EDITOR'S PROFILE of this issue

from a historical perspective …

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

June, 1963:

Cover: Although we don't have an image of the cover itself, it shows the Telstar satellite, which orbits at an altitude of 3,000 miles. The plan is to place a series of Telstars in orbit at 22,300 miles up, so they remain geo-stationary, "parked in the sky". This will provide 24-hour service, rather than the 38-minute contact of Telstar. More on page 8.

Page 4: The chairs of the AIEE and IRE SF Sections discuss what the new IEEE will look like to local members. It will move away from the AIEE's technical division structure toward a professional technical group arrangement, each with its own officers and planning its own meetings.

No cover was available to scan for the June 1st issue.

MEASURE MILLIVOLTS at 1000 MC

hp 411A RF Millivoltmeter now available. Measure low level radio frequency, radio frequency and intermediate frequency stage gain, and radio frequency in coaxial lines from 500 kc to 1000 mc, 10 mv to 10 volts. Measuring is simple, resolution is high, and thermal drift errors are virtually eliminated with the 411A Voltmeter. This remarkable instrument has true linear operation (no correcting networks) and readings are presented on a large, mirror-backed linear meter. Temperature stability is such that there is virtually no change from 10° to 40° C.

Specifications alongside indicate basic features of this important new, time-saving instrument. Other special features include: matched diodes protected against burnout; probe temperature compensated for low drift; amplifier photochopper eliminating contact noise, guaranteeing high sensitivity and zero-drift freedom; extra probe tips available including a 500 kc to 250 mc UHF tip, 100:1 Capacity Divider tip for measurements up to 1000 v peak, and Type N Tee tip for coax use to 1000 mc. Get a new 411A into action on your bench now!

SPECIFICATIONS

Voltage Range:

10 mv rms full scale to 10 v rms full scale in seven ranges; full scale readings of 0.01, 0.03, 0.1, 0.3, 1, 3 and 10 v rms

Frequency Range:

500 kc to 1 gc with accessory probe tips; usable indications to 4 gc

Accuracy:

500 kc to 50 mc, ± 3% of full scale; 50 mc to 150 mc, ± 6% of full scale; 150 mc to 1 gc, ± 1 db using appropriate probe tips

Meter Scales:

Two linear voltage scales, 0 to 1 and 0 to 3, calibrated in the rms value of a sine wave; db scale, calibrated from +3 to —12 db; 0 db=1 mw in 50 ohms

Probe Tip Furnished:

411A-21E BNC open circuit tip, 500 kc to 500 mc; shunt capacity less than 5 pf; max. input 200 v dc; input resistance at 10 mc typically 80K ohms

Galvanometer Recorder Output:

Proportional to meter deflection, 1 ma into 1000 ohms at full scale deflection

Power:

115 or 230 v ± 10%, 50 to 60 cps, 35 watts

Dimensions:

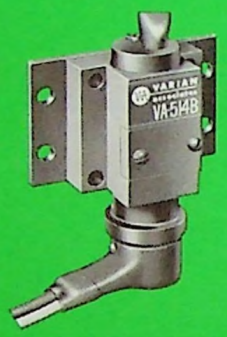
Cabinet Mount: 11¾" high, 7½" wide, 12" deep
Rack Mount: 6 - 31/32" high, 19" wide, 10⅜" deep behind panel

Price:

411A, (cabinet) $450
411AR (rack mount) $455

Data subject to change without notice. Price f.o.b. factory.

VARIAN TWO-CAVITY OSCILLATORS – 9.5-10.6 Gc							
CHARACTERISTICS	VA-520	VA-519	VA-518	VA-514	VA-516	VA-517	VA-511
200 W, 13.0 kV					●		
50 W, 10 kV						●	●
2 W, 4 kV	●	●	●	●			
FIXED FREQUENCY		●		●	●		●
TUNABLE 250 Mc SINGLE SHAFT	●		●			●	
CONDUCTION COOLED	●			●			
LIQUID COOLING		●	●			●	●
EBULLIENT COOLING					●		



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VA-517

WHICH VARIAN LOW-NOISE OSCILLATOR BEST SUITS YOU?

Varian's low-noise X-band klystron oscillators for CW-doppler or pulse-doppler systems are available with several power ratings and a wide selection of tuning and cooling arrangements. These two-cavity klystrons can be used to meet your requirements for drivers or power oscillators. Improved manufacturing techniques provide a long life of low-noise performance which is guaranteed for at least 500 hours. Frequency stability: excellent. Write for additional information.

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IEEE grid

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JUNE 1, 1963

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cover

An unusual view of Syncom and Telstar is seen in the drawing calling attention to the special technical sessions planned for WESCON. Three Syncoms, compared to about 50 Telstars, promise to blanket the earth with international TV, radio, and telephone service. Launched to an altitude of 22,300 miles, rather than the 3,000-mile altitude of Telstar, each "parked-in-the-sky" Syncom will, if successful, provide 24-hour continuous service, rather than the 38-minute service of Telstar.

Cover drawing courtesy of Cornell Dubilier Electronics Division of Federal Pacific Electric Company, Newark, N.J., and Bob Hanna, Northern California district manager. For more on the WESCON technical sessions, based on a record number of papers, see page 8.

ieee section chairmen through june 30, 1963

advertising

remarks from the chairs

The Grid *and the membership are privileged to hear from the chairmen of both merging sections. Victor Kaste and Peter Lacy, ably assisted by the officers of each section and members of special merger committees, have devoted many hours to details of the section merger now approaching successful conclusion, with the end of the fiscal/program year June 30.*

TO AIEE/IEEE MEMBERS:

As of July 1, 1963, you will be identified as a member of the San Francisco Section of IEEE. The main work of merging the AIEE and the IRE will be completed by then in almost all—if not all—parts of the country. There remains the adoption of section constitution and bylaws, which are still undergoing some minor revisions. These will be adopted formally as soon as possible, but, in any event, not later than the end of the calendar year.

