physics is of great interest to the Laboratory because of the potential use of radio methods to char-
acterize plasmas and the potential use of plasmas as radio devices. Measurement of plasma mechanisms is complicated by the number of parameters and variables involved, and by the fact that the numerical values of these quantities cover five to ten orders of magnitude in experimental plasmas.

Because of these problems, the prevalent theories apply to rather idealized plasmas, and often it is impossible to realize physically the assumptions that are used in the theory. Research at the Laboratory is presently limited to phenomena that are associated with the macroscopic properties of plasmas generated in the laboratory, and the goal is reasonably accurate measurement of plasma parameters, variables, and mechanisms.

Exploring millimeter waves

In microwave physics the staff is concerned with the generation, detection, transmission, and measurement of millimeter- and submillimeter-wave power.

Useful devices in industry are already operating at wavelengths as short as one millimeter. Thus, sooner or later the Laboratory is sure to be called upon to make numerous measurements and to provide standards of virtually every quantity that has been of interest at longer wavelengths, especially power, attenuation, and Q. Presently the Laboratory has no measurement facilities below 3 millimeters, but we hope during the next few years to have equipment working at wavelengths as short as 0.5 millimeter.

This group is also adapting the Fabry-Perot resonator for use in refractometers, wavemeters, and resonators for masers; is in the final stages of measuring the velocity of light at millimeter wavelengths with a Michelson interferometer, and is using the Stark effect—the splitting of spectral lines by the application of electric fields—to measure dc and low-frequency voltages with very high precision.

Creating microwave and HF standards

In the sections concerned with the creation and evaluation of microwave and high-frequency standards, research is usually aimed directly at a specific measurement application. Two of the basic measurement tools of industry invented by these groups are the RF micropotentiometers for providing accurately known microvoltages at radio frequencies, Fig. 3, and an improved bolometer bridge for measuring microwave power.

Among the national standards and measurement techniques the staff has developed in recent years are systems for measuring attenuation differences up to 120 dB in the 1–300 Mc/s frequency range with an accuracy of ±0.002 to ±0.05 dB; and in the 0–50 dB range, at 10 Gc/s, with an accuracy of ±0.0001 to ±0.06 dB. These high accuracies are possible at present only as attenuation differences in a system. Measurements on attenuators that must be inserted into the measurement system are more limited in accuracy due to mismatch errors. Reflection coefficients of 0.1 are measured to an accuracy of 1 part in 1000. These are the best values currently available, and are higher than the accuracies offered on a regular calibration basis.

Providing calibration services

NBS working standards for quantities in the high-frequency and microwave regions are established and maintained in the Electronic Calibration Center. Here the Laboratory provides those calibration services which are in sufficient demand to justify the development of instrumentation. Special calibrations not available through the Center can sometimes be arranged, but these

Fig. 3. Micropotentiometer operates on a simple principle: a known current is fed into a known very low resistance (one or more milli-ohms), and the potential drop across the resistance gives a voltage that can be precisely calibrated. Primary purpose is to provide accurate microvolts for checking standard-voltage generators or for use directly as a standard-voltage generator at all frequencies to 1 Gc/s.
may require time-consuming research and thus be quite expensive.

The Electricity Division of NBS, in Washington, D.C. is primarily responsible for standards and calibrations in the low-frequency region (below about 30 kc/s), but the Center also provides the low-frequency calibrations that are in greatest demand.

About half the Center's work load is devoted to the design and construction of the special instrumentation required to perform calibrations at optimum accuracies on a routine basis. It is interesting to note what routine means in this context. Since the Center calibrates interlaboratory standards for the nation's top standards laboratories in terms of the national standards, it is obvious that its shop-level calibrations carry a profound responsibility.

At high frequencies (30 kc/s to 300 Mc/s), the Center is equipped to calibrate standards of voltage, power, impedance, attenuation, and field strength. These standards are at present limited to those designed for continuous-wave measurements and those having coaxial terminals. For most quantities, calibration services are offered at the fixed frequencies of 30, 100, and 300 kc/s; and at 1, 3, 10, 30, 100, and 300 Mc/s. Continuous-frequency coverage is provided where feasible, but such calibration equipment is usually less stable and less accurate than that used at the fixed frequencies.

Microwave calibration facilities are being provided at the Center for the measurement of power, impedance, attenuation, and noise power. The initial goal is to cover the frequency range from 300 to 40 000 Mc/s for all quantities. For one quantity—the frequency of cavity wavemeters—the Center provides a calibration service to 75 000 Mc/s.

Examples of developments in this area include an improved measurement system for microwave impedance (reflection coefficient) calibrations based on reflectometer principles, and an improved microwave radiometer for use in measuring the noise temperatures of microwave sources.

The calibration workload of the Center, see Fig. 4, shows a dip in man-hours during 1962. This is largely attributable to a more efficient calibration program adopted by the Navy which reduces the number of standards sent to NBS for calibration. The upturn during 1963 is the result of some of the new services being offered by the Center.

Measurement needs of the future

To assist in planning for the future, the Radio Standards Laboratory staff has prepared a set of accuracy charts that summarize the state of the art, including existing national standards and calibration services, its five-year goals in national standards and calibrations, and the approximate present measurement needs of industry.

One example of such a chart is Fig. 5 showing microwave power standards in waveguide systems. It shows that at X band (8.2–12.4 Gc/s) a national standard exists in the neighborhood of 10^{-2} to 10^{-3} watt, to an accuracy of one part in 1000, and that this exceeds most of the present needs at this magnitude and frequency. At lower powers there is a continuing loss of accuracy until it is no better than 10 per cent at 1 microwatt. There is also a loss

Fig. 4. Calibration man-hours, by fiscal year, of the NBS Electronic Calibration Center. The dips and upturns evident in some of the curves are explained in the text.
Fig. 5. Accuracy sheet shows existing and proposed national standards and calibration serv-
ices, and the present measurement needs of industry.

Accuracy, one part in

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<th>Frequency</th>
<th>Existing capability</th>
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<td>1 MHz</td>
<td>0.1 ppm</td>
<td>0.05 ppm</td>
</tr>
<tr>
<td>10 MHz</td>
<td>0.5 ppm</td>
<td>0.25 ppm</td>
</tr>
<tr>
<td>100 MHz</td>
<td>1 ppm</td>
<td>0.5 ppm</td>
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The national standards program is being developed to meet the needs of industry and research. The goal is to provide a high level of accuracy and reliability in frequency standards and calibration services. The diagram illustrates the current and proposed capabilities for different frequency bands.

The National Institute of Standards and Technology (NIST) is responsible for establishing and maintaining the national frequency standards. These standards are used in various applications, including communication, navigation, and scientific research. The accuracy requirements for different applications vary, and NIST works to meet these needs through ongoing research and development.

The figure shows the current state of the art in frequency standard technology, highlighting the progress made in increasing the accuracy and reliability of these standards. The proposed improvements indicate ongoing efforts to further enhance the capabilities of the national frequency standards program.

The accuracy of frequency standards is crucial for many applications, and NIST plays a key role in ensuring that these standards meet the needs of industry and research. The diagram provides a visual representation of the current and proposed capabilities, illustrating the advancements in frequency standards technology.
lasers as, for example, measurements of the elements of the third-order tensor giving the nonlinear electric polarization of a material resulting from the application of two intense electric fields.

Other laser standards that are likely to be required, and which we are preparing to investigate, are power, spectral purity, directivity, quantum efficiency of mixers and harmonic generators, power dissipating ability, mode determination, modulation, and noise level. During the next five years, the staff plans to consider the use of double heterodyning systems for measuring attenuation, power, or other quantities at laser frequencies, and laser control by lower frequencies through phase or frequency lock.

The effect of quantum electronics upon radio science has grown until now it overshadows almost all of our future planning. In many projects it is the dominant area of study. For example, a group in materials research is working to establish material constants and characteristics that will provide energy level information for solid-state microwave and millimeter-wave applications. Development has begun on an antiferromagnetic resonance spectrometer, and preliminary antiferromagnetic resonance measurements are being made on systems with low Néel temperatures such as CuSO₄ and CoSO₄ (anhydrous). During the next few years, the group expects to extend these measurements to many more systems such as the double fluorides KMnF₃ (M = Mn, Fe, Co, or Ni) and MnTe, MnSe, and MnSb—including those with higher Néel temperatures.

In the area of nonlinear dielectrics, the Laboratory is beginning the development of a measurement technology to determine the material characteristics of ferro, ferri, and antiferroelectrics under a variety of control parameters. Classes of materials must be investigated for special characteristics such as domain structure and relaxation processes, and the investigations and measurement technology must be extended to optical frequencies. Special needs in this area include knowledge of materials sensitive to thermal environments, development of synthesized specimens of controlled structure and composition, and development of optical measurement equipment.

A goal that underlies all of this work is to increase the accuracy and reproducibility provided by our present macroscopic standards by developing standards (such as the atomic beams) based on atomic or molecular phenomena. Therefore we are increasing our studies into the possibility of deriving electromagnetic standards from such phenomena as the Zeeman effect, the Stark effect, Larmor precession, electron–proton resonance, and nuclear magnetic resonance.

**Closing the measurement gap**

In considering which steps can best help the Radio Standards Laboratory meet its responsibilities, the most obvious is one of selection: the weeding out of measurement needs that can be met by commercial laboratories, and the careful assignment of priority to the work that remains. This is being done, and already a substantial portion of proposed work has been eliminated.

Another possible step is to substitute precision for accuracy. Consider, for example, the cycle of events that has occurred in evolving the length standard. At first the standard of length was to be one ten-millionth of the quadrant of the meridian passing through Paris. Conceptually, this was very satisfying, but in practice it was inconvenient to use. Therefore an arbitrary standard, the meter bar, was adopted because it could be used with much higher precision.

Next the meter bar as a standard was replaced by the wavelength of krypton, at a temperature of the triple point of nitrogen. This is conceptually much more satisfying than the arbitrary meter. It now appears possible that by going to an oscillating laser we will have a standard of length that is much more precise than the krypton wavelength, but its unperturbed value may not be known with such absolute certainty. We might then arbitrarily adopt a laser oscillating under specified conditions as a more convenient standard than the krypton lamp.

The Laboratory is in a similar position with respect to Q factor. We have a bank of standard coils with which
other unknown coils can be compared more precisely than their $Q$ factor can be stated in terms of the ratio of energy stored to power dissipated per cycle.

Thus where precision exists with respect to existing arbitrary apparatus, we might quote the results of NBS tests with respect to the "standard of X" as maintained at NBS with, for example, a precision of comparison of perhaps one part in $10^4$ and with an accuracy with respect to the international standards of perhaps one part in $10^6$.

This would be analogous to the present situation for frequency in which an unknown frequency source can be compared to the national standard of frequency with a precision of one part in $10^{12}$, but the accuracy of the national standard of frequency with respect to the internationally accepted standard of time is only one part in $10^9$. This anomalous situation occurs because the internationally accepted standard of time (based on astronomical units) is very imprecise, although by definition it is infinitely accurate.

However, the substitution of precision for accuracy and the careful selection of priority do not strike at the heart of the problem, and the program of fundamental development which remains is sobering.

The main curves in Fig. 6 show (1) the annual factory sales of the electronic industry and (2) the annual expenditures of the NBS Radio Standards Laboratory—expenditures which provide the national basis of measurement for this industry. The secondary curves, identified on the figure, show expenditures in related areas.

Figure 7 gives (1) the ratio, since 1946, of the cumulative expenditures of the Radio Standards Laboratory to the cumulative factory sales of the electronics industry, and (2) the ratio of the annual expenditures of the Radio Standards Laboratory to the annual industry sales.

It is clear that there was a period of relatively low support for radio standards, and that in recent years this support has increased. The cumulative effect of the drop in support is seen in the curve which shows cumulative expenditures of the Laboratory relative to industry sales. This curve, which falls below the one showing the relative yearly ratios, indicates the possibility of a backlog of unmet demands.

To explore this situation, the Radio Standards Laboratory has analyzed current needs reported to the Laboratory and has estimated the effort it will take to meet these needs at a rapid but realistic rate of development. The needs in question were made as specific as possible by asking each company or organization involved to define the reason (application) for a reported need, and to estimate the required accuracy at particular points of magnitude and frequency.

These studies indicate a requirement for a significant enlargement in the program of the Radio Standards Laboratory if the very real and expressed needs of the industry are to be met in a realistically determined length of time. Significant enlargement means increases of the order of 30 per cent per year for several years.

This would be a challenge to any organization; it is a particular challenge to a government laboratory devoted to scientific research, whose basic product is knowledge or applied science in which advancement is recorded in the movement of a decimal point.

APPENDIX

Sources of information for Figs. 6 and 7 are the Electronic Industries Association and the National Science Foundation. The estimate that factory sales of the electronic industry will total $25$ billion by 1970 is from R. R. Dockson, "The Electronics Industry and the Dynamic Los Angeles Metropolitan Area," Growth Pattern Study No. 4, of the Union Bank, Los Angeles, 1962. The early expenditures of the Radio Standards Laboratory are shown dashed (Fig. 6) since it is difficult to isolate the work in radio standards from other radio research being conducted by NBS at that time. The Laboratory expenditures are expressed in fiscal years while all of the other values are in calendar years; the six-month offset between fiscal and calendar values is ignored. The 1964 figure for the Laboratory is an estimate as of September 1, 1963.
B. M. Oliver (F) was born in Santa Cruz, Calif., on May 27, 1916. He received the B.A. degree in electrical engineering from Stanford University in 1935 and the M.S. degree from the California Institute of Technology, Pasadena, in 1936. Following a year of study in Germany under an exchange scholarship, he returned to the California Institute of Technology where in 1940 he received the Ph.D. degree. From 1939 to 1952 he was employed at the Bell Telephone Laboratories, Murray Hill, N.J., in television research and radar development. He is now vice-president in charge of research and development at the Hewlett-Packard Company, Palo Alto, Calif. Dr. Oliver served as Vice-President of IEEE during 1963 and is a member of the American Astronautical Society.

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W. E. Taylor attended Purdue University and was awarded the B.S. degree in metallurgical engineering in 1942 and the Ph.D. degree in metallurgical engineering in 1950. While associated with Oak Ridge National Laboratory he undertook solid-state research in metals. He has taught metallurgy at Purdue University and the University of Tennessee. He formerly held the position of manager of material processes at Motorola's Semiconductor Products Division, where he is now manager of materials and microwave devices. For two years he was a professor at Michigan State University's Department of Metallurgical Engineering. He is a member of AIME and the American Physical Society.

J. C. Haenichen (A) attended Massachusetts Institute of Technology and received the B.S. degree in electrical engineering in 1958 and the M.S. degree in electrical engineering in 1959. He joined Motorola in 1959, where he has worked on the development of high-frequency silicon planar transistors for amplifier and switching applications, as well as original device design and process development of silicon mesa and planar transistors. In his present position as manager of new silicon device operations, he is responsible for the development and pilot production of all new devices whose feasibility and profitability have been established. Mr. Haenichen is a member of Tau Beta Pi and Eta Kappa Nu.

W. C. Davis (below) received the B.Ch.E. from Rensselaer Polytechnic Institute in 1950. At Sylvania and CBS Laboratories he worked on the development of black-and-white and color television tubes, and power transistors, respectively. He joined Motorola's Semiconductor Products Division in 1960, and at present is product manager for silicon controlled rectifiers.

G. B. Finn received the M.S. degree in physics from the University of Notre Dame in 1950. He has done considerable work in solar cells, silicon rectifiers, and germanium and silicon materials at Sylvania Electric Products, Silicon Corp. of America, Sarkes-Tarzian, Inc., and International Rectifier Corp. He joined Motorola in 1961 and is now manager of operations for diodes and rectifiers.
Alfred N. Goldsmith (F, L) noted radio, motion picture, and television inventor, devoted most of his early years to teaching at the College of the City of New York after receiving the B.S. degree there in 1907. He later received the Ph.D. degree from Columbia University in 1911. With the formation of RCA in 1919, he became director of research and later vice-president. He has been an independent consultant since 1933. Among other notable achievements, his work led to the first commercial radio with built-in speaker, and to the first commercial color television tube. A cofounder of IRE in 1912, Dr. Goldsmith served as President for 1 year, Secretary for 10, Editor and Editor Emeritus for 49, and Director for all 50 years of IRE's existence. He is now Editor Emeritus and Director Emeritus of IEEE and holds two of its major awards, the Medal of Honor and the Founders Award. Among many other honors and awards, he is a Fellow of six societies, an Eminent Member of Eta Kappa Nu, and a Life Member of the New York Medico-Surgical Society.

Wright H. Huntley, Jr. (M) was born in Loma Linda, Calif., on November 5, 1932. He received the A.B. degree in management engineering from Claremont Men's College and the B.S. degree in electrical engineering from Stanford University in 1958. From 1950 to 1954 he was on active duty in the U.S. Air Force as technical instructor in air-borne radar and electronic warfare. In 1955 he was employed by the Naval Ordnance Laboratory, Corona, Calif., in development of missile fuze systems. He has been with Stanford Electronics Laboratories since 1956, and is now research associate in the Systems Technique Laboratory. His activities have included design and development of scanning microwave antenna arrays, research in high-speed color display techniques, and electronic warfare subsystem research and development. He is now investigating possible applications of coherent light to aerospace problems.

J. J. W. Brown (SM) received the B.S. degree in electrical engineering from Purdue University in 1940. Following graduation, he joined the General Electric Company's test program. In 1941 he was assigned to the Aeronautics and Marine Engineering Department, and worked successively on servo and fire control systems, as liaison engineer to the MIT Radiation Laboratory, and as a design engineer on computers. Among other positions at General Electric, he was manager of materials handling and test equipment engineering and manager of the direct conversion projects operation. He is now manager of the power systems engineering operation. He is a member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi, and the Instrument Society of America.

E. M. Hunter (F, L) received the B.S. degree in 1926 and E.E. degree in 1930 from Worcester Polytechnic Institute, and the M.S. degree in electrical engineering from Union College in 1931. He joined the General Electric Company in 1925. He has had a number of managerial assignments in electric utility application engineering operations. His present position, that of manager of power transmission engineering in the power systems engineering operation, includes responsibility for ac transmission, high-voltage dc transmission, and the administration of the transmission laboratory at Project EHV in Pittsfield, Mass. Mr. Hunter is a member of Tau Beta Pi, Sigma Xi, NEMA, CIGRE, and the International Electrotechnical Commission.

John M. Richardson (SM) was born in Rock Island, Ill., on September 5, 1921. He received the B.A. degree in physics from the University of Colorado in 1942 and the M.A. and Ph.D. degrees in physics from Harvard University in 1947 and 1951, respectively. He served in the U.S. Naval Reserve from 1943 to 1946 on the staff of various electronics officer training schools. He was subsequently employed by the Denver Research Institute. Since 1952 he has been with the National Bureau of Standards, his work there has been in microwave physics, including microwave spectroscopy and interferometry, as well as the physics of ionized gases. His present position is chief of the Radio Standards Laboratory. He is a Fellow of the American Physical Society, Fellow of the American Association for the Advancement of Science, member of Commission I of the International Scientific Radio Union, and member of Sigma Xi.

James F. Brockman was born in Hong Kong, China, on November 9, 1924, and came to the United States in 1929. He received the B.A. degree from Yale University, New Haven, Conn., in 1949. Mr. Brockman joined the Boulder Laboratories of the National Bureau of Standards as an information specialist in the Technical Information Office. Since 1961 he has been assigned to the Bureau's Radio Standards Laboratory. He is at present teaching a course in technical writing in the graduate school of the NBS Boulder Laboratories, and is serving as the executive secretary of the 1964 Conference on Precision Electromagnetic Measurements, jointly sponsored by IEEE and NBS.
Scanning the issues

Submillimeter Wave Research. While appearing to be a specialized area, this has one of the broadest technical bases that can be imagined for a problem of scientific and practical interest. Almost every known phenomenon in physics has been examined for possible application to the problem of generating, transmitting, and detecting coherent ultramicro-wave energy.

Subject areas include classical electronics, quantum electronics, semiconductors, solid state, ferrites, ferroelectrics, field emission, tunneling, superconductors, physical optics, electromagnetic theory, acoustics, relativistic physics, nonlinear phenomena, plasmas, and spectroscopy.

The Millimeter and Submillimeter Conference held by the IEEE last year in Orlando, Fla., provided an excellent opportunity to assess the present state of the art and to review recent progress in this field. This was done in an excellent survey paper presented at the conference. The survey showed that unfortunately the situation with regard to submillimeter waves has not appreciably altered in the last four years. While several new ideas in the ultramicrowave area have appeared, the major effort has been in applying new technology to previously suggested ideas. This effort has yielded substantial progress but, as yet, no breakthrough on the problem.

