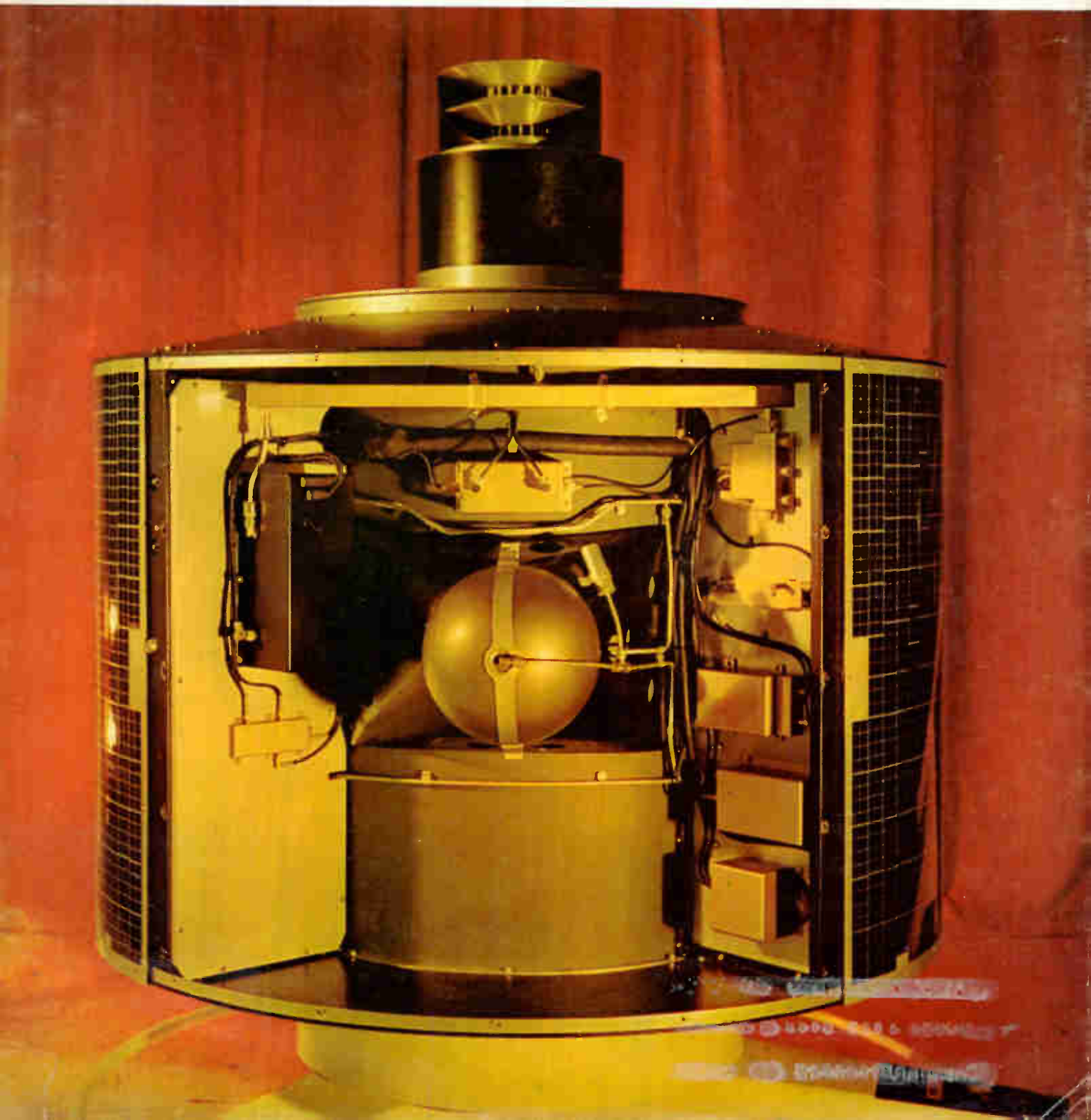
Electronics®

May 2, 1966
75 cents
A McGraw-Hill Publication

Below: Synchronous satellite for global communications: page 83



PIONEERS IN MINIATURIZATION

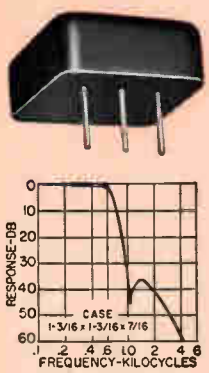
"SPECIAL" (CUSTOM BUILT) FILTERS

TO YOUR SPECIFICATIONS

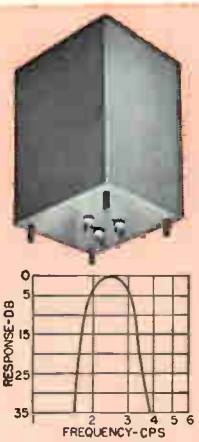
ILLUSTRATED ARE TYPICAL SPECIAL FILTERS

RANGE OF FREQUENCIES ON SPECIAL UNITS IS FROM 0.1 CYCLE TO 400 MC.

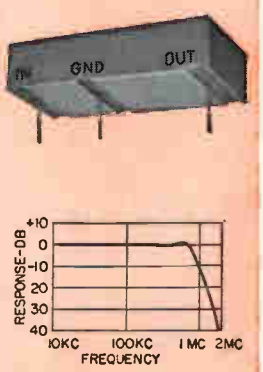
Over thirty years of experience in the design and production of special filters have resulted in UTC being a first source for difficult units. Present designs both military and commercial incorporate a wide variety of core structures, winding methods, and capacitors to provide maximum performance, stability, and reliability. Fully experienced, top engineering talent backed by complete environmental testing and life testing facilities assure the highest standard in the industry. Full analysis and evaluation of materials are conducted in UTC's Material and Chemical Laboratories. Rigid quality control measures coordinated with exhaustive statistical findings and latest production procedures results in the industry's highest degree of reliability.



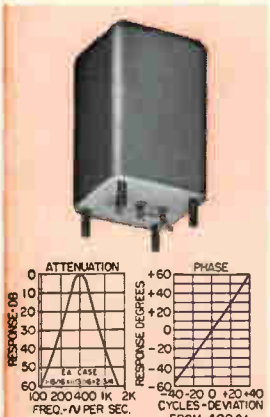
560 ~ Telemetering low pass filter. Available from 400 ~ to 70 KC. ± 7.5% bandwidth flat to 1 db. Attenuation greater than 35 db beyond the 2nd harmonic of — 7.5% frequency. Impedance 47K ohms. MIL-F-18327B. Wt. 0.8 oz.



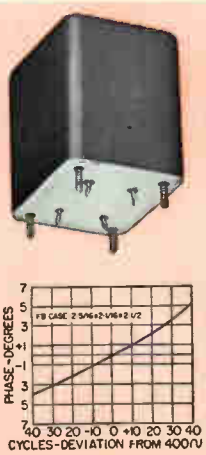
Low frequency band pass filter. Designed for 2.5 cps center frequency. At 2 to 3 cps within 3 db. At 1.5 cps and lower, and 4 cps and higher, greater than 30 db. Source and Load 10K ohms. Size: 4 x 4-11/16 x 6". MA MIL case, MIL-F-18327B.



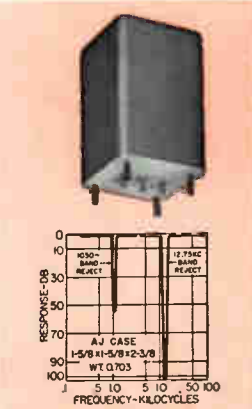
High frequency low pass filter. Zero to 700 KC within 1 db. 1.95 mc to 10 mc 40 db minimum. Source and Load 1000 ohms. Molded flat construction for printed circuit applications. Size: 1 x 2 x ½"; Wt: 1 oz. MIL-F-18327B.



Band pass 400 cycle Gaussian filter. Linear phase response in pass band. Attenuation 380 cps to 420 cps within 0.5 db. 2nd harmonic down 25 db, 3rd harmonic down 45 db. Source and load 5K ohms. MIL-F-18327B Wt., 0.9 lbs.



Minimum phase shift 400 cycle band pass filter. Within ± 1.5 db 370 to 430 cycles, greater than 45 db beyond 1100 cycles. 1K ohms to 100K ohms. MIL-F-18327B; 1 lb.



Band reject filters (two shown). The 1050 ~ filter has 50 db attenuation and is only 3 db at 950 and 1150 cycles. The 12.75 KC filter has more than 100 db attenuation and is only 3 db at 10.8 and 15 KC. Source and load 600 ohms, both are MIL-F-18327B.

MILITARY AND COMMERCIAL TYPES FOR EVERY PHASE OF THE ELECTRONICS ART

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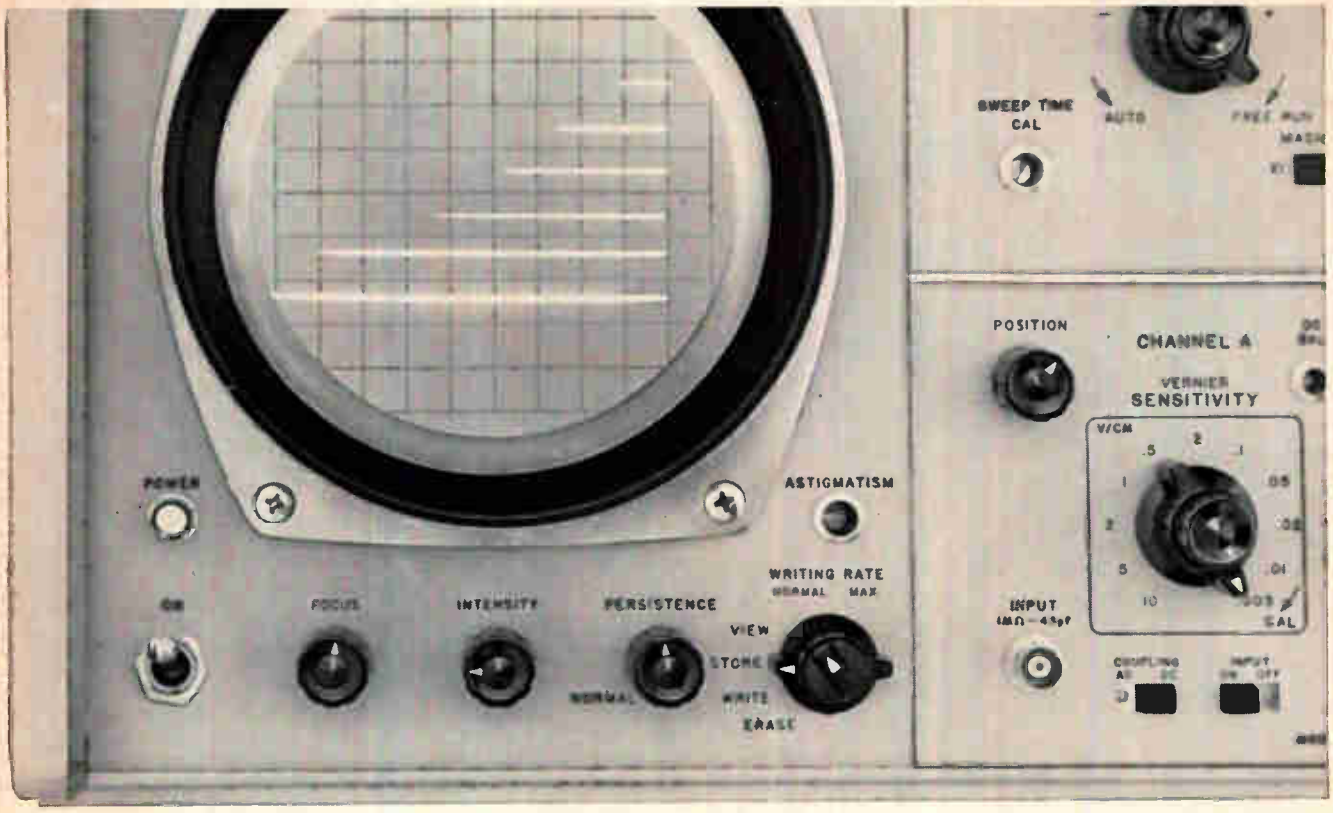
Circle 900 on reader service card

new measure of scope performance:



New Variable Persistence for Easy, Flicker-Free Viewing of all Waveforms

HEWLETT-PACKARD 141A STORAGE SCOPE: three in one!

1. ***VARIABLE PERSISTENCE*** with front-panel control, 1/5 sec. to 1 min. (continuously variable). Eliminates flicker on slow sweeps or fast signals with low rep rates. Easy viewing of slowly moving waveforms. See the complete picture on the screen at all times yet avoid any overlapping traces. Display several succeeding traces at once for direct comparison. Get clear pictures of jittery signals, persistance adjusted so that repetitive signal builds up, random signal doesn't.

2. ***STORAGE SCOPE*** holds trace for up to an hour, for days with scope turned off. Study waveforms at your convenience without a camera. Capture fast single-shot events with writing rate >1 cm/μsec. Automatically integrate dim repetitive signals until bright enough to view, photograph conveniently. Store several single-shot signals on a single crt, photograph.

3. ***CONVENTIONAL PLUG-IN SCOPE*** accepts same plug-ins as the popular hp 140A Scope. Maximum versatility with five vertical, two time base plug-ins. Plug-ins provide sensitivities to 10 μV/cm, bandwidths to 20 MHz. Special double-size plug-ins for TDR testing of cables, connectors and strip lines, and for microwave measurements made with swept-frequency oscillators.

A special cathode-ray tube, plus Hewlett-Packard circuitry, combines all these advantages into a single instrument. Besides the unprecedented performance, you get storage with a high contrast, full 10 cm x 10 cm viewing area, no-parallax internal graticule, a 7.5 kV post-accelerator crt for high brightness... and a *full year's warranty on the crt at full specification!*

The 141A mainframe costs $1275. And 141A dual-channel performance with 20 MHz bandwidth and time base with sweep delay costs only $2450. A 100 μV/cm 400 kHz system costs only $1810.

Every combination of scope and plug-ins gives you Hewlett-Packard design and manufacturing quality. Backed up, too, by your Hewlett-Packard field engineer, who can help solve your measurement problem with a scope or with other tools from the broad line of high-quality instrumentation he offers. Give him a call for complete data on the 141A. Or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Prices f.o.b. factory.

HEWLETT hp PACKARD

An extra measure of quality

1047

What makes the new 0.002% dc calibrator practical?

NEW

BESIDES—1 ppm resolution on 1 to 1000 v ranges...up to 50 ma output current...MIL RFI specs...$2350 price

A 0.002% dc calibrator should have the *"stability"* necessary to keep the calibration cycle at 30 days or longer . . . otherwise, it will require frequent calibration. *(Stability of the new Hewlett-Packard 740B insures rated accuracy for 30 days.)*

A 0.002% dc calibrator should be *"self-aligning"* ...otherwise, it will require extra time to calibrate. *(With a standard cell and screwdriver, the new hp 740B can be calibrated in 15 minutes. Check this against your present or proposed techniques.)*

A 0.002% dc calibrator should have remote sensing terminals *"at the load"*... otherwise, the voltage drop in the connecting leads will degrade the accuracy.

A 0.002% dc calibrator should have a *zero control* ...otherwise, the thermals and dc offset, sometimes generated in the equipment under test, cannot be balanced out.

PERFORMANCE

The hp 740B has six digit resolution with discrete steps of 1 ppm at full scale from 0 to 1000 volts dc. It complies with MIL-I-6181D on RFI. Noise and hum from 0.01 Hz to 1 Hz is less than 1 ppm of range.

New hp 7408 DC Calibrator

The specified accuracy of ±0.002% of setting +0.0004% of range is ideal for calibrating digital and differential voltmeters, potentiometers, precision voltage dividers and other production and lab usages.

MULTIPLE USES

You also can use the 740B as a 0.005% dc differential voltmeter, a 0.01% precision dc amplifier and a high impedance voltmeter.

DC STANDARDS

Used in conjunction with the Hewlett-Packard 419A DC Nullmeter and the 735A Transfer Standard, it lets you carry precise standards anywhere you need them. The portable Hewlett-Packard 735A Transfer Standard with typical 5 ppm/mo. stability allows you to do calibration and standards work out of the standards lab. Application Note 70 explains the use of this unique combination of instruments that provides you with a new measurement concept. Ask your Hewlett-Packard field engineer for your copy and for complete information on the 740B and related instruments. Or write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

HEWLETT hp PACKARD

An extra measure of quality

Electronics

May 2, 1966
Volume 39, Number 9

Electronics Review

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Electronics Abroad

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Readers Comment

Accurate observer

To the Editor:

Your article on the Orbiting Astronomical Observatory [March 21, p. 37] contains three errors that should be corrected in the interest of accurate reporting.

The first OAO has an aiming capability of at least ±15 arc seconds, rather than ±1 arc minute. It is also significant that it holds this accuracy for at least 50 minutes.

The six gimbaled star trackers represent a redundant capability in case of a star tracker failure or in case one or more star trackers have no acceptable star within their field of view. Only three star trackers are required to be locked on stars at any given time and, in many instances, two are sufficient.

The article states, "A composite spectral picture will be built up and relayed to a ground station." There is no computer on board the OAO. A magnetic core memory retains data collected during each orbit and sends it to the ground in digital form once per orbit. All data processing, computing, analysis and graphic or pictorial study is performed at ground station facilities.

R. H. Tripp
OAO Program Director
Grumman Aircraft Engineering Corp.
Bethpage, N. Y.

▪ Saying that a "composite spectral picture will be built up and relayed to a ground station" does not mean that there is a computer on board the OAO.

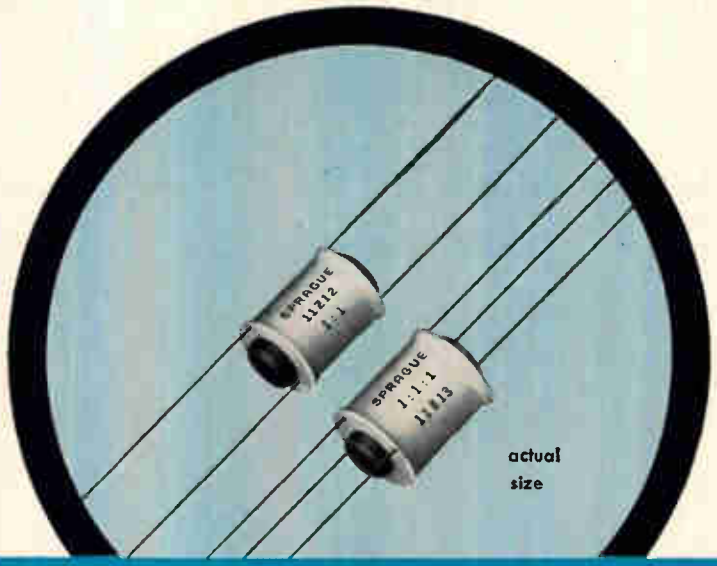
Not alone

To the Editor:

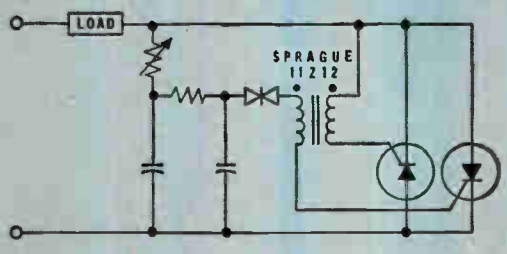
Thank you for the editorial "IEEE settles for second rate sessions," and for printing the letters of comment which followed [March 21, 1966, p. 4 and p. 23]. I was beginning to think that I was the only one who noticed that selling group insurance seemed to be the major activity of the IEEE headquarters staff.

Could it be that the merger of

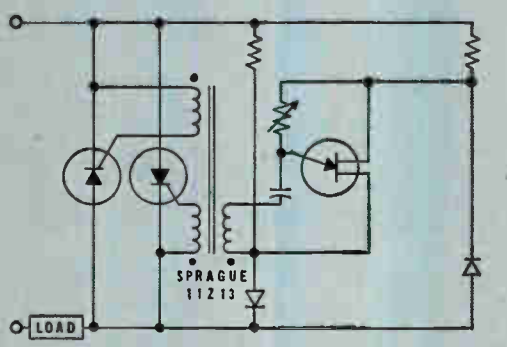
New from Sprague!



TRIGATE* PULSE TRANSFORMERS... the industry's lowest-cost SCR triggers!



This breakdown-diode/transformer triggering circuit is a typical application for Type 11Z12 Trigate Pulse Transformers.