The merger activity has proceeded smoothly. As in other sections, and in the institute as a whole, the business of merging has gone ahead here in an atmosphere of cooperation and understanding and with the best interests of the combined membership in mind. In this regard, your local merger committees elected to simplify the merger by staying with the single section concept. This particular choice in no way implies that after the merger the single section concept is necessarily the best in the future for serving the needs of the members of this area. The Los Angeles groups are now exploring the benefits of establishing a district in place of the previous section setup and creating several new sections from the previous subsections. We are watching the developments in Los Angeles, since, in many ways, our circumstances are quite alike.

The principal changes you will note under the IEEE banner will be some new faces, greater selection of technical programs, and fewer general meetings. The section committee structuring will be modified; however, the work of the section will go on much the same as it has in the past except for a larger executive committee and full-time executive secretary with staff. The shift of emphasis toward more technical programs will be the biggest change. The technical division program as we have known it in the AIEE will continue next year, but the plan is to work away from the technical division type setup toward a professional technical group arrangement. Explorations are going on now to blend parts of the many specific technical fields represented by broad AIEE technical division classifications into existing and new professional technical groups. In the near future, you will be given a full explanation of professional technical groups, how you can join existing ones, and what procedures to follow to establish new ones. Each PTG chapter, of which there can be many in a section, will elect its own chairman and other desired officers, arrange its technical meetings, and administer funds assigned to it.

Subsection activity will proceed much the same as in the past. Reno and Shasta subsections are now a part of the Sacramento Section. In the San Francisco Section we start out with East Bay, Fresno, and Santa Clara Valley subsections. As contrasted to PTG's, it is expected subsections will offer more varied and general technical programs.

The semimonthly IEEE **Grid** will be the official publication of the San Francisco Section. The IEEE **Grid**, a self-supporting publication, is an excellent vehicle for announcing meetings and reporting on matters of interest to the members. The future of the **San Francisco Engineer** is not certain at this time. At the current and projected costs of this monthly publication to the IEEE, the distribution to our members is beyond our section's financial means. There is general accord with the idea of a San Francisco Bay Area engineering publication which would serve to bring all of the engineering societies

TO ALL SFS IEEE MEMBERS:

Vic Kaste's message covers the local merger scene in detail, so little need be added on the initial steps. The next question is: Can this larger organization be comfortable and fulfilling in local professional activities?

In the realm of cities, companies, and crowded luncheon spots many flee the large aggregate. It connotes an impersonality and possibly even callousness. We certainly hope that the moderate increase in size that has come about through merger will not result in any such feeling in this section of IEEE.

This "lonely crowd" frustration need never come. Our defense can be the professional technical group chapters and the subsections. Consider first the PTG, based on its antecedent, the PG of the IRE. If one is a specialist, there is such a group for him: Information Theory, Electron Devices, or Reliability and Quality Control. In contrast, if a member has broad technical interests, he may wish to join an industry-oriented PTG such as Military Electronics or Broadcasting.

These PTG's have a local membership that is typically a few hundred in strength. They have the full responsibility of planning their meeting programs. There is a nominal planning framework in a section-wide program committee that attempts to avoid conflicts and encourages joint PTG meetings when a topic has a broad interest.

The PTG's also have their own transactions, with a circulation of international range. The editorship of each of these journals is assigned to a highly respected and willing member for a term of a few years. Frequently, these editorships fall in the vigorous and stimulating San Francisco Section.

Next, the subsection plays an important part for members in communities away from the concentration now present on the Peninsula and in San Francisco. Their program coverage can be broad and their atmosphere club-like. Frequently, a subsection will plan a joint meeting with a PTG. The subsection will certainly play an important part in our industry's growth and its dispersion away from overconcentrated centers.

Let us now look at the core of the section. This is the section office and the IEEE **Grid.** Here, under professional direction, we can coordinate our affairs and quickly inform the entire membership of meetings to come, reports on past meetings, and provide coverage on many other local developments important to the profession.

It is expected that there will be a refreshing realignment of the PTG's to enlarge their scope to cover new interests and review previous roles. Section officers also encourage your suggestions and the contributions of new ideas to the **Grid,** the office, and the section operating policies.

PETER LACY
CHAIRMAN
SAN FRANCISCO SECTION
IRE/IEEE

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closer together. It is hoped the **San Francisco Engineer** can develop into such a publication, and at a cost that will attract all of these societies.

The AIEE is a rich heritage, and we hope all of you profited from its many technical and professional opportunities. The potential opportunities in IEEE are even greater. It does not matter whether you call it "I.E.E.E.," "I Triple E," or "Eye E Cubed," but it is important that you participate by taking an active interest and part in making your society mean more to you and your professional associates!

VICTOR E. KASTE
CHAIRMAN
SAN FRANCISCO SECTION
AIEE/IEEE

MEETING CALENDAR

SAN FRANCISCO SECTION

7:30 P.M. • Saturday, June 15

Annual meeting, dinner-dance
Place: Diablo Country Club, Danville
Cocktails: 7:30 P.M. (no host)
Dinner: 8:30 P.M. (New York steak)
Dancing: 9:00 P.M. to 1:00 A.M. to the music of the "Stardusters"
Reservations: $7.50 per person. Limited to 400 persons. Tickets may be reserved through Mrs. Doris Gould, Section Office, DA 1-1332, DA 1-1333. No tickets sold after June 10.

TECHNICAL DIVISIONS

Industrial

6:00 P.M. • Tuesday, July 2

(Social "get together" with electrical maintenance engineers)
Dinner: 6:30 P.M., Concord Inn, Concord
7:00 P.M., introduction of Howard Grotts, electrical engineer, Tidewater Oil, and Moon Yuen, electrical project engineer, Bechtel Corporation
7:30 P.M., group will immediately leave for guided tour of new $20,000,000 iso-cracking installation at Tidewater Plant installed by Bechtel
Following plant tour there will be a meeting at the Tidewater Recreational Facility building for review of electrical design features of this computer-controlled installation.