An area of particular interest is the generation of millimeter and submillimeter waves by Cerenkov radiation effects. In the last four years, more experimental work on the Cerenkov problem to reduce principles to practice has been performed than at any previous time. It has now been demonstrated that the Cerenkov interaction, which is also a traveling-wave interaction, can be as strong as that in conventional tubes. Thus, the present state of the Cerenkov art is that, under the appropriate conditions, this interaction can be relatively strong and the efficiency of the devices

be made comparable to microwave tubes. With appropriate techniques, it is conceivable that a CW Cerenkov device operating at 200 kV is practical. With an appropriate feedback system, it may even be made into a self-excited source.

Yet, while substantial progress in this and other areas has been made, especially in technology in the last few years, the submillimeter wave problem appears as formidable as ever and no major new idea has yet been recognized. (P. D. Coleman, "State of the Art: Background and Recent Developments—Millimeter and Submillimeter Waves," IEEE Trans. on Microwave Theory and Techniques, September 1963.)

Four-Dimensional Antennas. The use of time as a fourth dimension in the design of antennas, first suggested about five years ago, is showing promise of becoming an important method for improving their performance. Recent tests with an experimental time-modulated array has yielded impressive results.

In the experiments, an array of eight equally spaced slot radiators was connected to a series of on-off switches which were programmed to operate automatically in certain sequences. For example, in one sequence, the outer pairs of radiators were successively switched off until only the inner pair of radiators was operating. The cycle was repeated at a 10 kc/s rate. Thus the length of the array was time modulated, going in quick succession from an 8- to a 6-, 4-, and finally a 2-element array.

The net effect was to produce in quick succession a series of radiation patterns in such a way that the side lobes of one would be partially cancelled by the minimums of another when averaged over a number of cycles. The patterns shown in the accompanying illustrations are indicative of the substantial side-lobe reduction that is obtained with this technique. It is quite literally true that, in the jargon of Madison Avenue, "a new dimension has been added" to antenna design and performance; namely, time. (W. H. Kummer, A. T. Villeneuve, T. S. Fong, and F. G. Terrio, "Ultra-Low Side lobes from Time-Modulated Arrays," IEEE Trans. on Antennas and Propagation, November 1963.)

The Posistor. The advent of semiconductor components and their widespread use in circuits brought with it an increased need for temperature compensated devices. Fortuitously, the same technology that gave rise to the transistor also made it possible to produce elements whose resistance varied with temperature. As a result, the thermistor has been widely used for this purpose for a number of years.

The dominant need in the past has been for elements that displayed a negative resistance-vs.-temperature characteristic. The thermistor is therefore normally regarded as a negative coefficient
device. However, a new type of thermistor has now appeared on the scene which has a large positive resistance-temperature characteristic. The new component has been appropriately dubbed a “posistor.”

The posistor consists of barium titanate ceramics whose resistance has been markedly reduced by doping with certain elements. A typical characteristic curve, given in the accompanying illustration, shows that the posistor has a negative characteristic at low temperatures (below $T_p$) and also at high temperatures (above $T_x$), with a pronounced positive characteristic between $T_p$ and $T_x$ which reaches a maximum slope at $T_M$. In typical posistors, $T_p$ would occur near room temperature, $T_M$ at from 50 to 130°C, and $T_x$ at 180°C or above.

As the first resistive component to exhibit a large positive temperature coefficient of resistance, the posistor is certain to find wide application as a thermal sensing element, a temperature control device, and a heat dissipater for electrical and electronic apparatus. (O. Saburi and K. Wakino, “Processing Techniques and Applications of Positive Temperature Coefficient Thermistors,” IEEE Trans. on Component Parts, June 1963.)

Solid-State Networks. The enormous solid-state technology spawned by the transistor has had a heavy impact on the science and art of electrical and electronics engineering in many diverse ways. Most of the fields thus affected are readily identifiable and well known, even to the casual observer. But in a few instances the influence of solid-state developments has been outwardly less apparent, albeit inwardly just as profound.

Not the least of these is the field of network theory. The convenience and effectiveness of the transistor and the tunnel diode as active elements have resulted in the development of a whole new area of network theory in the past decade, generally known as “active networks.” It is also worthy of note that the introduction of the transistor has done more to close the gap between network theory and practical circuit design than any other development in the past 30 years.

But as invention is sometimes the mother of necessity, so it is that progress in solid-state electronics has brought with it an even greater need for closer cooperation between the network theorist and the circuit designer. Most significant of all, a third party is now becoming intimately involved—the device designer.

In another area of potential importance, present network synthesis procedures assume that the circuit elements available to the designer have the exact values called for by the synthesis calculations. But such is not the case. The fabrication process, especially for solid-state devices, inevitably introduces significant variations in device characteristics, and gives rise to problems of tolerances and probability distributions.

Today’s microelectronic circuit designer needs better procedures for coping with production tolerances and improved methods for selecting component values.

Perhaps most interesting of all is the possibility that the network specialists of tomorrow will move out well beyond the boundaries of conventional passive and active network theory and turn their attention to such matters as constraints on circuit performance (such as power consumption), optimization of performance measures, and properties of materials—an area which might be designated as “multivariable network theory.” In so doing, it will no longer be enough to describe networks in terms of their electric and magnetic properties. In the systems of the future it will be necessary to deal with acoustical, mechanical, optical, and thermal effects.

Whatever specific developments the future brings, it is clear that the time has passed when one can treat solid-state electronics design as a combination of devices with lumped elements to achieve particular functions. A broader approach is required in which one simultaneously designs an active device and the particular environment in which it will operate—an approach that will depend on a strong cooperative network development effort. (J. H. Mulligan, Jr., “The Role of Network Theory in Solid-State Electronics—Accomplishments and Future Challenges,” IEEE Trans. on Circuit Theory, September 1963.)

Multiplex Pioneer. Multiplex telephony first saw service in 1918 with the inauguration of a high-frequency carrier-current system between Baltimore and Pittsburgh that was capable of carrying five conversations simultaneously over the same pair of wires. This event can be counted among the major milestones of the communication field. It may surprise some to learn that efforts to develop a multiplex system date back as far as the early 1890s. An account has just been published concerning one of the very first of these efforts on the part of John Stone, revealing the unusual and previously unreported circumstances under which he got some of his many worthwhile ideas.

Stone is not as well known to the present generation as he ought to be. Mathematician, physicist, electrical engineer, inventor, and above all a brilliant scholar, he was a towering figure whose work had great influence—probably more than that of any other single individual—in stimulating an early interest in radio experimentation and development within the United States. Of particular interest to IEEE members is the fact that in 1907 he organized the world’s first radio engineering society, the Society of Wireless Telegraph Engineers, which five years later merged with the Wireless Institute to form the IRE. A charter member of the IRE, Stone served as its Vice-President in 1914 and President in 1915.

The paper just published enables readers to become better acquainted with a great pioneer and with one of his many important contributions in the field of high-frequency electricity. More than that, the author provides hitherto unavailable information of historical interest which complements and supplements the epochal Colpitts-Blackwell carrier paper which appeared in the 1921 AIEE TRANSACTIONS. Finally, the episode related here provides a vivid example of the dreams and difficulties experienced by an inventor and the frustration of being ahead of his time. For, in order to become a practical reality, multiplex telephony had to wait two decades for the invention of the band filter and the vacuum-tube oscillator and amplifier. (J. Blanchard, “A Pioneering Attempt at Multiplex Telephony,” Proc. IEE, December, 1963.)
Advance abstracts

The IEEE publications listed and abstracted below will be published in the near future. Information on prices can be obtained from IEEE, Box A, Lenox Hill Station, New York, N.Y. 10021.

Proceedings of the IEEE

Vol. 52, no. 1, January 1964

A Survey of Ionospheric Effects upon Earth-Space Radio Propagation—R. S. Lawrence, C. G. Little, H. J. A. Chivers—The frequency dependence is derived and the order of magnitude is presented for various ionospheric effects upon radio waves which have frequencies greater than the penetration frequencies of the ionosphere. Among the phenomena considered are phase-path length changes, refraction, frequency change, group-path delay, polarization rotation, and absorption. A detailed discussion is given of the magnitude and variability of ionospheric absorption, refraction, scintillations, and polarization changes.

Signal Detection With a Laser Amplifier—Herbert A. Steiner—The use of signal-to-noise ratio as a figure of merit for a signal detection system involving a threshold detector may lead to erroneous conclusions when the signal strength, in absolute terms, is small. Recourse to approximations or exact distributions must be made and the notion of statistical separability must be reappraised. A new figure of merit utilizing the idea of statistical separation is defined. The method is applied to the question of the efficiency of a laser amplifier in a pulse detection system.

Consequences of Symmetry in a Periodic Structure—P. J. Crepeau, P. R. McIsaac—Periodic guiding or radiating structures at microwave frequencies often possess symmetry properties in addition to their axial periodicity. These include reflection and rotation symmetries, either separate alone or in conjunction with translations. These symmetries influence the characteristics of the electromagnetic fields associated with the structures. Therefore, useful information concerning the fields can be obtained from the symmetry properties without resorting to detailed field solutions or to equivalents. These symmetry properties are conveniently analyzed by introducing symmetry operators for which the structure is invariant.

This paper shows that two symmetry operators, the screw and the glide, are particularly important in determining the dispersion characteristics of the structures. Some of the implications of these symmetries for leaky wave antennas and microwave tube interaction circuits are explored, and their consequences are examined to facilitate the analysis and synthesis of periodic microwave structures.

An Analysis of Corona-Generated Interference in Aircraft—R. L. Tanner, J. E. Nanovic—Triboelectric charging, occurring when an aircraft is operated in precipitation, raises the aircraft potential until corona discharges occur from points of high dc field on the aircraft. These corona discharges generate noise which is coupled into receiving systems. The magnitude and spectral distribution of this radio interference, called precipitation static, depends upon three factors: (1) the strength and spectral characteristics of the source discharges; (2) the manner in which the disturbances produced by the discharges couple into the antennas; and (3) the magnitude of the discharge current and its distribution among the discharging extremities.

The coupling between the antenna and the noise source is discussed utilizing a reciprocity relationship. Because the geometry of an aircraft is complicated, and a purely theoretical approach to the determination of coupling factors is not possible, a technique developed for measuring absolute values of coupling factor as a function of frequency and position on the aircraft is described.

The spectral character of the corona-noise source is studied, including a study of how the source spectrum varies.

To test the validity of the theory and the results of the laboratory work, calculations are made to predict the noise currents induced in the two test antennas employed in a flight-test program conducted on the Boeing 367-80 aircraft (prototype of the KC-135 and 707). The results of these predictions are compared with the noise spectra measured in flight.

Some Techniques for the Elimination of Corona Discharge Noise in Aircraft Antennas—J. E. Nanovic, R. L. Tanner—Theories of noise generation and coupling are applied to the problem of devising techniques for the elimination of precipitation static interference in aircraft. The logical consequences of the theory are employed in devising several versions of a decoupled discharge capable of providing precipitation static noise reduction of 60 dB. The performance of four decoupling techniques is determined and successful flight tests of the dischargers are described. Various proposed discharger designs are considered in light of the coupling theory, and their performance when tested in the laboratory is discussed. Several antenna designs capable of providing precipitation static reduction on vehicles which do not permit discharger installation are proposed and tested in the laboratory. Electronic techniques for reducing precipitation static interference by operating on the signal at the receiver are considered.

Although many of the proposed precipitation-static-elimination techniques are not entirely satisfactory, the decoupled dischargers and decoupled antennas work well enough so that precipitation static interference need not pose a problem under flight conditions normally encountered.

Conservation of Coupling Between Modes of Propagation—a Tabular Summary—Casper W. Barnes—There are four distinct ways in which two modes of propagation can be coupled comparatively; i.e., coupled so that the total amplitudes satisfy either a power conservation law or a Manley-Rowe relation. The type of coupling that results in any particular case depends upon the relative parities of the modes, the relative directions of the group velocities and, in the case of parametric coupling, the relative magnitudes of the frequencies of the two modes. Each of these four types of coupling results in a distinct and characteristic type of behavior.

A set of tables is presented that summarize the principal characteristics of the four distinct types of coupling for both direct and parametric coupling.

Correspondence

A Content Addressable Distributed Logic Memory with Applications to Information Retrieval—E. S. Spiegelhal—A New Sensitive Method for Gain Measurements—K. Hasegawa, O. Nishino
A Low Inductance Tuned Diodc Mount—M. V. Schneider
Pulse-Time Modulation and Frequency Modulation Using the Step Recovery Diode—K. Hussein, T. Inamune
Post amplifier Noise Temperature Contributions in a Low-Noise Receiving System—C. T. Stelzried
Studies Concerning the Piezoelectric Control of an Electronbeam Display—Y. Yamamoto, J. Frost
Noise in Magnetron Injection Guns—R. P. Wadhw
Electrochemical Nerve Models as “Neurors”—R. M. Stewart
Physical Nature of the Doppler-Frequency Spectrum from a Rotating Planet and its Effect on Detection—E. O. Willoughby
Ferroresonant Effect Caused by Nonlinear Loaders—A. Korpel, V. Ramaswamy
A High Current Density Brillouin-Focused Electron Beam—L. Kakushina, C. C. Johnson
Content-Addressable Distributed-Logic Memories—R. P. Edwards
Relationships Between Kinds of Network Parameters. Not Assuming Reciprocity or Equality of the Waveguide or Transmission Line Characteristic Impedances—R. W. Beatty, D. M. Kerns
Periodic Discontinuities in a Transmission Line—Jose Perini
Some Properties of a Group of Co-Phased Wave Antennas—R. F. Keister
Collector Depletion Region Transit Time—F. N. Trofimenkoff, O. Nakahara
Experiment on Quasi-Fundamental Mode Oscillation of Ruby Laser—Y. Suematsu, K. Iga
A Parametric Amplifier with Double-Tuned Idler Circuit—W. Heinlein
Optimum Control of Digital Systems Subject to Saturation—Julius T. Tau
High-Performance Field-Effect Transistors Formed by Redistribution—D. A. Hodges
Laser-Emission from a Moving Ruby Rod—I. Free, A. Korpel
Electrohydrography—Albert H. Taylor
Amplitude Modulation of Light by Reverse Biased p-n Junctions—C. A. Rento
Loessless Beam Combination for Optical Heterodyning—A. E. Siegman, B. J. McMurty
WWV and WWVH Standard Frequency and Time Transmissions—National Bureau of Standards
Magnetic Tuning of CW InSb Diode Laser—P. J. Phelan, Jr., R. H. Rediker
Predicted signal geometry: Obtaining a More Highly Collimated Light Beam of Greater Intensity from GaAs Lasers—Francis Harper
Silicon Carbide Diode Lasers—R. N. Hall
Zener’s Maximum Efficiency Derived from Irreversible Thermodynamics—Jose M. Borrego
A Mechanical Model for Fitzgerald Contraction—Lewis Epstein
Optically-Induced Ultrasonic Waves in Transparent Dielectrics—A. J. DeMaria
Impulse Response Stability Criteria—R. W. Newcomb
Audio-Frequency Characterization of Radar-Absorbing Material—L. C. Lynnworth
Comment on the Transient Phenomenon in an Isotropic Plasma without Collision Loss—Charles M. Knop
Comment on “Microwave Measurement of Conductivity and Diadic Constant of Semiconductors”—D. A. Holmes, D. L. Feucht
Sampling Properties and Bandwidth Occupancy of Signal Envelopes—Horst Vorbeck
Further Discussion of “Aperature - to - Medium Coupling Loss”—H. Staras, C. A. Parry
Some Statistic Results for Distance-Measuring Equipment—E. A. Harrison
The Variable-Drift Biased-Gap Klystron—Ibrahim Hefni
Immittance Charts with Negative Real Parts—A. B. McNaughton, J. G. West
A Technique for Measuring the Spectral Density Matrix of Two Signals—David R. Brillinger
The Broad-Band Signal Response of a Phase-Steered Linear Receiving Array—W. B. Adams
Optical Heterodyning Using Point Contact Germanium Diodes—C. N. Patel, W. M. Sharpless
Optimum Size of Radio Astronomy Antennas—F. D. Drake

IEEE Transactions on Information Theory

Vol. IT-10, no. 1, January 1964

The Extension to Probability Distributions for Detection with Spatial Filters W. D. Montgomery—The idea of extending partial descriptions to a probability density function on a minimum information (maximum entropy) basis is applied in the context of detection with spatial filters; i.e., filters with two-dimensional input and output used for detection. Several two-dimensional moment descriptions are thus extended; moment descriptions are worked out in detail.

Time-Frequency Duality Phillip Bell—A concept of duality is developed, called time-frequency duality, which is applicable to a class of networks called communication signal-processing networks. Such networks consist of an interconnection of basic elements such as filters, mixers, delay lines, etc. The usefulness of time-frequency duality stems from the fact that two partly different and in a sense noncommuting systems have identical behavior patterns except for an interchange of roles played by time and frequency. As a result, the solution to a detection or information problem may be found directly from the solution of the dual problem, if known, merely by replacing variables and quantities by their duals. This application of time-frequency duality is illustrated in the problem of measuring the transfer function of a scatter medium by means of an optimal gating operation prior to spectrum analysis.

Another approach to time-frequency duality, the generation of new ideas for communication signal-processing techniques, is illustrated by the dual of the Kineplex communication system. A third benefit is the insight gained from a change of viewpoint—illustrated by the characteristic of time-variant linear channels. Such channels may be characterized in an interesting symmetrical manner in time and frequency variables by defining dual system functions.

Coding for and Decomposition of Two-Way Channels Frederick Jelinek—A discrete memoryless two-way channel is defined by a set of transmission probabilities P(\( y \mid x, x \)), where \( x \) and \( y \) are the transmitted signals, and \( x \) and \( y \) are the received signals. Shannon showed that if \( x \) and \( y \) are generated independently and without regard to the past, then the rates (R) of information transmitted through the opposite channel directions will lie in a region \( G_T \) of the plane. The problem of whether the regions \( G_T \) of the past are allowed to influence the selection of the input signals is investigated. Two-way channels are analyzed to determine the statistical characteristics of matching source signals.

Error Analysis of a Statistical Decision Method R. Altman—A procedure is developed for the recognition of patterns as members of certain classes that the probability distributions of certain characteristic features are known. Bounds on the statistical error are derived for a decision based on the maximum likelihood criterion. These bounds are evaluated in the case of normal distribution and assumed independent features. Conditions are given under which the error tends to zero as the number of characteristic features goes to infinity.

Transmitted-Reference Techniques for Random or Unknown Channels C. K. Rushforth—A particular approach to the problem of communicating in certain random or unknown channels is considered. A set of signals is chosen, each member of which is partitioned into a known primary portion and a message signal. The channel is assumed to be linear, and divided into a multiplicitive and an additive portion. The primary portion is assumed to have the same response to both message and reference components, while the additive noises are independent, the signal and reference component. The channel outputs and the additive noises are further assumed to be Gaussian.

Under these circumstances, the optimum receiver is shown to cross-correlate the message portion of the received signal with a filtered version of the posterior mean of the channel output, which is merely a filtered combination of the prior mean and the perturbed reference signal. This is an interesting extension of the optimum receiver to the case of additive Gaussian noise. Several special cases are considered which yield additional insight into the operation of the optimum receiver.

A Note on Power-Law Devices and their Effect on Signal-to-Noise Ratio C. N. Berglund—The effect of power-law devices, used as either band-pass nonlinear amplifiers or envelope detectors, on the signal-to-noise ratio is determined for both limiting cases of very large and very small signal-to-noise ratios. Parameters are derived for the degradation in S/N in terms of the envelopes and phases of the signal and noise. The results hold for Gaussian and non-Gaussian noises and modulated and unmodulated signals, and allow important conclusions to be reached concerning the value of power-law devices in communications systems in various signal and noise environments.

It is found that band-pass nonlinear amplifiers can generally be chosen to improve the S/N if the input S/N ratio is small and the noise is non-Gaussian. In this case such filters usually degrade the S/N since they exhibit a "small-signal suppression" effect in all noise environments except in the case of unmodulated sine-wave interference.

Unified Analysis of Certain Cofherent and Non-Cofherent Binary Communications System Seymour Stein—A general result is presented for the error rate performance of common binary signaling-detectors. The concepts of certain and noncoherent detection (generalized to all noncoherent detection systems utilizing two basic waveforms) and phase-shift keying with a noisy reference signal (generalized to all coherent detection systems utilizing a single basic waveform) are introduced. The unified result is achieved by exploiting a fundamental relationship between noncoherent and coherent operation. Additionally, some useful results not without cost are presented.