This unijunction-transistor/transformer triggering circuit is a typical application for Type 11Z13 Trigate Pulse Transformers.

*trademark

Dependable enough for industrial equipment, yet priced for high-volume commercial applications

Here's good news for designers of appliances; lighting controls; air-conditioning and heating controls; industrial controls. You can actually cut costs while upgrading your present method of SCR triggering!

Type 11Z Trigate* Pulse Transformers offer these unique features:

1. Balanced pulse characteristics and energy transfer from primary to secondary and tertiary windings.
2. Minimum saturation effect to allow operation where increased pulse widths are required.
3. Fast pulse rise time and increased current capability to prevent SCR *di/dt* failure.
4. Increased energy transfer efficiency.

Designed for operation over the temperature range of —10 C to +70 C, Trigate Pulse Transformers are available in 2-winding and 3-winding configurations for half-wave and full-wave applications. Both designs are rated for use with line voltages up to 240 VAC.

For complete information, write for Engineering Bulletin 40,003 to the Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247.

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THE MARK OF RELIABILITY

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You'll find all these in some Standards Labs

(and some of them in all Standards Labs)

Compare C to One Part Per Million

The Type 1620-A Capacitance-Measuring Assembly is a complete setup for the precise measurement of capacitance from 10^{-17} to 10^{-6} farad with 0.01% accuracy and 6-figure resolution. Measures D at 1 kHz from 0.000001 to 1 and G from 10^{-6} μ℧ to 100 μ℧, both with 4-figure resolution. Price $2090.

Highly Stable Reference Standard Capacitor

Long-term drift of a Type 1404 Reference Standard Capacitor is less than 20 parts per million per year. It is a 3-terminal, hermetically sealed, gas-filled primary reference standard and is available in 1000-pF, 100-pF, and 10-pF values. Price: $225.

Compare L to One Part Per Million

An inductance bridge, audio oscillator, and detector are all included in the Type 1660-A Inductance-Measuring Assembly. Measures inductance from 0.1 nH to 1111 H with an accuracy of 0.1%, direct reading. In-line decade readings and indicated decimal points. Price: $1825.

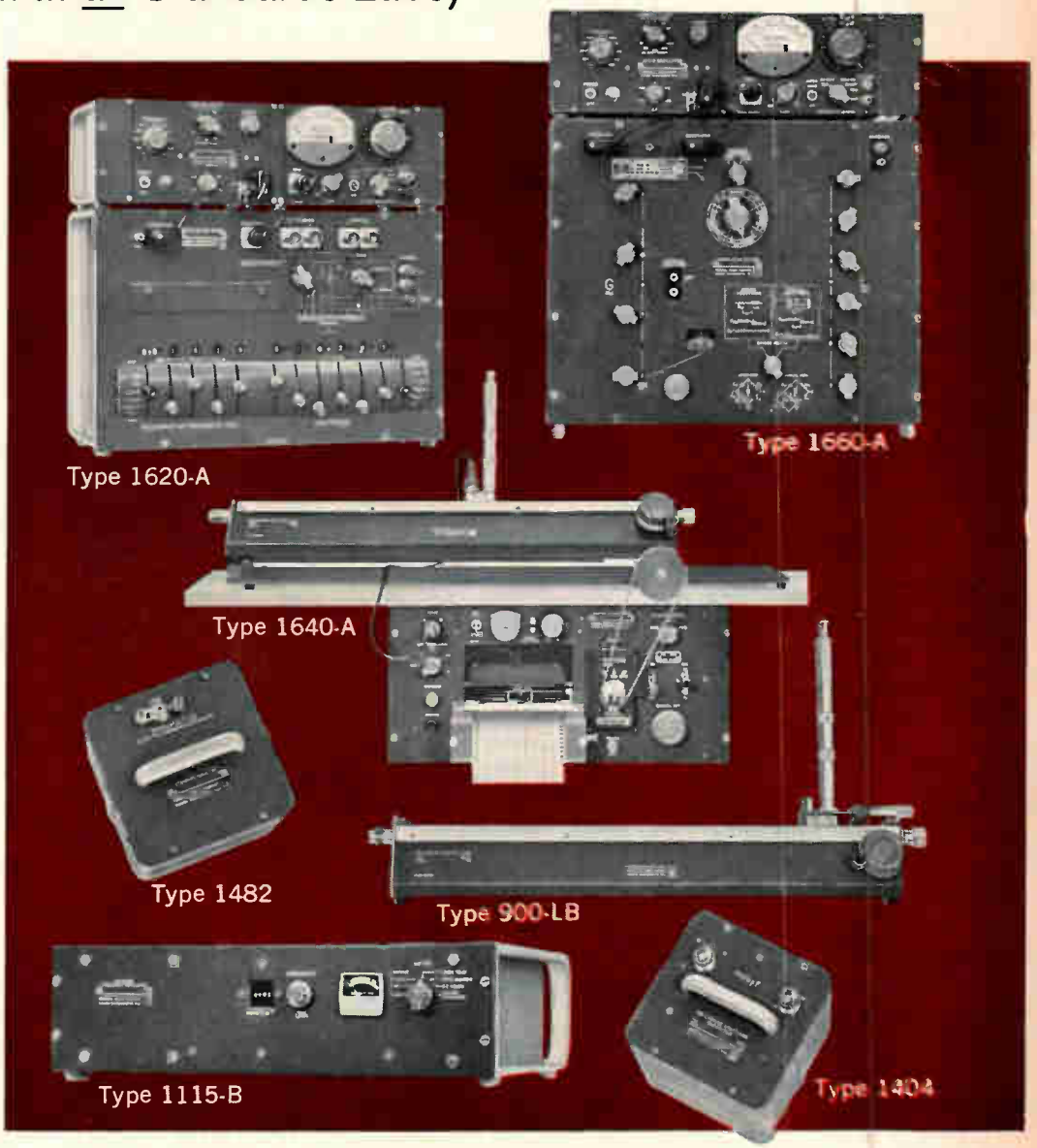
For measuring L or loss of iron-core coils, there are the Type 1630 Inductance-Measuring Assemblies. L, as well as R and Q, can be measured at nine frequencies between 50 Hz and 15.75 KHz with the Type 1630-AV ($3595); at power-line frequencies with the Type 1630-AL ($2810). Accuracy of L measurements is ±1%.

Inductors Stable Within ±0.01% Per Year

The Type 1482 Standard Inductor is an accurate, highly stable standard of self-inductance for use as a low-frequency reference or working standard in the laboratory. Available in values from 50 μH to 10 H. Prices: $140 to $265.

High-Stability, 5-MHz Standard-Frequency Oscillator

Standard deviation (sigma) of the all-solid-state Type 1115-B is less than 50 x 10^{-11} for 1-ms averaging time, 10 x 10^{-11} for 10 ms, 1.5 x 10^{-11} for 0.1 s, 1.0 x 10^{-11} for 1 s and 10 s. Aging rate is less than 5 x 10^{-10} per day after 30 days, typically less than 1 x 10^{-10} per day after one year. Built-in nickel-cadmium batteries provide standby emergency power for 24 to 35 hours. Outputs of 5 MHz, 1 MHz, and 100 kHz. Price: $2050.



Slotted Line with Minimum Residual VSWR

VSWR of the Type 900-LB Precision Slotted Line is under 1.0013 at 300 MHz and under 1.009 at 8 GHz. Characteristic impedance is 50 Ω ±0.1%. Instrument is equipped with a GR900 Precision Coaxial Connector which can accommodate a wide variety of GR900 coaxial standards. Precision adaptors to most coaxial connectors are also available. Price: $800.

Record VSWR from 1.0002 to 1.20

The Type 1640-A Slotted Line Recording System is the only system that can provide a 4-inch-chart recording of VSWR measurements with the full scale adjustable from 1.008 to 1.20. Smallest division is 1.0002 with full scale adjusted for 1.008. System includes a Type 900-LB Precision Slotted Line with a Type 1521-SL Slotted Line Recorder connected to it through a chain-drive mechanism. Price: $2200 (60-Hz model).

Plus . . . *many more R, L, and C standards, bridges, frequency and time standards, and GR900 coaxial standards. Write for complete information*

Prices F.O.B. West Concord, Massachusetts, and apply only to orders originating in the U.S.A. and Canada

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Circle 6 on reader service card

the IRE and the AIEE destroyed the competition necessary to preserve the health of the two groups?

R. L. Kile
Member, IEEE
San Jose, Calif.

Scr's big potential

To the Editor:

I was surprised that the article "Scr's on wheels" [Feb. 21, 1966, p. 31] did not at least speculate on the fantastically large potential automobile market for the electrical drive system developed by Lear Siegler. If the prototype model, for an army truck, shows a 20% fuel savings, it would seem reasonable to assume that similar or even greater savings could be realized in passenger cars. An added bonus would be a corresponding decrease in the amount of exhaust released to poison the atmosphere.

A number of other advantages suggest themselves: 1. It should be possible to make four-wheel drive optional on almost any car at relatively low extra cost; 2. The hump in the floor caused by the driveshaft would be eliminated: 3. Antiskid control could be designed into the system; 4. Maintenance and repair of the electric system should be easier, quicker, less expensive. Because of the almost infinitely variable range of "gear ratios" between the primary-engine speed and the driving wheels speed, the electric system would seem to be capable of faster acceleration than any mechanical system using fixed gear ratios, and this of course suggests an immediate application to racing cars. It would certainly be interesting to see a comparison between the estimated cost of the electric system and the present automatic transmission system.

Gerald Shirley
Aldshir Manufacturing Co.
Tuckahoe, N. Y.

Amperex deserves credit

To the Editor:

I would like to correct an erroneous impression given by your article "A LID with legs" [April 18, p. 39]. Alloys Unlimited does not now, nor intend to, offer LID's to the marketplace. LID's (leadless inverted devices) are semiconductors offered to the market by the Amperex Electronic Corp. Credit for the development of manufacturing techniques, as well as marketing features, of these microminiature semiconductors belongs exclusively to Amperex.

You have correctly stated that Alloys Unlimited, through its subsidiary, Frenchtown-C F I, Inc., is supplying microminiature metallized ceramic parts to Amperex as a piece part in the manufacture of LID's. This ceramic package is called our Versa-Pak and patent application has been made by Alloys Unlimited, Inc.

We are proud of our advanced technology in fabrication of precision ceramic parts which makes it possible for the semiconductor manufacturers to offer such unique products as LID's. Our technology leads to the introduction of new products to the industry, for example, ceramic substrates for monolithic integrated circuits, as you have correctly stated in your article.

Gregory S. Coleman
Vice President, Marketing
Alloys Unlimited Inc.
Melville, N. Y.

People

Once a week, along with 15 or 20 other engineers and scientists, **Eph Konigsberg** attends an in-house course in physiology at Electro-Optical Systems, Inc., Pasadena, Calif. The course is part of a company program to give employees some knowledge of unfamiliar fields to help them in their work. For Konigsberg, the course is especially significant because he is product manager of a biomedical instrumentation group recently formed by Micro Systems, Inc., an Electro-Optical subsidiary.

The group, formed to develop and produce microminiature transducers and strain gauges for use in physiological research, so far has designed a pressure transducer that's planted in a blood vessel.

The company entered the medical business about two years ago when the profession began asking for research devices.

Konigsberg spends a good deal of time with researchers, discussing their needs. He says one important advantage his small group offers is the direct link between the customer and the engineer.

To the electronics industry, one of the most important men in the Pentagon is the new occupant of Room 3D1047, **E. Grogan Shelor Jr.** Lettered on the door is his title: Assistant Director of Defense Research and Engineering (Communications and Electronics). Shelor will help make key decisions on what research and development projects get money in such fields as radar, data processing, inertial guidance, navigation, communications, night vision and electro-optics.

Shelor came to the Pentagon af-

Show us where you can't afford to use silicon power and we'll show you the new Bendix B-5000. (25 watts at 2.5 amps, 10 volts and 100 C.)

It costs under 40¢.*

New manufacturing and packaging techniques make the B-5000 possible. These techniques include new internal device element assembly, along with new-concept plastic molding operations. The result is a simple, low-cost, reliable silicon power transistor *with no power compromise* when mounted upon the normal heat sink.

B-5000's low cost opens up whole new application areas for you. Now you can afford to put silicon power to work in many industrial and consumer products. Lighting equipment, TV sets, audio amplifiers, appliance sensing amplifiers and industrial controls, to mention a few. Compare the cost of the Bendix® B-5000 with any other silicon power unit of equal rating. You'll discover significant savings.

B-5000 offers advances in size, weight and thermal resistance. Leads and collector strips are a highly conductive material, offering excellent solderability, strength and ability to withstand flex and pull. Plastic encapsulant offers outstanding insulation resistance, hermeticity, adhesion ability and high temperature characteristics. In no way does B-5000 compromise traditionally accepted reliability practices.

With B-5000 you can tailor mounting techniques to fit your needs exactly. Depending on heat sink, available space and degree of assembly line mechanization, B-5000 can be mounted in the fashion best suited to your operation. For example, B-5000 is readily adaptable to the newer assembly solder techniques without degradation. B-5000 lends itself equally well to other commonly used production line techniques.

Electrical specifications

Characteristic	Limits			Test Conditions				
	Min.	Max.	Unit	VCB V	VCE V	IC A	IB mA	TJ °C
VCEO	35	—	V			0.2		
ICEO	—	10	mA		25			
ICBO	—	1.5	mA	14				150
VBE	—	1.2	V		14	0.5		
hFE	30	250	—		14	0.5		
hFE	20	—	—		14	1.0		
VCE(s)	—	1.2	V			1.0	50	

Absolute maximum ratings

VCEO = 35 volts, IC = 3 amps, IB = 1 amp, Tstg = −65 to 175°C, TJ = −65 to 150°C.

For complete information about the new Bendix B-5000 silicon power transistor, write to us in Holmdel, New Jersey.

*In volume quantities

Bendix Semiconductor Division
HOLMDEL, NEW JERSEY

THE Bendix CORPORATION

People

ter 15 years at the Bendix Corp. He becomes one of three assistants to Thomas F. Rogers, the deputy director of research and engineering in charge of electronics and information systems. Rogers' other assistants are Robert H. Scherer, in charge of command and control, and Sam Koslov, who specializes in intelligence and reconnaissance.

Reliability push. "One of my principal efforts will be to push a general upgrading of the reliability of military electronic equipment, particularly items in common use by all three services," says Shelor. "We need some major improvements."

"I will also be heavily involved in getting development of a tactical communications satellite system under way and in spurring progress in night vision devices, which are needed so greatly in Vietnam."

At Bendix, Shelor was assistant manager of the government products group. Earlier he had been manager of communications and navigation engineering, and before that manager of advanced products development and director of engineering.

John Blair has joined the Raytheon Co. as corporate director of research and scientific liaison. Blair enters the industrial research field after seven years on the electrical engineering faculty at Massachusetts Institute of Technology.

Blair, 36, will supervise all company-funded research programs in Raytheon's research division and in its operating divisions.

"I will also try to bring in senior research personnel, on the Ph.D. level," says Blair.

One of his major assignments will be to keep abreast of the technology coming out of the universities, government laboratories and other nonprofit research organizations.

MACHLETT

MACHLETT ML-8618 magnetically beamed triode requires 10 to 100 times lower drive

	IN PULSE SERVICE		IN RF TELEGRAPHY AMPLIFIER/OSCILLATOR SERVICE	
	ML-8618	Conventional Triode	ML-8618	Conventional Triode
Power Output	6 megawatts	6 megawatts	200 kilowatts	200 kilowatts
Driving Power	2.5 kilowatts	400 kilowatts	0.7 kilowatts	7.2 kilowatts
Filament Power	2.5 kilowatts	4.0 kilowatts	2.5 kilowatts	4.0 kilowatts
	RESULT: ML-8618 reduces pulse driving power by a factor of 100 or better.		**RESULT: ML-8618 reduces rf driving power by a factor of 10 or better.**	

Machlett's exclusive development, magnetically beamed tubes like the ML-8618 give you these advantages:

- By magnetically controlling the trajectory, electrons from the cathode bypass the grid structure so that nearly all emitted electrons reach the anode.
- Grid current is very low because of the great reduction in grid interception—about 3% as compared to 25% in conventional triodes.
- Low grid current means that grid dissipation no longer limits tube power.
- Parallel plane electrode structure eliminates "shielded" portion of filaments, permits 360° of the cathode surface to face anode surface and complete use is made of the filaments emission surface—result is higher cathode current per watt of heating power.

For details, write The Machlett Laboratories, Inc., Springdale, Conn. 06879.

RAYTHEON

THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

FAIRCHILD SEMICONDUCTOR/A Division of Fairchild Camera and Instrument Corporation ■ 313 Fairchild Drive, Mountain View, California (415) 962-5011 ■ TWX: 910-379-6435

CHI

How many integrated circuits manufacturers shipped more than 3 million units last year?

One.

Meetings

Symposium on Human Factors in Electronics, IEEE G-HFE; Radisson Hotel, Minneapolis, **May 5-6.**

Conference on Photographic Science and Engineering, SPSE; San Francisco Hilton, San Francisco, **May 9-13.**

Design Engineering Conference, American Society of Mechanical Engineers, McCormick Place, Chicago, **May 9-12.**

Institute on Systems Science, American University Center for Technology and Administration; Twin Bridges Marriott Motor Hotel, Washington, **May 9-12.**

Standards Laboratory Conference, NBS; National Bureau of Standards, Gaithersburg, Md., **May 9-12.**

AE-4 Electromagnetic Compatibility Conference, SAE; U.S. Navy Engineering laboratory, Annapolis, Md., **May 10-11.**

Packaging Industry Conference, IEEE G-IGA; Hotel America, Hartford, Conn. **May 10-12.**

Symposium on Hydrogen Thyratrons and Modulators, U.S. Army Electronics Command Advisory Group on Electron Devices; Hexagon Building, Fort Monmouth, **May 10-12.**

Telemetering Conference and Exhibit, ISA, AIAA, IEEE; Prudential Center, Boston, **May 10-12.**

Seminar on Electroluminescence and Semiconductor Lasers, IEEE; Stevens Institute of Technology, Hoboken, N.J., **May 11.**

Analysis Instrumentation Symposium, ISA; Shamrock Hilton, Houston, **May 11-13.**

National Forum of the American Helicopter Society, American Helicopter Society; Sheraton Park Hotel, Washington, **May 11-13.**

National Colloquium on Information Retrieval, ACM Group on Information Retrieval; University of Pennsylvania, Philadelphia, **May 12-13.**

Vibration Testing and Measurement Conference, Training Services Inc., Tustin Institute of Technology; Park Sheraton Hotel, N.Y., **May 13-14.**

National Aerospace Electronics Conference (NAECON), IEEE; Dayton Sheraton Hotel, Dayton, Ohio, **May 16-18.**

National Power Instrumentation Symposium, ISA; Statler-Hilton Hotel, Detroit, **May 16-18.**

Symposium on Biomedical Sciences Instrumentation, ISA; Disneyland Hotel, Anaheim, Calif., **May 16-18.**

Symposium on Microwave Theory and Techniques, G-MTT of the IEEE; Cabana Hotel, Palo Alto, Calif., **May 16-19.**

Antisubmarine Warfare Inner Space Conference, National Security Industrial Association, U.S. Navy; Interdepartmental Auditorium, Washington, **May 17-19.**

National Operations Research Meeting, ORSA; Miramar Hotel, Santa Monica, Calif., **May 18-20.**

International Communications Conference, IEEE, University of Pennsylvania; Sheraton Hotel, Philadelphia, **June 15-17.***

Call for papers

Symposium on Prospects for Simulation and Simulators of Dynamic Systems, AFOSR, Westinghouse Electric Corp.; Westinghouse Defense and Space Center, Friendship Airport, Baltimore, Md., Sept. 26-27. **May 15** is deadline for submission of six copies of a 1,000-word abstract on problems on transport and diffusion, fluid mechanics, statistical mechanics, adaptative equipments, hybrids and on-line real-time multiaccess systems and other man-machine combinations to S. Burick, Symposium Secretary, MS 452A, Westinghouse Electric Corp., P. O. Box 746, Baltimore, Md. 21203.

Aerospace and Electronic Systems Convention, IEEE, Sheraton Park Hotel, Washington, Oct. 3-5. **May 15** is deadline for submission of 250-word abstract on systems organization, radar, sonar, navigation, command and control, instrumentation and telemetry systems, and system integration and support to Dr. Harold Schutz, technical program chairman, MS 443, Aerospace Division, Westinghouse Electric Corp., P. O. Box 746, Baltimore, Md. 21203.