PROFESSIONAL TECHNICAL GROUPS

Space Electronics and Telemetry

8:00 P.M. • Tuesday, June 18

"Parametric Amplifiers"
Speaker: Dr. George Matthaei, Stanford Research Institute, Menlo Park
Place: Lockheed Auditorium, Bldg. 202, 3251 Hanover St., Palo Alto
Dinner: 6:15 P.M., El Camino Bowl, 2625 El Camino Real, Mountain View
Reservations: Tom Linders, RE 9-4321, Ext. 28394 or 28453, by 1:00 P.M., June 18

meeting ahead

PARAMETRIC AMPLIFIERS

George L. Matthaei, manager of the electromagnetic techniques laboratory, Stanford Research Institute, will address PTGSET at its June 18 meeting in Lockheed Auditorium on the principles of parametric amplifiers.

The tutorial summary of basic parameteric amplifier concepts will begin by comparing the action of a time-varying capacitance with that of a time-varying resistance such as that in a conventional microwave mixer. The energy relations involved in various parametric devices will be discussed and elementary equivalent circuits for a pumped variable-capacitance diode presented.

Using these representations for the pumped diode, it is a simple matter to compute the impedance at the input at the signal input frequency as

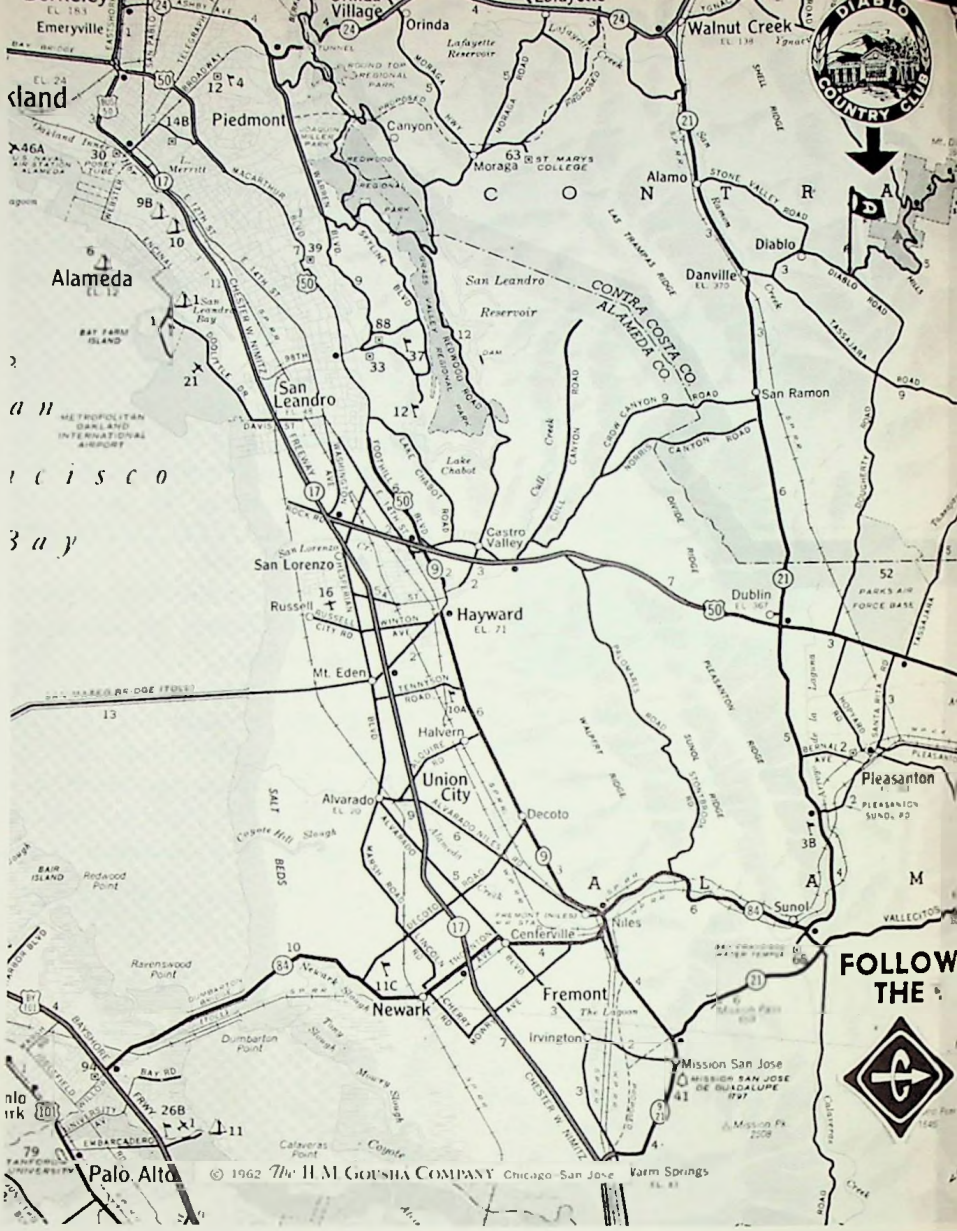
George L. Matthaei

a result of any given terminating impedance seen at the sideband frequency. Operating properties will be summarized for: upper-sideband up-converters, lower-sideband up-converters, degenerate and nondegenerate parametric amplifiers, and amplifiers consisting of a double-sideband up-converter combined with a resistive down-converter.

Dr. Matthaei attended the University of Washington and received a B.S. degree in electrical engineering 1948. He then did graduate work at Stanford University and received a Ph.D. degree in electrical engineering in 1952.

While at Stanford he was a research assistant in the electronics research laboratory where he did work on network synthesis. In 1951 he joined the faculty of the division of electrical engineering of the University of California at Berkeley where he became an assistant professor. He continued research on network synthesis and supervised graduate student research in that field. During 1955 to 1958 he was a member of the technical staff of the Ramo-Wooldridge Corporation. He was engaged in system analysis and research on microwave components.

In September, 1958, Dr. Matthaei joined the staff of SRI. He is a member of the IEEE, the Professional Technical Groups on Microwave Theory and Techniques and on Circuit Theory, Sigma Xi, and Tau Beta Pi. He was the winner of the 1961 microwave prize of the IRE Professional Group on Microwave Theory and Techniques.



