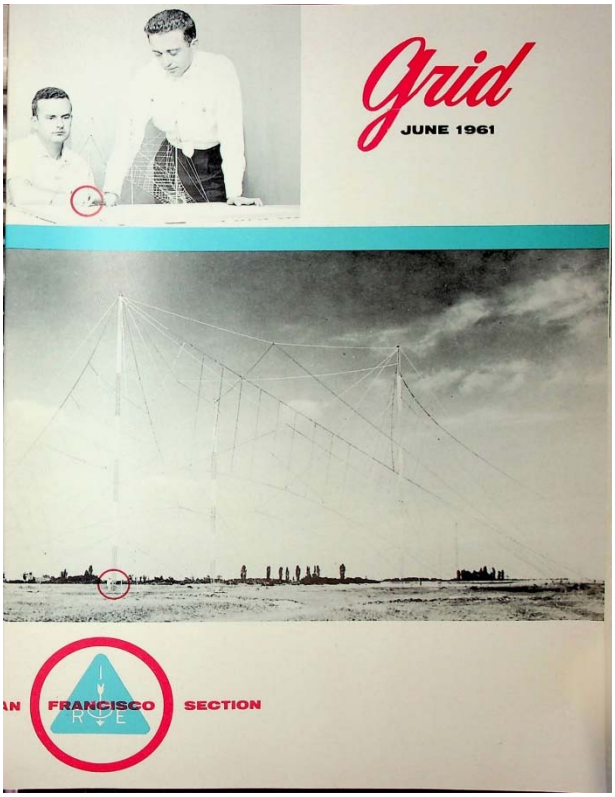
EDITOR'S PROFILE of this issue

from a historical perspective …

with Paul Wesling, SF Bay Area Council GRID editor (2004-2014)



June, 1961:

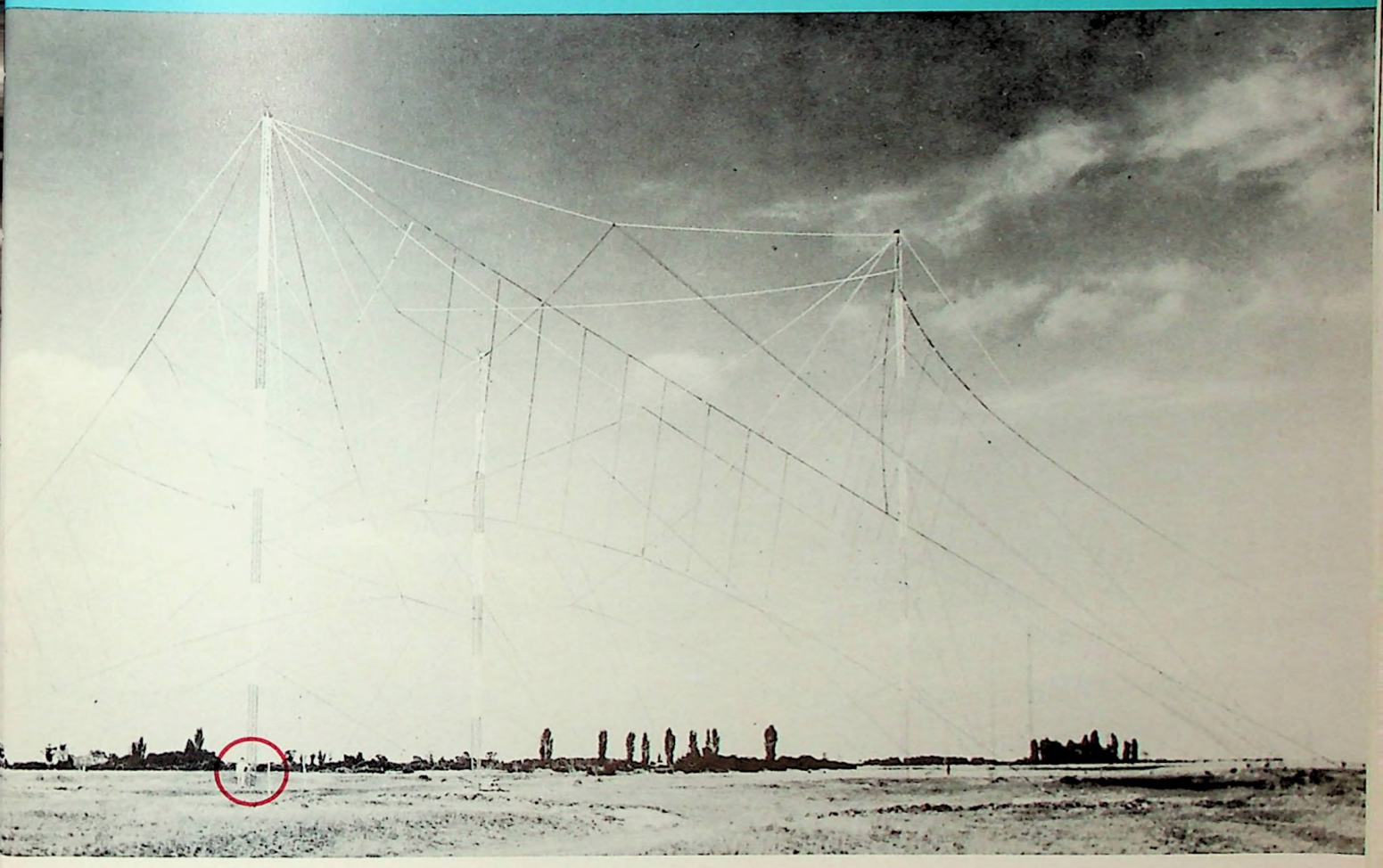
Cover: The model of a log-periodic antenna array, above, and the actual installation in New Zealand. This one covers the HF and VHF bands. More details on p. 10.

p. 26: With the manned space program gearing up, a lot of interest is developing in the Mercury program. In this photo, local engineers show a disconnect fuse for the capsule's retro-rocket.

p. 32: Wayne Amacher moves to the Bay Area as an IRE member. Wayne becomes active in various chapters and at the Section level over the years; he and I worked on several projects together. James (Jim) Gabbert joins IRE. He owned and ran several radio stations, including KPEN. We students at Stanford in the '60's enjoyed his early experimental transmissions of FM stereo, with a steam locomotive entering softly from the left, gaining speed (and volume) as it approached the center, and then exiting right with its whistle lowering in pitch due to doppler shift.

Grid

JUNE 1961

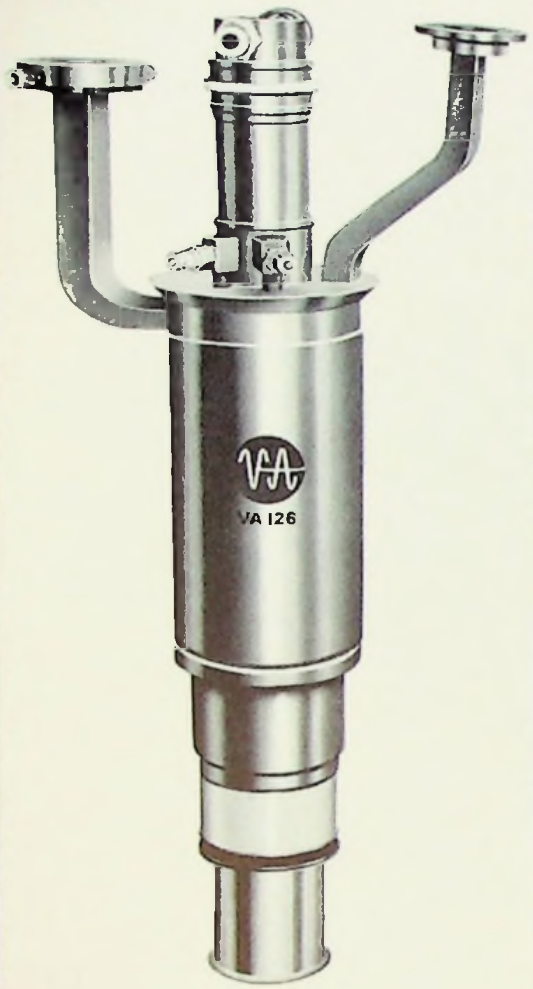


AN FRANCISCO SECTION

BANDWIDTH WITH HIGH EFFICIENCY

HIGHEST POWER TWT

3 MEGAWATTS AT C-BAND



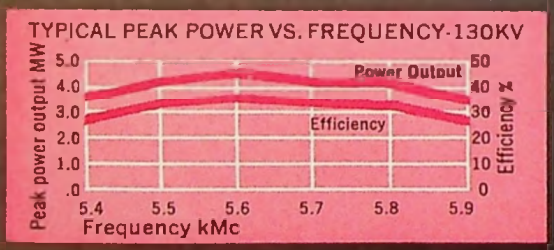
VA-126 TWT
3 MW Peak
5 KW Average
5.4 to 5.9 kMc

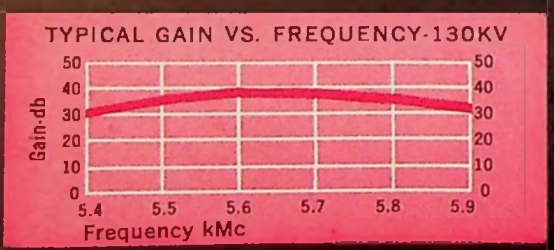
Varian Associates' new VA-126 pulse power amplifier traveling wave tube is particularly well-suited for advanced coherent radar systems employing frequency agility. With high gain and high efficiency over the full bandwidth, the tube offers a new standard in transmitter performance.

The VA-126 produces 3 MW peak and 5 KW average power, from 5.4 to 5.9 kMc. Gain, 35db; efficiency, 30%. Self-centering in electromagnet. Liquid cooled.

The VA-126 has 500 Mc bandwidth and excellent phase stability. These are desirable characteristics for pulse-to-pulse frequency changes, phase coding, chirping (frequency changes within the pulse), and electronically-steerable antenna arrays.

Varian's unrivaled capability in the development of advanced microwave tubes is at your service. For further data on the VA-126, write Tube Div.





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Arnold 6T tape cores (aluminum-cased and hermetically-sealed) offer you three very important design advantages. *One:* Maximum compactness, comparable to or exceeding that previously offered only by plastic-cased cores. *Two:* Maximum built-in protection against environmental hazards. *Three:* Require no supplementary insulation prior to winding and can be vacuum impregnated after winding.

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Use Arnold 6T cores in your designs for improved performance and reduced cost. They're guaranteed against 1000-volt breakdown . . . guaranteed to meet military test specifications for resistance to vibration and shock . . . guaranteed also to meet military specifications for operating temperatures. The 6T hermetic casing method is extra rigid to protect against strains.

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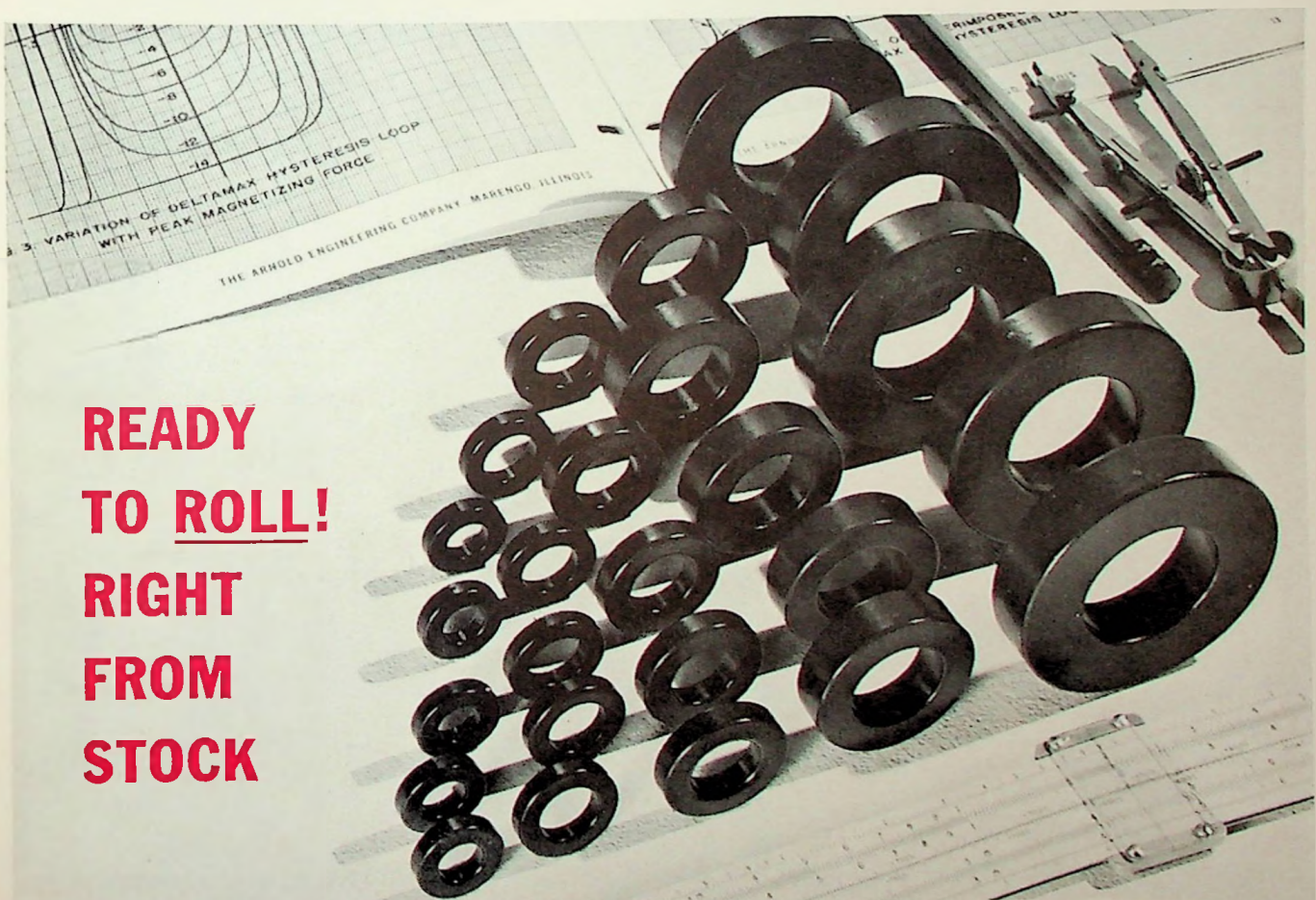