* **Meeting preview on page 16**

Now, BOTH in one instrument

HIGH POWER, LOW NOISE

—the HP 230A 10 Mc to 500 Mc Power Amplifier

The Hewlett-Packard Model 230A is the ideal RF amplifier for both high and low-level applications. With a typical noise figure of 6 to 8 db, the instrument provides up to 30 db gain and a maximum power output of 5 watts.

Typical Applications include:

SIGNAL GENERATOR POWER AMPLIFIER — Provides up to 15 volts output from standard VHF signal generators for receiver testing, watt and voltmeter calibration, antenna testing, and attenuation measurements. May also be used to drive antennas for remote systems testing such as aircraft ILS.

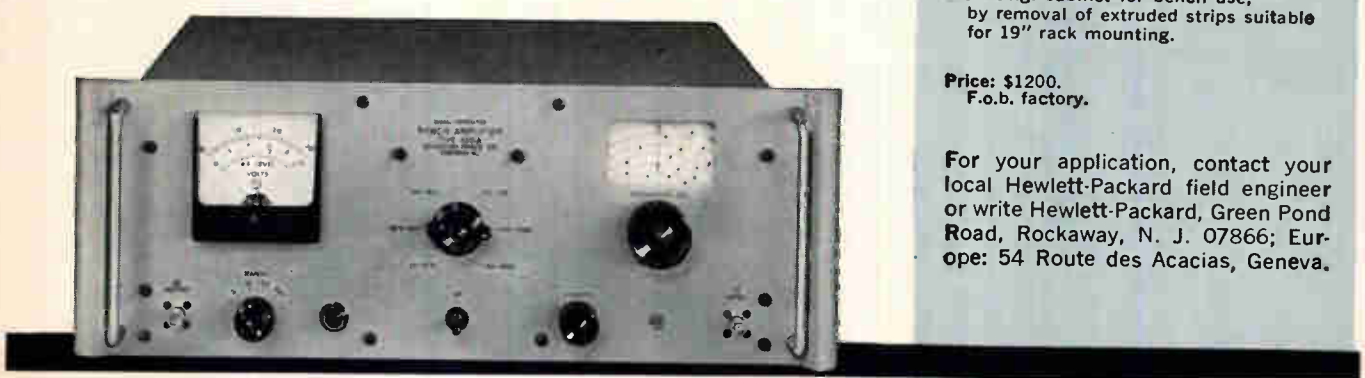
RECEIVER PRE-SELECTOR — When used as a pre-selector with conventional communications receivers, fractional microvolt sensitivities are attainable.

TUNED SELECTIVE FILTER — Provides a convenient means for the selective amplification of RF signals in the 10 to 500 Mc range with excellent rejection of undesired frequencies.

HARMONIC AMPLIFIER — May be used to amplify desired harmonics in the output of signal generators and frequency synthesizers thereby extending their useful range.

FREQUENCY COUNTER PRE-AMPLIFIER — As a pre-amplifier for conventional frequency counters, such as the -hp- 5245L, will provide a 15 to 30 times improvement in input sensitivity. Remote, off-the-air frequency measurements of FM broadcast and communication transmitters may be readily performed.

RF MILLIVOLTMETER PRE-AMPLIFIER — Used as a pre-amplifier for RF millivoltmeters, such as the -hp- 411, the 230A will provide 15 to 30 times improvement in sensitivity.



Specifications

Frequency range: 10 to 500 Mc (MHz) in six bands: 10 to 18.5 Mc; 18.5 to 35 Mc; 35 to 65 Mc; 65 to 125 Mc; 125 to 250 Mc; 250 to 500 Mc.

RF gain: 30 db (10 to 125 Mc); 27 db (125 to 250 Mc); 24 db (250 to 500 Mc).

RF bandwidth: >700 Kc (10 to 150 Mc); >1.4 Mc (150 to 500 Mc).

RF output:

Range: up to 15 volts across external 50-ohm load.

Impedance: 50 ohms

Calibration: 0.2 to 3 volts f.s.; 1.0 to 10 volts f.s.; 2.0 to 30 volts f.s. (increments of approx. 5%).

Accuracy: ±1.0 db of f.s. (10 to 250 Mc), ±1.5 db f.s. (250 to 500 Mc).

Leakage: Effective shielding is greater than 40 db.

RF Input

Level: (for 10 volt output into 50 ohms): ≤0.316 volts (10 to 125 Mc); ≤0.446 volts (125 to 250 Mc); ≤0.630 volts (250 to 500 Mc).

Impedance: 50 ohms

AM range: reproduces modulation of driving source 0 to 100% up to 5 volt maximum carrier output.

AM distortion: <10% added to distortion of driving source.

FM range: reproduces modulation of driving source except as limited by RF bandwidth.

FM distortion: negligible distortion added to distortion of driving source for deviations and modulation frequencies <150 Kc.

Incidental AM: <10% added to modulation of driving source at 150 Kc deviation.

Power: 105 to 125 v or 210 to 250 v, 50 or 60 cps, 150 w.

Mounting: cabinet for bench use; by removal of extruded strips suitable for 19" rack mounting.

Price: $1200. F.o.b. factory.

For your application, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

An extra measure of quality

Data subject to change without notice.

Meeting preview

Global communications

Reports on ground terminals from West Germany, Canada, Japan, Britain and the United States will be heard at the 1966 IEEE International Communications Conference, June 15 to 17, in Philadelphia. More than 140 papers will be given at 39 sessions. The sponsor is the Communications Technology Group of the Institute of Electrical and Electronics Engineers.

A general discussion of communications satellite systems will be led by J. M. Barstow of the Communications Satellite Corp. A comparison of the quality of satellite and cable circuits, based on interviews with 4,000 people who made transatlantic calls, will be given by G. K. Helder of Bell Telephone Laboratories, Inc., a subsidiary of the American Telephone & Telegraph Co., in a special session on global communications.

The National Aeronautics and Space Agency's worldwide communications network will be described by agency representatives.

Microwave. Four sessions will deal with microwave technology. A review of late developments in low-noise traveling-wave amplifiers will be given by B. P. Israelsen and K. B. Niclas of the Watkins-Johnson Co.

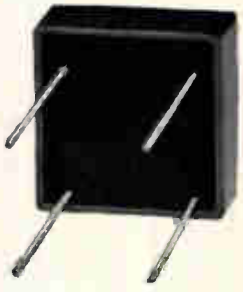
In a session on lasers, B. R. Shah of the International Business Machines Corp. will discuss two experimental optical links connecting high-speed tape units. W. K. Pratt and R. J. Norton of the University of Southern California will describe an experimental polarization technique of modulation in an optical communications system.

Phase vocoding, in which speech signals are represented by their short-time phase and amplitude spectrums, will be described by J. L. Flanagan and R. M. Golden of Bell Labs.

S. C. Fralick, G. L. Slenkovich and D. L. Wilson of Sylvania Electric Products, Inc., a subsidiary of the General Telephone & Electronics Corp. will discuss the design and performance of an adaptive receiver which searches a wide frequency band for signals of unknown frequency.

There's a rumor going around that the best diodes are made by the big companies.

I'll rectify that!



Company size is not a criterion of ability to manufacture. Specialization is such a criterion, however. Slater is a specialist in the design, development and production of high reliability silicon rectifiers and assemblies.

Slater produces in volume *single junction* diffused 1 and 2 ampere silicon diodes with up to 2000 volts PIV. All units are controlled avalanche. In addition all units provide a 20% safety factor on all specifications.

Slater manufactures 1 ampere hermetically sealed diodes up to 1000 volts PIV with guaranteed maximum recovery times of less than 100 nanoseconds. These units permit operation in high frequency applications such as inverters, ultrasonic generators and power supplies.

Slater supplies combinations of specifications in their assemblies previously unavailable in the industry. The Slater rectifiers SLA-01 to SLA-020 are less than 1/5 the size of comparable rectifiers. They feature up to 20,000 volts PIV and 200 Mils average rectified current with extremely low leakage and low forward voltage drop. Additional units up to 100 KV PIV are also available. Our specialized production skills enable us to state that we have the lowest price per voltage and ampere rating in the industry.

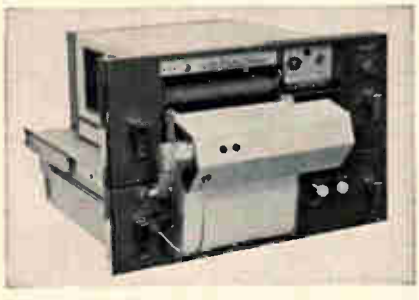
We know that we must perform to get your business. Test us! Give Slater your problems to solve. When you are in need of a source of high voltage rectifiers, full-wave bridges, miniature assemblies, or 1N3189 series diodes to MIL-S-19500/155 . . . try looking in a direction you may not have explored before. Look to Slater. We think you'll like the results.

Slater

SLATER ELECTRIC INC.
SEMICONDUCTORS DIVISION
45 Sea Cliff Avenue • Glen Cove, N.Y.

The 1966 Reference Guide to CEC Oscillographs, Direct Writing Recorders, Accessories and Support Equipment

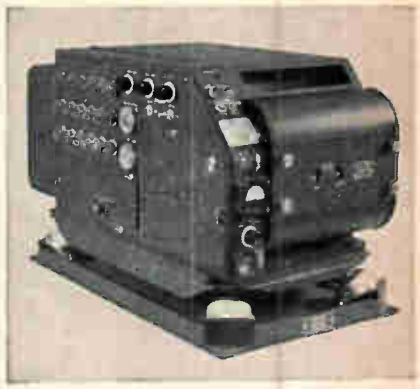
Type DG 5511—CEC's all-new, solid-state DG 5511—the first low-cost, three-in-one portable direct-writing recorder—provides capabilities formerly achieved only through multiple instruments. Plug-in signal conditioners are available to accommodate a wide range of voltage inputs. *No* preamp is needed for high-level signals. Users may convert from high-level to low-level inputs by a simple change of plug-in attenuator/amplifier units. The DG 5511 combines ease of operation with a high degree of resolution on heat-sensitive paper.



Type 5-124—Shown above with the DataFlash Takeup Accessory which requires only 1 second to readout, the 5-124 has become a new "must" for industry. Portable and easy to operate, this instrument offers big recorder capability in a small-size, low-cost package. The 5-124 provides up to 18-channel print-out recording, 10 speed ranges, and record-drive systems with 16 options from 0.25 ipm to 128 ips.

Type 5-133—The most advanced instrument yet perfected, the 5-133 combines high speed, reverse operation and CEC developed DataFlash® in *one universal transport*. Designed to record 12, 24, 36 or 52 channels of data on 12-inch-wide light-sensitive paper, its overall capabilities exceed the most demanding technological requirements. The 5-133's static magnetic lamp power supply provides a start-restart time of *less than a second*, regardless of input voltage variations. Available in RFI certified configurations (including the remote control unit), the 5-133 offers such other advantages as: slot-exit capability up to 160 ips; adjustable grid line intensity; record/event numbering selected by front panel switch; automatic record length control, continuously variable from 0 to 150 feet; 12 recording speeds, pushbutton selectable, galvo light intensity controls; and modular construction for maximum convenience and efficiency.

Type 5-119—A truly universal oscillograph, the 5-119 has become a popular, proven performer for laboratory, mobile, airborne and marine use. Both d-c and a-c powered models are available. The 5-119 accepts all three types of record magazines, DATAFLASH, DATARITE, and conventional, making it possible to utilize every known photographic technique on either the 36- or 50-trace models.



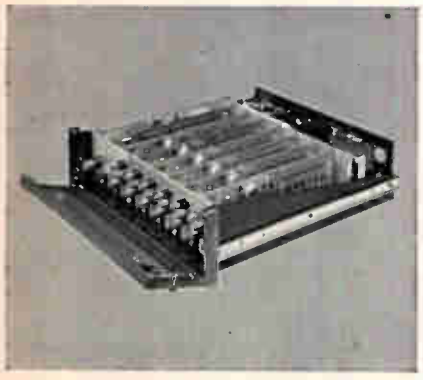
Type 5-114—Versatile, accurate and rugged, the 5-114 records data of static and transient nature on 18 or 26 channels, 225-foot records on 7-inch-wide paper are produced at speeds from ½ to 115 ips; and the many CEC galvanometers available for use with this instrument permit the recording of dynamic phenomena in the frequency range of d-c to 5000 cps.

NEW THERMAL WRITING RECORDER

Type DG 5510—CEC's all-new, 8-channel Thermal Writing Recording System brings a significant advance in performance and reliability to direct-writing oscillography. The basic 5-510 recorder is a self-contained instrument with driver amplifiers and power supply capable of accepting a wide range of high-level input signals. Interchangeable plug-in attenuator/preamplifiers are available to further extend the input range. The system employs a heated writing stylus to deliver sharp contrast rectilinear traces on CEC's Data-Trace® Thermal-Sensitive Paper.

Other outstanding features include: Solid-state electronics • Immediate readout • Superior frequency response • Calibrated zero suppression • Cabinet mounting, including dolly for complete mobility.

CEC Accessories, Signal Conditioning and Support Equipment



DataDigit™—A unique Datagraph® Accessory. When used with any CEC direct writing oscillograph, the new DataDigit Accessory literally provides a new dimension in data recording with digital numeric high-speed optical recording. Speed, accuracy, and flexibility that were previously unattainable can now be realized even at moderate and slow paper speeds.

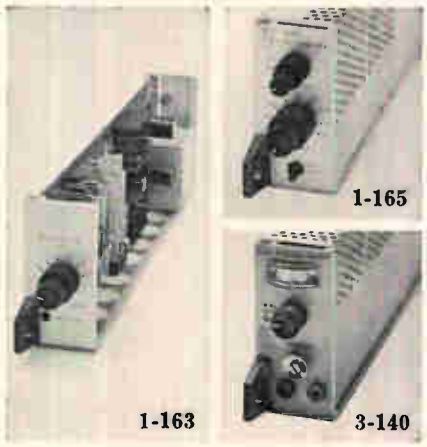
The DataDigit is virtually a quantum jump in recording techniques, providing the features of the fastest digital printer in conjunction with a light beam oscillograph. And, being a completely self-contained accessory, this instrument can be used with any existing oscillographs *without modification.*

Fundamentally, this accessory generates the necessary waveforms to print decimal data on standard photographic papers. Up to 26 columns can be printed at speeds to 1600 lines-per-second.

Compared to the best previous methods, the capabilities of the DataDigit become significant indeed.

SPECIFICATIONS:

Print-Out—0 thru 9 • Input Data Format—10 line decimal • Input Voltages—Select command +5 v min. to +70 v max. • Input Impedance—Select command signal 20 k ohm resistive min. • Print Command—rise time 1 μsec; duration 2 μsec min.—400 μsec max.; voltage +5 v min. to 25 v max.; input impedance 550 pf • Power Requirements—voltage 90—135 v or 180—270 v; frequency 48—420 cps; wattage 120 max. • Physical Characteristics—5¼" H x 19⅜" D x 19" W. Mounts in standard EIA rack, slide rackmount available.



Type 1-163 D-C Amplifier—single-ended, low-gain, wideband.

Type 1-165 D-C Amplifier—differential, high-gain wideband.

Specifically designed for compatibility with all CEC series 7-300 Recording Galvanometers, the 1-163 and 1-165 Amplifiers have the output capability (±10 volts, 100 ma) and a plug-in damping assembly to properly damp and drive all other currently available recording galvanometers.

Type 3-140 Constant Voltage Supply—the 3-140 is an excellent d-c excitation source for any input signal device requiring d-c excitation within the range of 1 to 24 volts.

Type 23-109B Oscillogram Processor—the 23-109B is completely self-contained, needing only electric power for operation. The compact, motorized unit develops and dries oscillograms to produce "archival" quality records. Easy to operate and portable, the processor can be used by personnel with no previous photographic laboratory experience.

CEC Technical Supplies—CEC offers a complete selection of supplies needed to operate CEC DATAGRAPH oscillographs; print-out papers, recording papers and developing solutions. For complete information on any CEC oscillograph, accessory, signal conditioning, support equipment or technical supplies, call or write CEC Data Instruments Division for Kit #9001-X5.

CEC
Data Instruments Division
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New TTL complex-functio for lower-cost

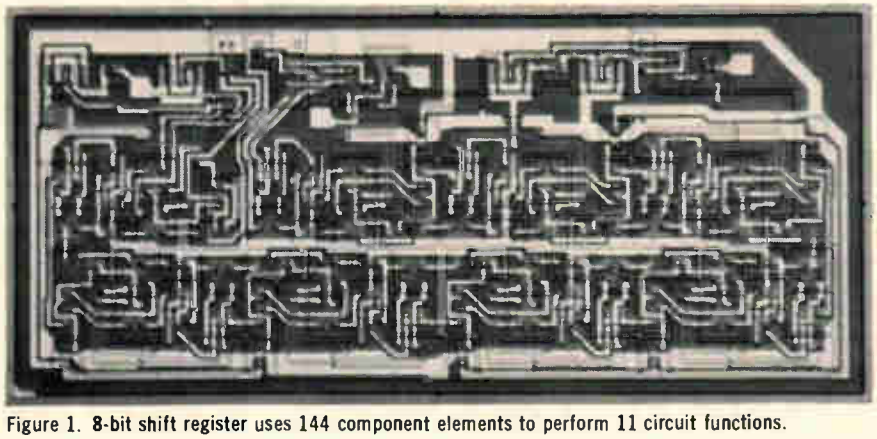

Figure 1. 8-bit shift register uses 144 component elements to perform 11 circuit functions.

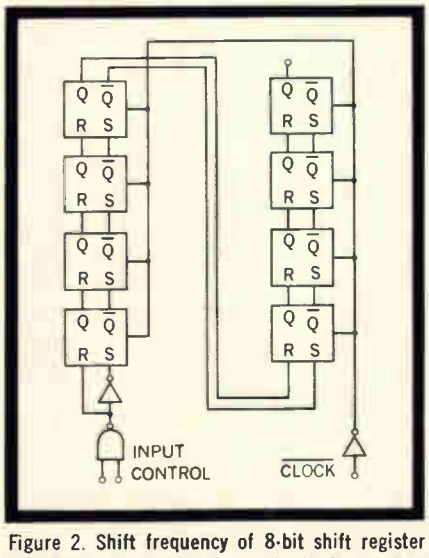

Figure 2. Shift frequency of 8-bit shift register is 15MHz, an order of magnitude faster than comparable MOS circuits.

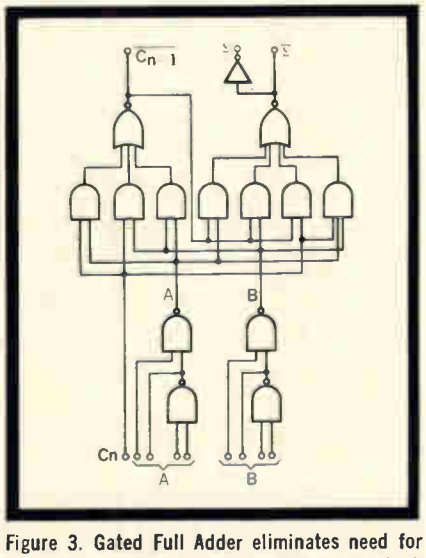

Figure 3. Gated Full Adder eliminates need for extensive "look-ahead" and "carry-cascading" circuitry, greatly improving performance.

Your equipment designs can now take ad vantage of the latest integrated-circuit tech nology with TI's new TTL complex function These units include more than ten circu functions interconnected on a single silicon ba

These new complex circuits make possible r ductions of 50 percent or more in parts alon with one package now doing jobs former requiring five to nine standard TTL integrated circuit packages. Additional savings are realize through simplified board layout and reduce handling and assembly.

The new complex functions are the initi units of a family now being designed which com plements and expands TI's standard Series 5 TTL logic line. The full benefits of Series 5 performance are retained, along with improve ments in speed and power drain. Most of the ne complex functions are available both in militar (Series 54) and industrial (Series 74) version

SN5491/SN7491
8-bit Shift Register

This high-speed 8-bit serial shift registe replaces nine standard TTL units. Power di sipation at 190 mW is one-third that of th equivalent nine packages. Shift frequency 15 MHz, two orders of magnitude faster tha comparable MOS circuits. The 60 by 130-m silicon bar uses 144 component elements perform 11 circuit functions, including eigh flip-flops, input gating, and a clock buffer.

The serial-in/serial-out shift register requir only one signal input, since an inverter included internally. The SN5491 can also b used for delay-line applications.