The Design of FM Pulse Compression Signals Evert N. Fowler—This paper gives a procedure for designing an FM signal of arbitrary envelope shape so that it will have a specified spectral modulus, and hence a specified autocorrelation function. The design procedure, which is based upon an approximate analysis, gives not only the duration-bandwidth product of the signal but the envelope of the signal, and the modulus of the signal spectrum.

The Autocorrelation Function of the Output of a Nonlinear Angle-Modulator P. H. Wittke—Calculating the autocorrelation function of the output of a randomly frequency-modulated oscillator with a nonlinear tuning characteristic is similar to calculating the characteristic function of a functional of the form \( f(\hat{\theta}(t), y(t)) \). This functional has arisen in a number of other stochastic problems, and so the techniques which have been applied to these problems may be used to determine the autocorrelation function of this functional. For example, if \( f \) is a first approach to a nonlinear frequency modulator, a linear plus square-law modulator characteristic and a Gaussian modulating signal are assumed, a technique similar to that used in the analysis of the square-law detector by Kac and Siegert, and extended to this case, is applied. Then an expression for the autocorrelation function of the oscillator output is obtained in terms of two Gaussian integrals. For an important class of kernels, these equations may be solved and the autocorrelation function evaluated. As an example, the calculation is carried out for a low-
pass modulating signal. Results for phase modulation are also included.

An Estimate of the Variation of a Band-Limited Process A. Papoulis—Upper and lower bounds are established for the mean-square variation of a certain process $X(t)$. The power spectrum is bounded by $\omega_0$, terms of its average power $P_0$ and the average power $P_1$ of its derivative. It is shown that

$$\sigma^2 = \frac{1}{2\pi} \int_{-\infty}^{\infty} \left| X(\omega) \right|^2 d\omega$$

where the upper bounds are valid for any $r$ and the lower bounds when $r > 0$. These estimates are applied to the mean-square variation of the envelope of a quasi-monomonic process.

On a Class of Cyclically Permutable Error-Correcting Codes Peter G. Neumann—Cyclically permutable codes have error-correcting properties which are preserved by the cyclic permutation of any of their code words. Results are summarized of an empirical investigation of certain of these codes, which have been considered by the authors in a previous paper by E. N. Gilbert. These codes are thought to be fairly nearly optimal. Estimates of the number of code words are also given. The codes may be suitable for use in certain asynchronous multiplex communication systems.

Coherent Extraction of Signals from Turbulent Noise D. H. Tack, R. E. Ziener, R. F. Lambert—Results are reported of some theoretical and experimental studies on the extraction of signals from convecting and decaying fluid dynamic turbulent noise. An analog correlation receiver was used. An extension of the theory of correlator analysis for finite observation times to the case of a linear time-varying delay is presented. Detailed study of the time and variational characteristics of the output signal from a correlation receiver permits a prediction of the signal-to-noise ratio in the receiver and its dependence upon various fluid dynamic fluctuation, signal, and correlator parameters. The gain in S/N for periodic and Gaussian random signals in extraction from turbulent noise is found to depend upon (i) a ratio of correlation lengths involving several statistical properties of the turbulence obtained from a model of the space-time correlation structure, (ii) a characteristic frequency to a characteristic frequency of the turbulence; (iii) a time bandwidth product associated with the effective finite averaging time of the correlator and a characteristic frequency of the convolution of the S/N spectra.

Experimental studies in a subsonic wind tunnel employing acoustic signals are in good agreement with theoretical predictions of the gain in S/N ratio. Some receiver design considerations emerge from the analysis; of special interest are the influence of linear scanning and ranging and the finite lifetime of the turbulence on the required averaging process.

Several Classes of Codes Generated from Orthogonal Functions P. Hsieh, M. Y. Hsiai—A method of designing codes from orthogonal functions utilizing the existing knowledge of discrete error-correcting binary codes is given. The method consists in constructing the transformation matrix, $\left[ a_{ij} \right]$, that performs the linear transformation by taking the finite set of orthogonal functions into the set of continuous code words. Several classes of code words are found that have $a_{ij}$ transformation matrices $[ a_{ij} ]$ use symbols 0, $-1$, 1, and each row of which contains equal numbers of a's and b's. The number of these codes is greater than the randomly found existing codes in the sense that with the same number of orthogonal functions and distance criteria, more code words can be obtained.

IEEE Transactions on Microwave Theory and Techniques Vol. MTT-12, no. 1, January 1964

On Stripline Y-Circulation of UHF H. Bosma—The simplified boundary value problem of the circular stripline Y-circulator is stated and described. Results are summarized. The calculation parameters are calculated and discussed. The frequency characteristics are evaluated and a general method for making the device bandwidth presented. From the calculated and measured field distribution, an explanatory description of the circulation mechanism is given. Finally, in addition, some experimental results are presented and the features for use at UHF are discussed.

A Technique for the Design of Multiplexers Having Contiguous Channels Edward G. Cristal, G. L. Matthaei—An example of a simple, efficient comb-line filter having contiguous channel frequency bands is presented. This procedure, the individual channel band-pass filters are designed low-pass prototype filters and their harmonic frequencies at one end only. The use of parallel-connected band-pass filters designed in this fashion, along with a simple prototype network, is shown to be capable of giving a near constant input conductance across the operating band of a multiplexer. A three-channel design example using comb-line band-pass filters was tested out and its input admittance and attenuation characteristics were computed. This design was also constructed and a computer and experimental results demonstrate the validity of the theory.

Four-Port Crossed-Waveguide Junction Circulat- ers L. E. Davis, M. D. Coleman, J. J. Cotter—A detailed account is given of the experimental investigation which has led to the design of four-port circulators at frequencies from 2.5 to 25 Gc/s. The complex behavior of these devices is clarified by establishing the modes of circulation in any particular waveguide passband. The modes are defined in terms of their characteristic fields $H$ required, the microwave frequency $f$ and the direction of circulation. The theoretical characteristic field is computed for four-port junctions and the experimental results demonstrate the validity of the theory.

Some Aspects of the Design of Wideband Up-Converters and Non-Degenerate Parametric Amplifiers W. J. Getinger, G. L. Matthaei—Practical design of the diode resonator amplifier is seen to be extremely important if large bandwidth is desired in a varactor-diode parametric amplifier. Case-by-case study of the diode-resonating circuit at a frequency between the frequencies of the signal input and the sideband resonances, are examined in some detail. It is shown that the frequency of this intermediate resonance can greatly influence the bandwidth capabilities of an amplifier design, and the optimum frequency of a resonance is given for various wideband upconverters. The optimum frequency of such a resonance is greatly different if the diode is resonated in series than if it is the diode is resonated in shunt. It is believed that the same results would also apply for lower sideband upconverters and non-degenerate parametric amplifiers. Some upconverter designs were worked out and their computed responses are given including the effects of all of the parasitic elements of the diode resonator circuits. The widths of the order of an octave are obtained. A systematic design procedure is given for wide-band non-degenerate parametric amplifiers which use the diode resonator circuit of the idler termination. Some designs of this type were also worked out and their computed responses (including effects of all of the parasitic diode parameters) are presented. Bandwidths...

A Universal Wall-CURRENT Detector F. C. de Rond—A universal X-band waveguide detector has been developed which offers the possibilities of a broadband untuned detector with a tunable frequency. The wall-current detector is a reflectionless two-ports with an insertion loss, not less than 0.65 dB, between X-band phase shift, 10 mV/mW and a frequency characteristic which repeats within ±0.15 dB over the whole X-band. Such a result many frequency dependent measurements can now be done automatically with reasonable precision. Fluctuators and reflectometers will be simplified, resulting in a higher precision.

A sum detector and a difference detector have been made. They can be used for phase-sensitive detection, zero measurements, etc.

The wall-current detector can easily be scaled down to millimeter waves.

The exact design of the Wideband Upconverters and Non-Degenerate Parametric Amplifiers W. J. Getinger, G. L. Matthaei—Practical design of the diode resonator amplifier is seen to be extremely important if large bandwidth is desired in a varactor-diode parametric amplifier. Case-by-case study of the diode-resonating circuit at a frequency between the frequencies of the signal input and the sideband resonances, are examined in some detail. It is shown that the frequency of this intermediate resonance can greatly influence the bandwidth capabilities of an amplifier design, and the optimum frequency of a resonance is given for various wideband upconverters. The optimum frequency of such a resonance is greatly different if the diode is resonated in series than if it is the diode is resonated in shunt. It is believed that the same results would also apply for lower sideband upconverters and non-degenerate parametric amplifiers. Some upconverter designs were worked out and their computed responses are given including the effects of all of the parasitic elements of the diode resonator circuits. The widths of the order of an octave are obtained. A systematic design procedure is given for wide-band non-degenerate parametric amplifiers which use the diode resonator circuit of the idler termination. Some designs of this type were also worked out and their computed responses (including effects of all of the parasitic parameters) are presented. Bandwidths...
as large as 33 per cent are obtained depending on the peak gain and operating frequency range of the designed amplifier.

Microwave Breakdown Near a Hot Surface M. Gilden, J. Pergola—Microwave breakdown near a hot surface in a waveguide system was studied to determine breakdown dependence upon the thickness of the adjacent film of hot gas and its associated temperatures. The effect of the variation of the film thickness with the flow rate on the bulk of the gas was of particular interest. To carry out the theoretical analysis, a more general breakdown equation was derived to take into account the temperature gradients. Experimental results supporting the theory are presented.

The study shows that, although the breakdown in a waveguide system is lowered by the presence of a hot surface, a sufficiently rapid flow of the bulk gas tends to restore the field as a result of the reduction in the thickness of the film of hot gas. This effect occurs in addition to that reduction resulting from cooling the surface.

First-Order Theory for Oblate and Prolate Anisotropic Artificial Dielectrics R. C. Leach*—Lumped circuit expressions for the electric permittivity and magnetic permeability tensors of artificial dielectrics are derived. These are expressed as functions of particle size, density, and dielectric constant, as well as a function of the incident electromagnetic beam direction with respect to the orientation of the dielectric. Only the case of a uniform density of equally oriented particles is considered. The results are valid in first order for the prolate and oblate spheroids.

Spheres and disks are obtained as limiting cases.

Octave Bandwidth Tunnel-Diode Amplifier Jack H. Lepofl, Gehron J. Wheeler—Tunnel-diode amplifiers are limited in bandwidth by stability problems and by the bandwidth of available circulators. The stability problem is solved by using an amplifier circuit with steep gain skirts. Then, as the circuit reflections arise outside the operating frequency band, the gain drops below the level needed to sustain oscillations.

Three tunnel-diode amplifiers for the frequency ranges 2 to 3 Gc/s and 3 to 4 Gc/s are combined with hybrids and low-pass filters to provide an octave bandwidth amplifier. The octave bandwidth is based on the techniques of band-pass filter techniques. The gain exceeds 10 dB over this band with noise figure better than 4 db.

The Investigation of an Electron Resonance Spectrometer Utilizing a Generalized Feedback Microwave Oscillator John B. Payne, III—An approach entirely different from the usual is taken toward the development of a “self-stabilized” paramagnetic resonance (EPR) spectrometer system that eliminates the usual low-power klystron oscillator, the electronic-frequency-stabilizing equipment, and the complex superheterodyne detector without sacrificing sensitivity. This system, which is known as an oscillator-spectrometer, consists of a microwave amplifier containing a simple-carrying network element in the positive feedback loop. The microwave device oscillates at the network's central resonant frequency with essentially instantaneous frequency stability. Expressions relating the change in power level and frequency of oscillation as a function of the change in the network attenuation and phase at magnetic resonance are derived. The system’s ultimate sensitivity is determined by analyzing the noise within the oscillator loop. In general, the noise level is minimized by the detection of the resonance signal is principally generated by the amplifier, and thus a simple video detector can be used. The sensitivity of this spectrometer was found to be comparable with that of the conventional bridge-type spectrometer.

The Application of the Focused Fabry-Perot Resonance-Analysis Method to Diagnostics R. Primich, R. A. Hayami—The use of a focused Fabry-Perot resonator at microwave frequencies for plasma diagnostics is discussed. It is shown that corrections for changes in sensitivity in the measurements of the properties of transparent plasmas and dielectrics of two to three orders in magnitude can be expected. Losses have been indicated. It is indicated that under certain circumstances, re-fractive index changes in the gaseous environment may be significant and that measuring these changes is included. The extension of the techniques to the optical part of the spectrum is shown to be promising. Experimental results, obtained with the use of a cavity at 70 Gc/s, are presented and appear to confirm the main predicted features.

Exact Design of Band-Stop Microwave Filters B. M. Schiffman, G. L. Matthaeus—An exact method for the design of band-stop filters that adapts synthesis techniques developed by Ozaki and Ishii is discussed. This method places no theoretical limit on the width of the stop band, though for reasons different (but equivalent) circuit configurations are used for stop bands of different widths. These configurations for band having previously included open-circuited stubs separated by lengths of line; a second form using resonators that are separate from the main line but parallel to it, so that coupling takes place by way of fringing fields; and a third form in which the resonators are attached directly to the main line, but are folded parallel to it so that coupling is both by direct connection and by fringing fields. Easy-to-use formulas are given for the exact design of band-stop filters from low-pass filters, and equations are given for converting from one filter structure to any of the other equivalent forms. The experimental results of trial designs are presented.

A Harmonic Rejection Filter Designed by an Exact Method Bernard M. Schiffman—An exact design procedure for band-stop filters is used to design a transmission-line filter with one point of infinite harmonic frequency and one point of infinite attenuation at a harmonic frequency. This design method is based on the generalizing of the response of a low-pass prototype into a transmission-line filter. Here a three-element Chebyshev filter is chosen as the prototype and the otherwise generally obtained expressions for the special case of rejection of the second harmonic.

A High-Power Waveguide Waveguide Joint P. H. Smith, G. H. Mongold—A conceptually new type of contactless multichannel rotary waveguide joint is described. Power-handling capability without pressurization excesses that of the associated waveguides. Electrical features include elimination of impedance and phase variations with rotation, exceptionally low loss and power leakage. Operation is possible over a 10 per cent frequency band with a maximum SWR of 1.15.

Experimental results on a C-band model are given. Both electrical and mechanical design features are presented for a compactly folded design for operation at multi-megawatt peak power.

Theory of a Strip-Line Cavity for Measurement of Dielectric Constants and Gyromagnetic-Resonance Line Widths R. A. Waldron—The cavity consists of a half-wavelength or wavelength of strip line, short-circuited at both ends, and open along the sides. For measuring properties of samples, it has two apparent advantages over the more usual coaxial line method; the sample is simpler in shape, and it can be inserted without inserting a vacuum cavity. Perturbation formulas are obtained for the frequency shift and change of Q on inserting a sample into a position of zero electric or zero magnetic field. The Q of the cavity in the absence of a sample is calculated by a perturbation method. The limiting sample size for a given accuracy to be obtained is also discussed.

Exact Design of TEM Microwave Networks Using Quarter-Wave Lines R. J. Weissinger—Modern network theory procedures, based on Ozaki-Ishii synthesis techniques, are reviewed for application in the synthesis of the practical microwave networks using parallel coupled bars or series and shunt stubs, or both. The circuit equivalences and identities obtained are theoretically valid over the entire frequency spectrum and lead to several physical configurations having identical response functions. These equivalent circuits often allow simplification of the physical circuitry and realization of both broad and narrow bandwidths. The problem of practical circuit configurations is discussed from the viewpoint of obtaining a wide range of circuit element values. Neglecting multiple responses, TEM low-pass high-pass and band-pass Butterworth filters are shown to offer steeper band edge characteristics than those of the corresponding lumped element filters. The use of complementary filters to match a source and load over a wide frequency range and TEM realizations of these complements are obtained. A simple procedure for obtaining element values is described. The first complete examples is described. An analysis of parallel coupled filters is made and a simplified equivalent circuit is obtained. An exact synthesis procedure for parallel coupled filters and their equivalent form is given. Construction details and experimental results are described for two filters which use series stubs.

On the Synthesis of Dual-Resonant Coaxial Cavities F. M. Wultz—Mathematical analyses of multi-cavity transmission lines predict the possibility of shifting one of the spurious resonant frequencies (present in all coaxial cavities) to a desired frequency, thus allowing one cavity to do the work of two. The specific problem considered is the design of cavities to resonate a terminating capacitance (e.g., tube electrode). "Varactor resonator," "varactor cavity," two harmonically related frequencies, with the additional requirement that two of the resonances remain nearly independent. This model will offer wide variations in the magnitude of the terminating capacitance. (As one obvious application, a cavity meeting these requirements would make possible an inherently aligned single-cavity frequency multiplier.)

Curves based on computed results for specific cases are presented. Experimental cavities constructed according to the predicted designs have exhibited performance which is in very close agreement with the analysis, thus verifying both the validity of the method of analysis and the feasibility of the desired result. Application of the same techniques to other applications of parallel-cavity problems (e.g., single-cavity mixers, voltage-tube filters) are suggested.

IEEE Transactions

Vol. BME-10, no. 4, October 1963

Electromagnetic Determination of Carotid Blood Flow in the Anesthetized Rat P. Cox, H. Arora, A. Kolin—The design and performance and an described of the small-sized wire electromagnetic flow transducer built to date. The design is miniaturized as to the total volume of the device as well as the size of the artery it
accommodates. The use of this transducer for recording of blood flow in the smallest species of animal employed until now in blood flow research was made possible by the use of plasmochemical observations in anesthetized rats are presented.

Improved Transducer for External Recording of Arterial Pulse Waves M. David, B. Gilmore, E. Frei—This paper describes a new instrument for frequency response for recording arterial pulse waveforms. It uses a fluid-filled chamber and a stiff diaphragm to which a shunt of semiconductor strain gauges are cemented.

An Analysis of Desmedt’s Titration Procedure H. Hirsch—The “titration” procedure reviewed together with its application to the auditory system of the cat. The relevant portion of the auditory system is described by a mathematical model, and calculations based on it show the merit of titration over the direct observation of a stimulus–response ratio. The model yields a good approximation to Desmedt’s experimental titration data.

The Locus Concept and its Application to Neural Analogs E. R. Lewis—A new approach to analog simulation and study of the neuron is proposed. This approach is based on recent evidence indicating that the individual nerve cell is functionally much more complex than the classical view of a synaptic region coupled directly to a spike or impulse. At least two different regions are involved. One provides a reliable low-frequency tuning or pacemaker function; the other provides nonlinear amplification of both the synaptic and the pacemaker potentials. In addition, the synaptic regions have been found to provide a large variety of intracellular phenomena. In the view now held by many physiologists, the spatial distribution of these functionally distinct regions within a single neuron determines its information-processing capabilities.

The behavior of each of the functionally distinct regions of the neuron is discussed. Simple transistor circuits which may be used to simulate individual regions are also described. Groups of these circuits may be connected to form analogs of the entire neuron or any part thereof. Special emphasis is placed here on the synaptic functions, with only a cursory discussion given for the other regions.

Design of a Mechanical Cardiovascular Simulator Peter M. Newgard—Results are presented of a study to determine design values for a basic hydraulic parameters of a mechanical pulse duplicator that reproduces as many as possible of the significant source and load characteristics.

The method of approach was, first, to investigate the physiological system to determine what parameters are important to the production of the dynamic pressure–flow situation in the vicinity of the heart valves. A conceptual mechanical design was then developed that would use these same parameters to model the source and load characteristics. Finally, an electronic analog computer was used to find design variables of the conceptual model and test its response as compared to published data on response of the human cardiovascular system.

Design values are given in tabular form. Waveform recordings of system responses are shown, along with similar recordings reported in the literature, and comparisons are made.

A Method of Measuring Eye Movement Using a Selerometer, S. Collin in a Magnetic Field David A. Robinson—With the subject exposed to an alternating magnetic field, eye position may be accurately recorded from the voltage generated in a coil of wire embedded in a scleral contact lens worn by the subject. With the use of two magnetic fields in quadrature phase and two coils on the lens, the horizontal, vertical, and torsional eye movements may be measured simultaneously. The instrument described has an accuracy and linearity of about 2° at a vibration of 15 seconds of arc and a bandwidth of 1000 c/s.

Electronically Controlled Stage for Systematic Scanning of Microscopic Areas E. J. Reger, E. A. Tonna—An instrument has been developed to scan automatically a microscopic area for high-resolution observation of light-transmitting properties of biological materials on the cellular and subcellular levels.

The specimen may be viewed through an aperture that varies with the microscope both visually and electronically while the slide is electronically manipulated to scan a rectangular area, the shape and width of which are independently adjustable from 5 to 100 µm.

The slide is swept back and forth horizontally at a uniform rate that is adjustable from 0.4 to 4 µm per second. At the end of each horizontal sweep it is moved vertically by an adjustable step of 0.2 to 10 µm. The scanning process enters automatically unless the selected area has been passed.