How to reach the Diablo Country Club, Danville, where the first merged San Francisco Section IEEE annual meeting, a dinner-dance, will be held Saturday, June 15. No-host cocktails, 7:30; New York steak dinner, 8:30; dancing from 9 to 1 to the music of the Stardusters. Early reservations, limited to 400 at $7.50 a person, are recommended. Call Mrs. Doris Gould in the Section Office and follow this by mailing a check to be sure that your tickets are reserved and mailed to you.

transition notes

PTG TITLE CHANGES

Two professional technical groups recently revised their titles on the national level to reflect changing emphasis. PTGI became the Professional Technical Group on Instrumentation and Measurement (PTGIM). PTGRQC became the Professional Technical Group on Reliability (PTGR).

CAREER NEWS FROM HUGHES

Aerospace Divisions in Culver City, California

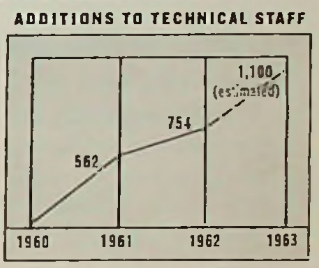
NEW AND CONTINUING PROGRAMS AND PROJECTS

F-111B PHOENIX Missile System
MMRBM (Integration, Assembly and Checkout)
SURVEYOR Lunar Landing Vehicle
SYNCOM Synchronous Communications Satellite
POLARIS Guidance
TOW Anti-tank Missile
ARPAT
VATE Automatic Checkout System
FALCON Missiles
HARD POINT DEFENSE

These examples of Hughes Aerospace activities are representative of *more than* 230 major product and service capabilities ranging from aerospace vehicles to ASW systems.

GROWTH OF THE TECHNICAL STAFF

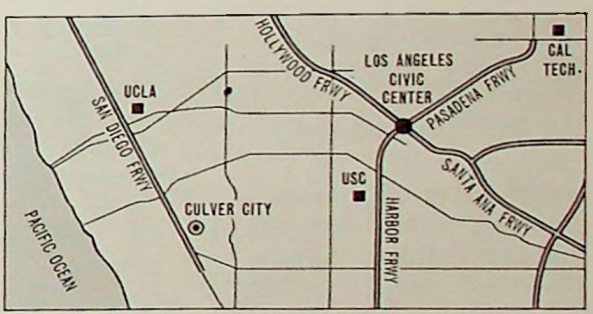
Of the nearly 9,000 employees of these divisions, 2,600 are Members of the Technical Staff. Average length of experience is 10.0 years. Average age is 32 years.



OUTSTANDING TECHNICAL FACILITIES

This giant environmental test chamber at Hughes new Space Simulation Laboratory is just one of a complete range of facilities maintained by the company for the Technical Staff. Hughes physical plant and professional atmosphere, unexcelled in industry, encourage individual achievement.

HUGHES/CULVER CITY & LOS ANGELES



Hughes Aerospace Divisions at Culver City offer engineers and scientists a unique combination of urban and suburban advantages. The plant is immediately adjacent to a major freeway. Los Angeles Civic Center is about a half-hour distant. Beach communities are just minutes away. Attractive residential neighborhoods are nearby. UCLA, USC and Cal Tech offer outstanding educational facilities.

IMPORTANT OPPORTUNITIES, steady growth, advanced facilities, fine living conditions—these are the advantages which Hughes Aerospace Divisions can offer you at Culver City.

Requirements include an accredited degree in E.E. or M.E. and specialized experience which can be related to development of aerospace vehicles. U.S. citizenship required.

For immediate consideration please airmail your resume *today*. We promise you a reply within one week.

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Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City, 47, California

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RECORD PAPER RESPONSE

Organizers of the technical program for the 1963 Wescon report a wide choice for the morning and afternoon sessions to be held daily at the Cow Palace. A record 300-plus papers have been submitted for consideration along with 20 invited papers to make up the regular morning sessions, presenting the reviewers and session organizers one of the most exacting tasks in Wescon convention history.

Dr. Jerre D. Noe of Stanford Research Institute, technical program chairman, said that a cursory examination of the submissions has assayed unusually high quality and a range of bright new ideas.

Ahead of the preliminary program to be formed in May, Dr. Noe has announced four special sessions for the afternoons of Wescon. They constitute one of the main attractions of the convention, as indicated by a survey of attendees at the 1962 Wescon in Los Angeles.

A session on "Active Communications Satellites" will review devices presently performing and those anticipated to be lofted in the near future. Dr. H. Richard Johnson of Watkins-Johnson Co., Palo Alto, the organizer, has submitted the following subjects and speakers:

"Telstar," by Irwin Welber of Bell Telephone Laboratories, Murray Hill, N.J.; "Relay," by Warren Schreiner of Radio Corporation of America, Hightstown, N.J.; "Syncom," by Dr. Harold A. Rosen of Hughes Aircraft Co., Culver City, Calif.; "ComSat," by Wilbur L. Pritchard of Aerospace Corp., El Segundo, Calif.; and "Commercial Communication Satellites," by Beardsley Graham, president of Spindletop Research, Lexington, Ky.

"Life on Other Planets"—speculations based on electronic, physical, and biological investigations to the moment—has been organized by Dr. Elliott Levinthal of the exobiology laboratories, department of genetics, Stanford University. Dr. Joshua Lederberg of Stanford's department of genetics will treat on the biological background (the origin of life) and biological interest in the question. R. W. Bussard of Space Technology Laboratories will deal with travel beyond our planetary system but within our galaxy.

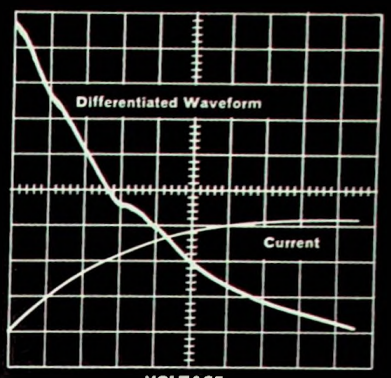
Noe

Johnson

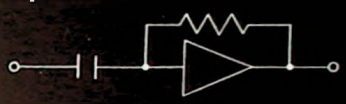
Dr. Bernard M. Oliver of Hewlett-Packard Co. will discuss the probabilities for communication with intelligent life on other planets. Finally, Dr. Levinthal will describe approaches to detecting life within our planetary system.