READY TO ROLL! RIGHT FROM STOCK

A rose by any other name . . . etc., etc., etc. Shakespeare, we finally realized, was right. In the depths of the night quite recently, we recalled, with not a modicum of horror, those first disastrous days when we were trying to put a name to the corporation now known as Rantec. "It's gotta have 'micro' in it," an officer high on the echelon (there were three of us at the time) claimed, "without 'micro' we just ain't in the electronics business." "Well, we're not, really," some wretched iconoclast put forth, "has anybody seen a contract around here yet?"

Having gotten rid of *him*, we settled down to facts, or some semblance thereof. R for radomes, ANT for antennas, EC for electronic components. RANTEC. Fabulous. Meaningful. Easy to say with your mouth full. And it was truly valid for about three and a half days. Although we still make antennas (and quite a number, if the truth be known), Rantec is now involved up to its neck in ferrite devices, multiplexers, waveguide components and microwave sub-systems. See what we mean.

The upshot of this entire thing has been a little game called "Pin the Tail on the Electronic Firm" which has succeeded in pulling our senior research engineers away from the ping pong table and our technicians away from the chessboard. The amazing thing is that the game has no prizes and nobody wins. Of course, nobody loses either which might or might not mean something. The rules are simple: name a fictional electronic firm. Although, as we said, there are no prizes, no one can deny us the right of picking our favorites. Try these on for size. (1) HydroPeptic, manufacturers of irrigation equipment; (2) Macroneurotic and its wholly-owned subsidiary. Frustronics, which provide problems instead of solutions; and (3) Myoptics, Inc. which designs and develops complete systems with equally complete obsolescence.

If first prize there were to be, it must be awarded to one of our brilliant electronic engineers who thought it might be wise to open up a second-hand hardware company in Culver City, California, and call it the Used Tool Company.

Any engineer on the outside who might have a smattering of knowledge about microwave theory or antennas or electronics of various orders and who might or might not want a job can join in the fun. Send your answer to Rantec Corporation, Calabasas, California. Rantec. That's pretty funny, right there.

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number 10

Grid

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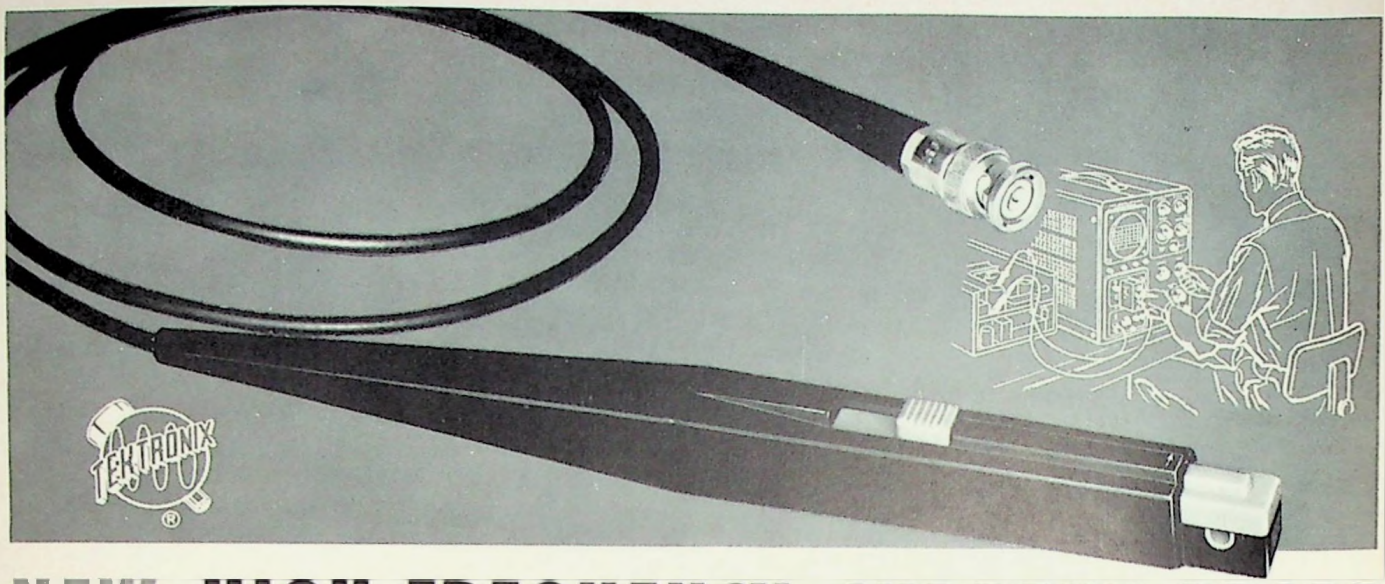
contents

cover

Scale model of an h-f horizontally polarized log-periodic antenna and its real counterpart located at Christchurch, New Zealand, are illustrated on the cover. Engineering and construction were handled by Granger Associates, Palo Alto.

Individuals are Dr. Ray Justice, head of the Granger antenna and microwave components group; and Charles E. Phillips, project engineer. Justice described the installation at a PGAP meeting May 10, reviewed on page 10.

Phillips, who took a leading role in the development and mechanical work, and supervised the installation, is visible to sharp-eyed readers at the foot of the left-hand mast, a spot corresponding to that indicated at his right hand in the picture of the model.



NEW HIGH-FREQUENCY CURRENT PROBE

for Your Tektronix Oscilloscope

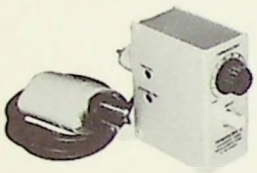
The P6016 AC Current Probe and Type 131 Amplifier constitute a current-detecting system for use with your Tektronix Oscilloscope. This system provides accurate displays for observation and measurement of current waveforms. Current range extends from less than one milliamp to 15 amps. Passband, with a 30-mc oscilloscope, is 50 cps to approximately 17 mc.

A second system comprises the P6016 AC Current Probe with a Passive Termination. Although less versatile, this system provides for observation and measurement of current waveforms at frequencies to approximately 20 mc with a 30-mc oscilloscope.

Long narrow shape and convenient thumb control make the P6016 easy to use. Just place probe slot over conductor and close slide with thumb—no direct electrical connection is required. Wiping action keeps core surfaces clean. Loading introduced is so light that it can almost always be disregarded.

SPECIFICATIONS

P6016 and TYPE 131 SYSTEM



Sensitivity with 50 mv/div Oscilloscope Input:
1 ma/div basic sensitivity. Ten-position switch provides calibrated steps of 1, 2, 5, 10, 20, and 50 ma/div . . . 0.1, 0.2, 0.5, and 1 amp/div, accurate within 3%. Continuous uncalibrated adjustment is possible by using variable control on the oscilloscope.

Noise:
Equivalent to a 100-microampere peak-to-peak input signal.

Risetime (with Type K or L Plug-In Unit in a Type 540-Series Oscilloscope):
20 nanoseconds (approximately 17 mc at 3 db down).

Low-frequency Response:
50 cps at 3 db down.

Maximum Current Rating:
15 amperes peak-to-peak.

Power Requirements:
105-125 volts ac, approximately ½ watt at 117 v.

P6016 and PASSIVE TERMINATION SYSTEM

Sensitivity:
Either 2 or 10 milliamps per millivolt of oscilloscope sensitivity, accurate within 3%.

Risetime (with Type K or L Plug-In Unit in a Type 540-Series Oscilloscope):
18 nanoseconds (approximately 20 mc at 3 db down).

Low-Frequency Response:
At 2 ma/mv—about 850 cps at 3 db down (5% tilt of 10 microsecond square pulse).

At 10 ma/mv—about 230 cps at 3 db down (5% tilt of 35 microsecond square pulse).

Maximum Current Rating:
15 amperes peak-to-peak.

COMMON TO BOTH SYSTEMS

Direct Current Saturation Threshold:
½ ampere.

Maximum Breakdown Voltage Rating:
600 volts, with thumb slide closed.

Insertion Impedance:
About 0.003 Ω at 1 kc—increasing as a function of frequency—with typically 1 pf capacitance between the conductor and probe case.

TYPE P6016 and TYPE 131 SYSTEM	$235
TYPE P6016 and PASSIVE TERMINATION SYSTEM	$ 90
Type P6016, purchased separately	$ 75
Type 131, purchased separately	$160
Passive Termination, purchased separately	$ 15

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Individuality

alone is not a true measure of an engineer's creativeness

Of course, it helps a bit.

But we're not asking you to jog around the neighborhood in Bermuda shorts or a souped up Model A to prove you can think for yourself. If, however, this somehow stimulates your thinking process, be our guest.

The main point is, RCA West Coast does not believe an engineer's creative abilities fit a specific pattern. Some of our engineers are conformists. Some are not. Some are individualists. Some are not. But *these* prime creative qualities they all share—courage, competence, optimism, and the ability to work together as a team. Solving difficult engineering problems. Right now we're looking for these able additions to this group:

Advanced Systems Engineers, Development and Design Engineers, and Project Engineers, with experience in these areas: Electronic Countermeasures, Data Processing and Computer Systems, and Missile Ground Support Systems.

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MEETING CALENDAR

Communications Systems

8:00 P.M. • Tuesday, June 20

"Time Delay and Echo Problems with Satellite Communication Systems"
Speakers: Dr. Larry Hunter and James Stewart, GTE Labs
Place: Room 126, H-P Wing, Electronics Research Lab, Stanford University
Dinner: 6:00 P.M., The Red Shack, 4085 El Camino Way, Palo Alto
Reservations: Donna Jean Harapet, RE 9-2344

Electronic Computers

8:00 P.M. • Tuesday, June 27

"Logical Synthesis and Fabrication of Cryotron Networks"
Speaker: John Bremer, G.E. Computer Lab, Mountain View
Place: Building 202, LMSD, 3251 Hanover Street, Palo Alto
Dinner: 6:00 P.M., The Red Shack, 4085 El Camino Way, Palo Alto
Reservations: None required

Reliability & Quality Control

8:00 P.M. • Wednesday, June 21

(Joint meeting with PGSET)
"Space Electronics"
Speaker: Harry R. Powell, reliability coordinator, Space Technology Labs
Place: Room 101, Physics Lecture Hall, Stanford University
Dinner: 6:00 P.M., Woodlands Restaurant, Stanford Shopping Center
Reservations: Marcie Muca, YO 8-6211, Ext. 2282, by noon, June 21

Space Electronics & Telemetry

8:00 P.M. • Wednesday, June 21

(Joint meeting with PGRQC, see above)

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wescon news

PUBLICATION POLICY

Fundamentally, the objective of the WESCON technical program is to present at WESCON the best possible technical papers by the best possible technical people. A second objective is to document and disseminate these papers to the widest possible audience.