SN5480/SN7480
Gated Full Adder

The SN5480 is a single-bit, high-speed, binar full adder with gated complementary input complementary sum outputs, and inverted carr output. The adder is designed for medium-t high-speed, multiple-bit, parallel-add/serial-carr applications, and is compatible with both TT and DTL circuits. The need for extensive "loo ahead" and "carry-cascading" circuitry has be eliminated. Performance is substantially bett than can be attained with five standard TTL int grated circuits connected to perform comparab full-adder functions. Speed (70-nsec add tim 8-nsec carry time) is about 35 percent faste and power dissipation (105 mW) is 20 perce lower. Price of the SN5480 is less than ha that of the equivalent five multi-function pac ages, with additional savings in circuit board assembly, and inventory.

SN7490
BCD Decade Counter

The SN7490 is a decade counter with binar coded decimal output. It can be used as a divid by-five circuit, a divide-by-two circuit, or divide-by-ten circuit with symmetrical squar wave output. This flexibility is achieved by e ternal connection of the leads. The count

integrated circuits from TI better-performing systems

can be reset to zero or a BCD count of nine. Count frequency is 12 MHz, and power dissipation is 150 mW. In addition to counters, applications include frequency synthesizers and digital test and readout equipment. Versions of this unit which will divide by 12 and 16 will be available soon.

New Multi-function Circuits Also Available

In addition to the new circuits with "third generation" complexity, TI also has expanded the family of standard Series 54 TTL multi-function circuits to 13. These multi-function units incorporate up to four circuit functions, with all inputs and outputs brought outside the package.

SN5453 - Quadruple 2-input AND/OR/INVERT Gate. This unit performs the OR function internally. It is expandable to 24 inputs using the SN5460 expander. Propagation delay is 30 nsec, power dissipation is 40 mW, and fan-out is 10.

SN5472 Master/Slave Flip-flop. This circuit features two 3-input AND gates at the J and K inputs. It has reset capability independent of the clock state. Propagation delay is 30 nsec, power dissipation is 40 mW, and fan-out is 10.

SN5473 Dual Master/Slave Flip-flop. This is a dual version of the SN5472. When supplied in the 16-pin plug-in package, separate inputs are provided for preset, clear, and clock lines for each flip-flop. Power dissipation is 40 mW per flip-flop.

SN5474 Dual Latch. The unit consists of two single-input master/slave flip-flops with set and reset. The gated latches are clock-controlled. Propagation delay is 30 nsec, power dissipation is 40 mW per latch, and fan-out is 10.

New Molded Package Gives You Broad Selection

Most of the 130 standard TI integrated circuit types are now available in a variety of packages. The newest addition is a molded package with 14 plug-in pins on 100-mil centers, with the rows spaced 300 mils apart. The new package is designed for economical high-speed assembly and testing, with an index notch for automatic insertion. The solid, molded construction provides maximum protection against shock and vibration. Reliability of the transfer-molding technique and the encapsulating material has been proved by TI's production of millions of SILECT™ transistors over the past two years.

Design Trends Toward TTL

TI's new complex-function and multi-function units emphasize the current design trend toward TTL for high-speed saturated logic. For an optimum combination of high performance and low cost, specify TI Series 54 TTL integrated circuits.

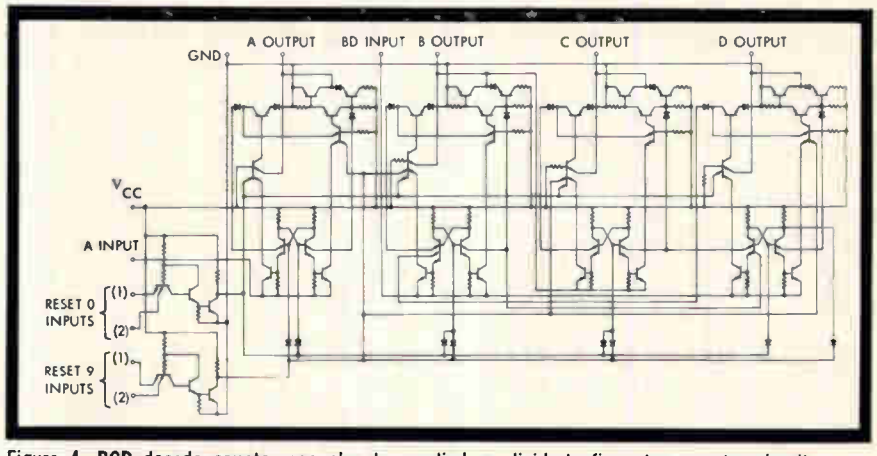

Figure 4. BCD decade counter can also be applied as divide-by-five, -two or -ten circuit.

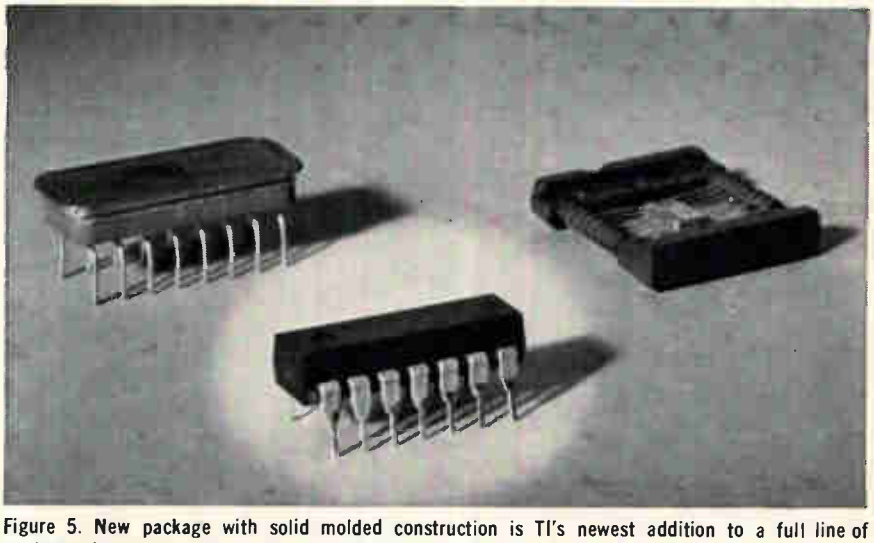

Figure 5. New package with solid molded construction is TI's newest addition to a full line of packages for every integrated-circuit application.

TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P O BOX 5012 • DALLAS 22, TEXAS

SEMICONDUCTOR PLANTS IN BEDFORD, ENGLAND • NICE, FRANCE • DALLAS, TEXAS 21802

KEPCO

REGULATED W R DC SUPPLIES

POWER SUPPLIES WITH EXPERIENCE

The WR Group includes eleven time-proven models from Kepco's current production of 230 standard models. Kepco's representatives in your area can supply you with complete technical information, application ideas, and delivery.

APPLICATIONS:

- ELECTROPHORESIS ■ RADAR
- ELECTROCHEMICAL PROCESSES
- MICROWAVES ■ PHOTOMULTIPLIERS
- COMMUNICATIONS-TELEVISION
- TELEPHONE SYSTEMS
- ELECTRO-MECHANICAL DEVICES

GENERAL SPECIFICATIONS:

- **Input:** 105-125 VAC 50-65 cps single phase
- **Operating Temperature:** -20° C to +55°C
- **Temperature Coefficient:** <0.01% per °C
- **Recovery Time:** 50 microseconds
- **Isolation:** 400 volts (except HB 2050)
- **Meters:** Voltmeter and Ammeter
- Convection Cooling
- For Relay Rack or Bench Use
- Multiple output and high voltages
- Plate, Grid and Heater Voltages
- Continuously Variable, Zero to full output

MODEL	DC OUTPUT RANGE		REGULATION LOAD O-MAX		REGULATION LINE		RIPPLE RMS	AUX. OUTPUT 6.3VAC Unregulated
	VOLTS	MA.	%	ΔV	%	ΔV	MV	
2400 B - #1	0–150	0–5	*	*	*	*	1	
#2	0–400	0–150	0.025	0.1	0.1	0.4	3	10 AMP
#3	0–400	0–150	0.025	0.1	0.1	0.4	3	10 AMP
400 B	0–400	0–150	0.025	0.1	0.1	0.4	3	10 AMP
	0–150	0–5	*	*	*	*	1	
430 D - #1	0–450	0–300	0.025	0.1	0.1	0.4	3	10 AMP
#2	0–450	0–300	0.025	0.1	0.1	0.4	3	10 AMP
800 B - #1	0–600	0–200	0.02	0.1	0.1	0.4	3	10 AMP
#2	0–600	0–200	0.02	0.1	0.1	0.4	3	10 AMP
605	0–600	0–500	0.02	0.1	0.1	0.4	3	20 AMP
	0–150	0–5	*	*	*	*	1	
615B	0–600	0–300	0.02	0.1	0.1	0.4	3	10 AMP
	0–150	0–5	*	*	*	*	1	
1250 B	0–1000	0–500	0.01	0.1	0.05	0.4	3	
1220 C	0–1200	0–50	0.01	0.1	0.05	0.4	3	10 AMP
1520 B	0–1500	0–200	0.01	0.1	0.05	0.4	3	
HB 2050	0–2000	0–500	0.005	0.1	0.02	0.4	3	
HB 2500	0–2500	0–50	0.005	0.1	0.02	0.4	5	

*0-150V bias - Regulation: 0.01% Line / 2% Load at 150V

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Editorials

IEEE increases the bite

Starting next year, membership in the Institute of Electrical and Electronics Engineers will cost $25 a year instead of $15, a 67% increase. The society is having trouble making ends meet and has taken what appears to be an easy way out: boosting dues instead of tackling the ill that really ails it.

It is evident that the society is not growing with the fast-growing electronics industry. But even worse than its failure to attract new members from the new branches of electronics technology, is the IEEE's inability to keep its members. Too many are dropping out of IEEE activities; others are not paying their dues.

The increased dues may get the IEEE off the hook next year, but the deficit problem will only be staved off, not solved. It will be back again in another year or so. To many, the increase comes as a disappointing blow because the merger of the Institute of Radio Engineers and the American Institute of Electrical Engineers in 1963 was supposed to produce many economies.

IEEE's real problem is not financial; the deficit is just a symptom. These days the society is just not offering many electronics engineers enough incentive to encourage them to stay active and pay dues every year. While some companies will pay dues in a technical society for their employees, many others will not, so a lot of the members have to pay their own way in the IEEE and they expect some return from the society.

An engineer joins a technical society to add to his technical knowledge, to meet with others of the same profession to discuss technical problems and to win recognition from his colleagues. Today, many other groups—other societies, colleges in short courses and symposia, etc.—are doing the job of continuing the engineer's education a lot better than IEEE is.

IEEE's annual meeting, whose technical program we have criticized on this page repeatedly, is a good example of the society's failing. Though almost all knowledgeable engineers agree the program is terrible, the men at the IEEE headquarters seem perfectly happy with it. In fact, one assured Electronics that next year's meeting would be an exact duplicate of the 1966 fiasco. The same large number of poor quality papers. (Incidentally, he gave no assurances that some of the same bad papers might not be presented again to fill the program's needs for 400 or 500 reports.)

As long as the annual meeting—and many of the professional group meetings—suffer from malnutrition of content, IEEE is going to have trouble making ends meet. As long as many of the meetings are get-togethers for small in-groups that freeze out the average engineer, Mr. Average is going to stop attending.

Even though the percentage increase in dues is large, engineers could swallow it better if they believed the IEEE was really trying to cure its ills. Unhappily, in its zeal to stay solvent, the IEEE has lost sight of its main purpose: to operate a technical society for electrical and electronics engineers.

Apply the old to space

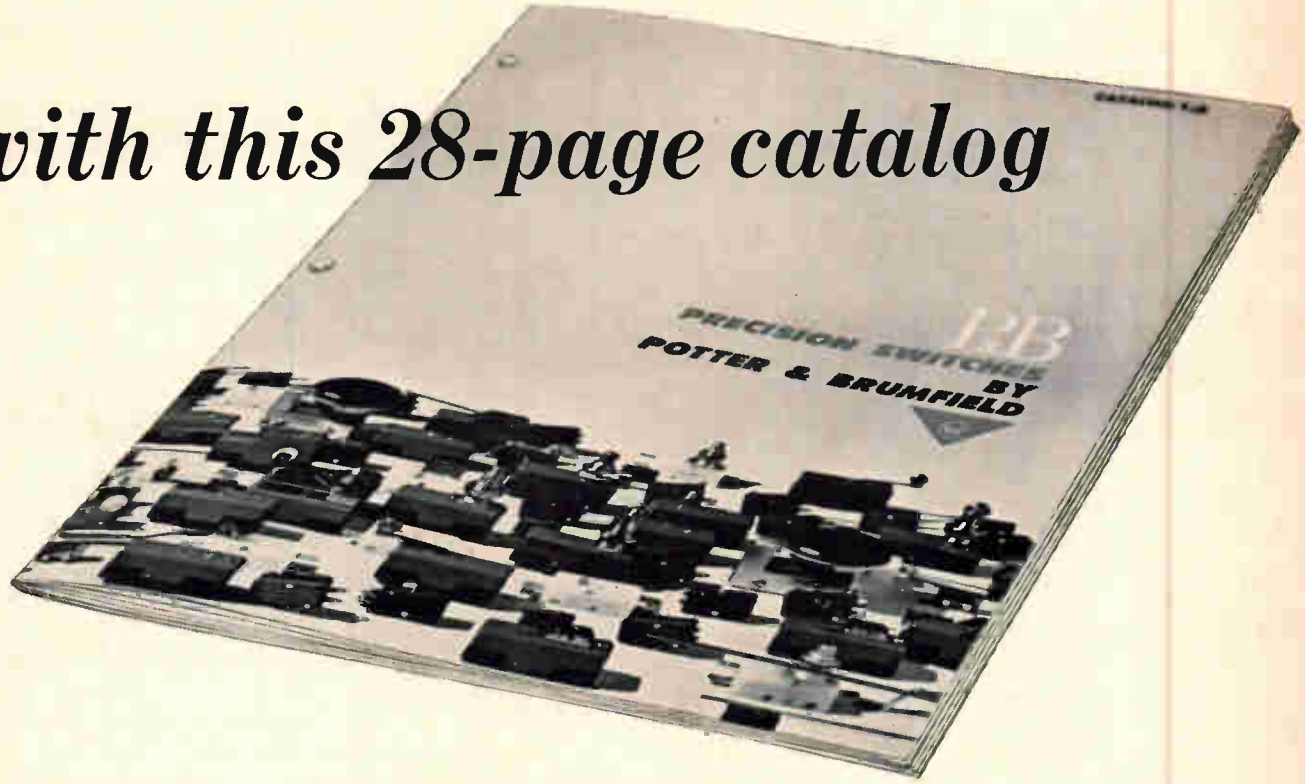
Before the end of 1966, communication by satellite will be a well established technique. The report, starting on page 83, shows that progress has been made at a far faster rate than even the most optimistic forecasters were predicting only a couple of years ago. Though communication by satellite is nearly a science-fiction idea, the major technical problems were prosaic; they were the same difficulties that dog designers of more usual electronics equipment—finding the right components.

Reliable communications by satellite, it turns out, depends on engineers finding precise resistors and capacitors and improving the life of traveling-wave tubes rather than something esoteric in rocket technology, space geometry or astrophysics.

The report also points out that the greatest technical challenges—and the richest rewards—lie in developing equipment for ground terminals, not for gear for the satellites themselves.

Though communication by satellite is clearly one of the great technical accomplishments of the 20th century, working in the field requires little in the way of radically different technology. What it does require, however, is a fresh creative look at the equipment and the techniques communications engineers have used in the past.

Check out P&B as a big new source for precision snap-action switches with this 28-page catalog



This catalog shows a wide variety of precision snap-action switches including general purpose, miniature, subminiature and appliance. Most are directly interchangeable with many competitive types. All meet U/L and CSA requirements and are available with a wide choice of actuators, contact arrangements and terminals. Mounting dimensions and materials meet military specifications. The designs lend themselves to almost limitless modification for adaptation to individual requirements. Send for your copy.

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Electronics Newsletter

May 2, 1966

Magnetics studies seen leading to new devices

Research in superconductivity is hastening the day when it will be practical to design higher magnetic fields into microwave devices that rely on interaction of these fields with electron motion. At the International Conference on Magnetics in Stuttgart, West Germany, last month, Arthur J. Freeman of the U. S. National Magnet Laboratory, Cambridge, Mass., cited new information emerging on flux flow in superconductors, the wave motions of superconducting electrons and similar phenomena.

It is now possible, Freeman said, for designers to start thinking of new dimensions in microwave signal generators, Hall-effect multipliers and other microwave devices which **will incorporate small, economical superconducting magnets producing 30, 50 or as high as 90 kilogauss.**

Also at the conference, Robert J. Spain of Laboratory for Electronics, Inc., Boston, reported on **a new thin-film technique that can be used in an all-magnetic logic network.** Domain tip propagation logic (DTPL) depends on the interaction of magnetic domains and walls in ferromagnetic thin films. Information is stored within regions of low coercive force channels in the form of domains of reversed magnetization, and it is propagated through the channels under the influence of an applied field by expansion of the domains at the tips, the spike-like extremities of the domains. The direction of domain tip propagation is sensitive to the magnitude and direction of the applied field, making it possible to design new types of thin-film shift registers with high storage density and speed. Experimental units with linear bit densities of 100 bits per inch have been operated with 300-nanosecond clock pulses.

The Boston scientist said multimegacycle DTPL shift registers with storage densities of several thousands of bits per square inch are feasible.

Sound method does dishes

Ultrasonic washers, long used by industry, may move into the kitchen to help housewives. **Acoustica Associates, Inc., of Los Angeles is planning to field test some of its dishwashers in about two weeks.**

The unit, called the Sani-sonic, operates between 22 and 25 kilohertz and will clean anything that an ordinary dishwasher can handle. **Acoustics says no detergents are needed with the system, only a wetting agent, and that it eventually hopes to eliminate the need for hot water.** The home unit will sell for about $500.

McGraw-Hill study cites record outlays for industry R&D

American industry is pouring a record $15.2 billion into research and development this year, up sharply from the $13.6 billion spent last year. **In 1969, R&D outlays should soar to $18.2 billion.** These are the findings of a survey conducted by McGraw-Hill Publications' department of economics and based on a broad sample of U. S. companies. Although the study didn't focus on the impact of electronics, a major portion of most R&D work is related to that field. The study made these major points:

- **This year industry will spend $1.1 billion on basic research, nearly $3.7 billion on applied research and about $10.5 billion on product development.** The bulk of research money is being spent by the aerospace, electrical and chemical industries.
- The aerospace industry expects that by 1969, 40% of its sales will be new products; and the electrical machinery industry, which includes electronics companies, foresees 25% of its sales made up of new products.

Electronics Newsletter

S band microwave space link relays high-quality tv

A new solid state microwave data link operating in S band provides 12 megahertz of modulation bandwidth for an "eye in the sky" communications link from a space vehicle to an earth-based receiver. The equipment, designed and manufactured for a military application by Microwave Associates, Inc., of Burlington, Mass., will relay pictures to earth while going through the atmosphere as well as from space. Most video channels have a modulation bandwidth of 5 to 6 Mhz.

The 20-watt transmitter is entirely solid state except for the traveling-wave tube final power amplifier. The spaceborne equipment dissipates 200 watts. The earth-based receiving system has a total noise figure of 6 decibels. A tunnel diode is the preamplifier.

Comsat to propose satellite network to serve U. S.

The tempo is picking up on planning for a communications satellite network for domestic customers. By Aug. 1 the Communications Satellite Corp. will submit a proposal to the Federal Communications Commission for the development of a stationary-orbit system for the U.S. Positioning the satellites where they could also handle traffic between the United States and Europe is something Comsat officials privately say they prefer. [For further details on communication satellites, see page 83.]

Comsat is considering satellites with a capacity of 3,000 to 12,000 voice channels that could be lofted in two to four years.

The surge in interest in satellite communications is also demonstrated by a study that Page Communications Engineers, Inc., will undertake. The Inter-American Development Bank awarded the company a contract to pick the most economic locations for satellite ground terminals in Latin America.

Raytheon builds 500-watt laser; efficiency is 15%

A continuous laser output of 500 watts at an efficiency of 15% has been produced by an experimental carbon dioxide laser at the research division of the Raytheon Co. in Waltham, Mass. A French company previously announced a high of 280 watts.