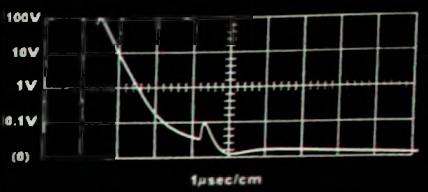
Dr. James C. Bliss of SRI has reported confirmation of three of four speakers for a session on "Information Processing in Living Systems." Scheduled thus far are: Prof. Donald Kennedy of Stanford, "Neural Processing"; Prof. G. D. McCann of Cal. Tech., "Sensory Perception — Focal Point of Interdisciplinary Research by Biologists and Engineers"; and Dr. Kenneth Brown of the UC medical school, "Rod and Cone Receptor Potentials from Monkey Retinas."

DISPLAY OF INTEGRATED WAVEFORM—transformer secondary voltage integrated and plotted against the transformer primary current—for enabling study of B-H loops of transformer cores.

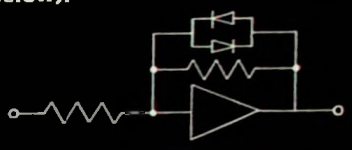


DISPLAY OF DIFFERENTIATED WAVEFORM—tunnel diode in liquid helium—for enabling detection of quantum phenomena at low temperature.

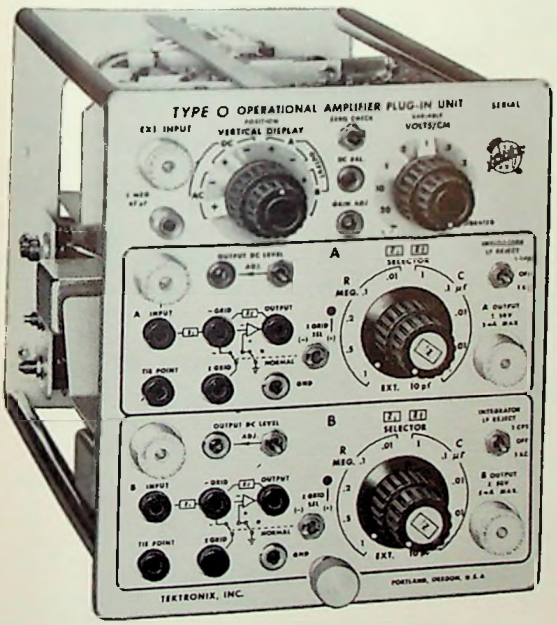




DISPLAY OF LOGARITHMIC RESPONSE—two pulses of widely varying amplitudes—for enabling observation of 100-volt pulse and 0.1-volt pulse in the same viewing area (simplified schematic shown below).



Operational Amplifier Plug-In Unit Permits Oscilloscope Measurements Under Dynamic Conditions



TYPE O UNIT U. S. Sales Price, f.o.b. Beaverton, Oregon $525

For a demonstration—
please call your Tektronix Field Engineer.

TYPE O UNIT—for Tektronix Oscilloscopes that accept letter-series plug-in units.

Using this new Operational Amplifier Unit in your Tektronix Oscilloscope, you can perform precise operations of integration, differentiation, function generation, linear and non-linear amplification.

You can accomplish many of these operations by simply manipulating the front-panel controls—for the Type O Unit features convenient *selection of precision input and feedback components.*

You can use the Type O Unit as a gated integrator . . . as a high-input-impedance amplifier . . . as a bandpass amplifier . . . as a constant-current-drive amplifier . . . as a peak-memory amplifier . . . as a function generator . . . as a capacitance-measuring device . . . as a low-current measuring device . . . and for many and varied other specialized operations—some performed *with* external circuitry and some *without.*

CHARACTERISTICS

The Type O Unit contains two complete operational amplifiers and one complete vertical preamplifier.

Each operational amplifier features 15 mc open-loop gain-bandwidth product, open-loop dc-gain of 2500, selectable input and feedback impedances, drift rejection for ac integration. The output of one operational amplifier can be applied to the input of the other for combined operations.

The vertical preamplifier can be used independently or to monitor the output of either operational amplifier. In a Tektronix Type 540-Series Oscilloscope, the passband is dc-to-25 mc, the risetime is 14 nsec, and the maximum calibrated sensitivity is 50 mv/cm.

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From Oakland, Berkeley, Richmond, Albany and San Leandro: CLifford 4-5353

education notes

CAL EXTENSION

Summer courses in subjects of interest to electrical and electronics engineers will be presented on the Peninsula and in San Francisco and the East Bay, beginning in June, by Engineering and Sciences Extension, University of California.

Switching Theory and Logical Design, to be offered in Palo Alto on Tuesday evenings, beginning June 11, is the second of two courses in this subject. Topics included are design of digital circuits; analysis and synthesis of diode and transistor circuits; analysis and uses of core memory devices; error detection and correction theory; and continuation of logical design study. Enrollment is open to persons who have completed the first course or who have equivalent experience. Class meetings will be held on Tuesday evenings at seven in Room 34, Wilbur Junior High School, Palo Alto. The course is taught by Richard W. Calfee, associate engineer, advanced systems development division, IBM, San Jose.

Engineering Electronics, also the second of two courses, will begin in San Francisco, Wednesday, June 19. Designed for the scientist or engineer who requires a basic understanding of electronic devices used in his work or who wishes to strengthen his theoretical knowledge, the course includes review of electron tube and transistor principles; audio-, video-, and radio-frequency amplification; waveform generation; computers; special-purpose tubes and semiconductors. Recent electronics advances will be surveyed. The course is open to anyone who has completed the first course or has equivalent experience. Classes meet at 7:00 p.m. in 204 Richardson Hall, U.C. Extension Center, 55 Laguna Street, San Francisco. Stephen V. Hart, director of Electronic Engineers International, San Francisco, is the teacher.

Three courses in computer theory and technology will be offered. Computer Programming: Machine and Problem-Oriented Languages, a new course, will be presented in 241 Cory Hall, U.C. campus, Berkeley, at 7:00 p.m., Mondays from June 10. The course is an introduction to programming languages, with emphasis on Fortran and FAP. Coding of a variety of numerical and logical problems will be discussed; students will code and run problems on an IBM 7090 as part of the computation laboratory.