To meet the second objective, it is planned to help get as many as possible of the technical papers presented at WESCON published in recognized technical journals at the earliest possible date. Particular encouragement will be given to authors to publish either in the Proceedings of the IRE or in one of the IRE Professional Group Transactions. Also, it is planned to make available both during WESCON and for a brief period after WESCON, preprints of the technical papers which have been orally presented in order to fill the gap between the time of oral presentation and formal written publication.

To help meet the first objective, the WESCON Board has decided not to publish a Convention Record. The Convention Record as it existed in 1959 and 1960 consisted of a written record of papers presented orally at WESCON. These papers were not subject to editorial review or to any of the very important technical criteria for publication which is common to all good technical publications. Nevertheless, the IRE journals and other technical media sometimes considered the Convention Record papers eqivalent to prior publication. Therefore, those authors who had good technical papers suitable for written as well as oral presentation were prevented from utilizing normal technical publication channels by having their papers appear in a "Record." As a result, many of the best papers were never submitted to WESCON but were submitted only for written publication in technical journals in order for the author to get the maximum technical recognition.

It is present WESCON policy to ask each author whose paper is selected for presentation at WESCON to submit the full text of his paper, including illustrations, if any, in a form suitable for preprinting. Simultaneously, each author will be encouraged to prepare his paper in a form suitable for publication with preference given to publication in an IRE journal, and those found suitable for publication by either the Proceedings or the Transactions will be published in the normal way.

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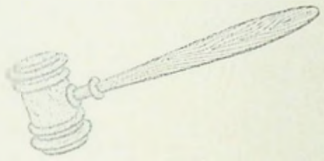


from the chair

THE SECTION YEAR

As 1961 comes to a close, I would like to take this opportunity to extend my personal appreciation and the appreciation of the entire membership to all those who have labored so diligently on Section affairs during the past year.

Your other Section officers and I all expressed the hope when we started the year that we would get to some new business this year. At the Section level, we have been concerned with at least three major areas of new business: 1) IRE relations with other societies and professional engineering legislation: 2) the problem of too many meetings; and 3) the preservation of historical information and equipment related to the growth of electronics in the Bay Area.

We have made a start on all of these problems, but with the exception of the first item above, no final policy has been evolved. In the case of IRE relations with other societies and professional engineering legislation, we are all indebted to Tony Siegman and John McCullough for the excellent report presented in the March 1961 **Grid** that summarizes the facts on this complex subject. As a Section we are not in a position to do more than keep our members informed in this area, so our policy is very simple, to do just this.

The problem of too many meetings has been studied, but we have not been able to see any helpful new course of action here. Perhaps the best thing we can do as a Section and as individuals is what we have been doing: do as good a job as possible on the meetings that we sponsor ourselves, such as WESCON and our local PG meetings, and limit participation in other activities to those we are sure will be effective.

In the historical committee under Earl Goddard's chairmanship, an excellent beginning has been made in Bay Area electronics history, and I believe we can look forward to a major effort in this area in the coming year.

Although we have made a little progress in new business this year, most of our efforts have been used in keeping things going from month to month, and I would like to commend all of the Section officers, directors, and committee members for their patient contributions during the past year. Our professional office staff under Miss Grace Pacak has done an excellent job and made many contributions beyond the call of duty. The publications board under Peter Sherrill and Howard Zeidler and our **Grid** editor Frank Haylock have produced their usual excellent product.

I personally have enjoyed the job of being your chairman. To those of you that are new to our Section and to those of you who have been around, but have not yet taken responsibility for helping operate your local Section of the IRE, I would like to say, try it. I think you will find it rewarding.

Donald A. Dunn

—DONALD A. DUNN, CHAIRMAN,
SAN FRANCISCO SECTION

Harry Powell

meeting ahead

RELIABILITY PROBLEMS IN SPACE

Many new and unique problems are arising as the result of our ventures into space. One of the most severe of these is the reliability requirement which is an order of magnitude higher than what we have become accustomed to in the past. Meeting these requirements will demand the best that is in our engineering, materials-application, manufacturing, and quality-control people. The nature of the new requirements and techniques for meeting them will be discussed at the joint PGRQC/PGSET session June 21. See the Calendar, page 8, for particulars.

Harry R. Powell, the speaker, has two areas of responsibility at STL: One is as staff engineer for reliability for the Atlas program office, where he is responsible for the overall Atlas weapon system reliability. The second is as the STL reliability policy coordinator, where he has responsibility for generating overall company policy on reliability and attempting to achieve uniformity of approach among the various groups working in reliability at STL.

He received his engineering degree from Duke University and has done graduate work at North Carolina State College, the University of Pittsburgh, and Boston University. His 16 years of industrial experience includes 12 years in the guided-missile field. He is active in several national organizations including the Institute, the Aerospace Industries Association, and the Operations Research Society of America.

He has been active in national symposia and seminars, having published approximately 15 papers, and is now a visiting lecturer at UCLA.

meeting ahead

VOICE IN SPACE

June 20 will find PGCS staging a two-speaker meeting on satellite communications. Details are in the Calender, page 8.

The speakers will discuss the comparative difficulties related to time delays and echoes for low-altitude and high-altitude satellite communications systems and will examine the trade-offs of solutions to the echo effects, particularly with respect to synchronous satellites used for global communications. Tape recordings will be used to demonstrate the effects on voice communications.

meeting review

BROADBANDING CHRISTCHURCH

Log-periodic antennas for h-f and vhf communications have been installed in New Zealand by Granger Associates—one of these being illustrated on the cover of this issue. These new applications of the log-periodic antenna were emphasized in a discussion by Dr. Raymond Justice of Granger Associates at the May meeting of the San Francisco Chapter of PGAP. The title of Justice's discussion was, H-F and VHF Log-Periodic Antennas.

The log-periodic antenna was first introduced by R. H. Du Humel and D. E. Isbell in 1957. This antenna is a member of the class of frequency-independent antennas proposed by V. H. Rumsey in 1957. Rumsey proposed an antenna of shape completely defined by angles as possessing pattern and impedance characteristics invariant with frequency.

The equiangular spiral antenna, introduced by J. Dryson and associates in 1959, was conceived from this angle concept. Although it is limited in bandwidth by excitation limitations and end-effects, bandwidths of 20 or 30 to 1 have been reported.

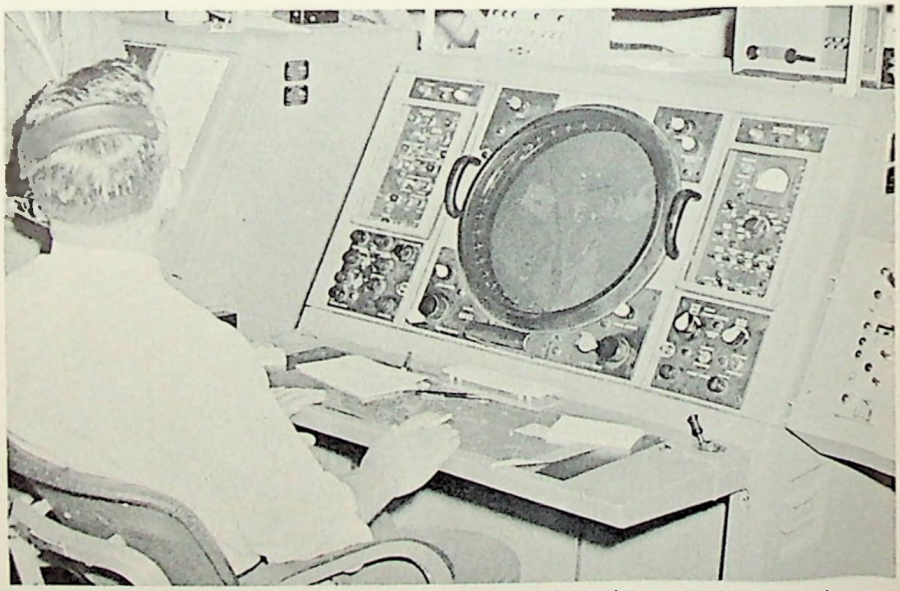
The log-periodic antenna is another approach to developing frequency-independent antennas or antennas possessing very broad frequency bandwidths. It is more accurately described as a pseudo-frequency-independent antenna because its shape departs from the angular defined model as proposed by Rumsey. It does, however, approximate the bandwidth characteristics of the spiral antenna. Bandwidths of 10 to 1 or greater have been reported for log-periodic designs. The name log-periodic is derived from the fact that impedance characteristics and pattern coverage vary periodically with the logarithm of the frequency. This variation can be made small or negligible and the impedance and pattern functions are relatively invariant over a broad frequency range.

The log-periodic antenna structure has an unlimited number of configurations. Basic configurations are periodic tooth structures and periodic dipole arrays. The essential characteristic in the shape of the log-periodic antenna is that the length and width of conducting surfaces, and spacings between conducting surfaces, are defined by one or more logarithmic ratios and by one or more limiting angles.

Log-periodic antennas may be designed to provide omnidirectional, bidirectional, or unidirectional pattern coverage with either linear or circular polarization. Applications of the log-periodic antenna have been primarily in the uhf band.

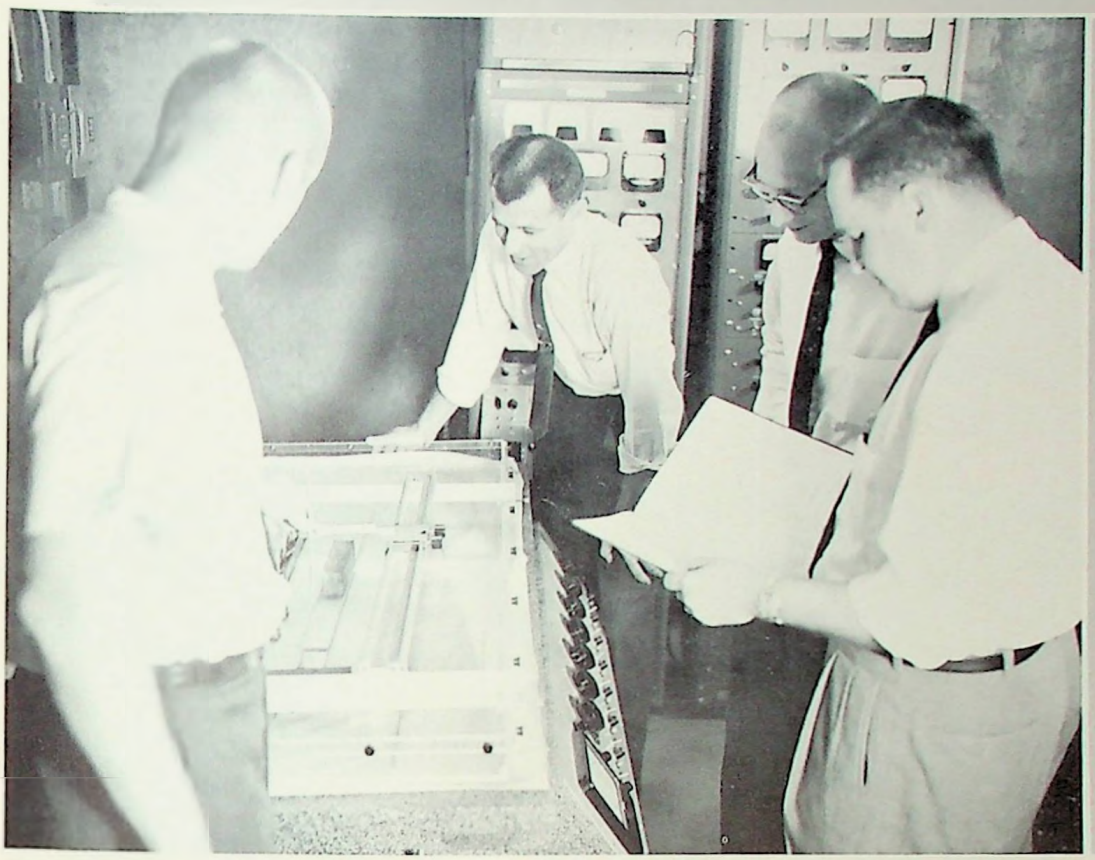
Justice, in his discussion, reviewed this development and description of the log-periodic antenna. This review was

(Continued on page 12)



Radar master console for the civil jet Oakland position at the FAA air-route traffic control center visited on the EBSS April field trip. Control position handles enroute oceanic and southbound jet traffic —T. Hamm photo

Are you a Microwave Tube Engineer?



"The emphasis of the company in the past has been production-oriented, backed up by a fine development and techniques organization. This emphasis will continue in the future, but a shift of orientation is taking place to include a continually larger stress on R & D."

This quote is taken from a recent magazine article written about Huggins Labs. Already, approximately 20% of the yearly company expenditures is allotted to Research and Development.