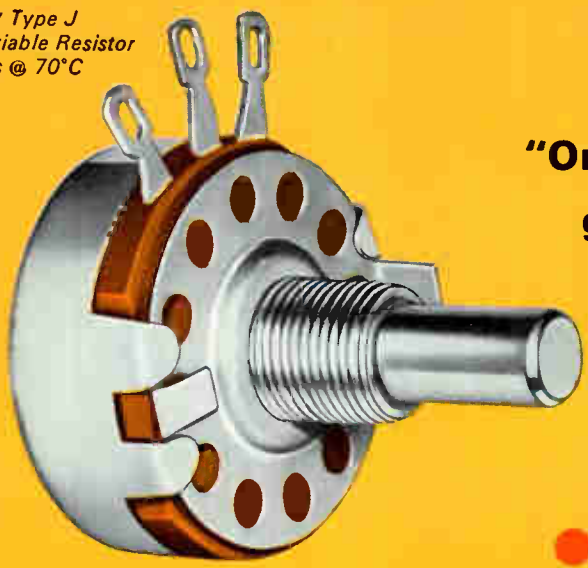
The Raytheon work is funded by the Army Missile Command, Huntsville, Ala. The researchers used a flowing gas mixture of nitrogen and helium with the carbon dioxide, in a water-cooled discharge tube 10 meters long.

The laser is expected to develop quickly into one of the most powerful and efficient tools yet. Warnings are being sounded about the personnel hazards involved in working with this device, whose output is at 10.6 microns in an invisible part of the spectrum.

Addenda

In a down-to-the-wire finish, the GPL division of General Precision, Inc., won the competition to build the doppler radar subsystem for the giant C-5A transport. The Canadian Marconi Co. was a close second to supply the radar to the Northrop Corp., which is building the C-5A doppler inertial navigation system. The GPL contract, valued at $1 million initially, will ultimately be worth about $16 million. . . . A station-keeping radar system that can keep up to 32 helicopters in flight formation is being developed by TRG, Inc., of Melville, N.Y. The $741,200 design contract was awarded by the Army's Electronics Command's avionics laboratory at Fort Monmouth, N.J. Over 90% of the system will employ integrated circuits.

ALLEN-BRADLEY *Type J Hot Molded Variable Resistor rated 2.25 watts @ 70°C shown 2 times actual size.*

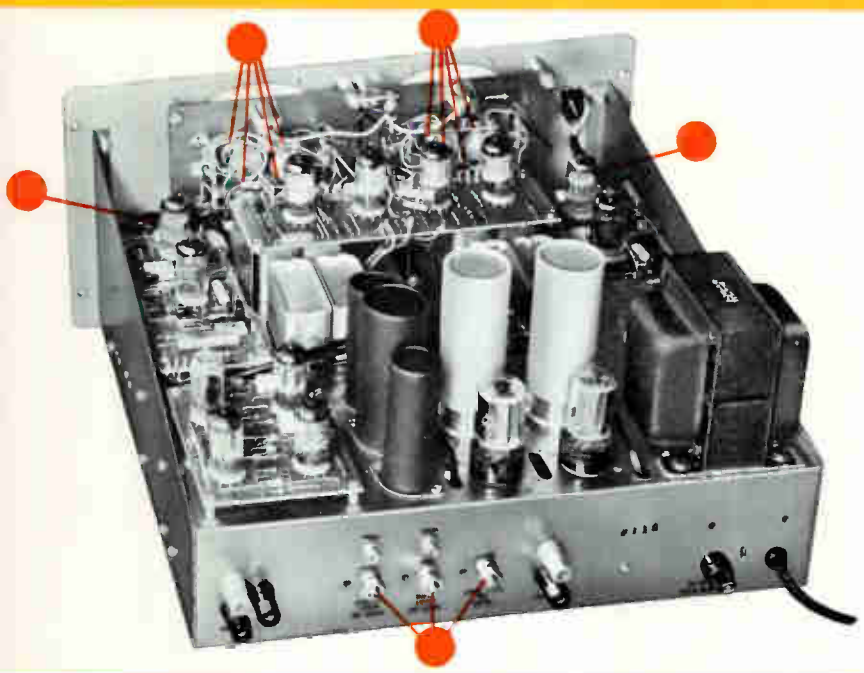


"Only Allen-Bradley Type J pots give us the smooth control

to maintain the high calibration accuracy of our instruments"

Krohn-Hite Corporation

This quickly locates the positions of the Type J potentiometers in the illustration below.



THIS KROHN-HITE VARIABLE FILTER provides low-pass, high-pass, band-pass, and band-reject operation with high and low cutoff frequencies independently adjustable from 0.02 cps to 20 kc.

IN THE MODEL 335, continuous tuning of the high and low cutoff frequencies is accomplished by simultaneously varying four potentiometers with a single knob. Only A-B Type J controls have been found to provide the smooth control and precise tracking without discontinuities to achieve the required calibration accuracy.

Krohn-Hite engineers have found that only Allen-Bradley Type J potentiometers provide the smooth control, low noise, long term stability, and low temperature coefficient they require for their precision instruments such as the variable electronic filter.

The Type J control has the resistor, terminals, faceplate mounting bushing, and insulating material hot molded into a solid integral unit. The solid resistance track assures smooth, quiet control that is free from the undesirable discrete steps of wire-wound units. On accelerated tests, Type J exceeds 100,000 complete operations with less than 10% resistance change.

Insure the performance of your equipment by insisting on Allen-Bradley Type J hot molded potentiometers. Besides, when you use Allen-Bradley fixed and variable hot molded composition resistors you provide your apparatus with the label of "quality." For more complete specifications, please write for Publication 6024: Allen-Bradley Co., 222 West Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Ltd. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

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TYPE F CONTROLS are for mounting directly on printed wiring boards by means of their terminals. Rated ¼ watt at 70°C. Values to 5 megohms. Type O are similar but rated 0.4 watt at 70°C.

TYPE R ADJUSTABLE FIXED RESISTORS are built to withstand environmental extremes. Only 1¼" in length. Have stepless adjustment. Watertight and can be encapsulated. Rated ¼ watt at 70°C. Values to 2.5 megohms. Type N for less severe environments are rated ⅓ watt at 50°C.

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for use in the 2.2 to 2.3 GHz frequency range

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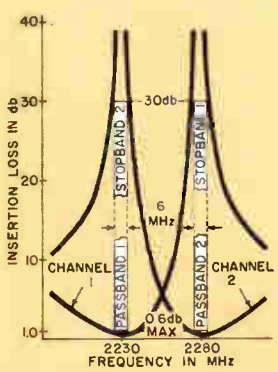
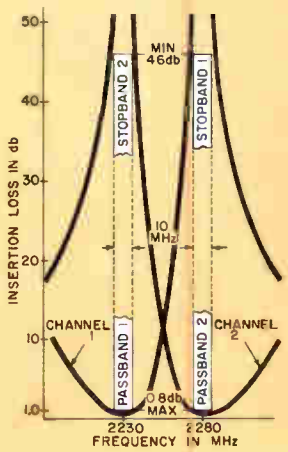
WITH ONE REJECTION CAVITY PER CHANNEL



WITH TWO REJECTION CAVITIES PER CHANNEL



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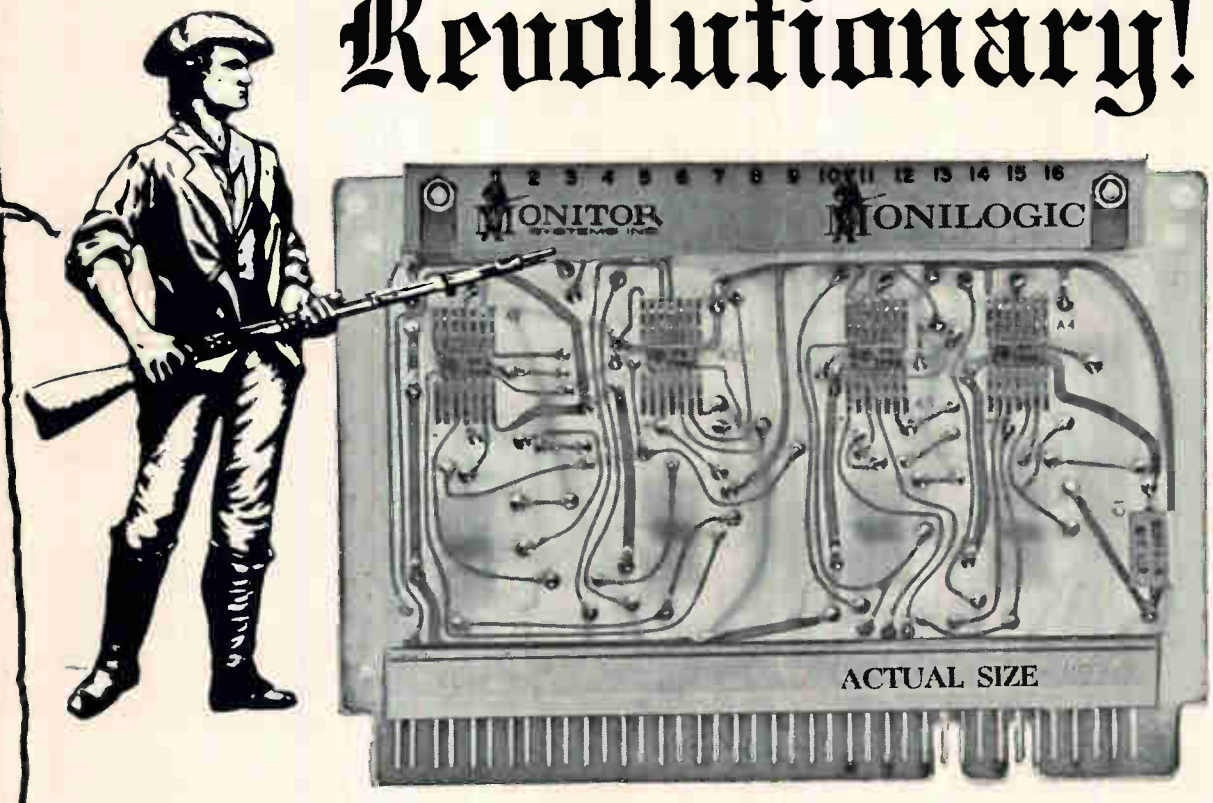

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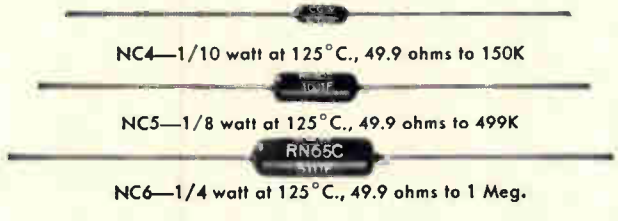

NC4—1/10 watt at 125°C., 49.9 ohms to 150K

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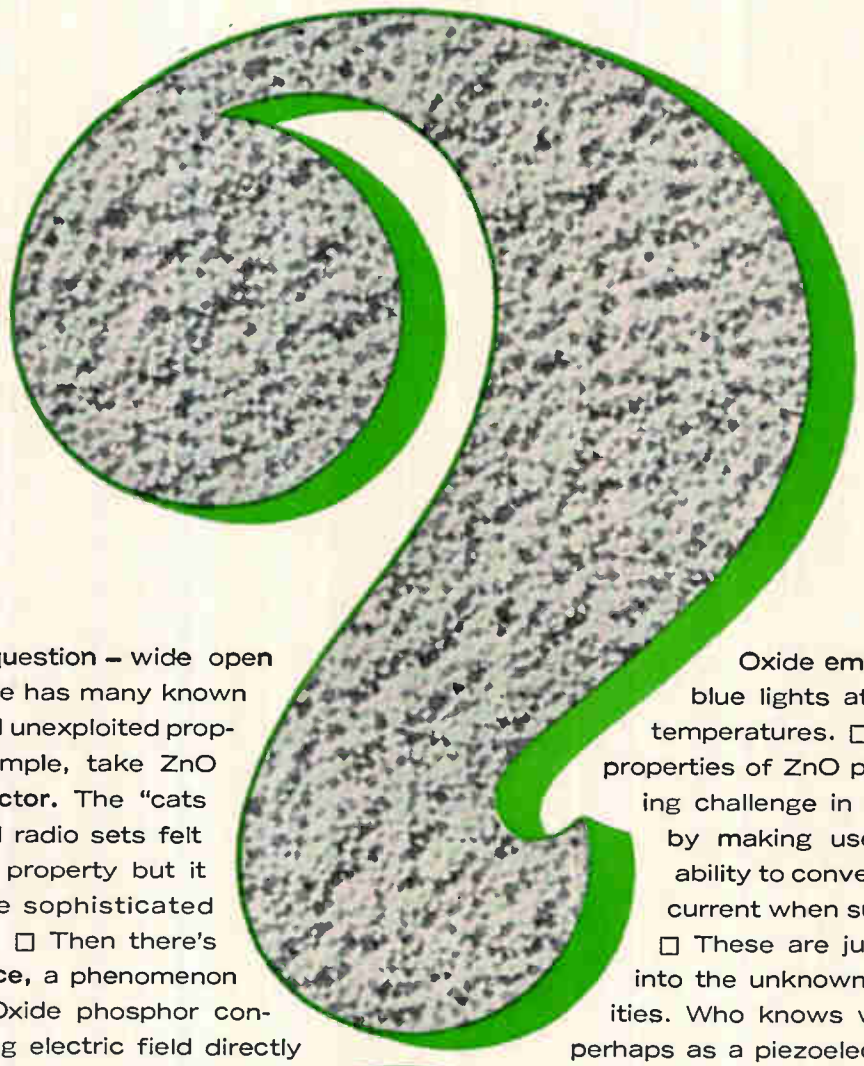

That's an open question – wide open because Zinc Oxide has many known but unexplored and unexploited properties. □ For example, take ZnO as a **Semi Conductor.** The "cats whisker" in crystal radio sets felt the effect of this property but it offers much more sophisticated possibilities today. □ Then there's **Electroluminescence,** a phenomenon in which a Zinc Oxide phosphor converts an alternating electric field directly into cold light. In using this property in light amplification, digital computers, television and other electronic devices, science is just crossing the threshold to a vast area of potentials. □ Other unexploited properties of ZnO involving light are **Thermoluminescence** – the ability to convert infra red rays into visible light, and **Candoluminescence** – wherein Zinc Oxide emits brilliant red and blue lights at specific elevated temperatures. □ The **Photovoltaic** properties of ZnO present an interesting challenge in energy conversion by making use of Zinc Oxide's ability to convert light into electric current when suspended in water. □ These are just a few glimpses into the unknown realm of possibilities. Who knows what ZnO can do, perhaps as a piezoelectric, as a thermocouple, as a resistance element, etc. □ But whatever the future possibilities, St. Joe Zinc Oxide will share in them so long as stringent scientific control of product purity and uniformity are prerequisites.

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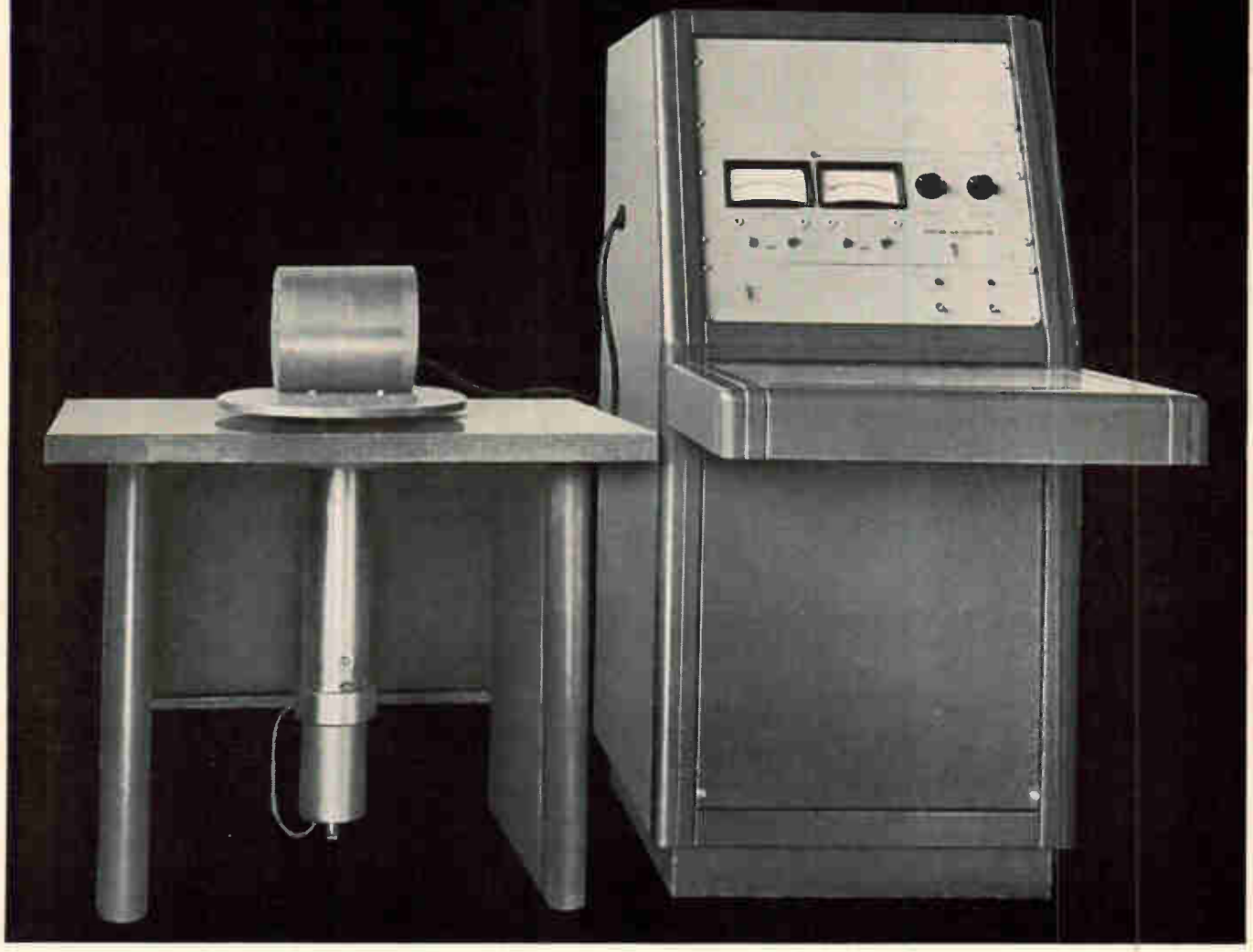
for measurement of remanent magnetic moments in rock samples



Princeton Applied Research Corporation's Model SM-1 Spinner Magnetometer is the first commercially available instrument for measuring remanent magnetic moments in rock samples. It will be valuable in geological research applications and in magnetic evalutions of samples procured during mineral and petroleum explorations.

The Model SM-1 simultaneously measures and displays on front panel meters the amplitudes of two orthogonal components generated by spinning a surveyed rock sample at a frequency of 100 cycles per second placed in a known orientation relative to pick-up coils. The detected orthogonal components of the magnetic moment of the sample define the magnitude and direction of the magnetic moment in one plane. The sample is reoriented in the sample holder and the measurement procedure is repeated to determine the moment in the orthogonal planes. Because no tuning adjustments are required in the system, operation is convenient and results are reproducible.

Technical features:

Sensitivity: Sixteen full scale ranges calibrated in terms of TOTAL MOMENT in emu from 0.5 x 10^{-6} to 50 x 10^{-3} in 1, 2, 5, 10 increments.

Calibration accuracy: The system is factory calibrated to within 0.5° phase and within 1% magnitude.

Sample size: Cylinder: 2.49 cm diameter, 2.28 cm length. Slightly larger or smaller samples can be accommodated.

Price: $8,000.00 (The Model SM-1 is also available with automatic digital read-out to alternately monitor the orthogonal components of the magnetic moment. Price: $9,750.00)

Write for Bulletin No. 125.

May 2, 1966

Electronics Review

Volume 39
Number 9

Instrumentation

Free spin

The wheel, man's first major success in reducing friction, set Joseph Lyman thinking about magnetic suspension as a possible way of eliminating friction altogether in sensitive instruments that contain moving parts. The wheel that Lyman thought about was a very special type of wheel—the gyroscope.

Combining his knowledge of gyroscopes (he holds one of the basic patents on the instrument) and his interest in magnetic suspension, he is developing a system that suspends a rotating 7½-pound shaft free of friction for a laboratory investigation of gravitational mass sensors.