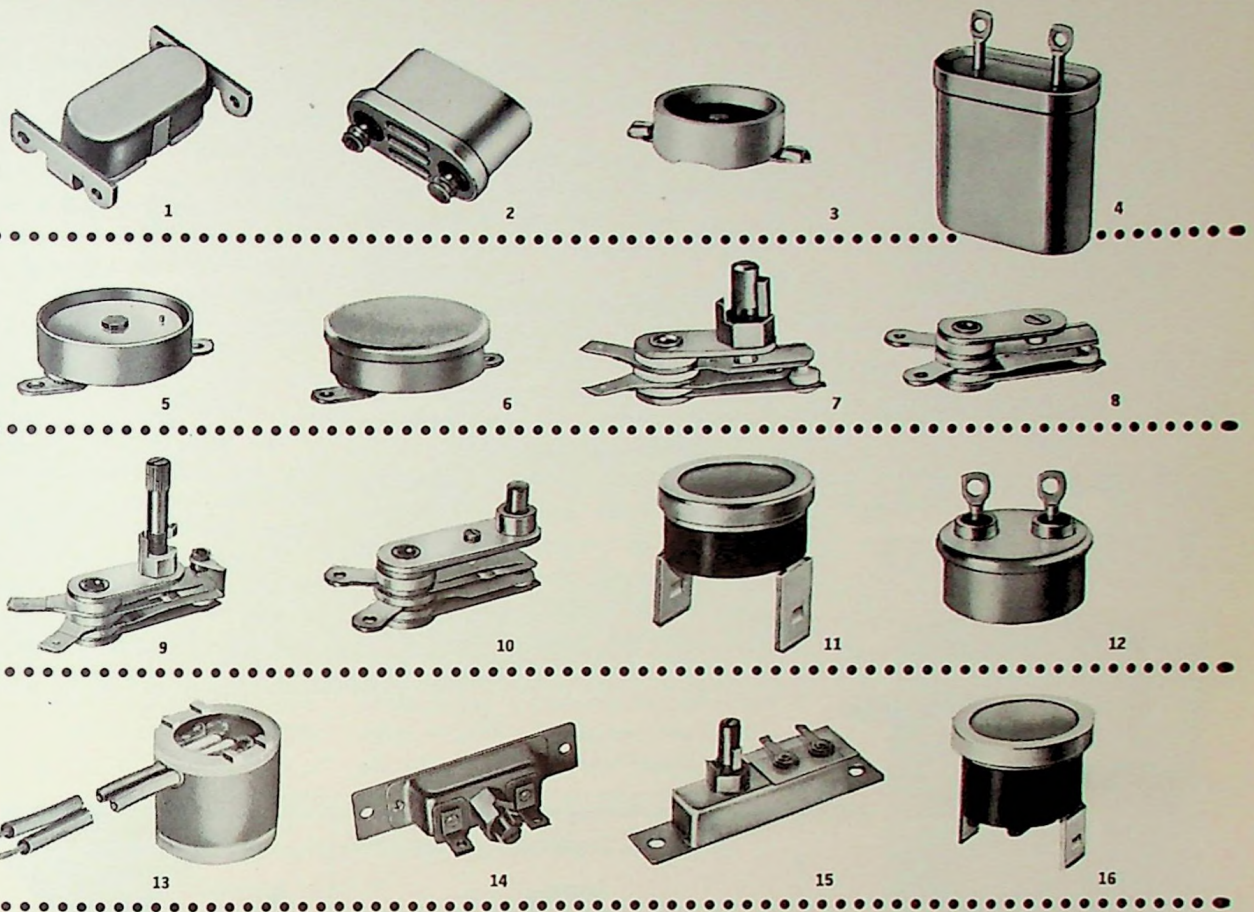
Introduction to Digital Computing Systems and Their Applications, a course for those without special computer experience who wish to familiarize themselves with applications of data-processing equipment, will be offered in both Berkeley and Palo Alto, beginning June 10. Electronic Data Processing: Programming a Business Computer will be given in Berkeley, beginning June 11; and two sections will be offered in San Francisco, beginning June 4 and 5.

Other summer courses in technical writing, calculus with analytic geometry, advanced calculus, and calculus review are scheduled in the University Extension summer program. Detailed course descriptions and schedules are contained in a brochure available from Engineering and Sciences Extension, University of California, Berkeley 4, THornwall 5-6000, Ext. 4151.

STEMCO THERMOSTATS

For Electronic, Avionic, Aerospace Applications

(Typical units shown; many other types available)



1, 2, TYPE C† semi-enclosed (1), hermetically sealed (2). Small, positive acting with electrically independent bimetal strip for operation from –10° to 300°F. Rated at approximately 3 amps, depending on application. Hermetically sealed type can be furnished as double thermostat "alarm" type. Various terminals and mountings. Bulletin 5000.

3, 4, TYPE M*† semi-enclosed (3), hermetically sealed (4). Snap acting bimetal disc types for electronic applications from —50° to 300°F. Rating: 3 to 10 amps at 115 VAC and 28 VAC/DC. Semi-enclosed with virtually any type terminal; hermetically sealed with pin or solder terminals, wire leads, various mounting brackets. Bulletin 6000.

5, 6, TYPE MX† semi-enclosed (5), hermetically sealed (6). Snap acting miniature units to open on temperature rise for missile, avionic, electronic and similar uses. 2° to 6°F differentials available. Rated at 3 amps to 1 amp, depending on duty cycle, at 115 VAC and 28 VAC/DC. Semi-enclosed types with metal or ceramic bases; hermetically sealed in circular or CR7 cans. Various terminals, mountings, brackets, etc. Bulletin 6100.

7, 8, TYPE S*† adjustable (7), non-adjustable (8). Positive acting with single stud or nozzle mounting. Operation to 600°F. Rated at 15 amps at 115 VAC, 7 amps at 230 VAC. Spade, screw or formed terminals, various adjusting stems, etc. Bulletin 1000.