The stage motion is produced by thermal expansion and contraction in tungsten wires through which the controlled heating currents are passed. Precise control of the velocity and position of the stage is achieved by the use of feedback systems to control the heating currents so that they are equalized, and therefore their temperatures, are accurately related to the values of analog control voltages. The relation between the horizontal and vertical stage displacements and the controlling voltages is linear within the precision of an ocular micrometer.

The Magneto-cardiogram—A New Approach to the Fields Surrounding the Heart Robert A. Streutker and Claire A. Sisson—Experiments have been conducted which reveal the existence of a detectable magnetic field associated with cardiac electrical activity. The relationship between the magnetic record and the electrocardiogram has been explored, and it is shown that under certain conditions of axis orientation the voltage induced into a toroidal sensing element around the heart has the form of the first time derivative of the electrocardiogram. A formula based on this principle has been developed to relate these two phenomena.

IEEE Transactions on Ultrasonics Engineering
Vol. UE-10, no. 3, December 1963

Spurious Signals Resulting from Second Longitudinal Mode Propagation in Stepped-Thickness Dispersive Strip Delay Lines R. E. Dean, H. G. Forbes—A mode ultrasonic strip delay line, there will exist, for a given frequency, a cutoff thickness below which propagation of the second longitudinal mode is not possible. The design of thickness-tapered ultrasonic strip delay lines to synthesize a linear delay-vs.-frequency characteristic frequently yields a cutoff condition requiring one or more thicknesses near or above the cutoff thickness of the second longitudinal mode. Delay lines fabricated from such designs having an end section capable of propagating the second longitudinal mode show a strong spurious signal appearing at frequencies above the cutoff frequency of the second longitudinal mode for that end section. The resulting spurious signals can be generated in any of several ways, depending upon the delay-line configuration and the manner of operation. The two essential features involved in all of the methods of generation are a conversion of energy between the first and second longitudinal modes and a reflection of the second longitudinal mode at cutoff. Clarification of the mechanisms producing the spurious signals has been useful in identifying which signals were first observed and, in addition, a new type of delay line has been designed which employs the second longitudinal mode near cutoff.

Effect of One Megacycle Ultrasound on the Genetics of Mice Edward B. Kirsten, Hans H. Zittel, John M. Robinson—The ages of one to seven days were radiated at a frequency of 1 Mc/s for a total time of about 1 minute. When bodily radiation was administered, both continuously and in brief pulses, at intensities ranging from 1/2 to 4 watts/cm². Ultrasound burning and paralysis were noted directly following radiation and appeared indiscriminately among the mice radiated at one power level. These disorders were found to be not only a function of intensity but were also dependent upon the age at time of radiation. The unaffected mice were bred brother-cross-sister for six litters with the average litter size being comparable with that of the control group.

The Sonar of the Sea Lion Thomas C. Poulter—W. Windthrop Kellogg has shown that the porpoise uses a system of sonar for purposes of navigation, feeding, avoidance of predators, and locating other porpoises. The author has observed some totally blind sea lions in their natural habitat over a period of two years and has found that they apparently remain in a good physical condition as animals with normal vision. Recordings were therefore made of the underwater signals produced by the fur seal, harbor seal, elephant seal, Steller sea lion, and California sea lions that were obtained from all of these species were found to be suitable for purposes of echo location. The California sea lion was therefore selected for study and it was found that it is capable of locating small pieces of fish in a tank in darkness just as rapidly as in daylight. An extensive analysis of the sea lion’s signals reveals an amazing sophistication of echoing techniques.

Trends and Problems in Sonar Transducer Design Ralph S. Woollett—The postwar trend to long-range sonars has led to the use of lower frequencies with correspondingly larger transducers in transducer size, to greater power, and to greater depths than were common in World War II transducers. The large high-power sources are currently formed as arrays of small transducers, but the acoustic interaction effects among these small transducers may cause severe problems, particularly when the transducers have high efficiency. The great depth requirement rules out the use of so-called “pressure-release” materials for sound isolation purposes, and the other means have to be developed to prevent destructive interference between out-of-phase vibrating elements. The application of this concept permits the use of adjustable, and hydroacoustic transducers to some of these problems is described.

IEEE Transactions on Electron Devices
Vol. ED-11, no. 2, February 1964

Transistor Noise at Low Temperatures W. C. Brunecky, E. R. Chenert, R. van der Ziel—It is shown that the shot noise theory of transistors holds for low temperatures in alloy junction transistors, provided that the effect of hole-electron pair recombination in the emitter
transition region is taken into account. The discrepancy between theory and experiment reported by Lee and Kaminsky can be accounted for by the fact that this process was ignored.

Nonlinear Theory for Laser Diodes A. C. Scott—This paper outlines a nonlinear theory for the output power vs. excitation current of an injection-doped laser diode. The dependence upon electric field amplitude of effective negative conductivity in the region of inverted population is derived and used to determine the level of steady oscillation in the quasi-linear approximation (nonlinear conduction current small compared with displacement current). This level is simply related to the output power. A field-dependent negative-conduction current is derived from the negative conductivity which indicates that at a certain approximation, the presence of two modes with the same polarization will be an unstable situation; one mode will grow at the expense of the other.

Nonlinear Theory for Laser Diodes A. C. Scott—This paper outlines a nonlinear theory for the output power vs. excitation current of an injection-doped laser diode. The dependence upon electric field amplitude of effective negative conductivity in the region of inverted population is derived and used to determine the level of steady oscillation in the quasi-linear approximation (nonlinear conduction current small compared with displacement current). This level is simply related to the output power. A field-dependent negative-conduction current is derived from the negative conductivity which indicates that at a certain approximation, the presence of two modes with the same polarization will be an unstable situation; one mode will grow at the expense of the other.

IEEE Transactions on Reliability

Vol. R-12, no. 4, December 1963

On the Reliability of a Worst Case Designed Nonredundant Circuit

Richard C. Dubes—Two algorithms are developed for finding the time-dependent reliability of any active-redundant system in terms of component failure probabilities. These algorithms apply to nonloaded continuously operating systems in which drift-type failures are neglected.

The first algorithm is used when each component can fail in only one mode. A procedure, based on the Quine-McCluskey technique from switching circuit theory, is stated in conjunction with this algorithm which permits rapid simulation of important system behavior. Two failure modes are permitted in the second algorithm. The relation between the expressions for the reliability expressions and the reliability probability that the system is nonredundant is given so that the algorithms do not depend on specific component failure distributions.

Optimizing Trade-Offs of Reliability vs. Weight

D. P. Herron—The necessary mathematical conditions are derived for maximizing system reliability for a given system weight or minimizing system weight for a given reliability. Cost may also be introduced. Several efficient methods of calculation are reviewed for determining the optimized reliability–weight relations.

Failure Concepts in Reliability Theory Robert A. Kirkman—Reduction and control of failures in electronics systems are essential because of (1) the need for maximum safety of personnel on exotic missions, (2) the long unattended life required of space systems, and (3) the high dollar costs to buy additional systems and support additional maintenance personnel required to compensate for the unreliability and system down-time.

As practiced in military organizations, efforts to reduce failures of parts by design controls and conventional statistical reliability methods are a necessary condition of reliability, but not a sufficient one.

For clarity and background, present reliability and failure-rate theory and practices are reviewed briefly and some limitations pointed out. The physics and mechanisms of actual failures are discussed. It is pointed out that failures follow the laws of cause and effect; they are therefore intrinsically predictable. The concept of random failures is valid in a statistical sense but it should not discourage efforts to predict and prevent individual failure by all means open to us. Use of limit state failure prevention is a thorough system test prior to use when the test is geared to look for failures where they should not appear.

Lack of precision in terminology is part of the problem of failure control: we commonly interne ong interferences to failures by source, by cause, by end effect of the failure. An improved organization and definition of failures are developed through which the methods, means, and limitations of failure detection, prediction, and prevention can be established.

Using the background developed, one can formulate a flexible but quantitative definition of failures in a mature system useful in their prevention, detection, and in defeating their consequences.

Approximation Formulas for Reliability With Repair Malcolm A. McGregor—A system consists of n-identical parallel subsystems, each having an exponential repair time, a failure rate that is constant, and an exponential distribution of times to repair. The system reliability with repair is the probability that more than q out of n subsystems are functioning at time t. Several formulas for the reliability of this system are derived, and an infinite series obtained, for the reliability as a function of t for any b, n, q. A numerical example is given.

Estimation, Hypothesis Testing, and Parameter Correlation for Markov Chains M. Tainiter—Four problems are discussed in statistical inference for Markov chains. Specifically, problems are described of estimation of unknown transition probabilities of first and second order stationary Markov chains, (2) test the hypothesis that a stationary Markov chain is of first order against the alternate hypothesis that the chain is of second order, and (3) test the hypothesis that a first order Markov chain has stationary transition probabilities against the alternate hypothesis that the transition probabilities are not stationary. A technique is also developed that can be used to determine under test which two parameters of a single electronic component drift independently of each other.

An Application of a Markovian Model to the Problem of the Reliability of Electronic Circuits M. Tainiter—A description is presented of how a model based on the theory of continuous-time Markov processes may be used to compute the reliability of electronic circuits, from data on the drift and failure of the individual components of the circuit. Several examples of the method are given to show that useful results are obtained.

Introduction to Cyclic Replacement Systems R. W. Winter—It is shown that there exists a certain treatment of problems akin to the classical "Swedish machine problem" is presented. Section I describes the nature of the systems known as cyclic replacement systems. In section II pertinent facts about Markov processes are gathered. Section III shows that a certain class of cyclic systems behave as homogeneous
IEEE Transactions on Power Apparatus and Systems

Vol. P-83, no. 1, January 1964

A Method for Economic Scheduling of a Combined Pumped Hydro and Steam Generating System P. J. Bernard, J. F. Dopazo, G. W. Stagg—A method is described for the optimum scheduling of pumped storage hydro in combination with a steam generating system. It also describes a computer program which determines weekly operating schedules for a pumped hydro station. The techniques developed can be used to evaluate future peaking capacity of this type and to estimate long-term operating costs for alternatives of steam and pumped storage capacity.

High-Voltage DC Transmission, General Background, and Present Technical Status A. U. Lunn—The key to practical application of high-voltage direct current for power transmission is the rectifier and inverter for high voltage required for the terminals of the dc line. The grid-controlled mercury-arc tube with grading electrodes has proved to be a suitable valve in such converters. Special features and characteristics of high-voltage converters and of the terminal stations are mentioned and projects in operation and under construction are specified. Future fields of application are discussed.

Operation and Control of High-Voltage DC Transmission System P. G. Engstrom—The special requirements on control of inverters for high-voltage dc transmission has led to a special control system, which is generally described. The cooperation between the regulators at each end of the transmission is important in order to reduce the consequences of disturbances in the converters. Also described are how the switching and blocking of valve groups are accomplished without using circuit breakers. The total protecting system in general is discussed.

Experimental Evaluation of Power-Line Carrier Propagation on a 500-kV Line D. E. Jones, B. Bzozi—The carrier frequency properties of a 40-mile section of a 500-kV transmission line have been measured. A method is presented whereby these results may be extrapolated to predict carrier operating conditions on the complete 230-mile line by making use of the principle of natural mode propagation.

Degradation of Insulating Materials by Electrical Discharges A. B. Hatherly, J. W. Heck—When discharges occur on the surface of, or in internal voids in, solid dielectrics, chemical changes in the solid and the gas take place and the solid builds up some of the damage played by chemical deterioration is clear. For example, a strained Vulcanized natural rubber, subjected to discharges in air, cracks under ozone, and attack by ozone will no longer support voltage. More commonly it is not clear if or how the chemical and physical processes are associated.

The uncertainty is apparent in the methods suggested for the measurement of discharge resistance of materials. In a British method, the time to breakeven point and peak of a charging rod and plate electrodes is used as a measure of discharge resistance. On the other hand, in some European methods, a large area of sample is exposed uniformly to discharge and the weight change or change in another property used to compare one material with another. In Artbauer’s opinion, there are objections to both methods but he favors a method based on time to breakdown.

At an international conference to mark the official opening of our Laboratories last year, Leroy, Lacoste, and Bui-Ai described the apparatus set up to determine the relationship between discharge parameters and chemical degradation of the solid. Only a few preliminary results were reported. As the system is designed to expose a maximum area of sample to discharges so that large amounts of deterioration can be accumulated in relatively short time. The study does not lend itself to measurement of the time to electrical breakdown. At the same conference the present writers reported some preliminary results using a cell designed primarily for the latter measurement, but arranged so that the chemical changes could also be measured. The object was to try to decide the importance of chemical deterioration in electrical breakdown. Some of the further work done on this investigation from which tentative conclusions can be drawn is described.

Studies of the Surge Response of Transmission Line Tower M. Kawai—A result is presented of field tests of towers whose heights are from 26 to 214 meters by the author’s new measuring method. This was agreed with those of the others. The surge characteristics of a tower were made clear by these measurements.

An Investigation of Corona Loss and Radio Interference from Transmission Line Conductors R. M. Morris, B. Rakoshada—A study of the interference (RI) from one single Drake conductor and one two-conductor bundle Drake installed on two short transmission lines has been measured at direct voltages up to 600 kV, positive and negative, under a variety of weather conditions and voltage levels. The Drake single conductor is a 1,108-inch-diameter 795-MCM (thousand circular mil) ac SR (saturable reactor) with 16-inch by 0.175-inch-diameter outer strands of aluminum. Comparisons of corona-loss performance of these two conductor systems, obtained from both short-term voltage increment tests and from long-term constant voltage tests with ground measurements, including a shielding method which substantially reduces the measurement errors ordinarilily introduced by solid insulation, is described. Results obtained from occasional surveys of RI at frequencies up to 10 Mc/s are presented.

A 4-Wire Solid-State Switching System: Numbering Plan and Signaling System A. K. Bergmann, F. H. Haferd—Signaling is simplified by the adoption of a universal numbering plan. Addressing between centers and from subscriber key sets uses the same in-hand VF combination. Station selection is accomplished with single frequency tones. For subscribers on local metallic lines, advantage is taken of the four-wire phantom for dc loop supervision and battery feed to normal subscriber instruments. Protection against fading or interruption of the trunk transmission path is achieved by a unique interlocking of all addressing and subscriber signaling, which is minimized by using a special grouping of VF combinations and timed single frequencies.

Electrical Features of the Selni Enrico Fermi Atomic Power Plant G. d’Arminio, L. Agnes, B. H. Axelsson, J. R. Hulley—The electrical features of an advanced nuclear thermal power plant under construction in Italy. The plant will utilize a pressurized water moderated and cooled reactor of advanced concept design.

Nuclear design of the EF Plant, following Yankee by several years, incorporates a number of improvements. These are fruit of intensive development, much of it based directly on Yankee performance and experience. Technical innovations are such, in fact, that the reactor system is considered as a forerunner of the latest generation of pressurized-water reactors. When operation is begun near the end of 1963, the SELN reactor will not only be the world’s largest, but will also be one of the most advanced water reactors.

Electrical Constants and Relative Capabilities of Bundled-Conductor Transmission Lines A. F. Gabriele, P. P. Marchenko, G. S. Vassell—The electrical characteristics of bundled-conductor transmission lines are analyzed in terms of the transmission capability of bundled-conductor vs. single-conductor lines. The results of the analysis are presented in the form of several graphs as well as extensive tabulations of bundled-conductor transmission line constants (inductive and capacitive reactances, surge impedances, and surge traveling-wave velocities) as a function of conductor size, bundled-conductor or intragroup spacing, number of conductors per phase, and phase separation. The range of application is such that transmission voltage classes between 69 kV and 700 kV are considered.

Engineering Design Features of the Pinard-Hammar 500-kV Transmission Line N. J. McCurrich, B. R. Murphy, M. Markowski—The engineering design features of the first 228-mile section of Ontario Hydro’s 500-kV transmission line are described. The various design criteria are discussed and reference is made to the authors’ paper on design principles and how these were used in the selection of conductor stranding and tension, tower foundations, guy systems, insulation, hardware, and grounding. Emphasis is on those aspects which are related to EHV transmission design.

Application of New Concepts to 500-kV System Insulation Coordination E. H. Gehrig, R. S. Gens, G. A. Tupper—Continuous system growth compels the designer to select transmission links with ever larger capacities and higher voltages. If the increase in the cost of facilities is kept in line with voltage, the cost of insulation in the transmission system, particularly that of solid insulation, becomes more and more pronounced as the size of the square of the voltage and consequently the cost of the component equipment increases. The most economical insulating structure for a given voltage is the one that will minimize the cost of insulation, whether it is a dielectric or a conductor. The concept of such insulation structures will be illustrated in the design of the 500-kV system.

Analysis of Power System's Power-Density Spectra J. L. Cooke—The power-density spectrum of a power system’s voltage is determined by considering it as a frequency modulation process. The load on the system is represented by a Gaussian, non-stationary, noise type of random variable. The influence of system parameters such as inertia, governor droop, servomotor time constant, and a transmission line with a sinusoidal impedance is investigated. This investigation is carried out numerically with the use of specific parameter values on a digital computer.
IEEE and American Standards

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*N. D. Kolpakov*

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Session of the A. S. Popov NTORJE (Electrical Society).

Reviews of translated articles

Radio Engineering and

Electronic Physics

Vol. 8, no. 1, January 1963

Problem of scanning in a system with a limited
number of positions—K. Sh. Zigangirov
In this article two scanning schemes for examining
a group of channels which might contain a
signal are compared. In one scheme each of
the channels is examined using a sequential
analysis technique until it is established that
the signal is present or absent. The same test is
then applied to the next channel. In the second
scheme a more complicated examination
method is proposed. The time for the opera-
tion of each method is then computed and the
second is shown to have the shorter time. This
article would have important implications to radar
problems where Doppler shifts of random nature
occur. Sequential analysis techniques have been
applied previously to determine the presence or absence of signals in radar
problems. However, this is the first time the
reviewer is aware that a multichannel case has
been discussed.—G. M. White

Electromagnetic waves in a rectangular wave-

guide with two ferrite slabs—D. N. Pokušin
This paper is concerned with the characteristics
of an ideal infinitely-conducting waveguide
with a ferrite slab of thickness D placed
along opposite walls and oriented parallel
to the electric field vector. The magnetizing
field is normal to the axis of the waveguide and is
directed parallel to the E field vector for the
TE\(_0\) mode in standard rectangular waveguide.

The author presents a summary of the
theoretical analysis of the various modes and fer-

nometric resonance of Lux, Button, Polder, and
Rado, and extends it to provide a basis for
examing the characteristics of the electro-
magnetic waves in the waveguide under various
combinations of conditions. Using an elec-
tronic computer, the author has obtained, and
preserves in graphical form, data showing the
influence of the magnetizing field and the
thickness of the ferrite slabs. He provides
curves of the retardation, and of the

components in the \(H_u\) and \(H_v\) modes as functions both of the magnetizing field and of
the ferrite thickness. For the purposes of calculation, the magnetization of the saturated
ferrite was taken as 140 gauss and the dielectric constant as 7. The waveguide was the standard
0.900 by 0.400-inch waveguide operating at a
free space wavelength of 3.2 centimeters.—
J. H. Vogelman

Method for investigation of cathode sputtering—
V. L. Veksler A new technique for measuring
the energy distribution of sputtered atoms
is introduced. The sputtered atoms themselves
impinge on a "tertiary" target and the energy
distribution of ions originating on the tertiary
target is determined. This method, especially
suitable for measurements in the high-energy
region, becomes feasible by the use of a ter-
ary target with a low sputtering threshold,
such as a base metal with a cesium surface film.
The author’s extensive effort on checking the
reliability of the experimental procedure to
justify the method must be appreciated.

This work is only the first step in the de-
velopment of this new measuring tool. Data
must be accumulated for interpretation of
obtained measuring results. Nevertheless, the
author was able to show the following: the
broadening of the energy spectrum with in-
creasing energy of the primary ions; the sput-
tering threshold for Mo by \(C_7\); the wide range
of energies of sputtered atoms (up to approxi-
mately 80–120 eV) in spite of the low average
energy; and the independence of the sputtering
coefficient on target temperature.—Paul H.
Gleichauf

Phase directivity pattern and the problem of
synthesis of an antenna—Ye. G. Zelkin As is
well known, the synthesis of a linear antenna
to realize a desired amplitude directivity pat-
ttern is not unique unless the phase pattern is
also specified. This paper deals with the speci-
fication of the phase pattern in such a way that
the synthesis of the antenna may be more easily
realized, and presents methods for carrying out
the synthesis.