Measure the mass. Lyman serves as a consultant to the Cambridge Thermionic Corp. of Cambridge, Mass., where he is putting the finishing touches on the system before it is shipped to the Hughes Aircraft Co. Hughes plans to use it to help in the development of gravitational mass sensors. The Hughes program, paid for by the National Aeronautics and Space Administration, seeks improvements in gravity gradient stabilization techniques for satellites [Electronics, May 18, 1964, p. 112]. Also, NASA wants to use gravity gradient sensors in a lunar orbit to measure the moon's mass distribution and in deep space probes to measure the mass of meteroids. Such studies require measurements so fine that even the slightest friction in the instrument would produce enough "noise" to ruin the results.

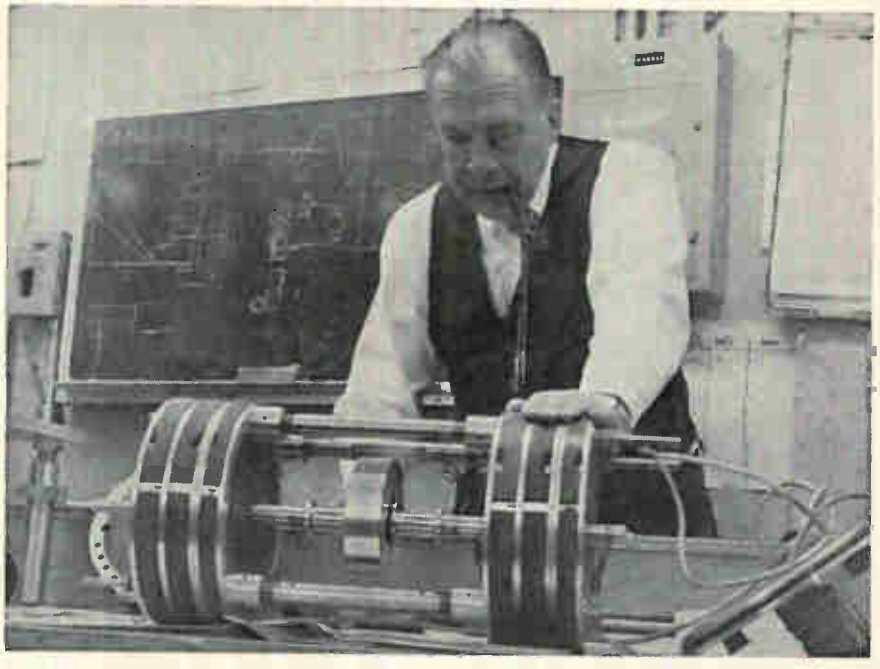
The magnetic suspension system, Lyman says, is the first that can suspend such a large weight both axially and radially.

Turn to d-c. The Cambridge Thermionic system, however, is being developed only for research—not as a spaceborne instrument. Lyman says that the system's power requirement is a major problem: 200 watts are needed to suspend the 7½-pound shaft. But he believes that by using direct current, instead of alternating current, he can boost efficiency.

Placed in vacuum. To support the spinning shaft, which is in a vacuum, Lyman built into its housing 28 magnetic coils, 16 of which provide axial support and 12 radial support. By placing the coils opposite each other, he restrained the shaft in all axes, but the rotational axis. Each coil acts as a series resonant circuit.

The inductive parameters are designed so that when a ferrite disk built into the shaft—acting as an armature—is centered between two opposing coils, each of the coils is resonant with a capacitor at a chosen frequency.

Stay in balance. Any external force tending to move the armature toward coil A will result in an increase in the coil's inductance, so that the current decreases. The current in the opposing coil, B, increases, strengthening its magnetism. The closer the disk comes to coil A, the weaker A becomes, and the stronger B becomes. B will exert a force sufficient to draw the disk into a neutral position. If the initial motion is toward B the reverse situation occurs.



Magnetic suspender. Researcher Joseph Lyman tests system for rotating 7½-pound shaft in a frictionless environment. The system is being built to help in the development of gravitational mass sensors.

In a second-generation system that Lyman is building, 56 coils will be used and he estimates that it will be able to support a 12-pound shaft.

Magnetic suspension has earthbound applications, too. A British company is investigating its use in textile machinery, where it would be used to "float" high-speed bobbins, eliminating wear. In France, researchers are studying frictionless support of rotating tungsten targets in X-ray tubes. And United

States scientists are investigating the use of magnetic support of gyroscopes in inertial guidance systems.

Oceanology

Now hear this

Later this month Navy technicians will tow a cigar-shaped research vessel out into the Atlantic and fill its lower compartments with water so that all but 50 feet of its 354-foot length is submerged. If all goes well, the craft's sensitive hydrophone array will be able to detect underwater sounds made up to 100 miles away.

The project doesn't involve eavesdropping on fish, although there are Navy experiments to detect the sounds of underwater life. This time the Navy wants to determine how different kinds of sea water affect the propagation of sound. The information gathered in the study may help in the development of highly sensitive listening devices that will track enemy vessels beyond the range of radar or sonar.

Home in. The sound-detection vessel, called Spar, for seagoing platform for acoustics research, was built for the Navy's Ordnance Laboratory by Aerojet-General Corp.'s shipbuilding subsidiary in Jacksonville, Fla. The 50-foot portion of the vessel that juts out of the water carries an ultrahigh-frequency direction finder, designed to home in on targets to within hundredths of a degree of arc. The submerged portion contains a large array of hydrophones that will monitor underwater sounds.

During tests, Spar will work with two other ships: a mother vessel linked to Spar with a floating umbilical cord and a sounding ship, at a distance, that will simultaneously produce a uhf homing signal and an underwater test sound. Spar will pick up the homing signal, automatically point its hydrophones at the sounding ship and then wait for the underwater sound wave to arrive. Carefully monitoring the signature of the received sound, through water of varying salinity and temperature, may produce information on how sound is propagated beneath the waves.

Data collected by Spar's listening devices is multiplexed and transmitted through the umbilical cord to the mother ship, where it is recorded for analysis.

Keep still. The unmanned vessel is the Navy's second acoustics research craft. The first, a manned vessel in operation for about three years in the Pacific, was developed by the Marine Physical Laboratory at the University of California. The Pacific ship has drawbacks, Spar developers claim: extra noise is produced by the men on the craft; in addition, Spar is said to be more sensitive to sound than the Pacific craft, but just how sensitive is classified.

Although the Spar is scheduled to become operational this month, further additions to its electronics hardware are planned. One is a laser instrument that will measure the slightest longitudinal twists encountered by the thin, long craft as it bobs in the sea. Spar researchers explain that even a small twisting motion will cause boresight errors between the hydrophones and the direction finder, since they are situated at opposite ends of the vessel.

In-depth listening. Acoustic research vessel will be launched by the Navy to gather information on how sounds are propagated under water.

Avionics

Elbow room

What started as a feud over the width of transatlantic airline corridors has evolved into an inquiry into the dependability of the electronic equipment that keeps the planes on course. The judge and jury is the Federal Aviation Agency. The airlines contend that the equipment is dependable enough to shrink the corridor to 90 nautical miles, but the pilots demand that the corridor be held at 120 miles for safety.

The issue had been bubbling for years. Then, in January, the FAA and aviation agencies in other countries acted to narrow the "lateral separation"—the distance between planes flying at the same altitudes.

Two views. In lengthy FAA hearings, spokesmen for the Air Line Pilots Association said that existing navigation devices just aren't good enough to fly safely in the narrowed corridors. Contesting the conclusions of a government study, they submitted a survey of their own, contending that 5% to 7% of flights studied drifted off course by more than 45 miles—an error big enough to carry the plane out of its assigned corridor and into a mid-air collision.

Airlines insisted that the pilots—and their equipment—are better than that. Samuel H. Miller, manager of flight operations for Pan

American World Airways, said Pan Am studies of its own flights show the planes can stay within the narrowed corridor more than 99% of the time.

The dispute involves two different systems: a doppler radar device, and one based on radio altimeters readings. The doppler system, supplied primarily by the Bendix Corp., computes drift and ground speed by measuring the frequency shift of four beams bounced off the ground or water. In the other system, radio altimeter readings are compared with barometric readings to compute air pressure slope and crosstrack wind components.

The airlines contend that present instruments are adequate when coupled with more accurate weather data, improved gyromagnetic compasses, computer-drawn flight plans and higher altitudes that make possible longer-range reception of ground navigation signals and more frequent celestial fixes.

But the pilots argued that only 14 of the 27 transatlantic airlines are doppler-equipped, and that even these planes are only as reliable as their last ground check signal.

Future devices. A spokesman for the pilots association did not single out any one device that it would like to have before accepting a 90-mile corridor, but presented a shopping list of possibilities. Among them: loran C, a lower-frequency, longer-range adaptation of present loran equipment; the British dectra system, a long-range version of the Decca Co.'s short-range decca system; and inertial guidance devices that Litton Industries, Inc., and the Sperry Gyroscope Co. are racing to supply. Sperry is a subsidiary of the Sperry Rand Corp.

Airlines currently are leaning away from ground navigation equipment, and want the cockpit to be self-sufficient. Pan Am already has inertial guidance equipment on order from Sperry. It also plans to use the system when the giant Boeing 747's begin coming into service in about three years. And inertial guidance devices are the most likely navigation system for the forthcoming supersonic transports.

Quantum electronics

Russians on the beam

Led by Nobel laureates A.M. Prokhorov and N.G. Basov, 13 Soviet researchers, the largest Russian scientific delegation ever to visit the U.S., attended the Quantum Electronics Conference last month.

While the quality of the work in lasers described by the Russians was indisputably high, American laser researchers queried at the conference said the U.S. was well ahead in most fields. The Americans were impressed by one result reported by Basov on semiconductor lasers pumped by electron beams and radiation from other lasers. With thin films of cadmium sulfide or cadmium selenide deposited on the surface of a Fabry-Perot resonator mirror, Basov reported achieving output powers of 200 kilowatts with an optical transformation efficiency of 50%. Power density was about 10 to 20 megawatts/cm^2. This is considerably in excess of the power achieved in similar work reported here: 16 watts of peak power with an efficiency of 8% using cadmium selenide.

Other Soviet laser activities mentioned by Basov:

- Development of an optical frequency standard using a laser in which the mirrors are replaced by a surface or volume diffuser. Although such a device has no spatial coherence, the output radiation is highly monochromatic, resulting in an accurate optical frequency standard.
- A method of producing sharp, high-power pulses by simultaneously Q-switching and modulating the duration of a laser beam and passing it through a nonlinear amplifier.
- Investigation of the power capability of ruby lasers which indicates that ruby is capable of power densities of 10^{11} watts/cm^2, much higher than is currently achieved.
- Development of a low-temperature, noble gas laser with output in the far ultraviolet region of the spectrum.
- A method of attaining parametric oscillators with continuous frequency tuning. The scheme uses potassium dihydrogen phosphate (KDP) crystals interposed in the beam to achieve the parametric action. Changing the angle between the direction of light propagation and the axis of the crystal by rotation changes the dispersion characteristics of the crystal and therefore the output frequency. A similar scheme had been previously reported by J.A. Giordmaine and R.C. Miller of Bell Telephone Laboratories, except that they used lithium niobate crystals instead of KDP. The Russians claim that KDP's characteristics allow tuning as a linear function of the angle change, while the frequency characteristic lithium niobate has a square root dependence on rotation angle. One scientist pointed out that the Russians probably can't get good lithium niobate crystals, and thus are pushing KDP work.

Hit the moon. During a session on applications, Basov remarked that with a laser they had been able to measure the distance to the surface of the moon with an accuracy within 100 meters. He refused to give details of the technique except to say it was "routine."

Americans at the meeting were somewhat puzzled by the statement, since there are craters and protuberances on the moon's surface much greater than 100 meters, and the point on the earth's surface from which the measurement was taken was undefined. One U.S. physicist thought Basov was really commenting on the ability of the equipment to resolve the signal from noise. In other words, returns from the moon's surface could be recovered through the noise level with a resolvability of 100 meters.

Mathematical mirage

The mind often plays tricks: it can produce a three-dimensional object

that isn't present. Now, researchers at the International Business Machines Corp. have discovered a way of reconstructing complex images of real or imaginary objects in three dimensions with computer generated holograms. The technique was developed by scientists at IBM's Research Laboratory in San Jose, Calif.

Their work is more than an exercise in illusion; its applications are practical. For example, with the aid of computer-generated holograms, military pilots may one day see reconstructed 3-D images of targets that now appear as blips on a cathode-ray tube. The synthetic holograms could also be used in character recognition and information storage, IBM says.

Black and white. Conventional holograms are formed by interferometric patterns created by coherent light scattered from a reflecting object and recorded on film. These holograms appear as seemingly random patterns of varying shades of gray on the film. When the processed film is reilluminated, the original object is reconstructed photographically in space in 3-D.

The IBM binary hologram takes the form of a series of black and white lines. In effect, the pattern acts as a diffraction grating with slits of varying sizes. When a plane wave of light passes through the slits, they deform the wave to produce the desired phase relationship on the other side of the film, forming the image.

A computer generates the synthetic hologram; the computer is programed to drive an x-y plotter that produces a pattern consisting of many short, parallel lines. The pattern is then reduced and recorded on film. Any shape that is mathematically realizable can be reconstructed—even one that never actually existed.

A. W. Lohmann and D. P. Paris, who described the binary holograms at the Quantum Electronics Conference in Phoenix, say the technique makes it possible to multiplex two or more images on a single hologram or reconstruct full color images by using polarized light.

Magnetic tuning

Shortly after the laser was developed in 1960 scientists tried their hand at various techniques to get different frequencies from the same device. Most of the work has centered on the beam after it was generated by the laser: parametric tuning, Raman effect and nonlinear optics—effective methods of "tuning" the beam but costly in terms of complexity and attenuation. A team at the Bell Telephone Laboratories, in search of a simpler way, is experimenting with a ferrite laser that's tuned internally by a magnetic field.

So far, the range of the tuning is relatively limited—about 60 angstroms, but, according to one of the developers, L. F. Johnson, the technique shows great promise because the tuning process itself doesn't contribute in any substantial way to the beam's attenuation. Magnetic tuning has another advantage: light emerging from the laser is polarized, and the degree of polarization can be kept under control.

The development is a three-part effort by IBM scientists: Johnson is an authority on lasers; J. F. Dillon, a magnetics expert; and J. P. Remeika, a crystal specialist.

The recipe. The crystal that Remeika grew is made of yttrium-iron garnet (YIG), which acts as a host for three rare earth elements. Of the total crystal, 2% is holmium, 5% is thulium and 5% is erbium. The experimental crystals are about five millimeters long and from one to two millimeters in diameter.

YIG is transparent to light wavelengths above 1.1 microns and holmium lases at 2.1 microns. Thulium and erbium have absorption lines between 1.1 and 2.1 microns. Since they transfer their excitation to holmium, they increase the absorption band of the holmium by absorbing energy at frequencies holmium normally would not see.

The crystal is placed in a magnetic field that is perpendicular to the length of the laser and strong enough to saturate the material. The laser is then cooled to the temperature of liquid nitrogen (77°K) and it's flashed with xenon lamps.

Just a twist. The researchers discovered that they could alter the laser's frequency by twisting the magnetic field about its own axis or by simply rotating the laser, which produces the same effect. They found that a 1° twist produces a two-angstrom wavelength change.

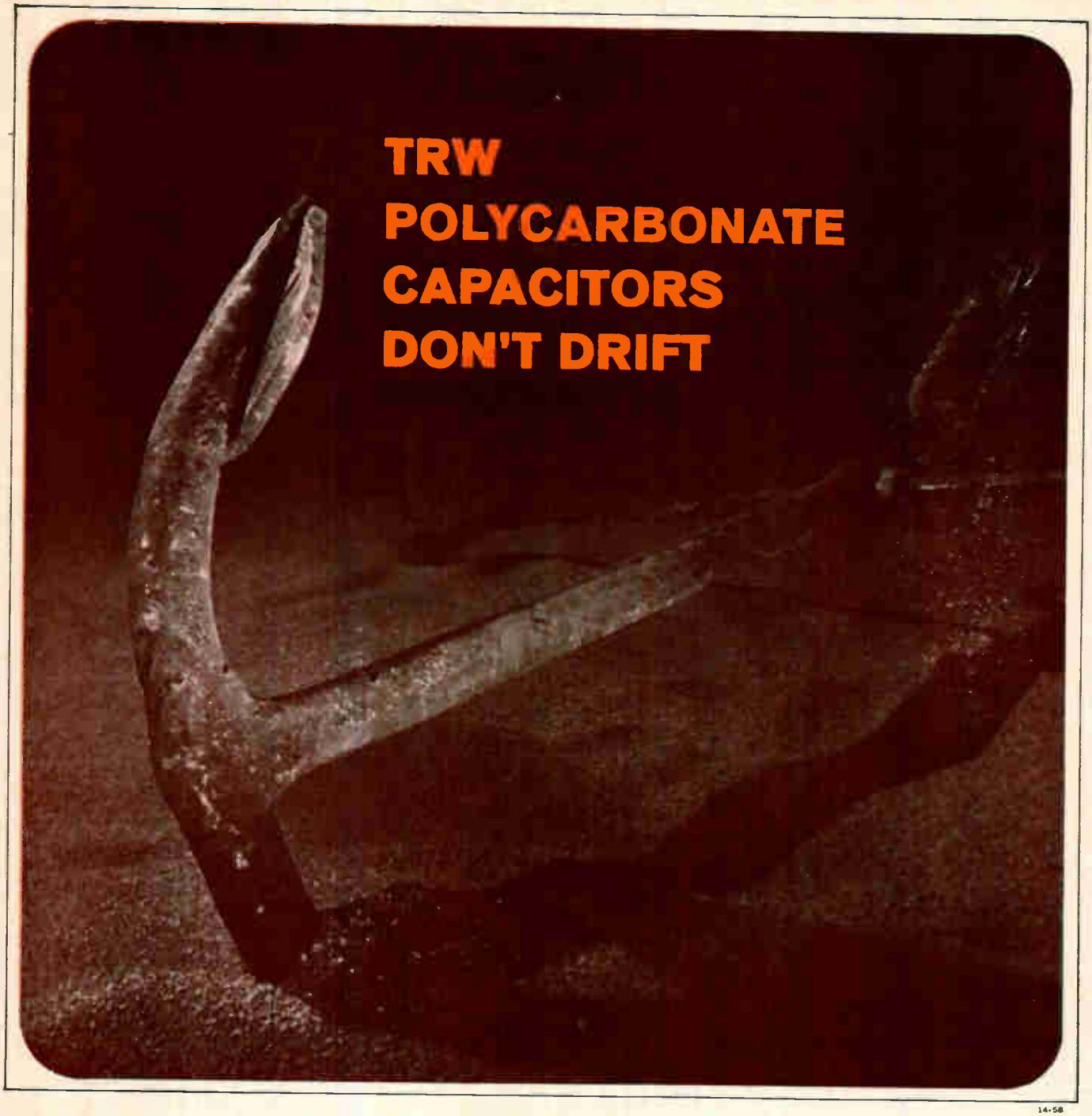
In explaining the reason behind the change, Johnson points out that the energy levels of the holmium ions are dependent upon the direction of the magnetic field; thus changes in the net direction of the field, relative to the crystal, produces changes in the beam's wavelength.

The gyrotropic nature of the magnetic crystal accounts for the second magnetic characteristic—polarization. Light propagating along the magnetization experiences an antireciprocal rotation of the axis of the linear polarization. At 77°K, the researchers observed a rotation of 140° per centimeter for two-micron radiation. The ability to vary the gyrotropic properties by moving the magnetization makes it possible to vary the threshold for emission and the direction along which emission can take place.

Sound deflector

Before a laser beam can be used in a television-like display, the beam has to be made to scan rapidly—much as an electron beam is made to scan across the face of a television tube, "painting" a picture on the tube. A team of researchers at the General Telephone & Electronics Corp.'s Bayside, N. Y., laboratory have developed a technique for making the beam scan with sound pulses.

The scanning, explain the developers, Vernon J. Fowler and Elliott S. Kohn, is accomplished with a transparent quartz delay line. Into the line are fed ultrasonic pulses. The pulses, each 0.13 millimeter wide, travel up the line, producing a localized index of refraction change at the point of the moving pulses. Hence, a part of the beam hitting the pulse is made to fan out as it leaves the quartz line, produc-



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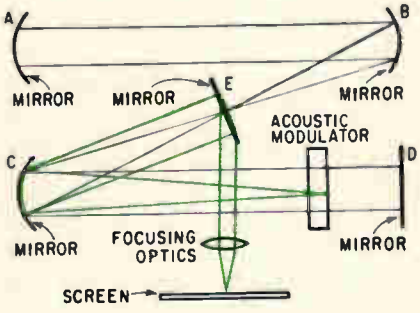
ing a moving series of fan-shaped light beams.