If you would like to become a part of this growing group, and participate in such stimulating areas as:

periodic permanent magnet focusing projects high power TWT research
low-noise TWT development electrostatic focusing projects . . .

and share in the benefits of those already enjoying:

company profit sharing stock purchase opportunity education tuition refund plan
affiliation with a team, some of whom have been associated with the TWT since its infancy, then:

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Members Goddard (above) and Theisner (below) give close attention during the May PGI meeting as Lenkurt Development Engineer Jack Silver tells about the new universal test system, set up to make 25 tests on a circuit board fresh from assembly line

MORE ANTENNAS

followed by the description of the use of periodic dipole arrays for h-f and vhf applications.

The periodic dipole array was introduced by Isbell in 1960. It is essentially a dipole array of progressively increasing element length and element spacing constructed such that adjacent lengths and spacings are related by a fixed logarithmic ratio. The lowest and highest frequencies of operation determine the number and size of elements needed for acceptable broadband operation. Endfire, or unidirectional pattern coverage, is obtained in the direction of the input terminals by transposing a two-wire feed line between adjacent dipole elements.

Justice described an h-f horizontally polarized design for short and medium length circuits as having typical pattern characteristics of 60 degree beamwidth, very low side lobes, and a constant vertical pointing angle over a 10-to-1 bandwidth. This description refers to the Christchurch, New Zealand, installation on the cover.

Justice also described a periodic dipole array capable of radiating different polarizations over the full vhf band. This array is essentially two orthogonal periodic dipole arrays oriented for quadrature space phase. Polarization versatility is obtained by appropriate phasing in the transmission line connecting the two arrays.

Justice concluded his talk emphasizing the usefulness of takeoff angle or angle of arrival studies to h-f antenna design. One such theoretical study correlating variations of the ionosphere with distribution of h-f receivers was described. This study, conducted at Stanford Research Institute by J. F. Cline, R. L. Tanner, and associates, was concerned with calculating the probability of frequency usage in air-ground h-f communication as a function of takeoff angle. This study, as well as similarly directed studies conducted in the past and those surely to be conducted in the future, allow a more reasonable and valid h-f antenna design such that pattern coverage is more effective and approaches the optimum coverage at each frequency of operation.

Justice received a BS degree in mathematics from Purdue University, and an MA degree in mathematics and a PhD degree in electrical engineering from Ohio State University.

He joined Granger Associates in December, 1959, as supervisory engineer in charge of antenna and microwave development. In 1958 he was supervisor of research and development in the radiation research and development section at Convair division of General Dynamics. There he directed the design and development work in radomes, antennas, microwaves, solid-state electronics, infrared and optics. From 1956 to 1958 he was with Convair, working in the development of monopulse radar antennas and related projects. Justice is presently head of the antenna and microwave components group at Granger Associates.

—J. MARTIN

meeting review

CUTTING CARRIER COSTS

After dinner attended by 16 members at the Gold Platter restaurant, the PGI May meeting convened at Lenkurt Electric Co. for a business meeting and a talk by Clay Rasmussen, instrumentation development manager at Lenkurt.

PGI Chairman Nicholas Pappas, after opening the meeting, introduced Rasmussen, whose topic was "Innovations in Test Instrumentation."

The problem facing Lenkurt, Rasmussen explained, was to develop production test equipment and methods adaptable to the many different carrier systems it produces, and at the same time to set a pattern to guide future carrier-system designs so adapters could be developed to accommodate all systems to a common test module. The object was to minimize production testing's share of the over-all cost.

To realize this ambition, the instrumentation development group, together with various project engineers assigned to development of the then-embryo Type 81A exchange-trunk carrier system, conceived a universal test system using a single removable adapter module and associated jig for providing the special signals, amplification, filtering, control, and nodal connections. The universal portion of the system included the programmer, sequencer, a-c/d-c converter, adc, printer, visual readout, and programmable power supplies.

Specifications were written for the desired instrumentation and system concept, and an internal cost estimate was proposed. To compare costs of internally designing and constructing the system against employing outside instrumentation manufacturers, bids were invited from several companies. This resulted in selection of an outside concern to design and construct the universal portion of the system.

(Continued on page 14)

Components were in the spotlight in May, during the three-day Electronic Components Conference. Shown above during registration are W. W. Wahlgren, Electro Engineering, one of the speakers on the program; Hugh C. Ross, Jennings Radio, general chairman of the conference; and J. J. Halloran, also of Electro, who served as a session chairman

MORE TESTING

From the nature of the first new product to be manufactured using the universal test system, it was known that two system units would be high-volume and that a third would be medium-volume. This called for design of special test sets, or adapter modules, that could be plugged into the universal test system for performance of specific tests.

The control panel for the test system had to be simple, yet completely functional. Simplicity of controls and procedures would permit use of a production operator at a reasonable wage rate without sacrificing efficiency of the quality-control function. For calibration and trouble-shooting purposes, however, a technician would be in charge in most cases.

The system devised to meet the objectives has considerably reduced the 20 per cent portion of the total manufacturing-labor cost formerly attributed to production testing, and also has reduced the time required for fabrication of equipment. The result is that Lenkurt is in a more favorable marketing position with respect to both cost and delivery.

As the workload for the new system reaches capacity, a duplicate system may be built at a greatly reduced cost by reason of the instrumentation standard used on the first system.

Following Rasmussen's talk, a tour was conducted to see the new test system and other steps Lenkurt has taken toward improved production test instrumentation. Guides were engineers Vince Babin, Ernest Gilmore, Ted Davis, George Griffith, and Jack Silver; public information supervisor Doug Hayward assisted.

Just imagine this picture without June Andrews and you have the idea of the Lockheed unfurlable spherical antenna such as PGAP considered at its April meeting

Among the stops en route was the standards laboratory, where Manager Les Burlingame described the functions.

Items shown in the factory were the carousel automatic coil winder, a semi-automatic capacitor hi-potting machine, and a high-speed capacitor grader.

Instrumentation Development Engineer Dale Arnold demonstrated the universal test system and answered questions on its circuitry and operation.

Comments from PGI members showed that Lenkurt's approach to this problem is novel, and can be applied to other companies and their products.

—LES BURLINGAME

meeting review

BLOWOUT IN SPACE

Dr. P. D. Kennedy of the electromagnetics laboratory at Lockheed missiles and space division spoke to the San Francisco Chapter of PGAP in mid-April. His topic was "Study and Design of Unfurlable Antennas."

Unfurlable antennas can be packaged into a small volume during spacecraft launching and then can be extended into large antenna structures when in space. Two types of unfurlable antennas were described: Mechanically-erected and pressure-erected.

Mechanically-erected unfurlable antennas assume the shape of a section of the spacecraft, such as a nose cone, during launch phase. When in space, the contoured antenna is unfurled to its radiating shape by a mechanical-erection mechanism.

Pressure-erected unfurlable antennas are housed in packages located in a section of the spacecraft during launch phase. When in space, the packaged antenna is unfurled to its radiating shape by a pressure-erected process. This process is derived from the familiar New Year's Eve party favor known to the trade as a "blowout."

Mechanical erection of essentially rigid sections is useful where the antenna contour is compatible with the vehicle structure, but much larger-size ratios can be obtained by pressure erection. A pressure-erected antenna is opened by inflation but has sufficient rigidity after being opened to maintain its shape after loss of internal gas pressure. Among antennas of the former type were a segmented circula-parabolic reflector, a linear array and a spirally telescoping dipole.

Kennedy, in his talk, discussed factors affecting the design of these antennas for space environments. Such factors included the resistance of antenna materials to radiation, high vacuum, micrometeorites, etc., as well as spacecraft antenna requirements for future time periods. The ground rules for the structural design of antennas were described to differ for space as compared to the earth and the earth's atmosphere. Antennas too fragile for atmospheric pressures can be constructed to satisfy the reduced structural limitations of space environments.

E. S. Kuh, associate professor at the University of California, Berkeley, was the scheduled speaker at the June PGCT meeting on parametric amplifiers

—Ken Smith photo

Of particular interest was an important breakthrough in the development of the pressure-erected unfurlable antenna—when a Lockheed engineer and his wife constructed an unfurlable antenna model with household aluminum foil. This idea was perfected for space environments by the development of plastic-coated aluminum sheets. The plastic coating was necessary to prevent depressurization by micro-meteorites.

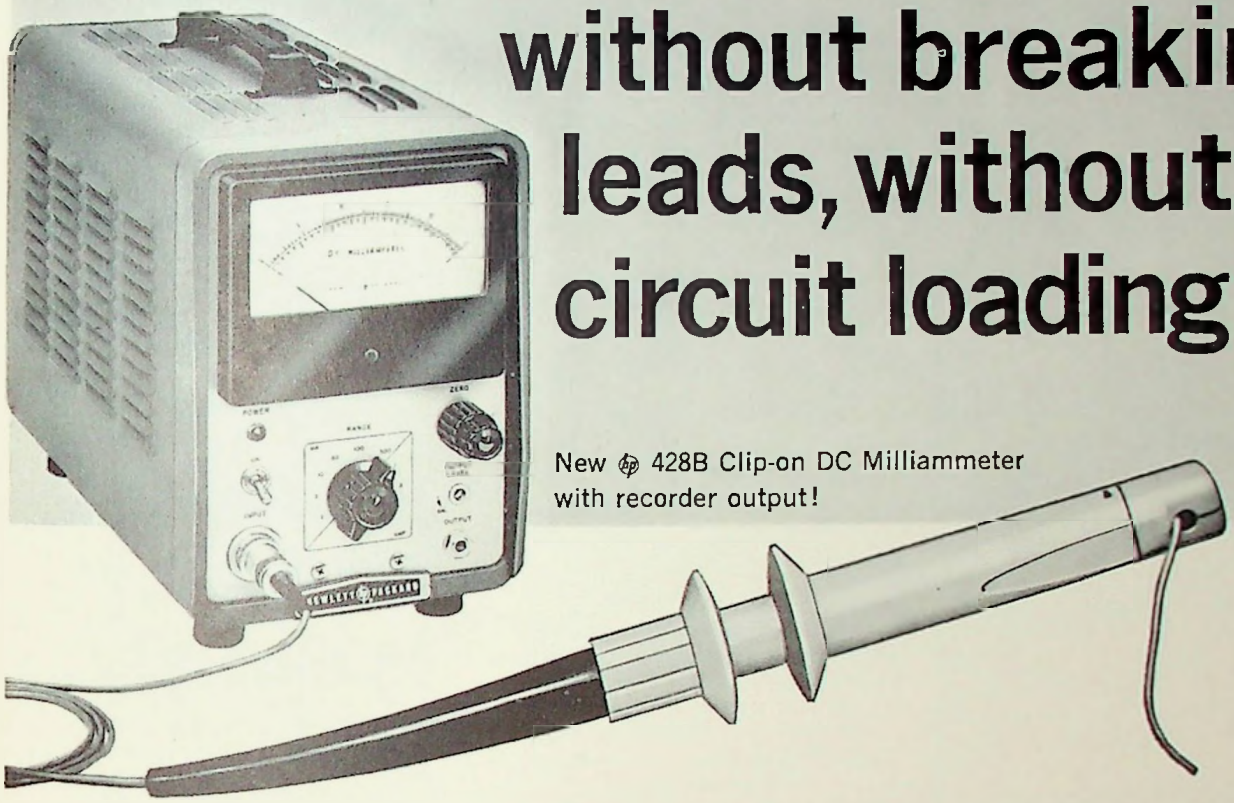
Kennedy illustrated both simple and complex unfurlable antenna designs capable of producing pencil-beam patterns, wedge-shaped patterns, and omnidirectional patterns. These designs are conventional antenna types such as linear arrays, reflector antennas, log-periodic antennas, etc., constructed for unfurlable packaging. The pressure-erected models were shown to be lightweight—such as an unfurled 8-ft log-periodic antenna held in midair by a single human hand.

In conclusion, Kennedy emphasized that while unfurlable antennas are not presently used on spacecraft in this country, in future years our space armadas will surely find application for these antennas. When these applications arise the speaker assured his audience that adequate designs will be available. Kennedy's talk was followed by a film presentation of the unfurlable antenna program at LMSD.

Kennedy received a BS degree in 1949 from the Newark College of Engi-

(Continued on page 16)

Measure and record DC current, 0.1 ma to 10 amps without breaking leads, without circuit loading!



New hp 428B Clip-on DC Milliammeter with recorder output!

Now you can measure and record dc current to 10 amps without interrupting the circuit and with no circuit loading. You simply slip the jaws of the hp 428B probe around a bare or insulated wire and read dc, even in the presence of equally strong ac on the same wire. No need to break leads. The 428B reads dc current directly in 9 ranges by sensing the magnetic flux induced by dc current in the wire.