The author’s approach is purely mathemat-
ical, and he lacks a valid criterion for
optimizing his choice of a phase pattern. A
more useful approach might be to ignore the
phase pattern and to seek aperture distributions
which can be realized when the antenna is
driven at a finite number of feed points.—R. B.
Kleiburz

Optimum parameters of multiscale measuring
systems—A. Ye. Basharinov, V. V. Akhlinos
This paper is concerned with the elimination of
ambiguities which may arise because of the
use of periodic probing signals, for example,
in a radar measuring system. The case of the
coherence of the signal and direction by phase techniques. A multi-

scale technique is discussed in which two or
more signals are used which have progressively
finer resolving powers or measurement scales.
Ambiguities in measurement are combated by
virtue of the fact that a given signal is used
only to examine a restricted range of param-
eter values determined from previous coarser
scale measurements and to obtain a more
accurate parameter measurement within that
range. Correlation receivers are assumed, and
the problems considered include (1) shaping
the correlation functions of the signals to
satisfy certain criteria on width of the main
correlation lobe and height of subsidiary lobes;
(2) the determination of relative measurement
scales of the several signals; and (3) the appor-
tioning of power among them.

The use of multiscale signals is a novel prac-
tical approach to the ambiguity problem, and
is an interesting alternative to the more com-
mon approach of designing the ambiguity-
combating features into one signal. For this
reason the paper has considerable merit; it is
concise and clearly written, and should be
of interest particularly to radar and sonar
engi-

ners.—C. A. Stutt

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<th>Publication</th>
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<tr>
<td>15th Annual Conference on Engineering in Medicine and Biology—November 5-7, 1962</td>
<td>M 5.00 N 5.00</td>
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<tr>
<td>PTGMTT National Symposium—May 22-24, 1962</td>
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<td>PTGRFI 5th National Symposium—June 4-5, 1963</td>
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<td>S-110A Installations of High-Pressure Pipe-Type Cable in the Western Hemisphere Operating at 69KV and Above (Revision of S-110)—November 1962</td>
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<td>State Space Techniques for Control Systems Workshop—June 1962</td>
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<tr>
<td>9th National Symposium on Reliability and Quality Control—January 21-24, 1963</td>
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At the touch of a button—the story of electric power, John Anderson Miller—
Mohawk Development Service, Inc. Schenectady, N.Y., 1962; 194 pages. §5.00. If the author had subtitled his book, "The Story of Electric Power Gen-
eration," instead of stopping one word short, there would be little for a reviewer
to discuss. Nevertheless, this book is a well-organized, interesting, tastefully il-
lustrated, and carefully documented ac-
count of the development of electric
power from 1882 to the present. It covers
old and new sources of power; tells how
the industry met challenges of disaster
and war; and of its phenomenal, geo-
metric progression growth. The author’s
emphasis, throughout the book, is on
prime movers and generators.

However, the generating plant, im-
portant as it may be, is but one of the
steps between extraction of energy from
fossil-fuel or water, and delivery to the
premises of the consumer. This reviewer
must emphasize that control, transmis-
sion, distribution, utilization—and
sometimes conversion—are equally im-
portant.

Without electric buses to transmit the
current from the power house, even one
million kilowatts of power at the termi-
inals of a 22-kV generator could not be
put to use. Some of the best minds in the
power industry have concerned them-
selves with the switching of high-voltage
ac lines and interruption of millions of
fault-current kVA. While there is no
available summary of the published data
on circuit breakers and their “brains”—
or protective relay systems—the six
multiyear indexes to AEE TRANSA-
tIONS list articles on all phases of the
subject.

No story of electric power can be com-
plete without reference to Nikola Tesla
and his induction motor that was pat-
eted in 1887. This invention, together
with long-distance transmission capa-
bility, was an important milestone in
establishing the supremacy of the ac
power system, and contributed inmeas-
urably to its growth.

In the chapter on lightning protection,
the 1524-page AEEE Lightning Reference
Book 3 should have been mentioned. A
great cooperative effort of industry was
responsible for this volume, which in-
cludes reprints of 200 papers and 425 in-
dex references.

Underground transmission is repre-
sented in the text only by reference to the
original Edison tube conductors of
1882. The evolution of impregnated-
paper power cable was related briefly in
an article by the reviewer in ELECTRI-
CAL ENGINEERING. 2 Missing from the
list of extra-high-voltage (EHV) research
projects in Chapter 15, is the AEIC-EEL-
Manufacturers EHV Cable Research
Project 1 at Cornell University, where
four complete 345-kV insulated cable
systems have been under test since Feb-
uary 1961.

A book must be very good indeed if a
reviewer can take serious issue with
nothing more than its subtitle. This is not
only a worthwhile treatise, but also it
satisfies a need. Electric power, although
taken-for-granted, is one of the greatest
contributions to the growth of the
United States. The author effectively
shows that the notable events in electric
power history may "convey a feeling of
drama and social significance." The
book is written in a readable style that
will appeal to the informed layman.

L. F. Hicke n e ll
Vice President—Engineering
Anaconda Wire and Cable Co.
New York, N.Y.

1. AEEE Lightning and Insulator Subcom-
mittee; AEEE Lightning Reference Book, 1918–
1935, 1937.
2. Hickernell, L. F., "Cable Engineering: A
3. "Extra-High-Voltage Cables" (13 papers),
461–581.

Cryogenics research and applications,
Marshall Sittig—D. Van Nostrand Co.,
§6.75. This book provides a readable
survey of the production and handling of
cryogenic fluids, and of the entire range
of their applications in military, indus-
trial, medical, and laboratory processes.
An account of cryoelectronic devices is
also included. The first eight chapters
describe the various cryogenic gases and
the methods of liquefying, storing, trans-
porting, and measuring their tempera-
ture. Also included is a collection of
thumbnail biographies of important con-
tributors to the development of the field,
as well as a chapter describing the prin-
cipal centers of cryogenic research
throughout the world.

The second part of the book is devoted
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Look at the curves for our new positive temperature coefficient thermistor compositions D and E and you'll recognize that you now have new and useful resistance/temperature characteristics at your disposal.

These new materials, together with our previously available A and B compositions, give you this wide range of switchpoints:

<table>
<thead>
<tr>
<th>Composition</th>
<th>Switch Temp.</th>
<th>Maximum Working Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>-55 C</td>
<td>110 C</td>
</tr>
<tr>
<td>A</td>
<td>0 C</td>
<td>135 C</td>
</tr>
<tr>
<td>E</td>
<td>60 C</td>
<td>135 C</td>
</tr>
<tr>
<td>B</td>
<td>90 C</td>
<td>135 C</td>
</tr>
</tbody>
</table>

You can read the right-hand column as the maximum temperature for working characteristics or as maximum continuous operating temperature, whichever is pertinent to your circuit.

Here's how we match our PTC compositions and applications: A—semiconductor device compensation, current limiting; B—current limiting, liquid-level sensing, overheat sensors; D—low-temperature compensation of silicon transistors and other semiconductor devices; E—liquid-level sensing, overheat sensing, current limiting.

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**Table:**

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<thead>
<tr>
<th>Composition</th>
<th>Part Number</th>
<th>Finished Body Sizes</th>
<th>Resistance</th>
<th>Ohms at 37.8°C</th>
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<tr>
<td>A</td>
<td>A1406P-1</td>
<td>0.420</td>
<td>1.80</td>
<td>650 ± 2%</td>
</tr>
<tr>
<td></td>
<td>A0905P-1</td>
<td>0.295</td>
<td>0.170</td>
<td>1100 ± 20%</td>
</tr>
<tr>
<td></td>
<td>A0910P-1</td>
<td>0.295</td>
<td>0.220</td>
<td>2100 ± 20%</td>
</tr>
<tr>
<td></td>
<td>A0610P-1</td>
<td>0.220</td>
<td>0.150</td>
<td>5000 ± 20%</td>
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<table>
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<th>Part Number</th>
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<th>Resistance</th>
<th>Ohms at 80°C</th>
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<td>0.280</td>
<td>0.180</td>
<td>5000 ± 20%</td>
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<td></td>
<td>D0906P-1</td>
<td>0.280</td>
<td>0.150</td>
<td>2400 ± 20%</td>
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<tr>
<td></td>
<td>D1406P-1</td>
<td>0.420</td>
<td>0.180</td>
<td>800 ± 20%</td>
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<th>Finished Body Sizes</th>
<th>Resistance</th>
<th>Ohms at 90°C</th>
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<td>E1406P-1</td>
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<td>0.180</td>
<td>56 ± 20%</td>
<td></td>
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<tr>
<td>E0906P-1</td>
<td>0.220</td>
<td>0.180</td>
<td>56 ± 20%</td>
<td></td>
</tr>
</tbody>
</table>
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IEEE Spectrum January 1964
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Reviewed this month in Proceedings of the IEEE


An introduction to semiconductor electronics, Rajendra P. Nanavati—McGraw-Hill Book Co., Inc.


Professional achievement for engineers and scientists, Tyler G. Hicks—McGraw-Hill Book Co., Inc.
252 CHANNEL AIRBORNE PCM TELEMETRY

Model 12-10 was developed and delivered in 90 days. This 420 cubic inch solid-state system features ± .2% accuracy from -20°C to +85°C and ± .1% accuracy from +10°C to +50°C.

The package includes a 90-channel primary multiplexer, a 135-channel subcommutator and a 45-channel subcommutator. Of the total 252 channels, 245 are data channels and 7 are used for frame synchronization. Sample-and-hold is provided for accurate measurement of ac signal voltages, and remote low-level subcommutation can be added with minor modifications.

The digital data output — obtained from a compact A-D converter — is a 10-bit serial binary code which includes a nine-bit data sample plus a single bit for odd parity. The system weighs just 15 lbs. and consumes only 7 watts power. An optional r-f package designed specifically for Model 12-10 is available on request.

An IDS Technician checks out the PCM package using specially designed IDS test equipment. Each unit is individually checked for performance and workmanship and copies of test data are submitted with delivery.

COMPATIBLE GROUND PCM STATION

Design considerations for a modular, solid-state PCM ground decommutation station compatible with the Model 12-10 airborne equipment and other IRIG systems have been completed. The station accepts serial, PCM/FM telemetry data and furnishes digital, analog and quick-look readouts. It is capable of operation in subcommutation or super commutation modes and each major assembly is designed for mounting in standard 19-inch relay racks.

These examples have been selected from a broad capability. For further information, please write or contact our Marketing Manager.

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125 VAC

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¾ H.P. 125 VAC
1½ H.P. 250 VAC

E19 DOUBLE POLE
15 Amp 125/250 VAC
¾ H.P. 125 VAC
1½ H.P. 250 VAC

E51 FEATHER TOUCH
Coin Switch
5 Amp 250 VAC

S25 OPEN BASIC
Cam Follower
10 Amp 125 VAC
5 Amp 250 VAC
½ H.P. 125/250 VAC

S38 DOUBLE POLE
Stack Switch
7½ Amp 125 VAC
5 Amp 250 VAC
½ H.P. 125/250 VAC

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* (Ice formed by thermoelectric cooling)

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(Reference temperature stability: ±0.025°C; Total instrument error: ±0.05°C from true 0°C).

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IEEE Spectrum January 1964
1953...
BIRTH OF A CORPORATION:

Community Engineering Corporation

CECO was started by three men, who designed and produced a quality amplifier for use primarily in community antenna television systems.

1964...
GROWTH OF A CORPORATION:  
C-COR Electronics, Inc.

Today, we engineer, design and manufacture a complete line of solid state and tube amplifiers with many applications in laboratory, space, telemetry and television electronics, and sell them throughout the world.

DESIGN & MANUFACTURE OF AMPLIFIERS

We believe our new name . . . C-COR Electronics . . . better identifies our products and continued growth. We will continue to produce a top-quality line of standard amplifiers; to build sophisticated units to meet individual specifications; to render our experience, technical knowledge, and service in the required manner. We are moving ahead . . . to stay ahead in electronics.

HIGH OUTPUT PULSE AMPLIFIERS

<table>
<thead>
<tr>
<th>Frequency Pass Band</th>
<th>Model</th>
<th>Gain db</th>
<th>Output Into 50 or *75 Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cps to 12 mc</td>
<td>1019-F</td>
<td>40</td>
<td>8 v p-p*</td>
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<td>20 cps to 70 mc</td>
<td>3029</td>
<td>20</td>
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<td>100 kc to 150 mc</td>
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<td></td>
<td>3066</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

1000 series, rack and panel unit with power supply.  
3000 series signal chassis only, available also as  
4000 series which includes power supply and instrument case.
The high-voltage barrier to passivated PNP transistors has finally been broken—but it took a new manufacturing process to overcome the obstacles.

Now from MOTOROLA
Epitaxial, Passivated PNP SILICON TRANSISTORS
Made by the Annular* Process

Some new words are being added to the dictionary of semiconductor terms—words like Annular* and Band-Guard†, words that relate to a new manufacturing process which will have a strong influence on transistor design and promises to open new areas for transistor applications. The Annular manufacturing process provides a new degree of freedom from surface effects for semiconductor products.

For years, the industry had been working to design high voltage silicon PNP transistors with the low leakage currents normally associated with NPN types, surface passivated by the planar process. For PNP devices, planar techniques proved inadequate since any attempt to increase voltage ratings beyond approximately 20 volts (through increasing collector material resistivity) induced a phenomenon, called channeling, which actually increased leakage current far beyond tolerable levels. Channeling is a condition whereby the surface portion of a transistor collector region actually changes polarity and becomes an extension of the base region. The base-collector junction, therefore, rather than coming to the top surface where it is protected from the environment by a silicon oxide coating, extends to the unprotected edges of the transistor where it is subject to contamination and surface damage. This phenomenon circumvents the passivation advantages of planar designs and results in excessive leakage currents.

The formation of channels has been traced to effects of ionized or polarized particles on or within the passivating oxide coating which create an electrical environment that tends to alter the apparent polarity of the material directly beneath the oxide—an effect which is particularly pronounced in lightly doped P-type material.

As a result of channeling, some manufacturers have reverted to earlier silicon mesa structures or have deliberately circumvented the oxide passivation in planar transistors in order to produce high voltage devices. These methods have yielded high voltage ratings but other characteristics of the resulting transistors do not compare favorably with those of surface passivated devices.

Now, Motorola has overcome these obstacles—but it has taken a new manufacturing process to do so. Rather than trying to eliminate the channel, Motorola, in a new series of "Band-Guard" transistors, has deliberately introduced a channel whose controlled characteristics completely overshadow the variable effects of any randomly induced channel, thus providing a high degree of performance stability. Moreover the controlled channel is terminated close to the base region by a diffused annular band of the same polarity as the collector region but with a resistivity level impervious to channeling. The collector-base junction, therefore, is properly terminated underneath the oxide coating where it is protected against environmentally induced leakage currents. The resultant "Band-Guard" PNP silicon devices, for the first time, combine the low-leakage characteristics of passivated junctions with the high-voltage characteristics of non-passivated, or mesa structures.

Though initially devised for the production of high voltage silicon PNP transistors, there are strong indications that the Annular process yields major benefits for NPN and field effect transistors and other semiconductor devices as well.

In view of these considerations, there is little doubt that the new, Motorola developed Annular process will take its place among the major milestones in the advancement of the semiconductor art.

*Patents Pending †Trademark of Motorola Inc.
If You're Specifying Motorola Annular Types...

You're Getting The Best PNP and NPN Silicon Transistor Value!

**THE ANNULAR PROCESS GIVES YOU:**

**HIGHER VOLTAGE | LOWER LEAKAGE CURRENT | IMPROVED RELIABILITY**

Motorola supplies the following annular transistor types . . . available immediately from distributor stocks:

### NPN ANNULAR TYPES

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
<th>Type 4</th>
<th>Type 5</th>
<th>Type 6</th>
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<td>2N2257</td>
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### PNP ANNULAR TYPES

<table>
<thead>
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<td>2N2904</td>
<td>2N2905A</td>
<td>2N2907</td>
<td>2N3134</td>
</tr>
</tbody>
</table>

Whether you're purchasing silicon transistors for current production or buying devices for advanced system applications, you get extra value when you specify ANNULAR transistors.

"new leader in Total Silicon Technology"

MOTOROLA Semiconductor Products Inc.

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Quiet sun years begin—
international cooperation makes program possible

We are in a new age of exploration of our environment—pushing at frontiers under, on, and above the ground of which the explorers of other ages did not even dream. Drilling below the ocean depths, mapping the Antarctic continent, exploring the upper atmosphere and space with direct probes, all activities of the past decade, have had one important manifestation that affects the world in more than a physical sense. They have given birth to, and in turn have depended on, international cooperation on an unprecedented scale.

The most recent formal international program of exploration is called the International Years of the Quiet Sun, abbreviated IQSY. It will operate during the two-year interval of January 1, 1964, to December 31, 1965, which includes the expected time of minimum of the 11-year cycle of sunspot numbers—a period of low solar activity.

The IQSY program is entirely one of basic science. It will be worth the cost if the only result proves to be an increased understanding of the universe. But it will be surprising if unforeseen practical benefits do not result also, as has been the case with all large programs of basic research in the past.

IQSY is an outgrowth of its opposite program, the International Geophysical Year (IGY), which was itself the largest international program of exploration ever undertaken. The IGY was a comprehensive examination of the earth, its atmosphere, and its spatial environment, during a peak of the sunspot cycle characterized by unusually high solar activity; the observations were made from July 1, 1957, through December 31, 1958. The wide scope of its efforts, which involved scientists of 66 nations, made possible the collection and analysis of an unprecedented body of scientific data.

Twenty to thirty thousand scientists in the cooperating countries took part, operating from some 4000 scientific stations. One of the most important contributing factors to the success of the IGY was the concept of synoptic observations—those made by the same
techniques at the same time from a number of places to give worldwide pictures which had never been available before. Synoptic observations were made possible by the agreement among all the scientists and laboratories involved that data would be exchanged and made available through a system of World Data Centers. In addition, the effort to secure observations in many fields at once on particular days agreed to in advance resulted in learning interrelationships that had not been previously known.

Most of the fields of study involved phenomena which occurred in response to activity on the sun, and it was the interrelationships among these phenomena which were so revealing. For example, studies in the fields of solar activity, aurora, ionospheric absorption, and geomagnetism all together enabled us to spell out the nature of the phenomenon of polar cap absorption (PCA) which can occur following a very large solar flare.

The very advantage of large solar activity resulted, however, in an overlap of events which often made it difficult to disentangle the exact sequence of cause and effect. In an interval when the sun’s disk is covered with active regions at all times, regions which are always “flaring” to some extent, it becomes very difficult to know which flare or subflare is responsible for a particular variation in the geomagnetic field. Furthermore, the ionosphere and the earth’s magnetic field never get a chance during sunspot maximum to subside back to an undisturbed state before the next disturbance occurs. Thus measures during the IGY itself did not show the full range of terrestial effects that might occur in response to solar variations. We never got down to where the zero point is.

Development of IQS Y. In an attempt to overcome these difficulties the idea began to grow, about the beginning of 1960, that an extensive program at the time of sunspot minimum would be a useful supplement to the IGY for those fields in which the solar variation was important. IQS Y was planned through a series of conferences and discussions on the international scientific scene to include activities in most of the IGY fields, but to omit such fields as oceanography and seismology, which are not markedly affected by the solar cycle.

IQS Y has developed, not as a miniature IGY, but as a full program that can take advantage of the opportunities for studying solar–terrestrial relationships at the minimum of the sunspot cycle. In a number of areas it will use techniques developed since IGY: in instrumentation, data handling, high-altitude balloononing, and sophisticated space probing.

Each of the more than 60 countries involved in IQS Y has planned its own program coordinated in consultation with the other countries at a series of international meetings spaced about a year apart. The overall program took final shape at the last of these meetings, in Rome, in March 1963. Working groups in the individual disciplines met and hammered out the necessary compromises to make an overall international program on which everyone could agree. The working groups’ decisions were presented as resolutions before a plenary session of the international IQS Y Committee, which examined them for potential conflicts. The final program is contained in a series of reports of the national programs appearing in the publiction IQS Y Notes, and in a series of instruction manuals for the individual disciplines. The Notes and the manuals are issued by the IQS Y Committee whose executive offices are in London, and are available to scientists in the United States through the U.S. Committee for the IQS Y, a committee of the National Academy of Sciences.

The Program. The United States program for IQS Y consists of researches in the fields of meteorology, geomagnetism, aurora, air glow, ionospheric physics, radio astronomy, solar activity, the interplanetary medium, cosmic rays, trapped radiation, and aeronomy. Emphasis will be placed on solar mechanisms; determining the state of the interplanetary medium during solar minimum; mapping the earth’s radiation zone to establish its configuration and density at minimum; observing solar events and the transit through the interplanetary medium of the solar plasmoids and the interaction of the plasmoids with the geomagnetosphere; observing at magnetically conjugate points on the earth the auroral, ionospheric, geomagnetic, and hydromagnetic consequences of such interactions; determining the energy content of the solar ionizing radiations that influence the aeronomy of the middle atmosphere; studying the winds and circulation of the ionospheric regions; determining the basic photophysical character of the middle atmosphere and ionosphere in its least disturbed condition; and undertaking such programs as studies of the low-energy portion of the galactic cosmic-ray spectrum that are best done during times of solar quiet. Also included will be the completion of certain network synoptic programs of aurora, geomagnetism, ionospheric physics, and cosmic rays throughout the present solar cycle, continuing what was done for IGY and since.