9, TYPE SA*† adjustable, or non-adjustable. Snap acting with electrically independent bimetal. Also single-pole, double-throw. Single stud or nozzle mounting. Rated at 1650 watts at 115-230 VAC only. Spade or screw terminals. Bulletin 2000.

10, TYPE SM*† manual reset. Electrically same as Type SA except for manual reset feature. Bulletin 2000.

11, 12, TYPE A*† semi-enclosed (11), hermetically sealed (12). Insulated, electrically independent bimetal disc gives fast response and quick, snap action control for electronic and apparatus applications from –50° to 300°F. Lower or higher on special order. Rating: 4 to 15 amps, depending on duty cycle, at 115 VAC and 28 VAC/DC. Various enclosures and mountings, including brackets. Bulletin 3000.

13, POTTED TYPES A* & G*. For refrigeration, air conditioning, or applications requiring a sealed thermostat, the Types A and G are available with lead wires and epoxy sealed. Type G is shown. Various mounting brackets. Bulletin 3000 for Type A, Bulletin 3500 for Type G.

14, TYPE R*† sealed adjustable, sealed non-adjustable. Positive acting for operation to 600°F. Rated at 15 amps at 115 VAC, 4 amps at 230 VAC. Screw terminals. Bulletin 7000.

15, TYPE W*† adjustable, or non-adjustable. Snap action bimetal strip type for operation to 300°F. Depending on duty, rated: 5 to 10 amps, 115 or 230 VAC. Screw or nozzle mountings; spade or screw terminals. Bulletin 4000.

16, TYPE G* exposed, or enclosed bimetal disc types, or epoxy sealed for moisture and dust resistance. Snap action for positive and instantaneous opening or closing of electronic and avionic circuits to 300°F. Various mountings and terminals. Bulletin 3500.

Illustrations, for general information only, do not necessarily show size comparisons. Fully dimensioned and certified prints on request. Manufacturer reserves right to alter specifications without notice.

***Refer to Guide 400 EO for UL or CSA approved ratings.**

†These thermostats covered by patents issued or applied for. A-3702A

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meeting review

175 COMPUTERS

Computers in control was the subject of Dr. J. E. Bertram, director of control theory research, IBM Research Labs, San Jose, before the March 14 meeting of PTGAC.

Dr. Bertram gave a discussion of industrial control problems and the application of digital computers to their solution. He pointed out that of approximately 10,000 computers in the U.S., only about 175 are actually used for controlling processes, and from these numbers one might draw the conclusion that process control was a small part of the role that digital computers play. However, he went on to mention that appreciation of the class of control problems to which digital computers may profitably be made is just beginning to be realized, and he expects this proportion to grow in the future.

For example, it is possible to identify the sort of problems to which computer control might profitably be considered. In the first place, the cost of the computer must be compared with other uses of process improvement investments. In addition, if K is the number of years during which the computer cost is to be paid off (a number between 1 and 2 in the United States), p is the percent improvement expected in profit from application of the control computer, and G is the dollar gross of the process, then the product KpG must be greater than or equal to the total cost of computer plus systems engineering plus modification to the process necessary for computer control.

Substituting typical numbers, one arrives at the conclusion that the process must gross approximately ten million dollars per year before computer control could be considered.

In addition to classifications of the processes to which computers can be applied, one can make some classification of the properties of the control computer which must be used. In the first place, the control computer is typically a small scientific machine with added capabilities costing approximately three times that of the basic machine. The control computer has the following properties:

- The number of inputs, in addition

to card and tape, will include from 200 to 300 analog inputs for thermocouple and other analog instrument variables, and a sizable number of on-off or contact inputs.

- The outputs of the machine, in addition to the conventional ones, will also include analog outputs and contact outputs.
- The machine programming will include an interrupt capability, both external and internal, so that the program can be interrupted when certain signals occur on its many input channels.
- The machine will have a large backup storage.
- The machine will contain a clock.
- The control computer will have some form of man-machine communication.

Once a suitable process has been selected, and an available control computer is to be used, the problem can be identified from the point of view of the control engineer as that of applied optimal control; i.e., as a dynamic process having a certain number of control inputs to be selected to maximize a performance criterion, a certain number of outputs, and an interaction with an environment. The assumption is made that the dynamic process interacts very weakly on the environment, but that the environment has considerable influence on the operation of the process. The optimal control problem typically begins with a performance criterion and a model of the dynamics of the process. It is these two elements which the control engineer must supply in the formulation of the applied optimal control problem before the program of the process control computer can be written. Dr. Bertram mentioned that the customer typically wishes to maximize the return on investment while maintaining product quality. The translation of such performance criteria into the mathematical form necessary for use in optimal control theory is an exceedingly difficult problem. Dr. Bertram suggested that in his experience, 25 percent of the systems engineering budget should be spent on getting the performance criterion expressed. Not only is the problem of expression of performance in mathematical terms a difficult task, but also the interaction of the several industries in a free

economy influences the criteria in an unknown way.

The second data necessary for application of the optimal control theory is that of a model of the dynamical system. Typically, in the processes with which Dr. Bertram is familiar, the plants have approximately 200 output variables and from ten to thirty controlled inputs. Of these many variables, only a few may be significant or enter directly into the performance criterion. The selection of the significant variables, and particularly the relations among those that appear in the performance criterion, is a problem of model making, the other very difficult aspect of the application of computers to complex processes. Generally speaking, this aspect of the problem begins with the postulation of a functional form of the relationship and the use of observations of the process to fit a statistically best model of this class to the observed data. During this data reduction, it is necessary to estimate the parameters in the dynamical equations, the state variables, and to take into account obviously erroneous data due to malfunction of unlikely phenomena during collection of the data. The statistical reduction of such data for the estimation of dynamic models and the detection of statistical "Outliers" in the data can only be done satisfactorily if the describing equations are linear. For this purpose, filtering in the form developed by Dr. Kalman of RIAS is most suitable. Finally, as the parameters are estimated, it is necessary to check that the dynamic model obtained is described by a well-conditioned matrix and that the resulting system is controllable, observable, and stable.