To measure current difference between two separate wires just clip the probe around them both and read, then reverse one lead and read their sum! For even greater sensitivity you simply increase the number of lead loops through the probe, increasing sensitivity by the same factor as the number of loops.

The recorder/oscilloscope output, dc to 300 cps, makes it easy to record dc levels as well as analyze ground buss, hum and ripple currents on an oscilloscope—all without circuit loading.

hp also offers Model 428A Clip-on DC Milliammeter. This instrument is similar to hp 428B except that coverage is limited to 3 ma to 1 ampere (6 ranges), the recorder output is not included, and price is somewhat lower.

SPECIFICATIONS

Current Range: hp 428A, 3 ma to 1 a full scale in 6 ranges
hp 428B, 1 ma to 10 a full scale in 9 ranges

Accuracy: ± 3%, ± 0.1 ma

Probe Inductance: < 0.5 uh introduced into measured circuit

Probe Induced Voltage: < 15 mv peak into measured circuit

AC Rejection: AC with peak value less than full scale affects meter accuracy less than 2% at frequencies above 5 cps and different from carrier (40 KC) and its harmonics. (On 428B 10 amperes range, ac is limited to 4 amperes peak)

Recorder/Oscillator Output: hp 428B, approximately 1.4 v across 1,400 ohms full scale. Frequency response dc to 300 cps

Probe Insulation: 300 v maximum

Probe Tip: ½" x 9/32". Aperture diam. 3/16"

Size: Cabinet, 7½" x 11½" x 14¼"; rack mount, 19" x 7" x 13" behind panel

Weight: Cabinet, 19 lbs; rack mount, 24 lbs.

Price: hp 428A, $500.00 (cabinet); hp 428AR, $505.00 (rack mount)
hp 428B, $550.00 (cabinet); hp 428BR, $555.00 (rack mount)

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CONTACT OUR ENGINEERING REPRESENTATIVES, NEELY ENTERPRISES, FOR INFORMATION—Los Angeles, 3939 Lankershim Blvd., North H'wd., TR 7-0721; San Carlos, 501 Laurel St., LY 1-2626; Sacramento, 1317 Fifteenth St., GI 2-8901; San Diego, 1055 Shafter St., AC 3-8106; Phoenix, 641 E. Missouri Ave., CR 4-5431; Tucson, 232 So. Tucson Blvd., MA 3-2564; Albuquerque, 6501 Lomas Blvd., N.E., AL 5-5586; Las Cruces, 114 S. Water St., JA 6-2486.

MORE UNFURLABLE ANTENNAS

neering, an MS degree in 1951 from Purdue University, and a PhD degree in 1958 from Ohio State University. All degrees were awarded in electrical engineering. During 1951-54, Kennedy was employed by Westinghouse Electric Corporation in Baltimore, Maryland. From 1954-55, he was employed by the U.S. Army, Frankford Arsenal in Philadelphia. From 1956-59, he was associated with the Ohio State University research foundation in Columbus, Ohio.

Since 1959, Kennedy has been employed by Lockheed missiles and space division in Sunnyvale, California. He is presently head of the theoretical analysis research section of electromagnetics research, electronic research and product development. His section is concerned with the analysis of propagation problems, communication systems, tracking systems, and antenna feasibility.

Kennedy is a registered professional electrical engineer in the state of Ohio. He is a member of the IRE, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

—JAMES A. MARTIN

meeting review

COMPUTER TALK

The significance of advanced programming techniques in the development of digital computers was discussed by Professor Harry D. Huskey of the University of California at the May PGEC meeting held at Lockheed. He reviewed the various ways by which computers can be described, including such techniques as system block diagrams, flow diagrams, logic equations and state charts.

The state-chart description is one which Professor Huskey feels would be of major assistance in formulating the design for a proposed machine. The description is readily translatable to a simulation program which would enable testing the characteristics of the proposed machine before the design has been completely determined.

He described the major desirable attributes of computer-oriented languages. Such languages remove context dependence, convert the information to sequential logic (since most present machines operate sequentially), and, desirably, would be computer-independent so that the same problem could be run on any machine. A desirable alternative, of course, would be to build computers whose machine language corresponded directly to a natural problem-descriptive language.

A large portion of the meeting was devoted to a discussion of trends in machine organization and design, reflecting Dr. Huskey's extensive background in both the application and the design aspects of digital computers.

—R. I. TANAKA

meeting review

TOWARD STUDENT FEEDBACK

A most interesting meeting of the local PGEC in March was held at the Lockheed Auditorium. Dr. Richard S. Hirsch, manager of the engineering psychology department of the advanced systems division of IBM at San Jose, spoke on "Teaching Machines." (This is not the act of teaching a machine but rather the machine teaching a student.)

Automated education is the inevitable corollary of automated production, and probably the only effective answer to acute teacher shortages in schools at a time when our population is expanding and scientific discoveries require increased teaching.

Early mechanical teaching aids were simple decks of flash cards with answers on the back and automatic slide and film-strip projectors. Present automated devices provide for greater flexibility of presentation, more student participation, and additional means to record and evaluate student responses. Future teaching machines promise to be but one part of a complex group of automatic attendance keepers, proficiency testers, report-card printers and electronic reference librarians—all integrated by central computer control into an efficient, automated education system.

The essential missing concept in the present mass educational methods, such as movies, radio, television, etc., is feedback—the regulation of a process with a sample of its own output. The new approach of automated teaching utilizes feedback. As information to be

(Continued on page 20)

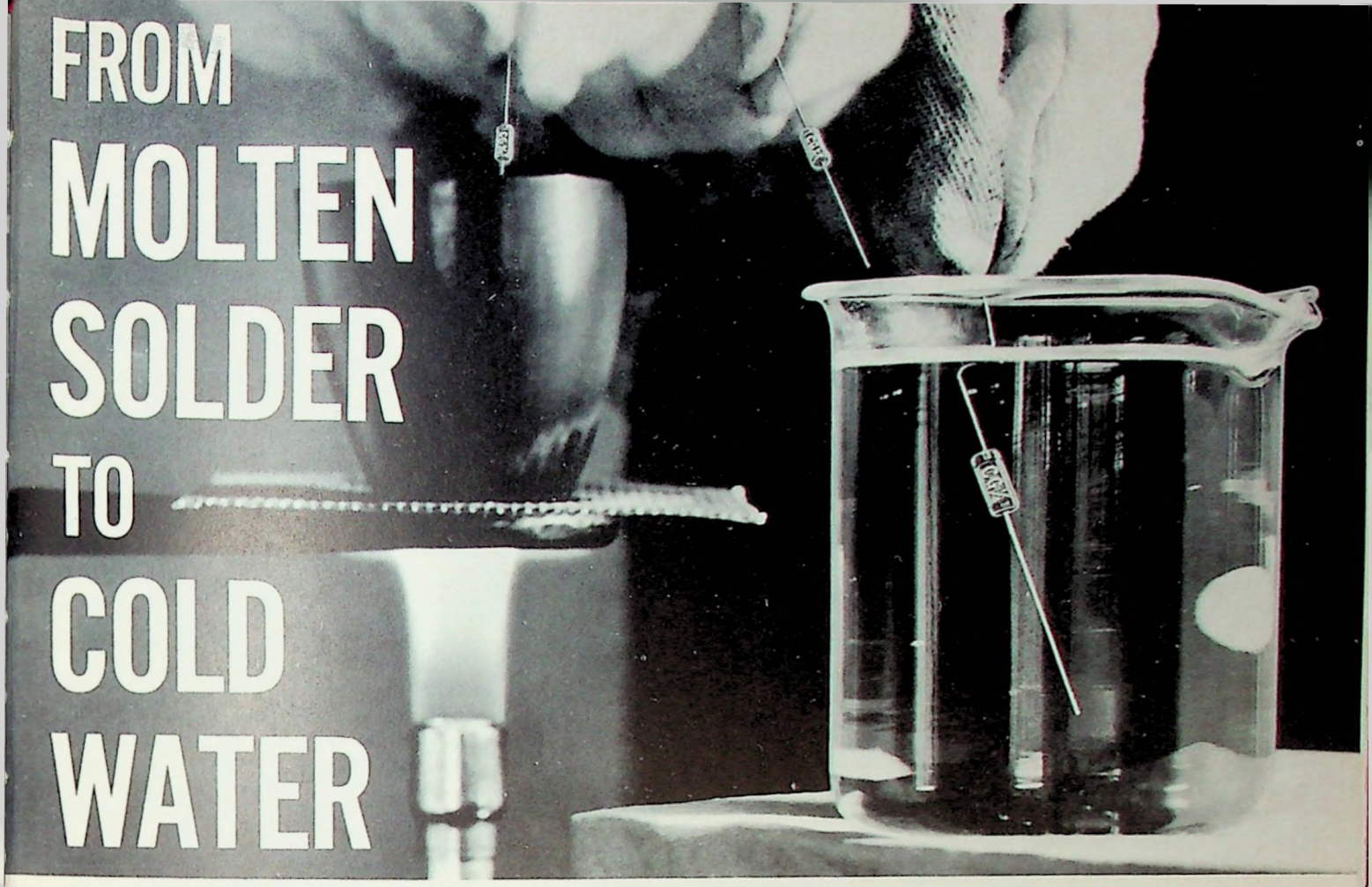
grid drive

LOST TO SPACE

Beardsley Graham of Lockheed missile systems division (as it was then called) joined the Publications Board of the Section in May, 1958. Since then he has served the Section with distinction in this capacity, always prepared to raise his voice for improvements in the **Grid**, and actions leading toward the highest possible quality publishing operations.

While "space" has been added by this time to the Lockheed divisional title, it has been taken away from Beardsley's schedule, and his extensive travel program impelled him to resign from the Board last month.

His experience and mature counsel have been of great value to the **Grid** and his participation in publication affairs will be missed.



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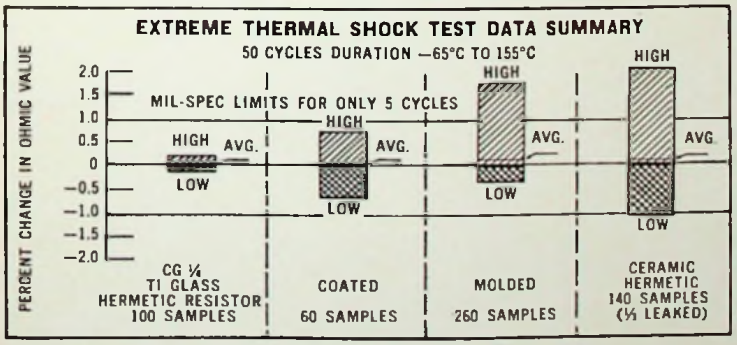