So far, the researchers say, 20 distinct spots of moving light have been produced, but they see no barrier to the design of a scanner with as many as 1,000 spots.

Getting it out. Getting the beam to scan is but one problem that the designers faced. Another is directing the scanning beam, but not the rest of the laser beam, to exit from the cavity. For this, the scientists designed a five-mirror laser cavity. As can be seen from the diagram,



Laser cavity designed by GT&E researchers uses sound pulses to cause a laser beam to scan. The technique could be applied in a television-like display system.

the beam produced by a helium-neon laser is reflected off mirror B and made to focus at the center of a hole in a flat aluminized mirror, E. The main beam passes through the hole, striking another mirror, C, that reflects it in the direction of the acoustic delay line.

At this point both the refracted beam and the nonrefracted beam strike mirror D and the light is reflected back through the delay line. Again, portions of the light are refracted by the shear pulses; thus a doubling effect is produced, with a fan pulse caused by each pass of the beam through the acoustic delay line.

Too narrow. The light is then reflected back to mirror C and subsequently toward mirror E. But when the fan-shaped light pulses reach the flat mirror, they are too wide to pass through the hole, so only the scanning pulses are reflected off the flat mirror and reflected out of the laser cavity.

The scanning pulses pass through cylindrical lenses and fall on a screen.

The speed and linearity of the swept beam makes the system attractive as a horizontal scanner in a tv display, the two GT&E researchers say.

Using a quartz line that's 10 centimeters long, Fowler and Kohn have produced a scan rate of 38 kilohertz (kilocycles per second). The area scanned by the beam is one centimeter wide, but again the scientists say they can eventually broaden it to as much as 10 centimeters.

Flow lightly

Conventional techniques for measuring the velocity of a fluid are self-defeating: even the smallest measuring device placed in the flow will read incorrectly because the obstruction will cause pressure changes and turbulence in the gas or liquid. The Brown Engineering Co. has turned to the laser for readings: nothing but the light beam enters the fluid, hence the flow is undisturbed.

Brown's laser velocimeter is designed to measure flow as slow as one inch per second and as fast as 1,000 feet per second. In fact, it's capable of obtaining a reading from a sample volume as small as one-millionth of a cubic inch.

Depends on shift. The instrument depends on measurement of the doppler shift of scattered radiation from a continuous-wave laser: a beam directed through a fluid will scatter if the fluid is in motion, and the scattered rays will experience a doppler shift; the unscattered portion of the beam will pass through the fluid without a frequency change. So, by comparing the frequency of the scattered and unscattered rays, the velocity of the fluid can be calculated.

The fluid that's being measured is passed through a transparent section of pipe and the laser beam is directed through it. A receiving lens on the opposite side of the pipe collects the unscattered beam and refocuses it on a mirror, which reflects the beam onto a photomultiplier tube. At the same time, the flowing fluid scatters part of the beam and those rays that are scattered at a specific angle are also focused in the photomultiplier. The two beams are optically heterodyned: the output is the difference between the scattered and unscattered frequencies.

So far, prototype instruments have recorded velocities with accuracies of within 2% to 3%, but greater accuracies are expected, the company says. Also, by redesigning the laser optics, three velocity vectors may be measured simultaneously; currently, only one vector is handled at a time. A three-dimensional velocity reading would be a valuable tool for measuring turbulence, such as in wind tunnels.

Military electronics

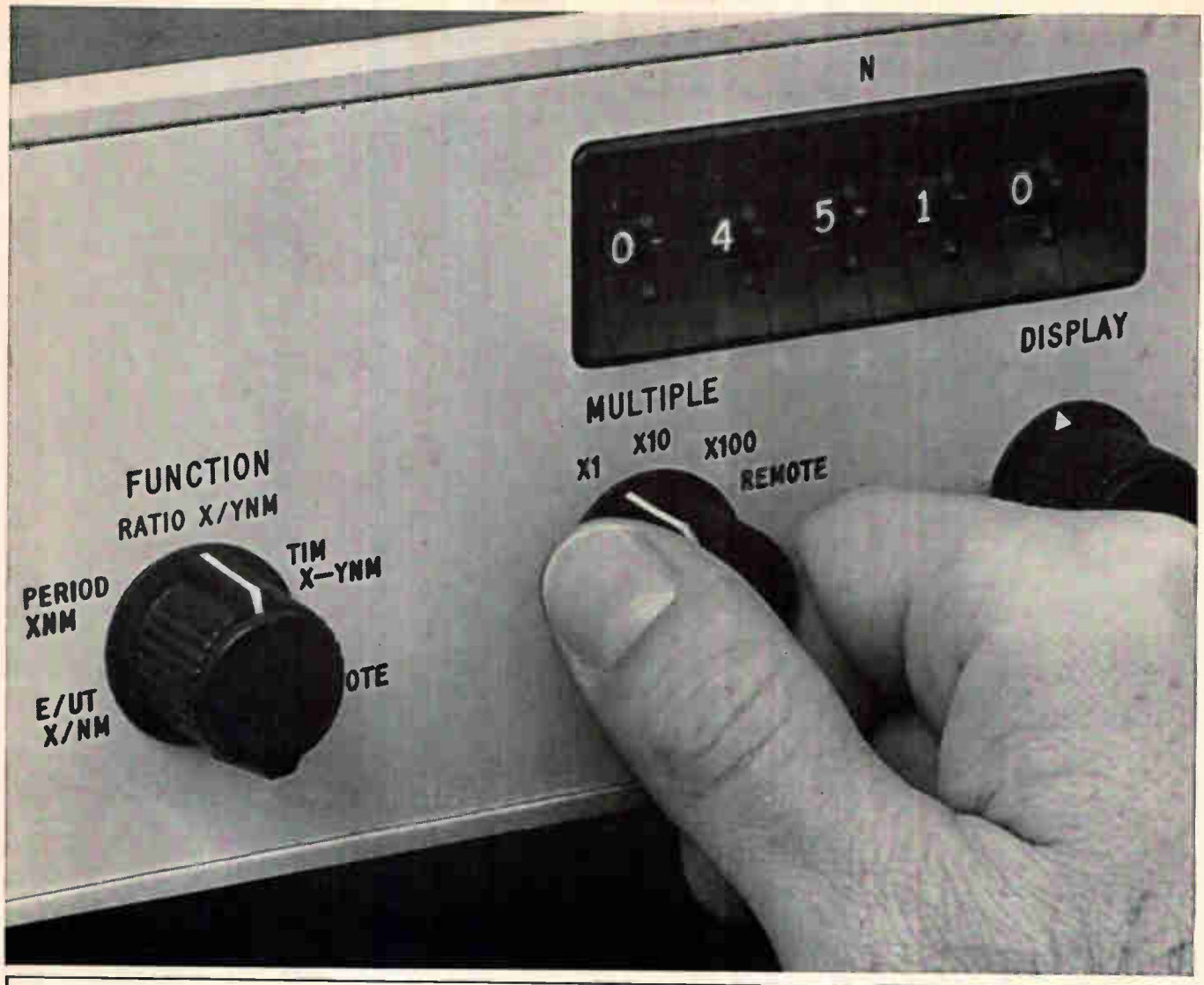
Qualified okay

Under pressure from Congress, the Air Force has made an agonizing reappraisal of its heavy reliance on nonprofit organizations for systems planning, engineering and technical direction.

The Air Force conclusions: there is a continuing need for the services of the Aerospace Corp. in managing space and ballistic missile developments and for the Mitre Corp. in such fields as air defense, command and control and communications. But it is ending the privileged position of Systems Development Corp. in computer programing design and is putting that company on the same footing as any other defense contractor.

Furthermore, the Air Force plans to tighten its management control of Aerospace and Mitre. And it served this notice on both: as conditions changes and in-house agencies and private contractors improve their capabilities in systems engineering and technical direction, a new look will be taken at the need for continuing the nonprofits.

Call it off. In view of the Air Force decisions, the Special Investigations subcommittee of the



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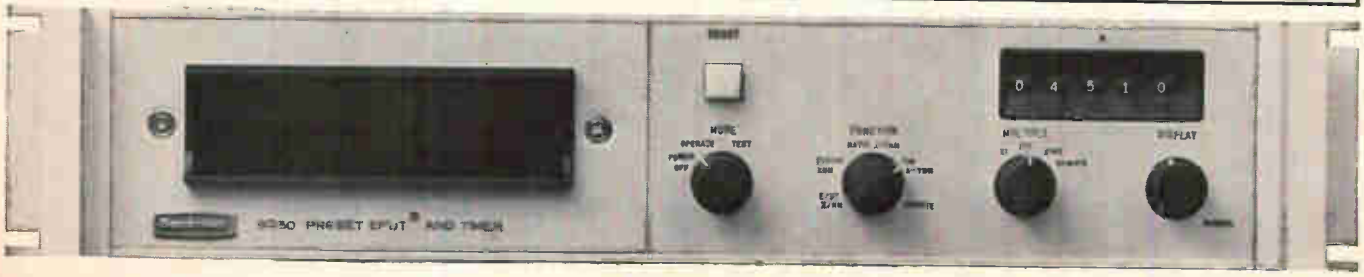


Circle 39 on reader service card

House Armed Services Committee is calling off a planned inquiry aimed at reexamining the role of nonprofits. The subcommittee began contemplating a broad inquiry after a series of hearings last year that zeroed in on management practices of Aerospace and the Air Force's control of the company. The congressional group concluded that Aerospace had squandered "millions" of tax dollars on new facilities, public relations, high pay and elaborate entertainment. It also charged that the Air Force had been too lax in permitting the nonprofit to demand "the benefits and prerogatives of private industry without any of the risks, plus the protection and security of the government without any of the restrictions."

After the congressional hearings, the Air Force named an eight-man committee to make a study of the service's relations with the nonprofits.

The study group agreed with most of the specific proposals made by the congressional subcommittee for improving management and fiscal controls over the nonprofits, and the Air Force, in turn, accepted them. The recommendations are primarily concerned with controlling the size of the organizations, making sure they use government facilities rather than plunging into building programs of their own, and encouraging them to devote at least 10% to 20% of their effort to research.

The study group found that the dollar ceilings that the Defense Department has imposed on the nonprofits to keep them from growing any larger is "healthy and desirable."

Pay scale. The group agreed that the nature of the work performed by nonprofits requires "elite" professional staffs that can be assembled only by paying higher than average salaries. It found Mitre's staff to be competent but in need of quality upgrading. But it said that while basic salaries paid by Aerospace appear to be in line, fringe benefits are much too generous.

Beyond its specific proposals, the study group reached some broad conclusions about nonprofits which the Air Force has endorsed and which the subcommittee does not plan to challenge.

It asserted that the Air Force has an "urgent . . . long-term and continuing need" for the "superior professional services" of Aerospace and Mitre. It thus rejected claims that Air Force in-house facilities and private contractors are now capable of taking on the specialized work performed by nonprofits.

Nor is industry "any better suited" to handle the job, the study group said. The group also termed "healthy" the Defense Department's conflict-of-interest ban that prohibits private firms which might act as systems planners and engineers from engaging in hardware development and production of the same systems. Without the ban, a private competitor having access to "inside" Air Force data and information could engage in unfair competition.

By the same token, this ban "complicates the likelihood that private industry ever will be able to assume" the jobs done by nonprofits, the study group concluded. But despite this rather sweeping assertion, Air Force Secretary Harold Brown said he will watch for changing conditions and consider alternatives to nonprofits as they arise.

Medical electronics

Monitoring the blood

A combination of electronics and fiber optics has solved one of medicine's most pressing problems: how to rapidly and accurately determine the oxygen saturation of blood in assessing and treating cardiac and pulmonary diseases.

Over the past four years, Optics Technology, Inc., in Palo Alto, Calif., has been working to develop an oximeter, an instrument that combines a fiber optics catheter and electronic comparator techniques to monitor blood oxygenation inside a living heart or other part of the body. Working with an assistant professor of medicine, Dr. Donald C. Harrison of Stanford University Medical School, Narinder S. Kapany, president of OTI, and a term of OTI physicists have successfully tested the instrument on humans.

The problem. Conventional methods for blood sampling require removing blood from the patient and waiting for the results of the analyses.

Oxygen saturation is the amount of blood hemoglobin that combines with oxygen to form an unstable compound called oxyhemoglobin. Hemoglobin is the iron-containing protein pigment in the red blood cells that transports oxygen throughout the body.

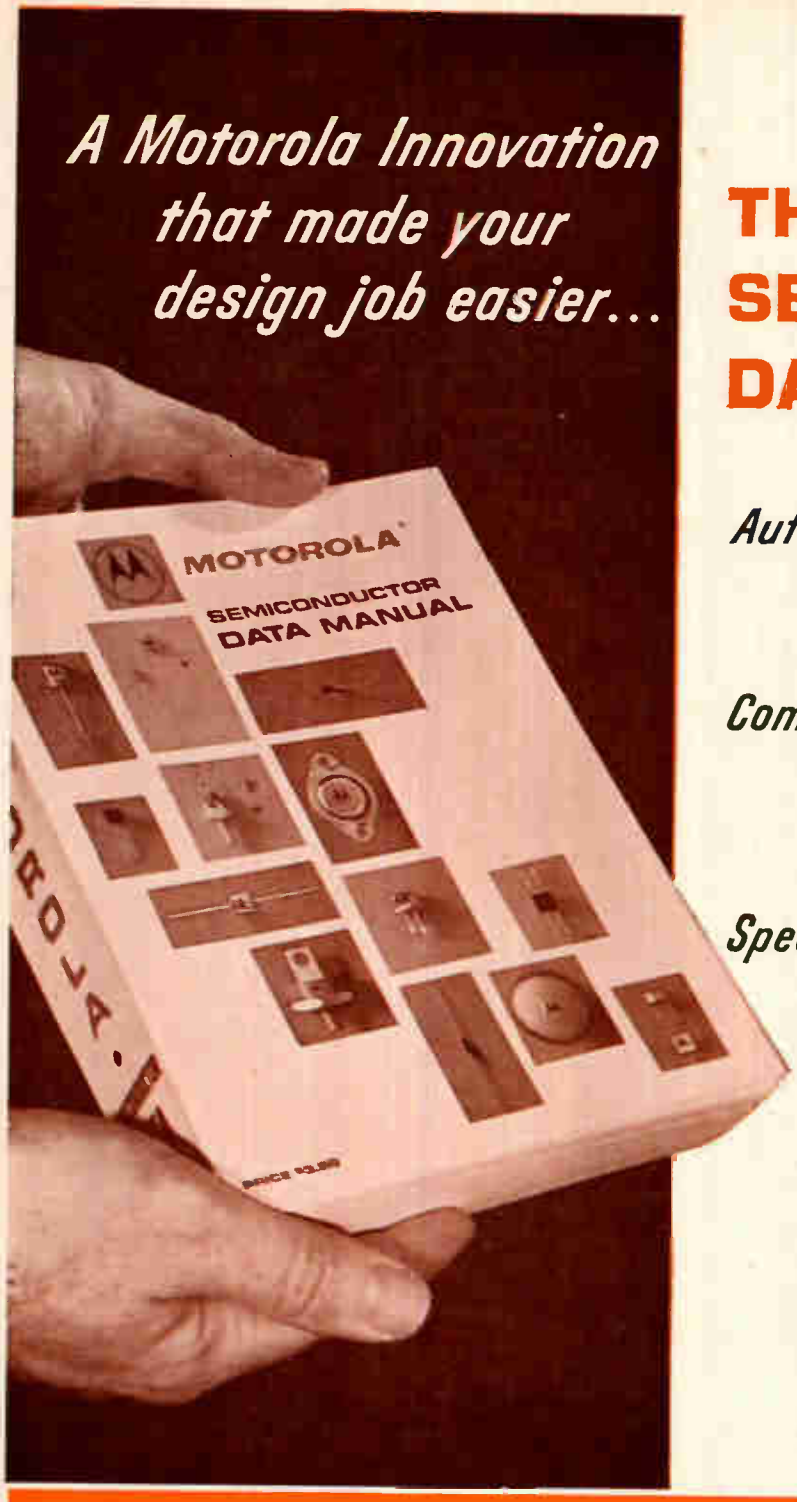
In blood oximetry, hemoglobin and oxyhemoglobin absorb light at two distinct wavelengths, 805 and 660 millimicrons. Because the absorption of light is markedly different at each wavelength, the ratio of absorption of the two wavelengths indicates how much of the blood hemoglobin is oxygenated.

When the OTI oximeter is used as a heart probe, three fiber optic bundles are incorporated into a standard cardiac catheter, typically 125 centimeters long and 0.23 centimeter in diameter. About 100 fiber bundles make up the three optical channels.

Into the heart. The doctor then snakes the thin catheter through a large blood vessel and into the beating heart. In the same way, the doctor can direct the catheter to any other organ that he wants to investigate. Once inside the organ, light from an outside source is directed through the bundle of fibers to the remote end of the catheter.

The light entering the blood is scattered by the red blood cells, illuminating an area about three millimeters in diameter around the tip of the catheter. The scattered light returning to the catheter tip is transmitted back outside the patient through the two remaining fiberoptics bundles.

Upon return, the two frequencies of the back-scattered light are con-



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Space electronics

New direction

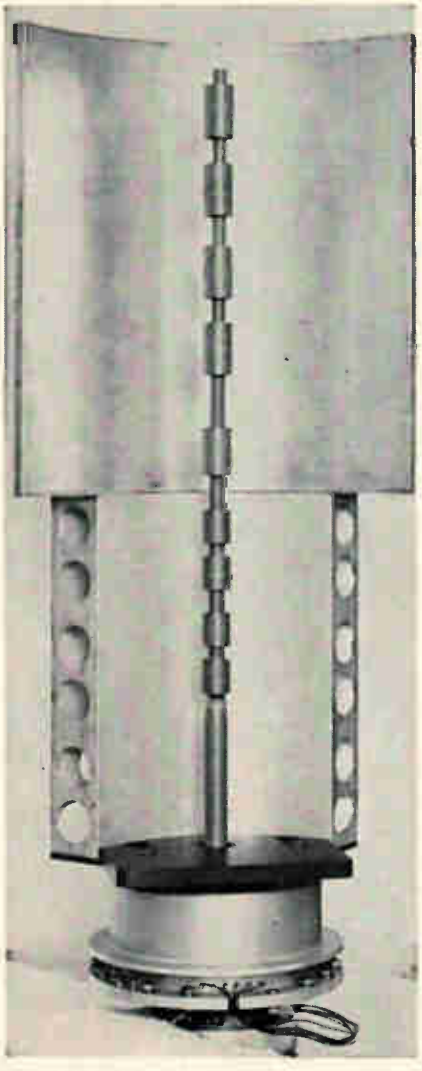
The current breed of communications satellites, from the Early Bird to the Blue Bird, uses a buckshot approach in beaming their radio signals to the earth: the signals radiate out like the ripples on a pond after a stone is dropped in the water. The result is that most of the signals are lost in space. Within the next one and one-half years, though, the approach will be more pointed: a new family of antennas is being developed that will aim a pencil-thin beam directly at the earth.

At two Washington meetings this month communications experts will learn more about the most promising techniques for aiming a narrow beam. The techniques involve despinning, or counter-spinning, an antenna.

Spin it. Obtaining a narrow, high-power beam isn't easy; complicating the designer's job is the prevailing method of stabilizing a communications satellite in orbit, which is to spin it like a top around one axis at about 100 revolutions per minute to keep it from tumbling. By spinning the antenna in the reverse direction, the effect is a beam that's always pointed at the earth.

The payoff is a big one. By beaming a stronger signal back to the ground, the satellite will be able to handle a great many more voice channels; also, a stronger signal means that a smaller, less complex ground station can listen in.

At the American Institute of Aeronautics and Astronautics' communications satellite conference this week, the electronically despun, phased array antenna design will be discussed by engineers from Sylvania Electric Products, Inc.'s Electronic Systems division. Sylvania, a General Telephone & Electronics Corp., subsidiary, is developing the antenna for the Communications Satellite Corp.'s global satellites. They are being built by TRW, Inc.'s Systems group for launching in 1968.



Antenna on the beam.