As a final example of the applications of computers to control, Dr. Bertram mentioned a particular reactor which was controlled by a computer using a program written in his laboratory. The dynamic equations involved seven states with four inputs in a nonlinear relationship. There were constraints on both state variables and control variables. In this case, the theory of dynamic programming was used to compute the optimal policy for a total of 476,000 states, a computation of which took approximately 82 minutes on a 7090 computer.

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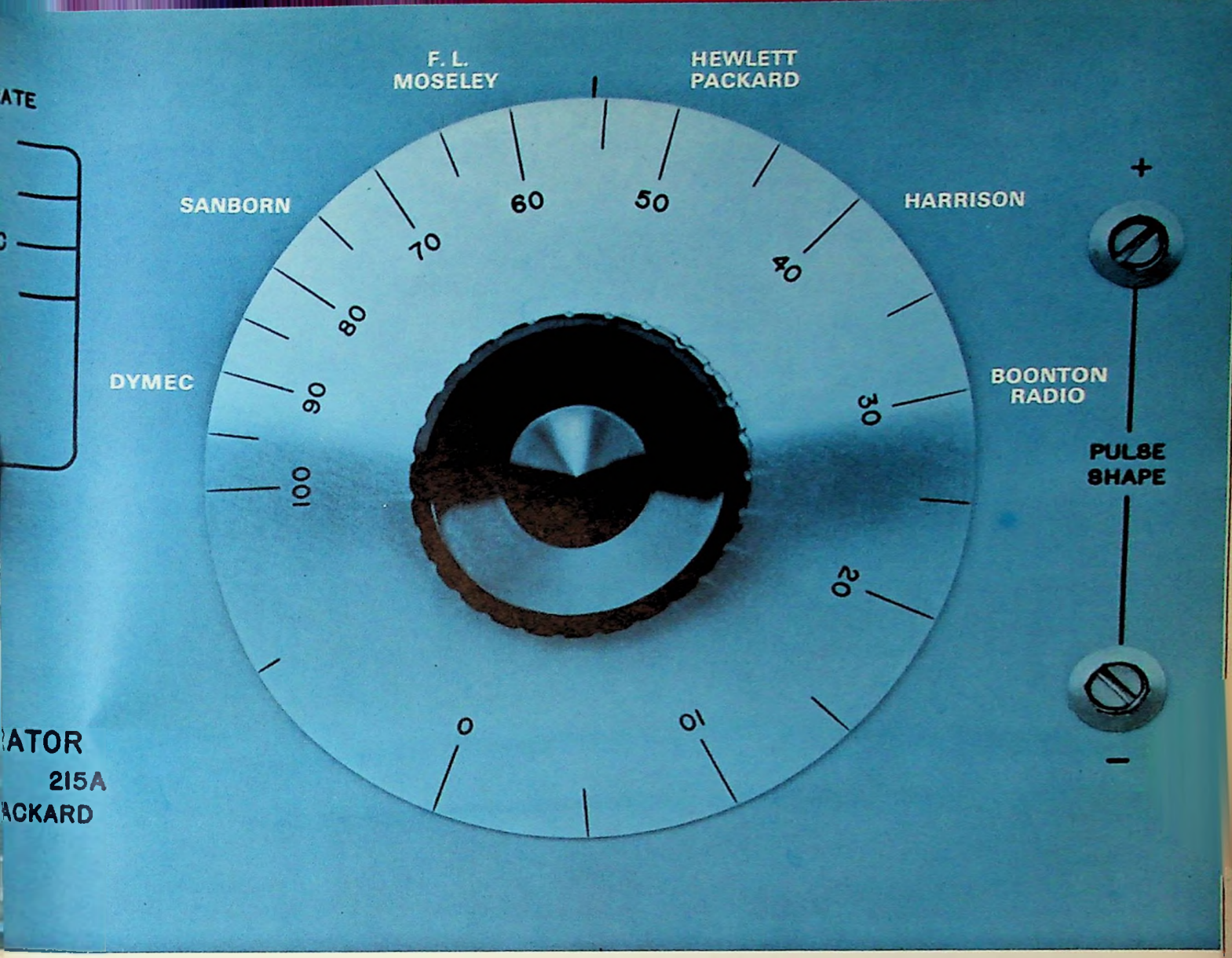

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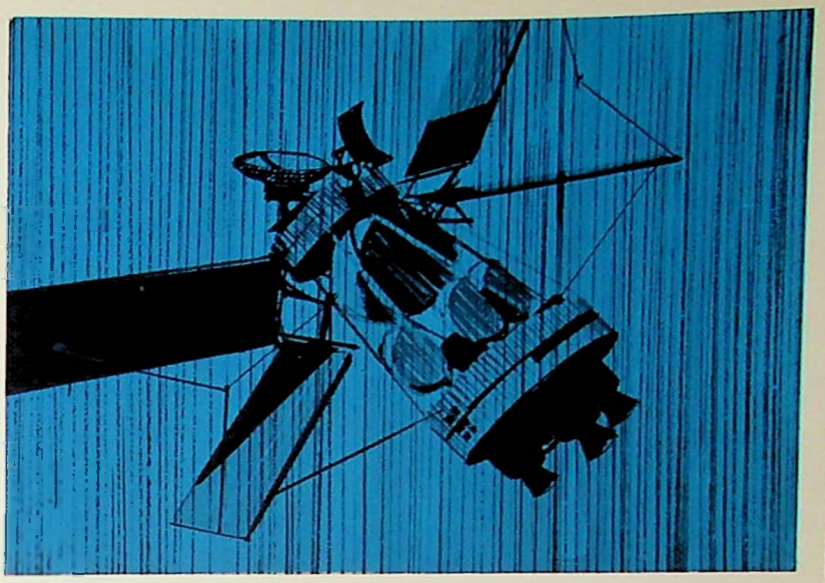

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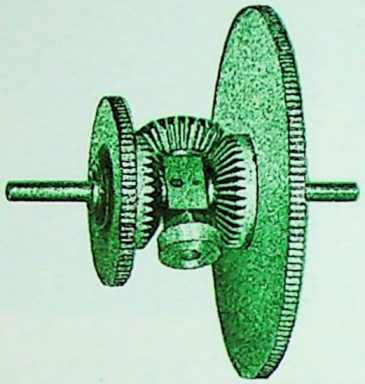

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