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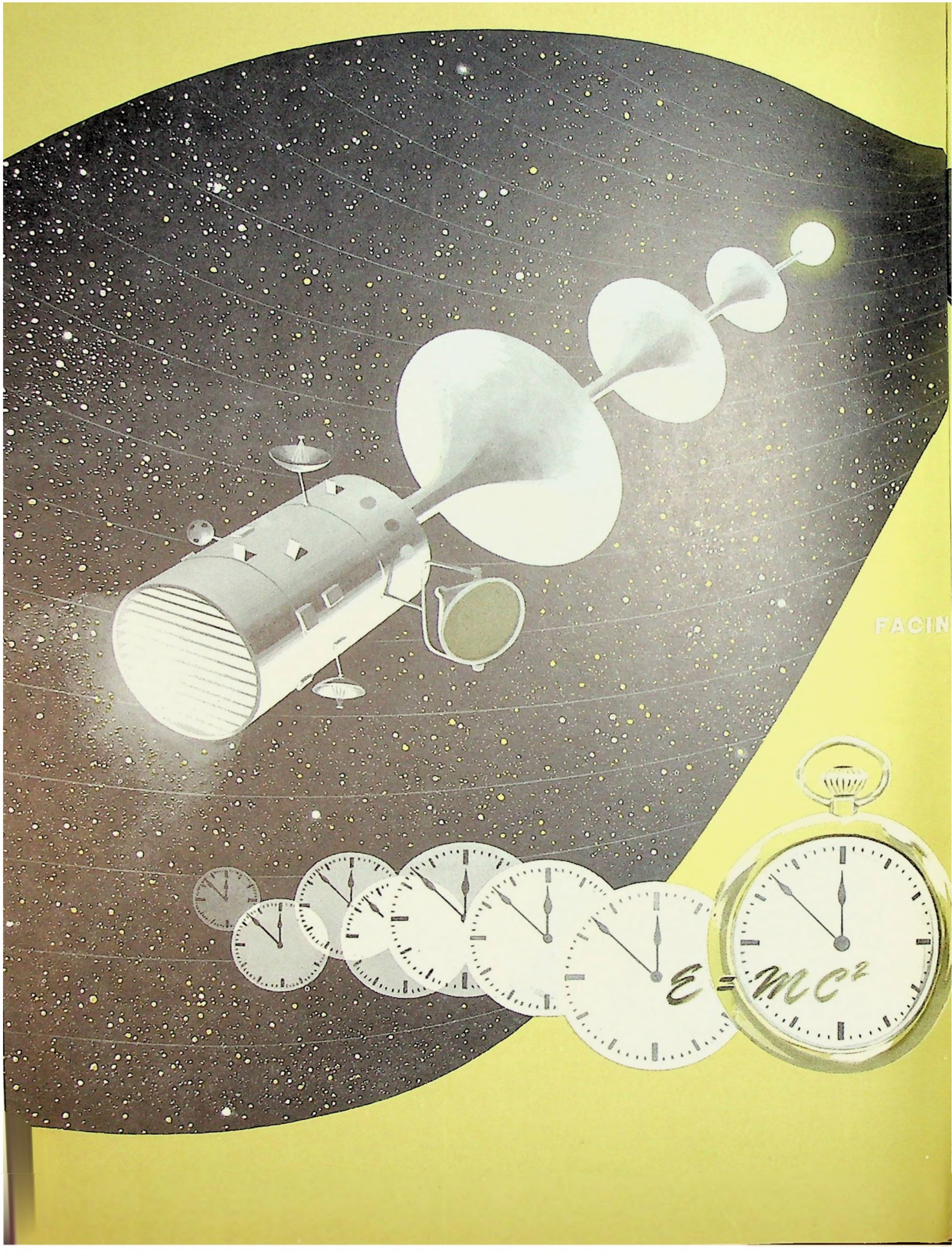
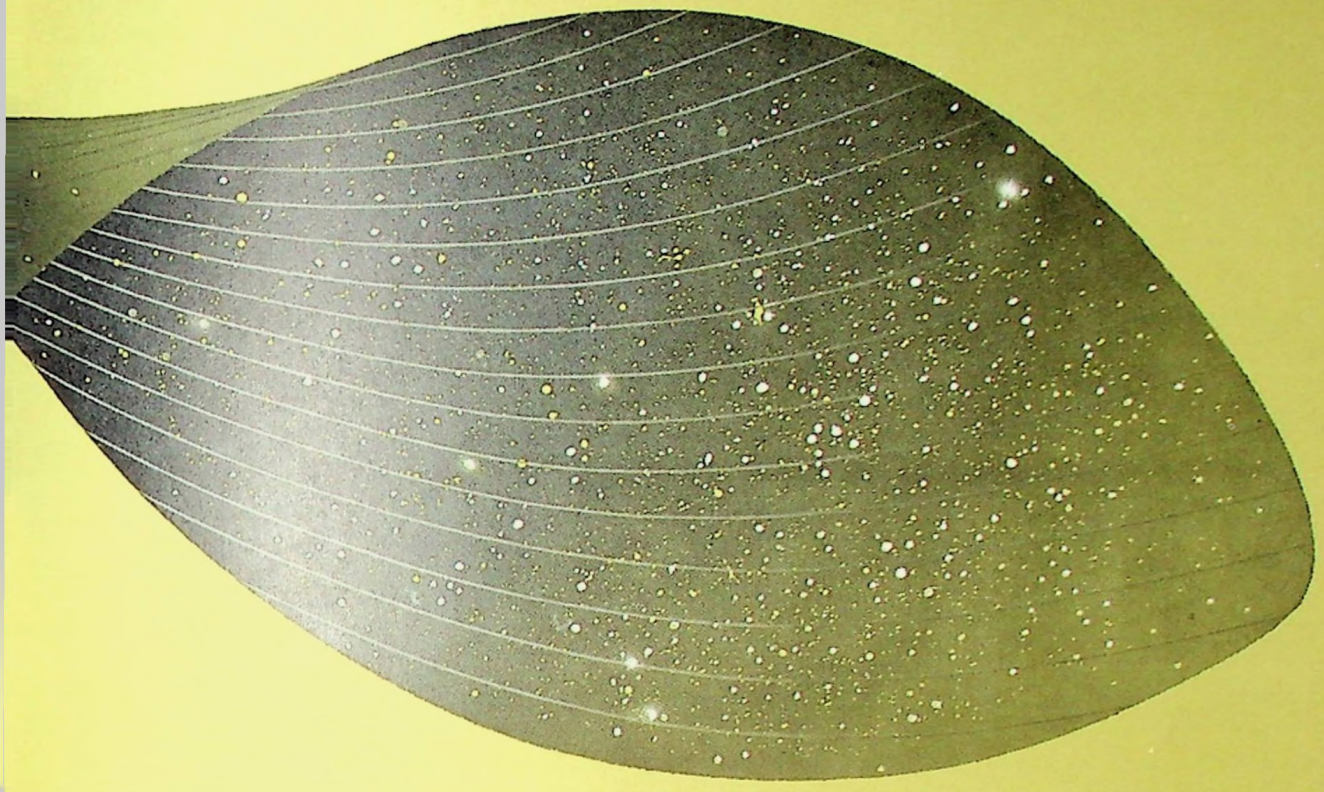

$E = mc^2$



HE FOURTH DIMENSION IN PROPULSION DEVELOPMENT

Whether the universe has a "saddle shape," or any shape at all, is a matter of interesting conjecture. The matter of space travel, however, is the subject of intense experimentation. A nuclear/thermionic/ionic propulsion system, currently being studied at Lockheed Missiles and Space Division, might well become the power source for space vehicles.

Its design incorporates a nuclear reactor only one foot in diameter, generating heat at a temperature of 1850°K. This is transmitted to banks of thermionic generators, converting the heat directly into electrical energy for the ion beam motor which uses cesium vapor as a fuel. The entire system is designed without any moving parts, minimizing the possibility of failure.

Lockheed's investigation of propulsion covers a number of potential systems. They include: plasma, ionic, nuclear, unique concepts in chemical systems involving high-energy solid and liquid propellents, combined solid-liquid chemical systems. The fundamentals of magnetohydrodynamics, as they might eventually apply to propulsion systems, are also being examined. Just as thoroughly, Lockheed probes all missile and space disciplines in depth. The extensive facilities of the research and development laboratories—together with the opportunity of working with men who are acknowledged leaders in their fields—make association with Lockheed truly rewarding and satisfying.

Lockheed Missiles and Space Division in Sunnyvale and Palo Alto, on the beautiful San Francisco Peninsula, is an exciting and challenging place to work. For further information, write Research and Development Staff, Department M-24C, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

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MORE STUDENT FEEDBACK

learned is presented, feedback from student to device assures the "mechanical" teacher that each part of the lesson is understood.

The human learner, in order to "accept" data presented to him, first must have it put forward in many small, clear steps, each logically built upon the concepts in earlier steps. Secondly, the extent of the learner's understanding must be determined and recorded before moving on to a more difficult step. Finally, the learner must be motivated to proceed to that more difficult step.

These human-engineering specifications represent the three fundamental concepts of behavioral psychology—stimulus, response, and reinforcement. Implementation of their sequence creates an engineering requirement for display, response, and evaluation-reward components, circuits, or units in any automated instructional system. A digital computer is almost certain to be the heart of most fully automated educational systems.

The meeting was concluded by a brief talk by Dr. Robert Magar of Varian, also active in this field, and a question and answer period in which both of the experts participated.

—J. A. BOYSEN

Dunwoodie *Tarczy-Hornoch*

meeting review

SCOPE VERSUS SCOPE

In mid-April, PGI held a workshop session to consider, "Oscillographic Sampling at 100 mc." The first speaker, Duane Dunwoodie of the Wiltron Co., explained their stroboscopic wideband sampling oscilloscope. A fast ramp and staircase sample pulse is triggered with respect to the wave being studied. The wave must be repetitious.

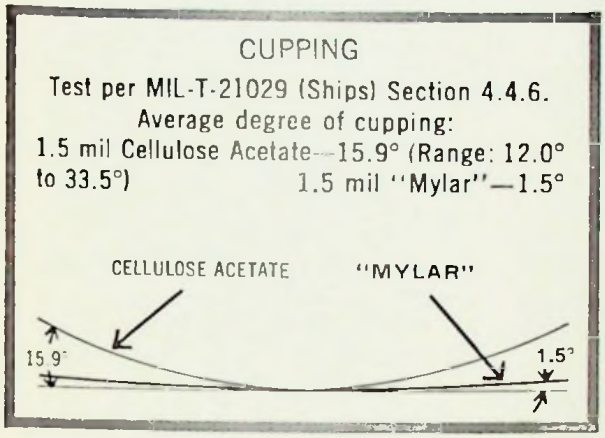
Since the stroboscopic principle is used, the scope can be made with components designed for relatively low frequencies. This is a definite gain in construction.

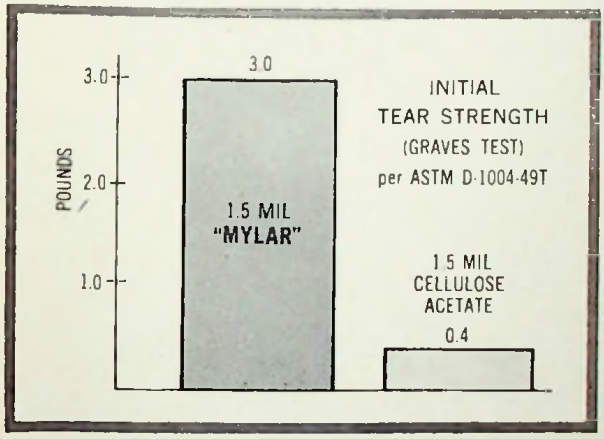
The scope permits the measurement of voltages 45-50 db down. Mr. Dunwoodie displayed a 100-mc pulse on his oscilloscope. The sensitivity is 10 millivolts.

Zoltan Tarczy-Hornoch of Eldorado

(Continued on page 22)

GUARD AGAINST READ/WRITE ERRORS WITH RELIABLE TAPES OF MYLAR®





Unstable tape can cup or ruffle—cause read/write errors because the tape loses contact with the recording and playback heads. Dimensionally stable "Mylar"* polyester film base prevents tape cupping or ruffling. It does not shrink from dryness or swell from excess humidity, but maintains the original width and flatness of the tape.

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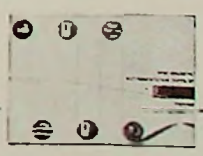
*"Mylar" is Du Pont's registered trademark for its brand of polyester film. Only Du Pont makes "Mylar".



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MORE SCOPE

Electronics described the oscilloscope his company markets and explained that it actually records events which are taking place at 100 mc.

They have made measurements to 400 mc. The instrument has less than 0.05 nanoseconds of drift. The accuracy of the instrument depends upon the crystal, but is in the order of one part in 1,000,000. It has a 2-nanosecond rise time and can measure to about 1 picosecond. Tarczy-Hornoch set his scope up and demonstrated that he would set it to about ⅛ in. on the delay line which was 1 picosecond.

—LESLIE G. BURLINGAME

meeting review

THERE IS NOTHING LIKE A MODEL

Members and guests of the Professional Group on Circuit Theory heard Professor John G. Linvill of Stanford University lecture on the topic, "Devices, Models, and Circuits" at its April meeting in the Hughes Room at the University of California.

Dr. Linvill's talk was opened with a reference to the distinction between the ideal elements of a mathematical model and their practical embodiments. This is implied by the existence of such words as "capacitance," an abstract property, and "capacitor," a physical component. It is often necessary to ignore the imperfections of real components in order to obtain a workable model of a device or system.

In the execution of analysis or synthesis, models serve as a bridge between device and properties. Models may be purely mathematical, or may be circuit representations of mathematical relationships. The latter lend themselves to further mathematical treatment for purposes of analysis, but the circuit representation can be very helpful in understanding the interactions of the factors modeled.