To accomplish these objectives there will be a solar patrol that includes optical flare patrol, radio patrol, and satellite observations. Work in geomagnetism will involve the operation of standard observatories, including those in the Antarctic, and satellite and space probe observations. Networks of all-sky auroral cameras, visual observations, spectrometer and photometer observations, and airglow observations will be active, including operations in the Antarctic and in Greenland. Ionosphere observations include a vertical incidence network, a radio noise network, a riometer network, and several whistler networks covering both very low and extremely low frequencies. Cosmic-ray work includes the operation of a chain of neutron monitors for lower-energy cosmic rays and meson telescopes for the harder component of the flux.

Special opportunities in solar–terrestrial relationships will be pursued by means of X-ray and ultraviolet telescopes, particle detectors, and energy analyzers on satellites, as well as by rocket and balloon observations of particle streams entering the upper atmosphere at geomagnetically significant locations. Such observations, along with the data derived from the synoptic networks, will provide information as to the identity, flux, and energy spectra of the particles, their spatial distribution, and their temporal history. Conjugate point observations will be made between various locations in Alaska, Canada, and the northern United States, and locations in Australia, New Zealand, and the Antarctic.

Coordination. Many of the IQS Y observations will be made on a continuing or a daily basis, but in some cases this would be too expensive or otherwise impracticable. Temporal coordination of these intermittent projects is accomplished through a program of so-called World Days and World Intervals. These are indicated on the International Geophysical Calendar in a format which was developed for the IGY and later modified. It marks intervals in which observers can expect that their colleagues in other countries and in other disciplines will be making an increased effort to obtain synoptic observations.
Different designations are used for intervals of differing lengths and periodicities. For example, a Regular Geophysical Day occurs each Wednesday throughout the two-year IGY. Regular World Days are three consecutive days of each month, always Tuesday, Wednesday, and Thursday near the middle of the month. These are intended for experiments which should be made for about 10 per cent of the total number of days throughout the year. The Wednesday that is a Regular World Day and a Regular Geophysical Day is a Priority Day, and there is one each month; on it both weekly and monthly observations would be made. Similarly, there is in each season a Quarterly World Day, and also a World Geophysical Interval consisting of 14 consecutive days intended for intensified programs aimed at the statistics of seasonal variations or the timing of seasonal changes. In addition to these arbitrarily chosen times, the calendar indicates the dates of solar eclipses and meteor showers which may call for special observations.

Certain other special days are not shown on the calendar because they cannot be predicted in advance; they are days of Alerts or Special World Intervals, which are declared by one of several solar–geophysical regional warning centers on the basis of observations of actual or impending solar activity, or solar-related events. Notices of the Alerts and Special World Intervals are distributed by telegram and radio broadcasts and through the meteorological telecommunications network.

World-wide cooperation in the timely exchange of collected data is an important part of the program. The exchange of data that are either raw or just sufficiently calibrated for use by others enables all investigators to have for analysis a wider span of data than they could expect to obtain by their own efforts. Making his data available to others on a timely basis involves some sacrifice on the part of the observer, because it forces him to a relatively short time during which his own observations are exclusively his for analysis and interpretation. That thousands of observers have been willing to join in this world-wide exchange for the good of all is a testament to their selflessness and their devotion to the progress of science.

The World Data Center system, developed for IGY, has remained in operation ever since. It comprises three major centers, World Data Center A in the United States, B in the U.S.S.R., and C having disciplinary components in Japan, Australia, and several western European nations. On a regional basis, original data, either raw or reduced, are forwarded to one of these three centers. Each center then sends copies to the other two, so that each accumulates identical global data. From these three centers or their elements data are supplied upon request, usually on a cost basis, to scientists and scientific institutions from their various regions. In the United States, several institutions and agencies, each responsible for a single discipline, form the total complex of World Data Center A. Coordination, particularly necessary in international exchange, is supplied by the National Academy of Sciences.

Organization. International scientific programs are formal arrangements developed among groups of people who are themselves members of sovereign states. Not all the people are subject to the same sets of laws, or to the same customs or political systems. In view of these differences, the scientists’ success in organizing international projects has required great diplomatic skill. Their success has been generally recognized as a pattern of human cooperation to be emulated in other fields.

A few dozen international scientific societies exist that bring together scientists or engineers with common interests. Normally the adherence to such a union is by country, with a national committee in each country. The membership of individuals in the union is through membership on a national committee, or on the recommendation of that committee. (Customs vary somewhat from one union to the next.) Since a number of problems and goals are common to the several unions, they have formed an International Council of Scientific Unions (ICSU), a sort of parental or supervisory body with its own officers and committee structure. United States adherence to any of these international bodies is through the National Academy of Sciences.

IGY was primarily the creation of three of the international scientific unions: the International Scientific Radio Union (URSI), the International Union of Geodesy and Geophysics (IUGG), and the International Astronomical Union (IAU). However, the enterprise involved other unions, notably the International Union of Pure and Applied Physics (IUPAP). Coordination of the IGY program was achieved under a special ICSU committee for the IGY, known as CSAGI (Comité Spécial de l’Année Géophysique Internationale). For the activities after IGY, a continuing Comité International Géophysique (CIG) was established, which in turn established a working group for IQSY and in March 1962, at the first IQSY General Assembly in Paris, the CIGIQSY Committee was formally appointed. This committee, under the chairmanship of Prof. W. J. G. Beynon of the United Kingdom, included representatives of the four scientific unions just mentioned, a reporter appointed by the appropriate scientific union for each discipline, representatives of other ICSU committees and international scientific organizations: the Scientific Committee on Antarctic Research (SCAR), the Committee for Space Research (COSPAR), the International Ursigram and World Days Service (IUWDS), and the World Meteorological Organization (WMO).

The latter group is somewhat more governmental in character than the others, being an agency of the United Nations. In addition, regional representatives are chosen to ensure that all areas of the world are adequately represented.

U.S. coordination in the IQSY program is provided by the National Academy of Sciences and the National Science Foundation. The Academy’s Geophysics Research Board (GRB), under the chairmanship of Dr. M. A. Tuve, has a Committee on IQSY chaired by Dr. M. A. Pomerantz. Its executive secretary is Stanley Ruttenberg, and its concern is with the international contacts essential in carrying out the program, the planning and balance of the U.S. program, and the coordination of the World Data Centers and data exchange generally.

In the later stages of the IQSY program’s development, the Academy sought formal Government endorsement through the National Science Foundation. Dr. A. T. Waterman, then director of the Foundation, obtained authorization for U.S. participation from President Kennedy, who, at the same time, designated the National Science Foundation as the agency to correlate the Federal Government’s regular activities that contribute to the program, and to coordinate and to arrange the budget for the additional activities. In carrying out these functions, the Foundation is guided by a panel of advisers from the scientific community.

Funding of special IQSY projects is done in the same way as the Founda-
tion's funding of other researchs.

The total U.S. contribution to the IQSY is, of course, far larger than the projects funded out of specially designated parts of the Foundation's budget. Work in the broad area of geophysics stimulated by IGY continued through the intervening years. The ongoing programs of many agencies, for example NASA, the Department of Defense, and the Department of Commerce's Weather Bureau and Bureau of Standards, all contribute to IQSY and are taken into account when the U.S. program is presented in detail to the international IQSY Committee. Their volume of work may be likened to the large, invisible volume of an iceberg that is below the water line. The added amounts from specially designated funds for IQSY projects are relatively smaller, and sometimes have the function of the keystone in an arch. They frequently establish a new station that serves to bind already existing stations into a series, or they may set up an experiment which should be carried out with the others to study their interrelationships or, again, experiments or observational programs that require a special interdisciplinary effort for completion.

Looking toward the future. It is, of course, too early to state precisely what new, exciting advances will come out of IQSY. However, we can discern two trends in modern science that are epitomized by this program. First, interest in international cooperation in science is increasing. Science has always been a cooperative effort characterized by cordial relations across national boundaries, but it is only very recently that tremendous improvement in transportation and communication has enabled people to pool their efforts on such a large scale. Looking at it another way, this pooling of effort can multiply the efficiency of every American scientist. He receives stimulation and information not only from his colleagues in the same laboratory, city, state, or country, but has these benefits from the world-wide body of scientists. Much duplication of effort is saved. Though sending a body of people to an overseas conference involves expense, usually the ideas brought back save larger expenditures that would have been planned in ignorance of other scientific work.

A second trend is the growth of a new area of scientific research—a field without a unique name but beginning to be recognized as an entity. It represents an extension upward of the interests of geophysicists (especially students of the atmosphere) to include the interplanetary medium, planetary atmospheres, even the weather of the solar atmosphere. Interests of many astronomers now extend downward into the earth's atmosphere. This mixing of concepts and methods from fields which were formerly widely divergent has been healthy for the growth of all.

One might, of course, describe the new field of interest as a simple extension of either geophysics or astronomy, but in practice it is more than that. A solar system with all its intricate interactions of parent star, interplanetary medium, magnetic and radiation fields, and solid planets is probably a common phenomenon in space. Nevertheless, the detail with which we can study our particular solar system is so much greater than the detail which we can bring to bear on analogous systems that it becomes a specialized problem within the broad field of astronomy. It is important, but not of overriding importance, in comparison with stellar evolution, the nature of the galaxies, cosmology, and the many subdivisions of these areas which form the main problems of astronomy.

At the same time, the new field is somewhat "far out" to students of the lower atmosphere, oceanography, and the solid-earth branches of geophysics. All these fields are affected by the sun and especially by variations of the solar output, but as soon as we get much below the level of the absorption of ultraviolet light by ozone, the fluctuations of solar energy input to the lower atmosphere and to the surface are vanishingly small. The main energy fluctuations are in the far ultraviolet, and they affect primarily the upper atmosphere. Readers of this journal will of course recognize that the ionosphere and magnetosphere, the regions of the atmosphere which are so critical to radio communications, are markedly affected by solar variations, so that a radio engineer is more concerned with solar activity than is, for example, an oce- nigrapher.

The activities of which we speak are sometimes called "space research," though that implies that the observations are made from space vehicles rather than from the ground. Ground-based work forms a substantial part of the activities in the field. The term "planetary sciences" has been frequently used; "space physics" and "space science" are other terms. Frequently the terminology is influenced by the traditional academic field out of which the new activity has grown in the local context. In the National Science Foundation responsibility for this general area is in the Program for Solar Terrestrial Research, a part of the Section for Atmospheric Sciences. The coordination of the IQSY is one of the activities of this program office.

We may confidently expect that while reaching into space and understanding more and more of the large-scale environment in which we move, we will, through such activities as the International Years of the Quiet Sun, mature both in knowledge and in our ability to get along with each other on the surface of our small planet.

Robert Fleischer
Coordinator for the IQSY
Program Director for Solar Terrestrial Research
National Science Foundation
Washington, D.C.

Approaching transonic commercial air travel propels all-weather landing systems to the fore

All-weather landing systems—with optimum operational capability in conditions of low and zero visibility—have been the goal, through the years, of the aviation industry. The expected increase in subsonic and transonic jet air travel in the next decade—and the complexity of safely and efficiently controlling and terminating air traffic according to its destination schedule—has tinged the problem with a sense of urgency. Diver- sion of flights because of weather conditions to alternate airports in the United States alone last year cost domestic carriers an estimated $60 million. In Europe, and especially in England, where greater low-visibility exposure exists, the hard-won time-saving potential of new very-high-speed aircraft is perhaps under graver threat than elsewhere.

Here, in the United States, high priority is being given to the early development of such a system. The Federal Aviation Agency (FAA) at its National
...the Problem Was Easier then!

Today terrain avoidance has been complicated by higher air speeds, ground search radars and more deadly defensive weapons. Thus the critical need for research on the terrain avoidance problem.

Evidence of Cornell Aeronautical Laboratory's leadership in researching the problem is given by the recent receipt of its 15th contract in this field. Since the first contract was awarded to CAL a decade ago, the Laboratory has performed such research for the Air Force, Navy, Army, commercial sponsors, and the United Kingdom.

By making this new knowledge available to scientists and to the military services concerned, CAL is actively advancing the state of the art.

But this is just one of the areas of technology in which CAL's technical staff is leading the way. Others are computer sciences, applied physics, electronics, operations research, aerodynamic and applied hypersonic research, flight research, applied mechanics, vehicle dynamics, life sciences, and systems research. If your experience qualifies you to join this team, we invite you to send the coupon below. It will bring you an interesting briefing on this community of science.

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The Department of Electrical Engineering at the City College of the City University of New York seeks staff in all academic ranks; Professor, Associate Professor, Assistant Professor, Instructor and Lecturer. For Professional appointments the Doctor's Degree is required. Opportunities available for combined research and teaching at graduate and undergraduate level. Salaries commensurate with qualifications and experience. Apply in confidence to Prof. H. Taub, Chairman, E.E. Dept., The City College, New York, N.Y. 10031.

Electrical Maintenance Superintendent, B.S. Degree in E.E., with minimum of 10 years' experience in electrical maintenance. To take charge of electrical preventive maintenance program and crew. Also, to be responsible for all electrical engineering in integrated pulp and paper mill currently involved in $21,000,000 expansion program. Salary open, commensurate with qualifications and experience. Excellent fringe benefits and experience. Write, giving resume of education and experience, to: William E. Fish, Personnel Manager, The Chesapeake Corporation of Virginia, West Point, Virginia.

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Address replies to Box Number given, c/o IEEE Spectrum, Advertising Department, 72 West 45th St., New York 36, N.Y.

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Electric utility distribution and transmission superintendent, 17 years' experience, returning from foreign assignment, seeks position anywhere U.S. or Canada. Available immediately. Box 8001.

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Astro-navigators are learning what the stars are like on the other side of space, with simulation equipment like Link's Star Field Projector. A quick flick projects any portion of the sky and its constellations—in any season, for visual reference. Link's activities in simulation equipment run the gamut from the Model 60, General Aviation Trainer for student pilots, to entire weapons systems like the F-4C. Other challenging projects at Link include the Apollo Mission Simulator and digital computers which will provide simulation computations for the complete GEMINI Mission. Link scientists and engineers are exploring a variety of approaches in the solution of Training Device problems. They enjoy salaries that are among the best in the field, unusual job stability, and every opportunity for professional advancement. Qualified individuals are invited to join the Link Division of General Precision, Inc. Resumes to Mr. Martin Jenkins will receive prompt attention.

OPTICS. Diversified programs in geometric and physical optics has created high interest areas which include improvements in metrology, automated electro-optical systems, photogrammetry, interferometry, pattern and character recognition and visual systems.

TACTICS. Must have comprehensive background in the design and development of simulators and fire control systems, simulation of bomb navigation systems, land mass systems, etc.

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ELECTRO-MECHANICS. Previous experience should be in field of simulators and specifically in area of controls and cockpit layout.

ELECTRONICS. Should have rigorous background in the logical design of special purpose digital computers for aircraft or space vehicle applications.

SYSTEMS. Past professional experience should encompass the systems design of space or airborne systems utilizing analog and/or digital computers.

RELIABILITY. Responsibilities will involve creation of reliability portions of proposals, analysis of designs on active contracts and preparation of reliability estimates.

IEEE spectrum JANUARY 1964
The Lincoln Laboratory, a research center of the Massachusetts Institute of Technology, conducts a program of general research with applications to urgent problems of national defense and space exploration. Scientists and engineers of many disciplines are engaged in fundamental investigations and technological development in selected areas of advanced electronics. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin. Lincoln Laboratory, Massachusetts Institute of Technology, Box 41, Lexington 73, Massachusetts

Solid State Physics
Information Processing
Radio Physics and Astronomy
Radar Design
Control Systems
Space Surveillance Techniques
Re-entry Physics
Space Communications
A description of the Laboratory’s work will be sent upon request.
Aviation Facilities Experimental Center (NAFEC) and elsewhere is evaluating a number of elevation guidance techniques in the region of flare-out and touchdown, representing approximately the last 100 feet of aircraft descent to the runway. Two broad system categories are under development: (1) the use of air-borne radio altimeters in conjunction with ILS (instrument landing system) and (2) the use of ground-based scanning radio beams to provide the aircraft with vertical and lateral guidance. More than 1100 automatic landings have already been successfully completed by an FAA test plane with AWLS equipment, mainly of the radio- altimeter ILS type. The British have also made thousands of successful landings with a similar system, BLEU (Blind Landing Experimental Unit). There is, in addition, a great deal of research and development throughout the aviation industry and among the major carriers.

Evolutionary development. The development of the ideal all-weather landing system is proceeding along an evolutionary path structured in three levels—Phases I, II, III. The movement from one level to another will utilize existing hardware and techniques in a more complex and qualitatively higher system involving a greater degree of automation.

Phase I equipment consists of the time-tested Instrument Landing System (ILS) and the barometric altimeter. ILS consists of four radio transmitting stations—on the ground at, and in the vicinity of, an airport—radiating lateral (localizer) and vertical guidance (glide slope) information to approaching aircraft. The received signals operate indicators in the aircraft to alert the pilot of any deviation from the ideal safe approach path to the correct touchdown point on the runway. Received ILS signals can be connected directly to the autopilot for automatically controlled approach. In Phase I operation, the qualitative level of the equipment must be such as to permit aircraft operations down to a 200-foot ceiling and 1/2-mile visibility. This state of equipment refinement exists today at a small number of major airports in the United States. Phase II facilities must meet a performance standard suitable for operations down to a 100-foot ceiling and 1/4-mile visibility. These facilities must be able to provide actual guidance considerably below these minima, so that they are acceptable at 100 feet and 1/4 mile from a regulatory point of view. Phase III will be that quality of ILS guidance suitable to meet the requirements of routine zero—zero landings.

AWLS symposium. Last Fall more than 400 experts from many countries met at Atlantic City, N.J., to discuss progress in developing automatic all-weather landing systems. The area of discussion embraced air-borne systems, subsystem development, and operational aspects of all-weather landing. The main emphasis was on the selection and perfection of a radio-altimeter—ILS system to meet an interim goal: aircraft operations down to 100-foot ceiling and 1/4-mile visibility.

Prior to the meeting, FAA officials...
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Currently, measurements of variations on the earth's magnetic field are being made at remote islands in the Pacific Ocean, providing clues to the effect of solar activity on its shape and stability. The influence of solar wind on the geomagnetic field is also being investigated in laboratory experiments, by bombarding magnetic fields with clouds of highly ionized gases.

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predicted that an all-weather system capable of inclusion in new or existing aircraft would be ready some time in 1966. The consensus, however, of research engineers, company administrators, and pilot representatives produced less sanguine expectations. Many formidable technical and operational problems remain to be solved to reach even the interim goal. In consequence, the FAA is now veering toward a somewhat later target date—1968 or 1969.

J. A. Ferrarese, FAA official, set forth the proposed FAA requirements for interim goal Phase II operations:

Ground facilities. (1) ILS—Quality of present localizer must be improved, quality of Phase I glide slope is adequate if air-borne equipment has acceptable glide slope extension. (2) Approach and runway lighting—Present approach light system with sequenced flashers and high-intensity runway lights with touch-down zone and centerline lighting is satisfactory for weather minima of 1300 feet RVR (runway visual range). There is possible need for improving the last 200 feet of the approach areas. (3) Runway visual range—Current FAA opinion is that two transmissometers (light intensity measuring devices) are necessary for each ILS runway. One will be located at the approach end and the other at the far end of the runway. As yet, there is no firm agreement on how the controlling visibility will be determined. FAA opinion is that the visibility reported by the transmissometer on the approach end should be the controlling one with the second transmissometer value used as information to the pilot. (4) There will be no additional runway length requirements for Phase II operations for propeller airplanes. For turbojet aircraft the runway length requirements now established (200-foot minimum ceiling and 1/2-mile minimum visibility) are considered adequate. The all-weather runway marking that is now prescribed will, of course, be required.

Air-borne equipment. (1) Dual glide slope and localizer receivers. (2) An automatic coupler with a flight director system backup—The auto coupler will have to be capable of consistently and smoothly flying Phase II ILS to a point from which a normal manual landing can be made with weather minima of 1300-foot RVR. (3) Instrument and equipment failure warning system—The warning system shall be such that the failure of any of the essential instrumentation and equipment must be immediately apparent to the pilot with a minimum of interpretation, leaving no doubt in his mind as to whether the approach should be continued or aborted. (4) Improved rain removal equipment—Present windshield wipers and air blast devices are inadequate, and much improvement is necessary. (5) Positive identification of the 100-foot point—A basic consideration for Phase II is the determination of the decision altitude:

Instrument panel in DC-7 fitted with FAA radio flare-out automatic landing system. Arrow points to indicator for radio altimeter, a key element in the system, which includes an air-borne computer and improved ILS as well as other equipment.
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the 100-foot point. Radar altimetry is apparently the best solution to this problem, even at locations with irregular terrain features, in conjunction with a simple method to determine the height above the runway. This method takes into account variations of the terrain prior to reaching the runway threshold. The airport, of course, would have to be surveyed to determine the indicated altitude for the actual 100-foot above runway elevation. (6) Proper go-around attitude information — The farther along the glide slope the incoming plane is, the more critical the missed approach becomes. Altitude margins for a go-around are continually narrowing. Consequently, the FAA believes that proper attitude information for a go-around is an essential part of the entire system. Information can be displayed by a go-around computer like SCAT or, perhaps, by appropriately calibrated attitude gyro.

**Ultimate goal — Phase III.** This is the ultimate system for zero-zero conditions that will utilize system and subsystem redundancy based on the radio altimeter, an air-borne computer, and ILS improved to meet all-weather requirements. On the basis of current flight experience, the system will operate in this way: The ILS localizer will provide the aircraft with lateral guidance to touchdown. Vertical guidance will be supplied by ILS glide slope and glide slope extension down to an altitude where the radio altimeter can supply precise height information. At that point, the radio altimeter will automatically take over the feed data to a flare computer. The computer will then vertically guide the aircraft to touchdown.

The pilot will retain full command of the aircraft at all times. There will be two separate and distinct air-borne channels, the automatic system and the pilot's monitoring system. Each will include ILS receivers — localizer and glide slope — radio altimeter, and flare-out computer. In normal mode, the automatic system will control the aircraft to an automatic landing. The independent pilot's system, paralleling each item of equipment in the automatic system, will allow the pilot to monitor the operation throughout and take over at any instant when he judges this to be necessary.

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International Space Communication Conference allocates radio frequencies for use in interstellar space

With the signing of the Final Acts, the Geneva Space Radiocommunication Conference, convened by the International Telecommunication Union (ITU), completed its work.

The main task of the Conference, attended by more than 400 delegates from 70 ITU member countries, was the allocation of radio frequencies for outer space activities and the consequent revisions of the Table of Frequency Allocations which is the heart of the Radio Regulations, the basic document governing the operation of radio throughout the world. This was last revised by the Geneva Radio Conference of 1959. The allocation of an adequate number of frequencies for outer space has become an urgent task since then because of the rapid growth of activity in space.

The Conference allocated, on a shared or exclusive basis, frequencies totalling 6076.462 Mc/s for the various kinds of space services, 2800 Mc/s of which are for communication satellites on a shared basis with other services. Thus, while at the 1959 Conference only about one per cent of the frequency spectrum was made available for outer space, about 15 per cent has now been made available.

The details of the allocations are shown in the accompanying table of frequency allocations. Where reference is made to Regions, Region 1 comprises roughly Europe, Africa and the Middle East, Region 2 comprises the Americas, and Region 3 comprises Asia and Australasia.

The Conference adopted a number of revisions and additions to other parts of the Radio Regulations, mainly concerned with general rules for the assignment and use of frequencies, notification and recording of frequencies in the Master International Frequency Register, the identification of stations, service documents, terms and definitions,
### Table of frequency allocations

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<tr>
<td>14.3-14.4</td>
<td>Radionavigation-Satellites, exclusive</td>
</tr>
<tr>
<td>15.25-15.35</td>
<td>Space Research, exclusive</td>
</tr>
<tr>
<td>15.35-15.4</td>
<td>Radio Astronomy, exclusive</td>
</tr>
<tr>
<td>19.3-19.4</td>
<td>Radio Astronomy, exclusive</td>
</tr>
<tr>
<td><strong>Millimetric waves</strong>, Gc/s</td>
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<tr>
<td>31-31.3</td>
<td>Space Research, shared</td>
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<tr>
<td>31.3-31.5</td>
<td>Radio Astronomy, exclusive</td>
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<tr>
<td>31.5-31.8</td>
<td>Space Research, shared in regions 1 and 3, exclusive in region 2</td>
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<tr>
<td>31.8-32.3</td>
<td>Space Research, shared</td>
</tr>
<tr>
<td>33-33.4</td>
<td>Radio Astronomy, only in region 1 and shared</td>
</tr>
<tr>
<td>34.2-35.2</td>
<td>Space Research, shared</td>
</tr>
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and special rules relating to particular services. These revisions and additions were required to make provision for the space services. In addition, the Conference accepted a number of important resolutions and recommendations. One of these deals with the future action to be taken by the ITU in the light of future developments in space radio communications.

One of the most important resolutions concerns space vehicles in distress or in an emergency. It notes that the frequency of 20 007 kc/s had been set aside by the Conference for this purpose and states that temporarily the distress signal used by ships or aircraft—(SOS) in radio telegraphy and MAYDAY in radio telephony—should also be used by spacecraft.

Another recommendation, addressed to the International Radio Consultative Committee (CCIR), emphasizes that “. . . the use of satellite transmissions for direct reception by the general public of sound and television broadcasts may be possible in the future” and urges the CCIR to expedite its studies on technical feasibility of broadcasting from satellites. Thus an important step has been taken toward the future possibility of the general public’s receiving radio and television programs directly from satellites.

A further recommendation called on the forthcoming ITU Aeronautical Conference to provide high-frequency channels (bands between 2850 and 22 000 kc/s) for communications for routine flights of transport aerospace vehicles flying between points of the earth’s surface both within and beyond the major part of the atmosphere.

Finally, a recommendation was adopted recognizing “. . . that all Members and Associate Members of the Union have an interest in and right to an equitable and rational use of frequency bands allocated for space communications” and recommending to all ITU Members and Associate Member States “. . . that the utilization and exploitation of the frequency spectrum for space communication be subject to international agreements based on principles of justice and equity permitting the use and sharing of allocated frequency bands in the mutual interest of all nations.”

The Conference is considered to have reached agreement on its difficult problems largely because of the high degree of harmony and cooperation that prevailed.
ENGINERGE SOCIETIES PERSONNEL SERVICE, INC. (Agency)

If you are an employer and are interested in a listing under our “Men Available” column, under the New York office section, write to the New York office, listing the applicant’s number, and a copy of his résumé will be mailed to you immediately. In the event that said applicant becomes employed by you, a placement fee in the amount of 2 per cent of the first year’s salary will be charged to you. The above does not apply to our Chicago and San Francisco “Men Available” listings.

If you are an applicant interested in any of our “Positions Available” listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee. Upon receipt of your application a copy of our placement fee agreement, which you agree to sign and return immediately, will be mailed to you by our office. In sending applications be sure to list the key and job number.

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Positions Available
January 1964

DEVELOPMENT ENGINEER, electrical graduate, with a minimum of 5 years’ experience in transistor high-frequency pulse and digital circuit design (nanosecond range). Broad background preferred encompassing vacuum-tube and analog techniques. Equal opportunity employer. L.H., N.Y. W-4014(b)

SUPERVISOR, BSEE, with 5 to 15 years’ managerial experience with electromechanical background and emphasis on electronic circuitry, as applied to production machinery, for a producer of precision multicolor printing processes. Will be responsible for recommendation, design, and application of electrical equipment to company products, assist on installation problems, and advise on plant electrical problems. $10,000-$12,000 plus profit-sharing retirement plan and liberal insurance program. Conn. W-4011.

PRODUCT ENGINEER, BSEE or BSME; with 2 to 5 years’ experience in production of electromechanical and/or electronic equipment. Good working knowledge of fairly simple solid-state circuitry. Will see that manufacturer holds to engineering specifications to $10,400. Fee negotiable. Metropolitan N.J. area. W-4005.

ELECTRICAL TRANSMISSION ENGINEER, BSEE, with 5 to 10 years’ experience in transmission line design, engineering and construction. Salary open. Apply by letter including salary requirements. Mass. W-3998(a).

JUNIOR ENGINEER, BS in EE or ME, with 0 to 2 years’ general engineering experience, to enter training program with corporate staff engineering group. Limited travel. To $8000. New York, N.Y. W-3988.

ELECTROCHEMIST, Ph.D. or equivalent degree, with knowledge of and competence in electrode kinetics from an experimental point of view, for investigations of electrode reactions in nonaqueous media from a fundamental point of view. Considerable independence in planning and executing the work. Salary open. Mass. W-3980.

TECHNICAL WRITER, engineering degree, with experience in preparing texts for proposals and publications, preferably relating to the electronic component field. Will write proposals for submission to customers concerning design capabilities, functional application and manufacturing delivery capabilities for manufacturers of electronic connectors. Will assemble detailed technical information to be written in letter form in support of bids to customers in the OEM, military and aviation markets. Salary open. Conn. W-3961.

ENGINEERS. (a) Research Engineer, degree in electrical engineering or physics, with 2 to 5 years’ experience. Work will include studies of the behavior of dielectrics at high frequencies, setting up instrumentation laboratory in connection with the development of microwave components. Salary open. (b) Sales Engineer Trainees, electrical or mechanical degree, plus component selling experience to OEM accounts. Indefinite training period at headquarters plant followed by territorial assignment somewhere in U.S. To $10,000 to start. Company pays fees. Headquarters, Central Penna. W-3957.

DESIGN ENGINEER. Capacitors, BSEE or equivalent product design experience in capacitor field. Experience in the design and product development of high-voltage capacitors; will be involved in design and development of capacitor units using dielectrics such as rolled Kraft paper, mylar, teflon, ionix and bentonite clay film capacitors. From $10,000. Company pays fee. Central Penna. W-3956.

SENIOR PROJECT ENGINEER, Cutouts, BSEE, with several years’ experience in cutout design, for design and development of distribution cutouts and fuse links. $9000-$12,000 plus annual cash bonus, profit-sharing retirement plan, full medical and group insurance, interview and moving expenses paid. Missouri. W-3953.

SALES ENGINEERS. (a) Senior Sales Engineer, BSEE, math or physics. Minimum of 3 years’ selling experience in electronics research and development to government. $10,000-$14,000. (b) Electrical Engineer, young, interested in sales work. Actual sales experience not necessary and/or will take non-degree sales engineer with ‘more years’ experience in command control sales. $10,000-$14,000. (c) Advanced Programs Command and Control—Marketing. Past experience in command and control electronics, missiles and weapons. For Army, Air Force, and Navy. MSEE required. $13,000-$16,500. East W-3924.

SALES ENGINEER, electrical graduate, with electrical equipment sales experience, to sell high-voltage power capacitors, large and small, through manufacturers’ representatives. Considerable traveling. $8000-$10,000. Headquarters, New England. W-3899.

EDITORIAL PERSONNEL. (a) Assistant Editor, BSEE, to procure and edit articles on theory and application. Will develop systems, control systems, digital data, etc. $9000-$11,000. (b) Assistant Editor, BSEE, background in electronics with a flair for reporting and writing technical articles in this field. $7500-$10,000. New York, N.Y. W-3882.

ELECTRONICS ENGINEER, at least a BS in EE or an ME, experienced in the design of electronic-electrical/mechanical control devices with some supervisory experience. Must be design and engineering competence necessary. Will develop commercial systems rather than production or industrial engineering. Should be interested in taking on administrative management responsibilities. $15,000-$20,000. Mass. W-3870.

ELECTRICAL ENGINEER, with at least 5 years’ experience in field or field-related power supplies, to design (both theoretical and practical) new models with specified characteristics and costs. Test prototypes and prepare reports on same and supervise others doing similar work. Must be versatile. Small but growing firm. To $12,000. Central N.J. W-3869.

DEVELOPMENT ENGINEER, graduate electrical, mechanical or chemical, with about 10 years’ experience in electronic equipment design, to design and develop control systems and components in process or steam power fields, to design and analyze electrical control systems for power boilers and boiler turbine units for field. Some overall and supervisory responsibilities. Must be familiar with some of the latest theories, have broad experience in all types of power generation. To $15,000. Conn. W-3863.

DESIGN ENGINEER, BSEE, with at least 3 to 6 years’ experience in the design and development of pulse system packages (modulators), charging chokes and pulse transformers for application in the radar field. Some overall and supervisory responsibilities. $13,000-$16,000. Upstate New York. W-3851.

SALES ENGINEER, Inertial Instruments Products, with experience in inertial guidance systems components for application and sales to military, industry, and potential customers. Complete knowledge of accelerometers, gyro’s and possibly attitude reference platforms; also design or systems engineering important. Will call on Air Force and Navy and possibly other services. Salary $12,000-$15,000, with possible additional salary related to specific product line; will act as company technical representative to potential customers; coordinate inputs from sales representatives with broad management objectives. $10,000-$16,000. New Haven, Conn. W-3851.

ASSISTANT CHIEF ELECTRICAL ENGINEER, graduate, with minimum of 10 to 15 years’ experience in transmission and distribution for a large firm of consulting engineers. Should have design, estimating, construction, and office experience to do all proposal and contract work on this type of work. $50,000-$80,000. East W-3846.

SENIOR ELECTRONIC PROCESS DEVELOPMENT ENGINEER, electrical engineer. physicist, etc., with inventive ability and flair for the unusual approach and solution to problems. Successful record of unique accomplishments in electrical/electronics fields; experience in optics, computing circuitry, control circuitry and/or process control desirable. Will be responsible for designing and developing electronic and electronic systems to control manufacturing processes—e.g. (1) make measurements of small angles and dimensions in the x-y range and (2) develop high-speed sizing-gaging control without “contacting” product. To $15,000. Mass. W-3825.
SENIOR ELECTRICAL ENGINEER, graduate, with about 1 year's experience in the preparation and supervision of electrical and power wiring as associated with institutional, industrial and government projects, and in the drafting of electrical circuits.

ASSISTANT TO ENGINEERS, with 2 to 3 years' experience; salary open; usual employee benefits including leave, group insurance, etc. Apply by letter including full résumé of education and experience and indicating salary requirements and data of availability. Virginia. W-3815.

PRECIPITATION ENGINEER, preferably electrical graduate, will consider mechanical or chemical graduate with the design of operation of electrical precipitators for the power industry. Field experience in locating and correcting any drafting deficiencies essential. $10,000-$12,000. Apply by letter giving complete information including salary requirements. East. W-3824.

ELECTRICAL ENGINEERS, market research, graduate EE, with 3 to 6 years' experience in industry (design, production, liaison, sales) in any one or more of the following broad product areas: digital computers, telecommunications, appliances, to function in a corporate or departmental assignment. Must have a minimum of 2 years' experience in design and development of electrical products, devices, and systems, and a strong background in electrical engineering. In excess of $12,000. New York Metropolitan area. W-3828.

RELAY PROTECTION ENGINEER, graduate electrical, with primary emphasis placed on power and at least 2 years' experience with an electric utility in relay and protection department or a minimum of 5 years' experience with a utility manufacturer of protective equipment in the field of protective relaying coordination. Should have good working knowledge of symmetrical components. Salary open. West. W-3753.

MAINTENANCE ENGINEER, graduate electrical, mechanical or chemical, with 0 to 2 years' experience, for planning and directing present and long-range programs of plant and office maintenance (preventive and otherwise) in ultramodern manufacturing facilities. Must be capable of immediate supervisory role. Fine future. To $9500. Central New Jersey. W-3687.

PATENT ATTORNEY, undergraduate science degree, preferably in electrical or mechanical engineering and an LLB degree; must be a member of state or D.C. bar, admitted to practice before the Patent Office. Must have a minimum of 5 years' experience as a practicing patent attorney (electronics area helpful) with a minimum of 2 years' experience in filing and/or handling patent applications. Salary: $15,000-$20,000 plus profit sharing. Company pays fee. Conn. W-3679.

PHYSICIST OR ELECTRICAL ENGINEER with experience in the development of gaseous discharge devices such as voltage regulators, thyatrons, gas arcs and gas tubes. Should have a good background in vacuum technology; prefer some production experience. Salary open. Company pays fee and relocation expenses. Central New Jersey. W-3657.

ELECTRICAL ENGINEERS: (a) Electrical Engineer with 5 to 10 years' experience, graduate or professional engineer, experienced in the electrical phases of iron and steel plant design. Capable of power and wiring, control, layout of substations, motors rooms, control houses, control panels, simple line schematic, interconnexion and wiring diagrams, interior and exterior lighting, etc. (b) Electrical Designer, minimum of 5 to 15 years' experience, graduate or professional engineer, experienced in the electrical phases of iron and steel plant design. Capable of power and wiring, control, layout of substations, motors rooms, control houses, control panels, simple line schematic, interconnexion and wiring diagrams, interior and exterior lighting, etc. Ohio. W-3617.

MEN AVAILABLE

New York Office

ELECTROMECHANICAL ENGINEER, B.S.; Physics; includes design and development of electromechanical systems and devices; 8 years' project level. Broad background including electrical, mechanical, production/service engineering, mathematical evaluation, relay control circuit design for automatic programming of machinery. $11,000. Any location within U.S. E-100.

ELECTRICAL ENGINEER, PROJECT SUPERINTENDENT, BSEE; 20 years' experience supervising hydroelectric and steam power plant design and construction including substations, transmission lines, quality and cost control, cost estimates and reports to promote financing, $14,000. Location immaterial. E-101.


PLANT ENGINEER, Printing, MSE; Management; 15 years' total experience in three years' experience in travel or relocation, modifications for versatility and special equipment design. Maintenance management. $15,500. Location immaterial. E-103.

ELECTRICAL ENGINEER, Power, MSE; 3 years' experience, partly with public utility companies and partly with manufacturer of heavy electrical equipment. Open. Location immaterial. E-104.

MANAGER, BS; 25 years with large corporation developing and promoting automatic welding has provided extensive technical knowledge of electronic and mechanical control systems, metallurgy, plus managing responsibilities in development, manufacturing, sales, profit analysis, market research and forecasting of industrial products. Residing New York Metropolitan area; will relocate. E-105.

PRODUCTION ENGINEER, Electrical, BSEE; 9 years' experience as an electronic engineer and 6 years as a machinist. Good electromagnetic background. Sketch, board and test circuits. $11,000. New York Metropolitan area and Long Island. E-106.

ELECTRONICS ENGINEER OR ELECTRICAL ENGINEERING TEACHER, BSEE, MSEE; 1/2 to 3 years' experience with electrical engineering; 1½ to 3 years' computer experience; one-half year system engineering study experience; one-half year microwave radio instructor, U.S. Army. Salary open. Location immaterial. E-107.

ELECTRICAL ENGINEER, Power Distribution, EE; 16 years' experience in low-voltage distribution system field. Automatic network protectors and relays, vaults and buses, field and laboratory testing of equipment $10,000. East, South, Midwest. E-108.

MARKETING MANAGER, BA and BSME; 20 years' experience in engineering, production and marketing; experience in electromechanical components and devices—industrial OEM, military—successful background in establishing product lines, marketing area, and sales organization. Can budget cost and project anticipated sales; excellent background in marketing. E-109.

CHIEF PLANT ENGINEER, BS, MS in EE; Professional Engineer; 12 years' experience in plant engineering and maintenance in food processing industry with 4 years in electronics industry. Experience in purchasing, building and equipment maintenance, new building construction and supervision, plant layout, liaison with contractors and architects. Established author. $15,000. East Coast or Chicago area. E-110.

ELECTRICAL ENGINEER, supervising testing, troubleshooting, installation; BEE; 1 year's experience designing transistor circuitry for military training devices; 1 year's experience preparing installation specifications and test equipment; 1 year's experience preparing, testing, and troubleshooting specs for telephone equipment. $11,000. Desires Europe—i.e., Paris, Brussels, Amsterdam. E-111.

JUNIOR ENGINEER, FIELD ENGINEER, BEE; recent graduate; electrical engineering laboratory has given practical experience in handling analytical procedures. $5500-$6000. Will travel or relocate; residing on Long Island, New York. E-112.

JUNIOR ELECTRICAL ENGINEER, BSEE; research assistant, quantum electronics laboratory, Purdue University; assisted in development of laser power meter. Prefers New York Metropolitan area. E-113.
**Interferometric device splits laser beam, permitting exact control of phase coherence for optical surveillance**

An optical circuit component capable of dividing or attenuating a laser beam has been developed.

The interferometric module, designed by Electro-Optical Systems under research and development contract for the Air Force Systems Command, Rome Air Development Center, is expected to meet a primary need for the precise control of visible and infrared coherent radiation from lasers and radars (infrared amplification by stimulated emission of radiation). Also, it represents a step in the ultimate utilization of these regions of the electromagnetic spectrum in communication and surveillance systems.