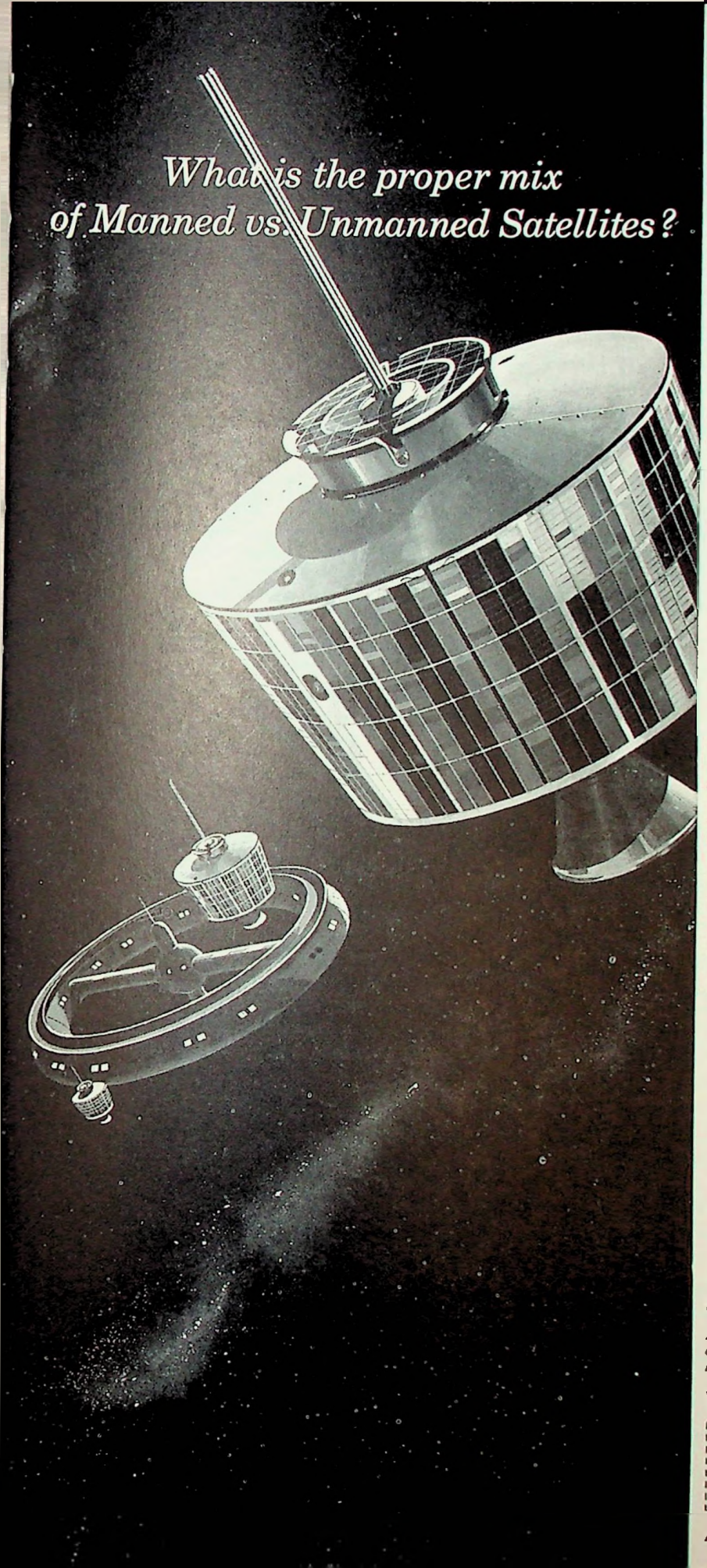
An example of the use of circuit modeling in analysis is the representa-

(Continued on page 24)

electronic components conference

PROCEEDINGS AVAILABLE

Proceedings of the 1961 Electronic Components Conference, San Francisco, May 2-4, covers sessions on Transistors and Solid-State Devices, Progress in Component Reliability, High-Voltage Components, Microwave Components, Components, Resistors, Capacitors, and Microminiaturization, Space Components, Materials and Related Devices; 38 papers, 540 pages; price $9.00; available from Hugh C. Ross, Jennings Radio Manufacturing Corp., P.O. Box 1278, San Jose 8, Calif.



opportunities for

systems analysts

Hughes Aerospace Engineering Division has openings for Systems Analysts to consider and analyze a wide spectrum of basic problems such as:

What are the requirements for manned space flight?

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Automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites.

IR systems requirements for ballistic missile defense.

Optimum signal processing techniques for inter-planetary telecommunications.

Analysis of weapon systems from conception through development, test and customer use.

Design concepts for new airborne weapon systems.

The positions involved with the solution of these basic and critical questions present opportunities for the optimum application of the technical and analytical backgrounds of graduate physicists and engineers with both systems and specialized experience.

If you are interested in helping to solve these questions and are a graduate physicist or engineer with a minimum of three years experience in weapon systems analysis, operations analysis, IR, physics of space signal processing or communication theory, we invite your inquiry. For immediate consideration, please airmail your resume to: **Mr. Robert A. Martin**, Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 47, California.

All qualified applicants will be considered for employment without regard to race, creed, color or national origin.

We promise you a reply within one week

HUGHES

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AEROSPACE ENGINEERING DIVISION

MORE MODEL

tion of transistor operation in terms of physical processes. Carrier concentration is chosen as the variable in the base region, and is made to bear a linear relationship to current by the introduction of appropriately defined circuit elements with the suggestive names "storance," "diffusance" and "combinance." The base region of the transistor is represented as a circuit using these elements, and the model is completed by displaying the nonlinear voltage-current relationship at the emitter-base and collector-base junctions.

The use of a model in synthesis was illustrated by an active r-c resonator where, for given configuration and active element characteristics, maximum obtainable performance was derived. Synthesis here was clearly the reverse of analysis, the same mathematical model serving for either process.

Linvill concluded his talk with a provocative example of an attempted synthesis where no analysis is yet possible —Crane's Neuristor, a device whose fundamental properties are stated. These properties, suggested by analogy with the neurons of a nervous system, are: propagation of a discharge with uniform amplitude and uniform velocity; existence of a threshold of stimulation; and existence of a refractory or insensitive time period following a discharge. The model of a neuristor, based on these properties, resembles a re-usable chemical fuse. Several possible connections of neuristors were shown, including a cell of information storage and a "relay." Introduction of the concept of the neuristor and demonstration of its use through models based on the concept has stimulated research for the corresponding device.

—DONALD A. PETTENGILL AND R. C. KIESSLING

J. G. Linvill, speaking at the April PGCT meeting

—Ken Smith photo

meeting review

CLASSY DATA

David A. Huffman, visiting associate professor ot electrical engineering at the University of California, Berkeley, addressed the May meeting of PGIT on Information-Lossless Automata.

Huffman first described the finite-state machine as one in which the output and the next state of the machine are uniquely determined by the input and the present state. Such a machine is information-lossless if knowledge of the output sequence, the initial state, and the final state are sufficient to determine uniquely the input sequence.

If, for each state, the output is different for the two different inputs, the machine is a Class I Information-Lossless Automaton. In this case the input sequence is recoverable in the order in which it occurred.

If, on the other hand, each state can be reached from only two others and the outputs along these two paths are different, the machine is a Class II Information-Lossless Automaton. In this case, the input sequence is recoverable in the reverse order to that in which it occurred.

Huffman showed the canonical forms for the Class I and Class II Automata and then displayed the canonical form of the most general information-lossless automaton.

This general form consists of an interconnection of the canonical forms of the Class I and Class II Automata. In the general case, the successive states of the Class I portion of the machine are recovered first in their direct order; the states of the Class II portion and the input sequence are then recovered in reverse order.

—D. BRAVERMAN

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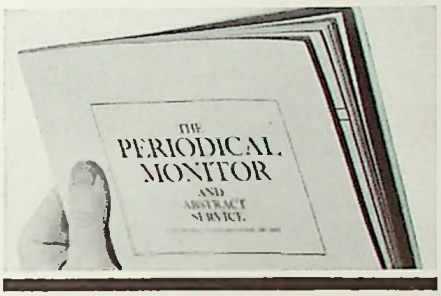

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SAMPLE ABSTRACTS

CONTROL ENGINEERING
Dec. '60, Vol. 7, No. 12

60.12.009

What's Needed for Safe, Reliable Process Monitoring, pp. 87-91. R. Sherrard. (General Electric Co.). Part I of two-part article uses Hanford reactor as example to show advantages of data sampling over continuous method in process control monitoring.

60.12.010

Generalizing the Adaptive Principle, pp. 93-96. J. E. Gibson (Purdue University). Part 3 of three-part article studies "ideal" generalized adaptive system as guide to optimum design, recommends improved "steep descent" method for finding feasible system.

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MORE SWINGS

Five Peninsula firms have been approved for membership in the San Francisco Council of the **Western Electronic Manufacturers Association** (WEMA). **Electromagnetic Technology Corp.**, Palo Alto; **Admiral Corp.**, 901 South California, Palo Alto; **Link division of General Precision, Inc.**, 1451 California Ave., Palo Alto; **Vidar Corporation,** 2296 Mora Dr., Mountain View; **Royco Instruments, Inc.**, 440 Olive St., Palo Alto. These new additions to WEMA have pushed the membership of the San Francisco Council past the 100 figure.

Dr. **Victor Met** has joined **Kane Engineering Laboratories** as manager of the waveguide components research and development group. Met has been with General Electric microwave laboratory since he came to this country as a permanent resident from Austria in 1955.

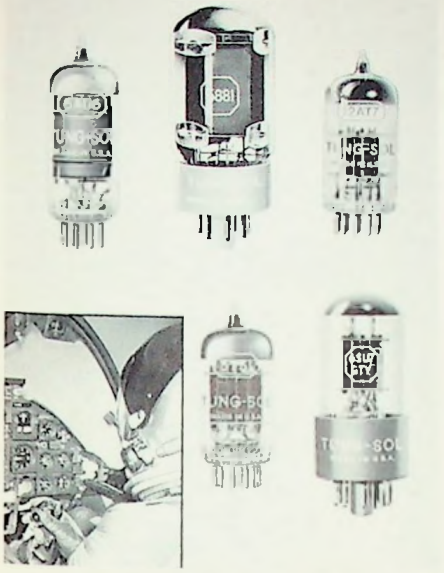
Servomechanisms Inc. has announced the appointment of **Transdynamics, Inc.**, 44 Encina Ave., Palo Alto, Calif., as sales representatives to handle the company's line of magnetic components.

Appointment of **Ralph J. Halk** as director of administration for **Broadview Research Corp.** has been announced. Halk was formerly a vice-president, treasurer, and board director of Granger Associates, Palo Alto. Prior associations were with Lenkurt Electric Co., San Carlos, and with Stanford Research Institute.

E. V. Roberts & Associates, 1560 Laurel Sreet, San Carlos, have been appointed distributors of the **Stereotronics Corp.** stereo-television kit which optically converts industrial tv to 3-D.

Frank Hennessey, radar antenna design engineer, has joined **Dalmo Victor Company,** Division of Textron Inc., as a senior engineer. Hennessey previously was associated with Lockheed missile systems division and with the Naval Research Laboratories.

Frank Hennessey, right, is greeted at Dalmo Victor Co. by another Lockheed alumnus, Will Chang, who came to DV from Burbank



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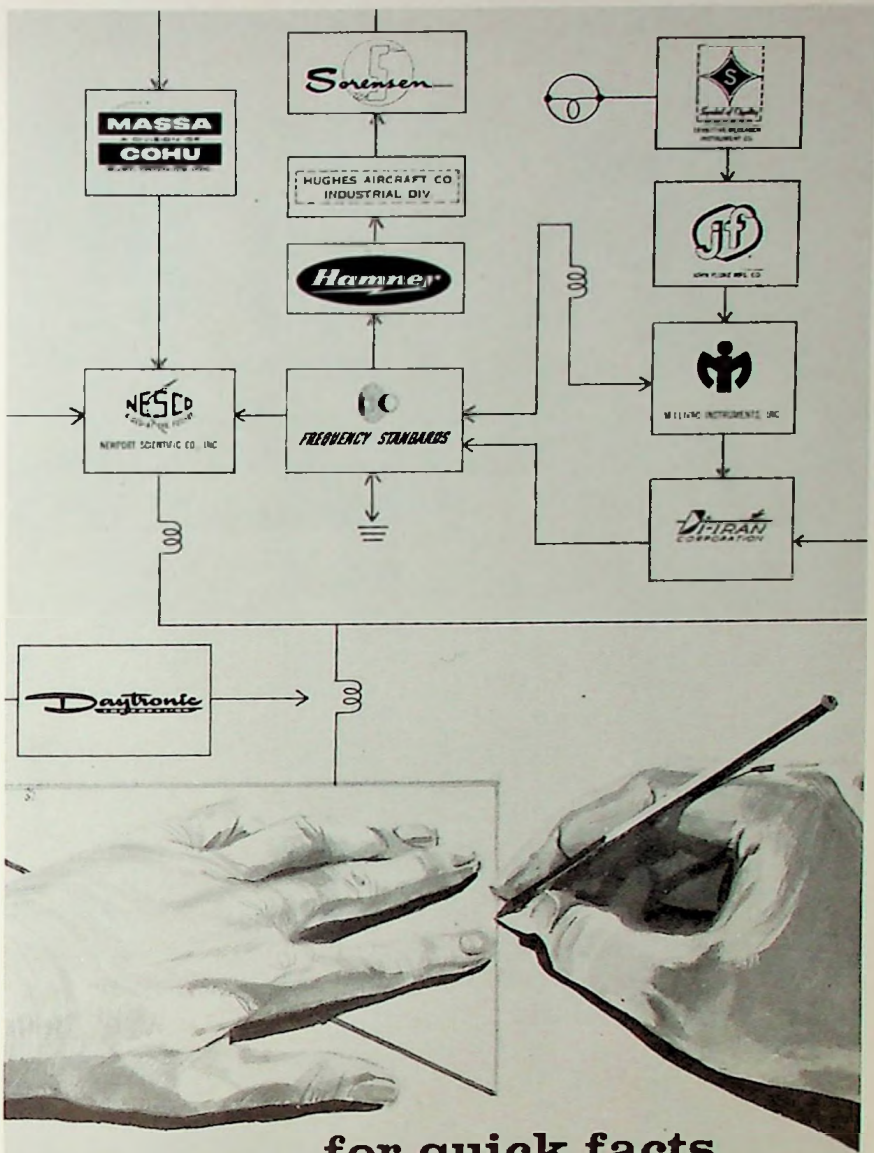

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events of interest

IRE MEETINGS SUMMARY

July 5-9—**Annual Convention, British Institute of Radio Engineers,** Oxford, England.