The optical component has particular significance in laser optical circuits where the original input light beam must be split or attenuated to perform additional system functions. It may prove to be an important contribution to future optical surveillance systems requiring exact control of phase coherence.

To avoid oversensitivity to manual control and to give compact, sturdy construction, the three main requirements of the device—laser beam phase shifting, power division, and attenuation—are accomplished without mechanical movement in a single interferometric configuration.

Paramount in this design are two gas-cell phase shifters capable of shifting laser beam phases over a 360-degree range. The phase shifters are each located between a 50-50 frustrated total reflectance beam splitter and a totally reflecting mirror to form a rectangular device with the reflecting surfaces at diagonally opposite corners.

Though other laser sources can be used in testing the optical component, EOS uses coherent plane-polarized beams from a ruby crystal laser and helium-neon gas laser with outputs at approximately 0.7 micron and 0.6 micron, respectively.

In operation, the laser beam is aimed into the rectangular interferometric module where it is divided by the first beam splitter. Half of the split beam is then fed directly through a gas-cell phase shifter onto a totally reflecting mirror where it undergoes a 90-degree directional change and continues into the output beam splitter.

The second half of the beam travels a similar circuit path but in different sequence. It is first reflected 90 degrees
Computer-generated movies communicate mathematical research in three-dimensional form

Computer-generated movies produced automatically by the S-C 4020 computer recorder were demonstrated at the 1963 Fall Joint Computer Conference, held last November at Las Vegas, Nev.

The S-C 4020 utilized as an animator, receives mathematically coded information from the computer and uses an electron beam as a pencil to create a series of drawings in rapid succession on the face of a cathode-ray tube. A camera mounted opposite the face of the display tube records the series of drawings on succeeding frames of microfilm. Typically, a single drawing is recorded on a film frame in less than 1/3 second.

Sequence of steps in the production of a computer-generated movie technique. Shown at left is a box-shaped satellite photographed on the face of the display tube inside the SC-4020 computer recorder. Next to the satellite is a clock to give time reference. At right is a time exposure of several drawings, showing the satellite in various positions at different times as it tumbles in orbit.

One of the films being demonstrated was created on the S-C 4020 operated by Bell Telephone Laboratories, Murray Hill, N.J. The film depicts graphically the various attitudes of a communications satellite as it tumbles through space during orbit. The satellite is represented as a domino-shaped box with sides identified by distinctive symbols. Each frame of film shows an accurately drawn three-dimensional representation of the satellite in slightly different positions along its course.

Prior to production of the film, an IBM 7090 computer was programmed to produce a magnetic tape containing the data necessary to study the satellite’s
Pictorial weather map can be prepared directly from computer signal by facsimile converter

A new electronic device can convert computer electronic signals directly into a pictorial weather map.

The device, called a facsimile converter, was developed for the Air Force by United Aircraft Corporate Systems Center, Farmington, Conn., to automate preparation and transmission of weather forecast maps. The converter permits facsimile transmission of computer-processed weather data directly to weather stations in the form of maps or photographs, without necessitating the actual drawing of a map.

The facsimile converter takes a signal coming from a digital computer tape and transforms it into the conventional analog signal which can be received on a weather station's facsimile receiver. The converter signal is transmitted directly over regular land communications lines, eliminating the scanning of hand or plotter drawn weather maps on a facsimile transmitter, as must be done at present.

Two facsimile converters were delivered to the Air Force Communications Service for installation in Global Weather Central at Strategic Air Command headquarters, Offutt Air Force Base, Omaha, Nebr.

Computer-processed weather data currently is used in preparing actual maps for transmission on a facsimile scanner, but the map preparation and scanning steps are not necessary with use of the facsimile converter.

Map-producing signals can be transmitted via the converter at any speed that equipment in weather stations is capable of receiving. Normal facsimile receiving speed is 120 scan lines a minute.

Facsimile converter (right foreground) makes possible the transmission of computer-processed weather data in the form of maps and other pictorial information that can be received on a conventional facsimile receiver (left). Converter transforms digital computer signals on magnetic tape into analog signals that can be received and printed by the facsimile receiver. Two of the converters are in use by the Air Force.
However, a high-speed monitor at Global Weather Central will turn out a map eight times faster than normal speed to permit a check and review of the completed product before actual transmission is made to weather stations.

In use, the facsimile converter will disseminate 24- and 36-hour computer-prepared forecasts showing isolines of pressure at selected altitudes over land and sea areas of the earth, as well as printed numeric data reporting pressure, winds, and temperature at selected grid points on the map face.

Raw weather data flowing into Global Weather Central from observation stations all over the world is computer-processed to prepare analysis and forecasts. In utilization of the facsimile converter, a second computer operation blends in the resulting forecasts with preprogrammed material representing the background map and other graphics material. The resultant magnetic tape, which is fed to the facsimile converter, contains the map, isolines, and numeric weather information, all in digital information bits.

The facsimile converter then transforms the information bits into one of two analog signals which instruct facsimile receivers either to print or not to print at every given point on the paper being fed through the receiver, thus producing a complete map. The program used was a product of the center.

Research may lead to use of human waste for purposes of powering future manned space flights

Scientists are conducting research that may lead to an efficient way to dispose of human waste during extended manned space flights. Philco Corp.'s Aeronutronic Division, Newport Beach, Calif., is conducting a one-year study of basic bioelectrochemistry for the National Aeronautics and Space Administration (NASA) Office of Advanced Research and Technology.

The Aeronutronic study is part of a broad NASA program of basic, applied, and developmental research into biochemical fuel cells. These cells may play

Research scientist uses a chronopotentiometric apparatus to obtain experimental data in a study of basic bioelectrochemistry being conducted for NASA. By passing electric current through electrodes, reactions can be simulated that would occur in a biochemical cell. Power may thus be generated from human waste.
a dual role in future manned spacecraft: disposing of human waste and providing auxiliary electric power.

It is believed electric power can be tapped from micro-organisms in the course of growth processes if a suitable electrochemical cell is used. Normally, this power is wasted as heat.

Research at Aeronutronic is concerned with identifying the chemical reactions that occur at the electrodes of the biochemical fuel cell, determining the efficiency to be expected from such fuel cells, and deciding which cells would be most useful.

In addition to possible space use, biochemical fuel cells may have military value as unconventional power sources in a variety of applications. They also may be used to provide power in fuel-poor, underdeveloped areas of the world.

**Papers on biomedical telemetry featured at Instrument Society’s 18th Annual Conference**

With “Frontiers in Instrumentation” as its theme, the Instrument Society of America’s 18th Annual Conference and Exhibit was held September 9-12, 1963, at McCormick Place, Chicago.

One of the highlights of the conference was a session on biomedical telemetry, programmed by the ISA Biomedical Sciences Division and developed by Lloyd E. Slater, who was then with the Foundation for Instrumentation Education and Research.

**Microcircuitry for biotelemetry.** A paper presented by Case Institute of Technology’s Prof. Wen H. Ko reviewed some of the remarkable developments during the past year in the area of microminiaturization of a tunnel diode FM telemetering transmitter. Many thin film and integrated solid circuits are now available for biomedical telemetry. Solid circuits are being produced with all the components either on a single silicon crystal wafer or several chips of single crystal wafers assembled on a substrate to form a packaged unit. An integrated transmitter of this type, whose overall volume is 0.012 cubic inch and which weighs about 0.02 ounce without battery, has been achieved.

Ko emphasized that the power supply now has become the largest and heaviest component in the system. Research experiments are being conducted by private industry using the environment of the electronic circuit. Radio waves, body temperature, motion, and chemical energy are being investigated as possible sources. The Case Institute has announced forthcoming experimentation in powering a model of the transmitter with body energy. The application of these transmitters in internal medicine, disease diagnosis, and biological experiments presents exciting future possibilities.

**Progress in physiological biotelemetry.** Professor Stuart R. Mackay, of the University of California, opened his paper with the observation that “swallowing a physician is rather inconvenient...” But swallowing a miniaturized radio transmitter, about the size of a large vitamin capsule, is relatively simple. Some of the medical data that can be transmitted from within the human body include local values of fluid pressure, temperatures, acidity (pH), oxygen tension, radiation intensity, the site of bleeding, and various bioelectric potentials associated with the heart and brain. With available modern components, a small frequency-modulated radio transmitter can emit signals for about a year. The unit may be either swallowed or surgically implanted in human tissue. If swallowed, the unit can reach parts of the body that would be inaccessible to observation except by surgery.

The type of transmitter that is used for intestinal data, for instance, contains the following elements: a coil and capacitor that constitute a tuned circuit having the characteristic frequency of oscillation, and a transistor and battery that serve to maintain the oscillations.

The complete assembly of a solid circuit disk with all components mounted...
Such a transmitter, used to record the pressure fluctuations accompanying the peristaltic action of the intestines, is activated by pressure changes that move the core toward or away from the coil, and thus alter the frequency of oscillation. Most of the energy radiated by the transmitter comes from the coil, which thereby serves also as an antenna. Long-life silver oxide batteries are used with silicon transistors. These pressure-sensitive transmitters have been used effectively to follow the course of intestinal activity recovery following abdominal surgery.

Another type of transmitter, involving the Mackay-Marg "onometer" principle (developed for eyeball tension measurement in the diagnosis of glaucoma), allows absolute blood pressure to be recorded through the intact wall of the blood vessel. When this unit is pressed against a blood vessel, until the wall is flattened onto the core and the surrounding insensitive annulus, the internal pressure will be indicated, independent of such factors as the tension in the intervening tissue.

Avian navigation research. Interesting data and clues leading to the future solution of the bird navigational instinct mystery, both in homing and migration, are presented in William E. Southern's paper, "The Application of Biotelemetry in Avian Navigation Research." During the summer of 1962, Prof. Southern, a biologist at Northern Illinois University, attached miniature radio transmitters to various species of American wild birds (purple martins, herring gulls and bald eagles) to track their diurnal and nocturnal flight paths. The transmitter-receiver tracking system consisted of field stations with triple-beam Mosley antennas on 30- to 40-foot towers and on mobile and portable units. A tracking system frequency of 26 Mc/s was used. In one instance, a bald eagle was tracked 42 miles from release point. The average tracking distance, however, was about 15.3 linear air miles. The flights, often erratic, were over diverse types of terrain. The radio tracking provided ornithologists and biologists with valuable information about the flights of birds in reference to various topographical, climatic, and other geophysical conditions. These experiments may be conducted eventually over the long-range major migratorial flyways.

Ruffed-grouse studies. Professor William H. Marshall, of the University of Minnesota Department of Entomology, Fisheries and Wildlife, gave a paper...
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Immature bald eagle with transmitter
packet on breast. Aluminum wire anten-
a and black harness material are
visible. The black hood is placed over
the head to calm the bird during handling

describing ruffed grouse studies by the
use of radiotelemetry techniques. The
major objectives of the 1963 winter and
spring field experiments were to study
the relationship between male and
female grouse during the breeding,
nesting and brood-rearing seasons. The
electronic equipment attached to the
birds for these purposes consisted of a
transmitter and power and harness
components, weighing a total of about
20 grams. The portable receivers used
by the participating scientists could
handle 12 individual transmitters at
discrete 15-Mc/s intervals between
150.815 and 151.185 Mc/s.

Fifteen grouse were RF marked with
transmitters and about 2500 locations
were obtained on these birds. Interesting
data were compiled on the shelter,
feeding, and mating habits during the
birds’ mating and breeding cycles.
The paper stressed, however, that an
insufficient number of birds have been
“wired for sound” to establish any
definitive conclusions.

NBS to publish
National radio science journal

The National Bureau of Standards an-
nounces changes in Section D of its
Journal of Research. Section D, until
this month called Radio Propagation,
is a national journal of radio science
published by NBS in cooperation with
the U.S. National Committee of the
International Scientific Radio Union
(URSI). In keeping with the broadened
scope planned for the new publication,
itis named Radio Science; it will
be published monthly rather than six
times a year as before. The subscription
price is $9.00 a year ($11.50 foreign).
Correspondence

On models for reality—Philosophy, including the more specialized philosophy of science, is not a particularly familiar topic with engineers. The practicing engineer (civil, mechanical, electrical, etc.) is likely to be a pragmatist who is not directly concerned with questions of basic research (or metaphysics or epistemology). He has little need for justifying what he does in terms of a philosophy—the obvious short- and long-run economic needs of society provide justification enough for a pragmatist. When an engineer turns to basic research, he becomes a scientist with a useful tool (i.e., engineering know-how) and forthwith joins with others in the physical and life sciences who seek to clarify basic questions. Sometimes the converting engineer needs a philosophic hand-hold in order to make the transition gracefully. The purpose of this note is to offer such a crutch—but I hasten to warn that the one to be discussed does not fall into the conventional pattern.

Current philosophy as it pertains to physical science seems to have been most influenced by the successes of Einstein’s theory and the often elegant logic of Bertrand Russell. I wish to describe an earlier and much less popular philosophy as formulated by Herbert Spencer (who was an engineer), T. H. Huxley, and others. Strangely, Spencer is scarcely even mentioned in many books on the philosophy of science most appropriate to the physical sciences.

Spencer championed the notion of thoroughly going scientific agnosticism—that nothing is provable or understandable. Indeed, this is a forlorn philosophy and it is apparent why a strong following did not develop, especially after these notions spread to morality, ethics, and religion. A typical situation given in support of Spencer’s philosophy is the limitlessness of matter—one can never really discover the logical limit of smallness on the one hand or of vastness on the other.

It is intended here to rephrase scientific agnosticism in a way that is somewhat more palatable, and perhaps even more than trivially different from that due to Spencer. Plenty of room will be left for separate opinion in metaphysics and religion, which the Spencerian dogma appears to abolish as inconsequential. Before proceeding, however, it is well to point out that what satisfies the life scientist in the way of a philosophy may not be embraced by a physical scientist. The former prefers to base his concepts on Darwin’s theory; the latter on mathematical logic. Perhaps this difference in point of view is due to preoccupation in the life sciences with evolving structures, whereas evolution as such has little or no bearing on problems of interest to the physical scientist. When one tries to build physical simulations of phenomena from the life sciences, the two points of view must be reconciled. Perhaps the following discussion can aid in this.

Let a phenomenon \( P \) be represented in symbolic terms, where symbols may be prose, logical statements, geometric structures, mathematical equations, and so forth. Phenomenon \( P \) is explained by truth \( T \), which can be expressed in an unlimited sequence of terms as

\[
T = T_0 + T_1 + T_2 + \ldots + T_n + \ldots
\]

where we suppose that \( T_i \) is the principal statement of \( T \). \( T_0 \) is the first-order correction term to \( T_n \), \( T_1 \) is the second-order correction term, and so forth. The independent variables in \( T \) are left unspecified for convenience—actually, everything that happens in the universe may have an effect on the single phenomenon represented by \( T \) (as in Lewin’s field theory).

Man, through several senses, observes \( P \) and seeks to discover \( T \). He attempts to construct model \( M \) in symbolic terms hoping that, at least for his requirements

\[
M = T
\]

Model \( M \) has a sequence of terms (albeit, many may be zero) so that

\[
T \approx M = M_0 + M_1 + M_2 + \ldots + M_n + \ldots
\]

Let us suppose that, by stroke of good fortune, a scientist finds a few of the leading terms in \( M \) which are also those in \( T \). Then

\[
T \approx M = T_0 + T_1 + T_2 + \ldots + T_q + M_{q+1} + M_{q+2} + \ldots
\]

in which event a model for the truth has been discovered. But caution must be exercised: \( M \) is not \( T \), but only
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approximates $T$. $M$ represents a fictitious world invented by the scientist in order to explain reality. Many scientists have been fooled into mistaking $M$ for $T$, especially if $M$ consists of a compact mathematical statement.

Along with a successful $M = T$ approximation, a model based on causal factors is often provided. This model is generally identical with the entire sequence $\sum M$. Let us next ask the question: How many symbolic models $M$ based on arbitrary causal factors exist whose first $q$ terms agree?, i.e., if

$$T \approx M_1 = T_0 + T_1 + \ldots + T_q + M_{q+1} + M_{q+2} + \ldots$$

$$T \approx M_2 = T_0 + T_1 + \ldots + T_q + M_{q+1}' + M_{q+2}' + \ldots$$

$$T \approx M_3 = T_0 + T_1 + \ldots + T_q + M_{q+1}'' + M_{q+2}'' + \ldots$$

and if each approximation conjures up a different set of causal factors, then which model and associated set of causal factors is the correct one?

From the foregoing it is evident that any one phenomenon can be approximated in terms of an unknown number of models $M$ and associated sets of causal factors. No single explanation can therefore be expected to be absolutely correct.

The task of the scientist is apparent from this argument. He must seek ever more accurate approximations to reality. In the process he may be able to rule out certain models with their indicated systems of causal forces in preference to others. In the course of his work, the scientist should be willing to modify his theories of causality, even drastically if indicated (which, unfortunately, sometimes involves emotional factors when "pet" theories are attacked). The frustrating thing about all this is that the process is never ending; existence of numerous and competing sets of causal factors must always be recognized. In fact, more causal systems may remain unknown than known! We can at least take comfort in the apparent never-ending need for (paid) scientists.

As an aside, the nature of an applied scientist can perhaps be clarified at this point. He seeks to adapt a known model to a current need. In this process, he does not obtain a more accurate approximation to reality except, perhaps, inadvertently.

Some phenomena have terms in the $T$ series which decrease very rapidly. In such cases, only a few of the leading terms need be discovered in order to acquire a relatively good model. Such is
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A definition of hot electrons. It seems appropriate to point out that the terms "hot electron diode" and "hot electron triode" as applied to a metal-semiconductor diode and a semiconductor-metal-semiconductor triode, respectively, are confusing, inasmuch as they suggest that other devices, in particular p-n junction devices, are not hot electron devices. The purpose of this note is to emphasize that conventional p-n semiconductor diodes and triodes are also hot electron (or hole) devices and to suggest that other more suitable terms be used to apply to the metal-semiconductor diodes.

The term "hot electrons" was evidently coined by Shockley to describe electrons in the conduction band of germanium that had been elevated to energies well above the bottom of the conduction band by a strong electric field. This does not imply, however, that electrons very near the bottom of the conduction band cannot also be hot electrons under suitable conditions. The proper reference level is the Fermi level and the correct definition of hot electrons must be those electrons associated with an excess density over the density corresponding to thermodynamic equilibrium with the lattice. The thermal equilibrium density is the product of the density of states in the material and the Fermi-Dirac distribution function for electrons at the appropriate lattice temperature. There are several ways of generating hot electrons (or holes) in various materials, as indicated in this list:

1. Photoexcitation in any material
2. Quantum mechanical tunneling, as in Esaki diodes and metal-insulator-metal structures
3. Minority-carrier injection across a forward-biased p-n junction
4. High-field acceleration in non-metallic materials, as in avalanche

John L. Stewart
Santa Rita Technology, Inc. Menlo Park, Calif.

the individual terms in T are as unknown as T itself. So we leave the problem at this point—perhaps the dilemma can be resolved through astrology. But in any event, I hope the discussion has softened the implications of scientific agnosticism by suggesting that truth may at least be achievable in the limit. I also hope that the notion of approximation serves to suggest a bridge with which different philosophies may be reconciled.
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breakdown in reverse-biased p-n junctions
(5) Schottky emission over a metal-semiconductor junction that is forward biased.

Any device utilizing any of these phenomena could be called a "hot-electron" (or in some cases "hot-hole") device, but such an adjectival phrase is not particularly definitive.

It is suggested that metal-semiconductor diodes be called M-S diodes, and that semiconductor-metal-semiconductor triodes be called S-M-S triodes or metal-base transistors.²

Donovan V. Geppert
Stanford Research Institute
Menlo Park, Calif.


Watch your language! My duties as Editor of the IEEE TRANSACTIONS ON ELECTRONIC COMPUTERS have made me sensitive to a number of solecisms and inaccuracies current in the speech and writing of the members of our profession. I hope that pointing them out may be a small step toward stamping them out. I find especially offensive:

1. The use of "finite" where "non-zero" is intended. Thus, engineers often speak of "a finite probability," just as though there were some other kind. Again, a recent book speaks of "finite-width sampling pulses" on one page and on the next of "finite band-width." One must read with care in order to recognize that the author means in one place "not zero" and in the other "not infinite"!

2. The careless redundancy of "binary bits." Since "bit" is a contraction of "binary digit," the repetition of "binary" is quite unnecessary.

3. "Hopefully." This adverb is enormously abused. For instance, "The signal is hopefully well above the noise." A signal cannot do anything "hopefully," or "cheerfully," or "happily." "Hopefully," like these others, is an adverb that may be used properly only to describe the actions of people. One may hope that the signal is well above the noise, but the signal itself is quite indifferent about the matter.

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