July 16-21—**4th International Conference on Medical Electronics.** Waldorf Astoria Hotel, New York, N.Y. Dr. Herman P. Schwan, University of Pennsylvania, School of Electrical Engineering, Philadelphia, Penna.

August 22-25—**1961 Western Electronic Show and Convention.** Cow Palace, San Francisco, California. Don Larson, WESCON Manager, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 6-8—**National Symposium on Space Electronics & Telemetry.** Albuquerque, New Mexico. Dr. B. L. Basore, 2405 Parsifal, N.E., Albuquerque, N.M.

Sept. 6-13—**International Conference on Electrical Engineering Education.** Sagamore Conference Center, Syracuse University; Adirondacks, New York. Dr. W. R. LePage, Syracuse University, Syracuse, New York.

Sept. 13-15—**IRE Conference on Technical-Scientific Communications.** Bellevue-Stratford Hotel, Philadelphia, Penna. George Boros, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Penna.

Sept. 20-21—**1961 Industrial Electronics Symposium.** Bradford Hotel, Boston, Mass. H. O. Painter, Jr., General Radio Co., West Concord, Mass.

NON-IRE LOCAL EVENTS

June 20—**Optical Society of Northern California** (joint meeting with SPIE and SPSE): "Fiber Optics" by Dr. Narinder S. Kapany, Optics Technology, Inc., Belmont, California. 8:00 P.M., Edwards Hall, Rickey's Studio Inn, El Camino Real, Palo Alto, California.

August 1-3—Fourth Western Regional Meeting of the **American Astronautical Society.** Sheraton-Palace Hotel, San Francisco. General Chairman: Saunders B. Kramer, Lockheed, Sunnyvale.

PAPERS CALLS

August 1—200-word abstracts for annual technical meeting of the Professional Group on Electron Devices (Washington, D.C.; October 26-28). Send to: I. M. Ross, Room 2A-329, Bell Telephone Laboratories, Murray Hill, N.J.

August 18 — Abstracts for Seventh Annual Conference on Magnetism and Magnetic Materials (Phoenix, Arizona; November 13-16). Send to: Peter B. Myers, Motorola Semiconductor Products Division, 5005 E. McDowell Road, Phoenix, Arizona.

the section

MEMBERSHIP

Following are the names of IRE members who have recently entered our area, thereby becoming members of the San Francisco Section:

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Wayne E. Amacher
Luc K. Baerman
Beryl L. Barber
Irwin Barr
Joseph F. Bennett
Frederick W. Binns
John Bollier
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Harrell L. Watson
William C. Watson
Willard H. Wattenburg
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Elrod T. Woodbury

Following are the names of individuals who have been elected to current membership:

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William C. Taylor
Robert E. Thomas
Alvin Twitchell
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John L. Wells
Dale H. Williams
Ben K. Wright
John C. Wurr
David H. Ziegler

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Almon E. Larsh, Jr.
C. Michael Melas

MEMBER

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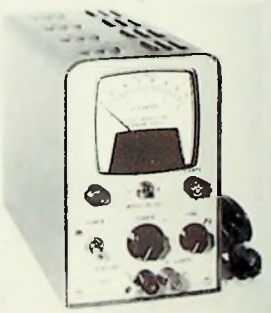

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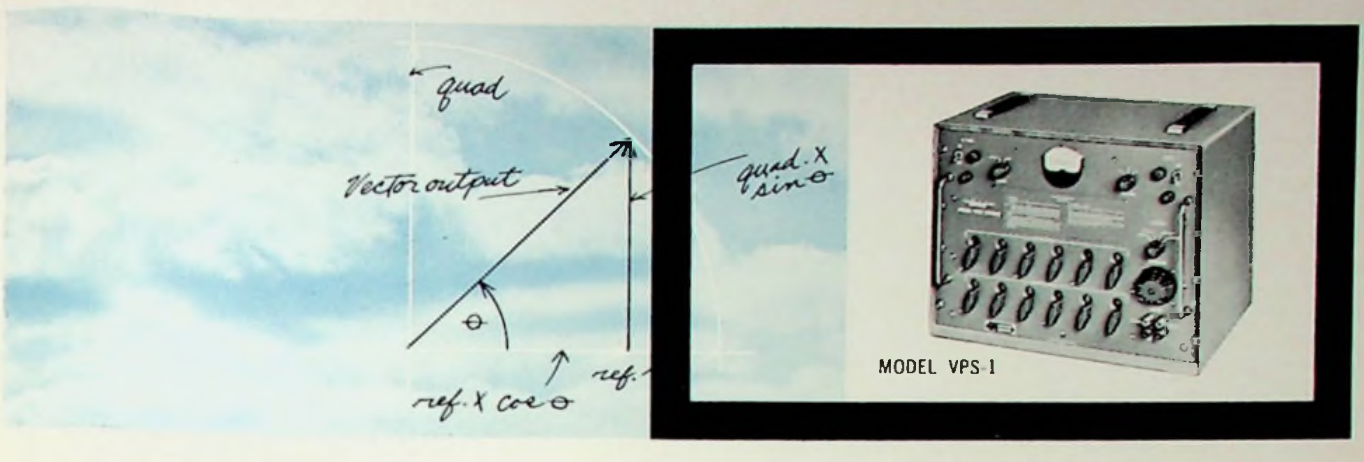

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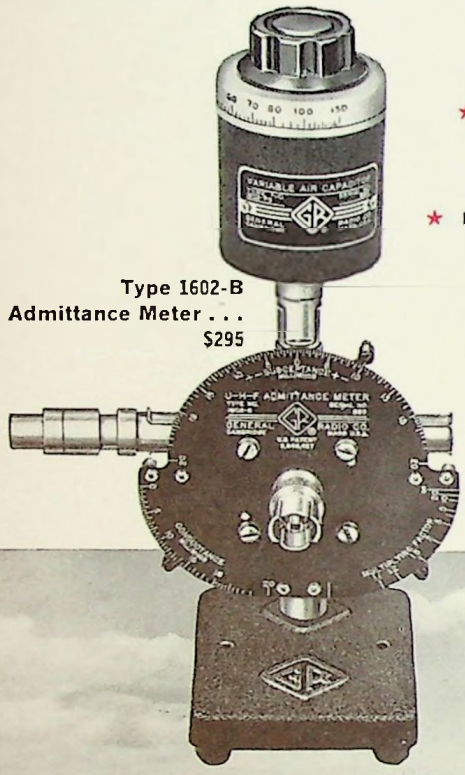

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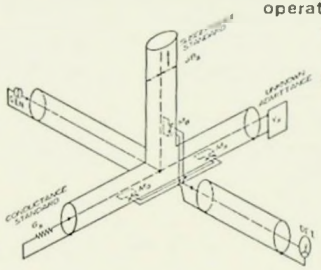

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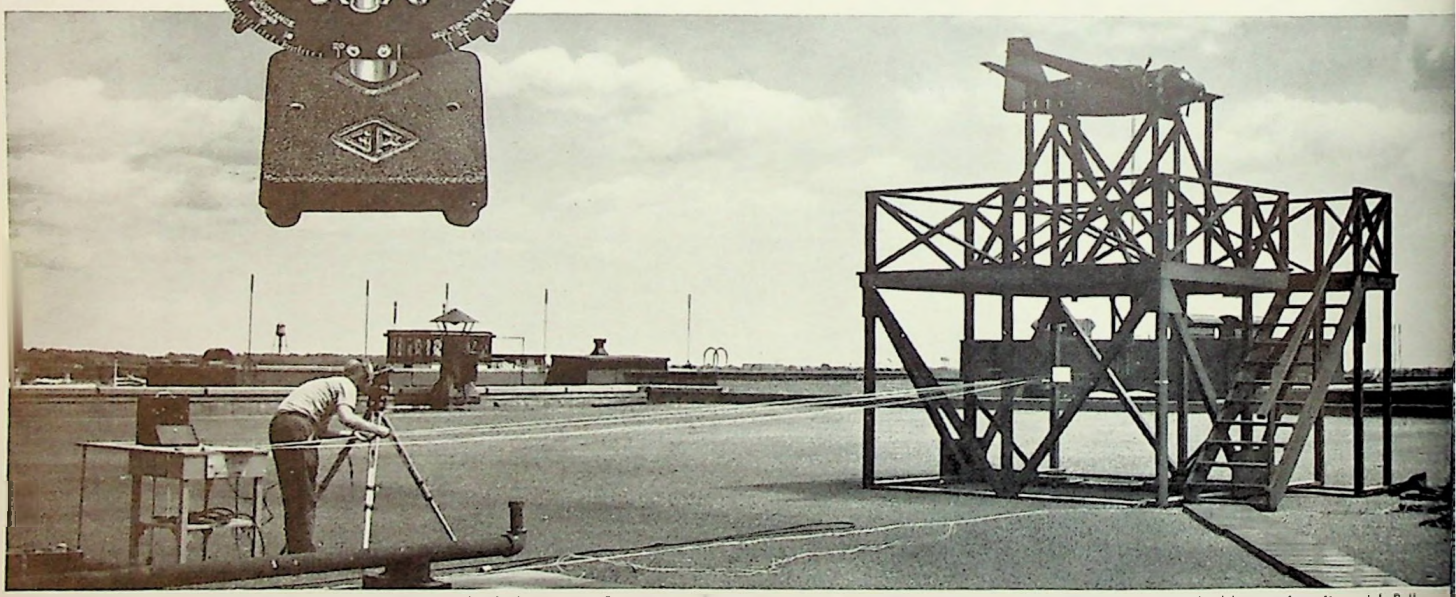
Conductance: 0.2 to 1000 millimhos
Susceptance: ±0.2 to ±1000 millimhos
With ¼-wavelength line between unknown and Meter, scales become direct reading in **Resistance** from 1 to 5000Ω, and **Reactance** from ±1 to ±5000Ω.

★ **EASY TO USE . . .** no sliding balances to chase . . . only three levers to adjust

★ **UNCOMPLICATED CONSTRUCTION** guarantees long, reliable operation and insures that basic ±3% accuracy will be held indefinitely.

★ **SMALL, LIGHTWEIGHT, PORTABLE . . .** ideal for antenna measurements

★ **A WIDE VARIETY OF ACCESSORIES** available to extend versatility:
Balun for measurements on balanced lines and circuits.
Component Mount for measuring circuit elements.
Terminations for measuring reflection coefficient.
Adaptors ranging from BNC to 3½-inch rigid line for measurements with any connector system.
Oscillators and detector systems for complete frequency coverage.



A tribute to the Admittance Meter's versatility is its use at Grumman Aircraft, Bethpage, Long Island. Grumman engineers were faced with the problem of making accurate measurements on developmental aircraft antennas without influencing, by their physical presence, the antenna's radiation pattern or impedance characteristics. As a solution, they mounted an Admittance Meter, a G-R Unit Oscillator, and DNT Detector System inside an aircraft model. Pull cords connected to the Admittance Meter's controls were run out to a remote point where the operator could make his measurements without disturbing the setup. By adjusting the cords and using a surveyor's transit to read the instrument scales, accurate measurements could readily be made.

Write For Complete Information

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

our 45th year in Electronics

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