No moving parts. The despun antenna uses no moving parts to despin the beam. Phase control is used to steer a ring array of individual radiators spaced uniformly in a circle. A power divider and a phase control circuit divide the transmitter power equally to ferrite phase shifters, which, in turn, provide the desired phased modulation to despin the beam. Performance will be good, but the phase shifters and other control equipment are heavy, consume relatively large amounts of power and require many components.

The first electronically despun antenna will be flown in an Applications Technology Satellite (ATS-B) to be launched late this fall. The antenna was built by the Hughes Aircraft Co.

The first flight of the mechanically despun antenna will be on the third ATS launch in the fall of 1967. Sylvania engineers also are building this antenna and will describe it at the State Department's Earth Station Technology Seminar, beginning May 16 in Washington.

The mechanically despun antenna with its spinning radiator or deflector does not require as much weight or prime power as the electronically despun system, but its moving parts make it difficult to assure long life.

The ATS antenna will have a net gain of 17 decibels on both the satellite transmitting antenna (4 gigahertz) and receiving (6 Ghz). Beamwidth will be 20° in both frequency bands. The system will weigh 10 pounds and need only 9.5 watts.

The antenna beam is despun by counter-rotating the parabolic cylindrical reflector system. The larger 4-Ghz transmit system is mounted "piggyback" on the 6-Ghz array. The feed consists of two full-wave colinear dipoles.

For full earth coverage, Sylvania says the electronically despun antenna is better at medium and low altitudes. The mechanical unit has the advantage at higher altitudes—the crossover is at synchronous altitudes or about 19,400 nautical miles.

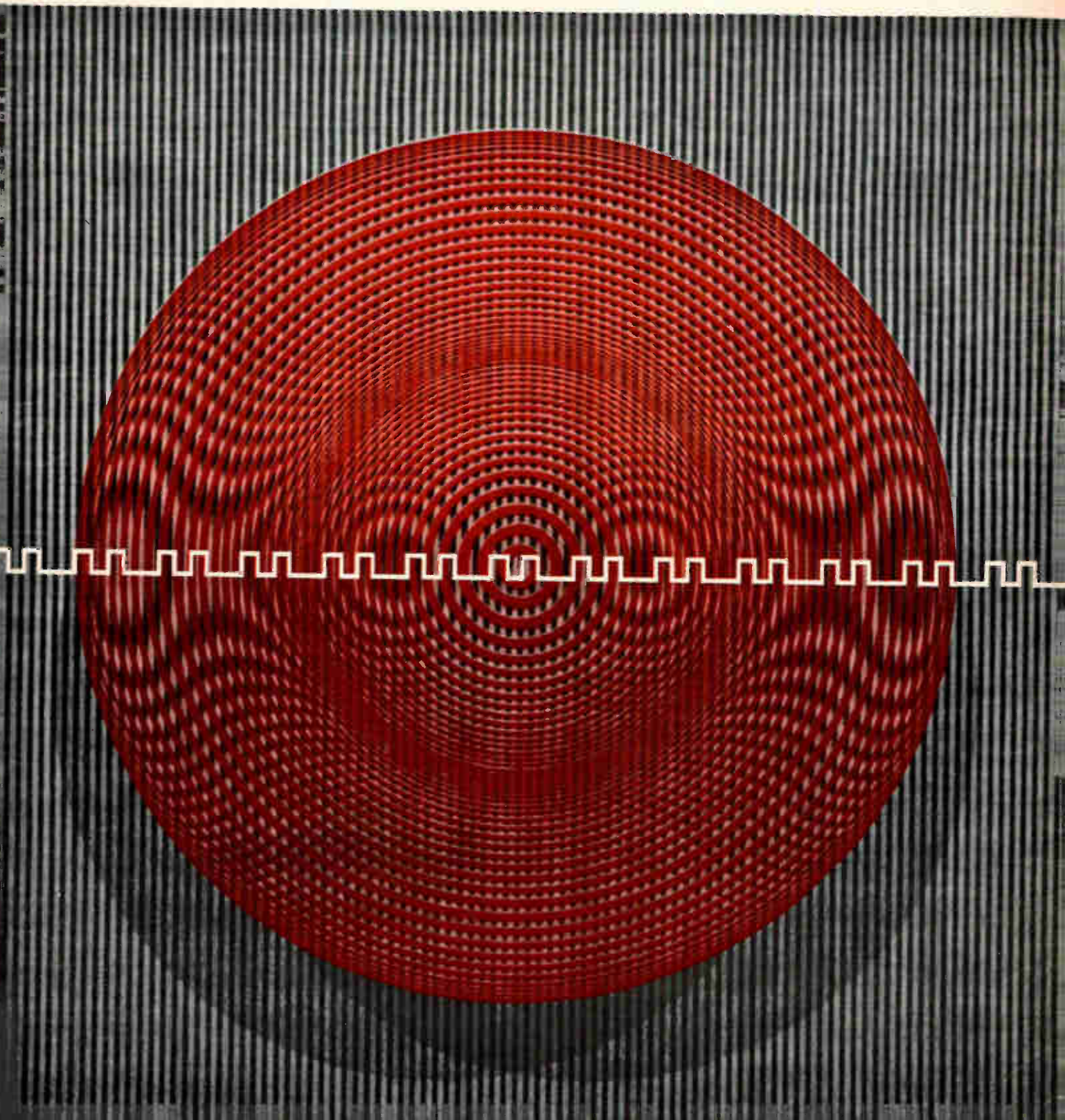
The electronically despun unit degrades gracefully in event of part failures while the mechanical unit is more apt to fail in a catastrophic manner. In case of failure, the electronic antenna can go to an omnidirection antenna pattern while the mechanical requires additional radio-frequency components to go to this mode. The choice between electronically and mechanically despun antennas depends on the particular requirements for a satellite system, Sylvania engineers say.

Creating optimum air/ground telecommunications systems requires: (1) Systems management capability in reliable airborne and ground-based telemetry equipment for all modes of operation—based on in-house hardware experience, and (2) Design and manufacturing capability at the highest state of the art to produce every component needed in air/ground telecommunications systems.

One company with all this experience is Vector.

Airborne Receivers • Analog-to-Digital Converters • Demodulators • Digital-to-Analog Converters • Discriminators • FM, PM and Beacon Transmitters • Format Converters • Frequency Multipliers • High- and Low-Level Subcarrier Oscillators • PAM and PDM Electronic Commutators • PAM/PDM Simulators • PCM Bit Synchronizers • PCM Multiplexers • PCM Simulators • Power Amplifiers • Power Supplies • Record and Playback Accessories • Signal Conditioners • Voltage Calibrators • Voltage Regulators

Vector DIVISION OF UNITED AIRCRAFT CORPORATION
SOUTHAMPTON, PENNSYLVANIA



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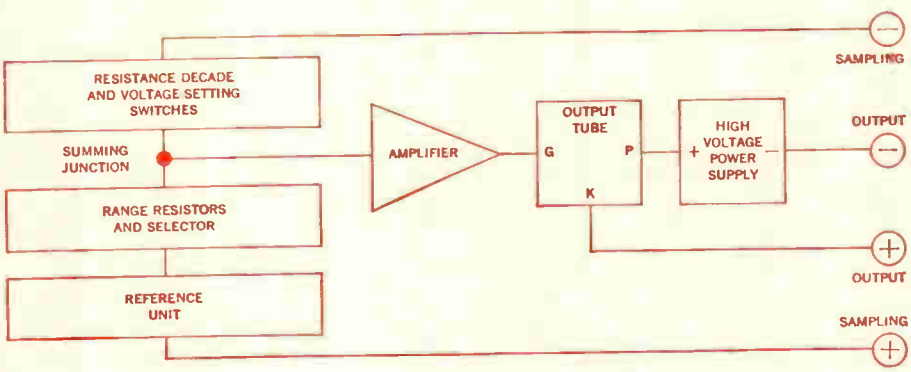

engineer's view:

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10 volt, 100 volt, 1000 volt ranges

10-μv, 100-μv, 1-mv steps

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0.0025% voltage output stability/8 hours

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Washington Newsletter

May 2, 1966

Congress again tries to guide defense spending . . .

Congress is beginning its annual effort to force Defense Secretary Robert S. McNamara to begin production of the Nike X antimissile system, to order development of a new long-range strategic bomber and to open a production line for a new air-defense interceptor. The battle will make a lot of headlines in the next few months, **but chances are McNamara won't move from his position on these weapons.** Congress may well wind up voting extra money for these projects, but it can't force McNamara to spend it.

The Senate Armed Services Committee, authorizing the expenditure of $17 billion in weapons procurement for fiscal 1967, starting July 1, **added $153 million to the bill for procurement of long lead-time items as a first step toward production of Nike X.** The committee was impressed by intelligence reports that Russia plans to begin deploying an antimissile system within a year or two and by the unanimous recommendation of the Joint Chiefs of Staff that the United States put its own system into operation.

Pentagon officials differ in their assessment of the intelligence reports. McNamara has held up production of Nike X in view of "all the uncertainties involved, including the nature and consequences of the Soviet reaction, the technical problems yet to be solved and the great cost involved."

McNamara leans toward eventual deployment of a simple version of Nike X to cope with the possibility of China's development of a crude intercontinental missile in the mid-1970's. He doubts that the Nike X could offer enough defense, when measured against its high cost, to warrant deployment against an attack by sophisticated Soviet missiles.

The Senate group also added $55 million to the Administration bill to allow the Air Force to open a production line for the F-12 interceptor. **But again McNamara wants to hold off on production.** He acknowledges that the plane would add greatly to antibomber defenses. But it isn't needed, he feels, unless Russia increases its bomber threat.

. . . raps McNamara on bombers

Meanwhile, a subcommittee of the House Armed Services Committee **is taking McNamara to task for his decision to phase out the remaining B-58 bombers and older model B-52's** and to replace them with a long-range bomber version of the F-111 fighter bomber, to be called the B-111.

The subcommittee believes the B-111 is an inadequate substitute for the older B-52's but approved it as a stopgap. **It recommended, however, that McNamara reverse his plan to phase out the B-58 and suggested that the full Armed Services Committee vote an extra $12 million for design of a totally new B-52 replacement.**

McNamara has permitted the Air Force to carry on conceptual studies for a new bomber and has approved work on advanced engines and avionics. While not closing the door to eventual development of the plane, he has strong doubts about the need for it.

The extra $12 million would be enough to start contract definition, which would be a tentative commitment to development and follow-on production.

Washington Newsletter

LBJ decides: MOL will lift off on the West Coast

President Johnson resolved a political squabble over whether launchings of the manned orbital laboratories (MOL) will be from the East or West Coasts. Florida congressmen had bridled at Air Force plans to launch the MOL from Vandenberg Air Force Base in California rather than Florida's Cape Kennedy. **Johnson sided with the Air Force.**

In a letter to a Florida newspaper publisher, Johnson said use of the Western Test Range was necessary to achieve a polar orbit without land overflights or a dog-leg maneuver that would reduce the payload. **He added assurances that Cape Kennedy would continue to be used to "maximum advantage" in the space program.**

This said, the political storm subsided.

Mobile radio study reorganized

The Federal Communications Commission's advisory committee for land mobile radio service is intensifying its study of advanced techniques in its effort to ease the problem of channel crowding. A new working group, headed by Jona Cohn of Motorola, Inc., was given an assignment to study such areas as multiple access, digital and broadband systems, increased use of cooperative base stations and possible expansion of the use of multiplexed transmitting facilities.

The Cohn group is one of six new committees formed by the advisory unit. **The reorganization of the study puts off any possible recommendations until at least 1967.**

Pentagon 'savings' to be assessed

The Special Investigations subcommittee of the House Armed Services Committee is looking into Defense Secretary McNamara's cost reduction program. Agents of the General Accounting Office (GAO) are assisting.

The subcommittee wants to determine the extent, if any, to which savings claimed by the Pentagon have been exaggerated. McNamara asserts that the Defense Department is spending $4.8 billion less a year than it otherwise would have if the cost reduction program had not begun when he took over in 1961.

McNamara tried to get the GAO, an arm of Congress, to audit the savings program when he first established it, but the GAO refused, so he set up his own group of auditors to validate the savings claims.

FAA lukewarm on televising radar to pilots

The Federal Aviation Agency is likely to tune out television in the cockpit, despite generally favorable pilot reactions to a live test last year [Electronics, Nov. 29, 1965, p. 44]. In the test, an image of the airport surveillance radar at Boston's Logan International Airport was broadcast by an educational tv station and received on 4-inch and 5-inch sets between seats in the cockpit. Fourteen pilots—including FAA men experienced in reading radar, professional pilots and amateur fliers—tried the system—all said they favored tv radar. Eleven of them, including radar beginners, said they found it easy to identify their own blip even on the small screen. **But FAA safety pilots, who rode alongside the 14, reported that the pilots spent about half the time watching the screen instead of scanning the sky. The safety pilots said the system could turn out to be a hazard for pilots flying on visual flight rules without a copilot.**

Other factors weighing against wide-scale adoption are cost and tv channel space, even though radar images conceivably could be broadcast in a band smaller than required for conventional tv.

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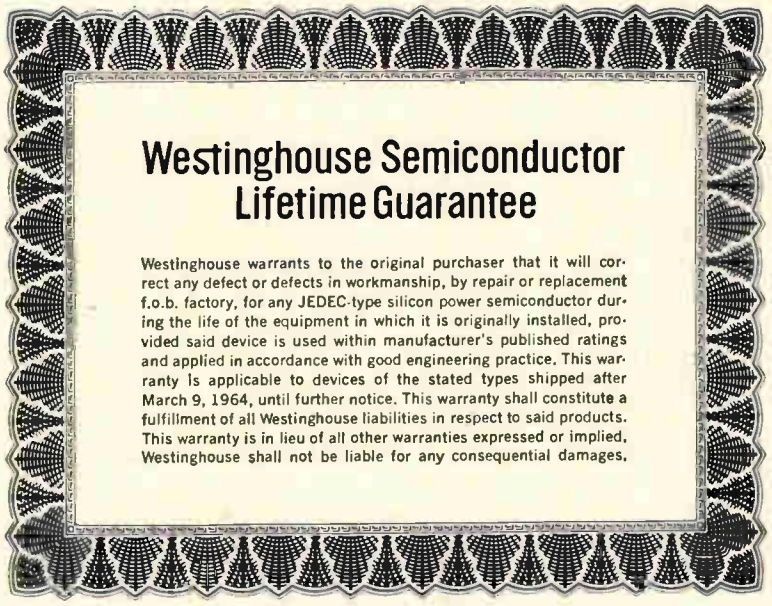

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First off-the-shelf DTL in dual in-line pack Made for low-cost manual or machine insertion. Operating temperature +15°C to +55°C.

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Optimum power, speed, and noise immunity
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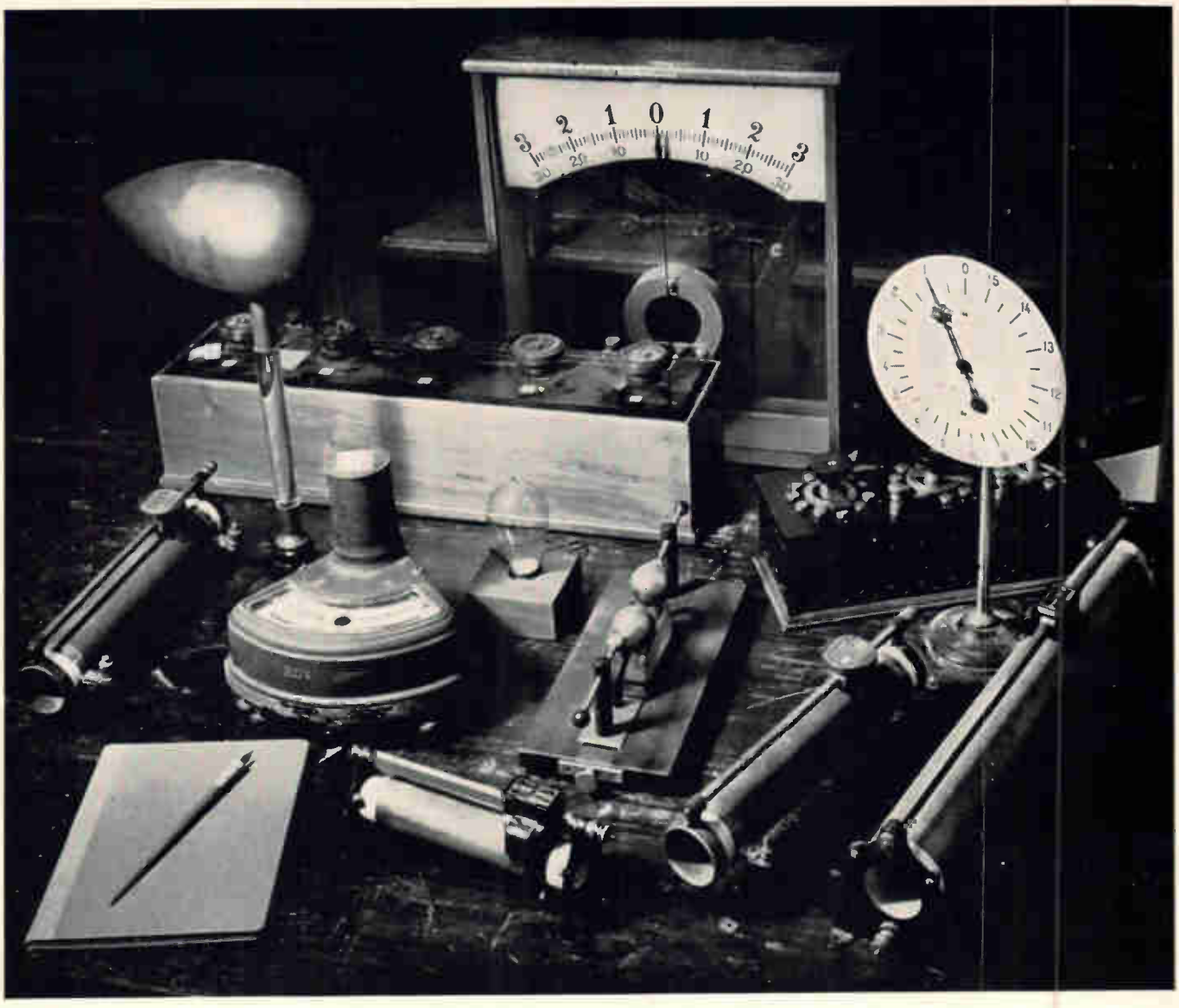

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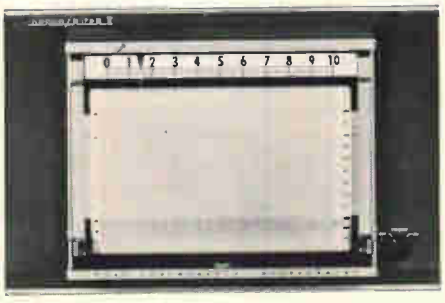

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New Micro-miniature G/M Analog Voltage Multiplier as small as 0.1 cubic inch, weighing as little as 0.1 ounce.

MONOLITHIC MICRO CIRCUIT BLOCK for analog voltage multiplying of D.C. and A.C. voltages.

ADDITION, SUBTRACTION, MULTIPLICATION, DIVISION AND EXTRACTING A ROOT of many voltage variables may be handled by one G/M Magnetic Microblock.

PRODUCT ACCURACY of up to 0.2% of full scale, with very slight derating over a wide temperature range.

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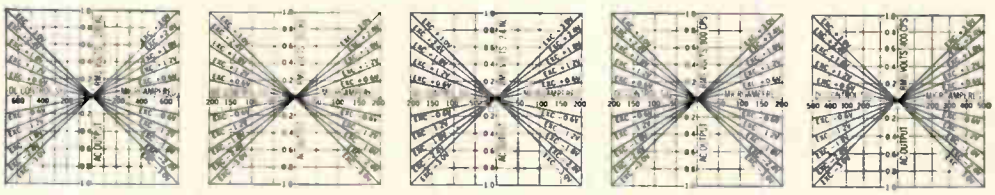

TYPE NUMBER	MCM-827-2	MCM-836-1	MCM-845-1	MCM-847-1	MCM-848-1
Accuracy (% Error of Theoretical Prod.)	1% Maximum	Approx. 0.5%	Less than 1%	2% Maximum	5%
Input Control Signal Range	0 to ± 800 μa (DC to 5,000 cps)	0 to ± 200 μa (DC to 200 cps)	0 to ± 200 μa (DC to 100 cps)	0 to ± 200 μa (0 to 50 cps)	0 to ±500 μa DC (DC to 40 cps)
DC Resistance of Input Signal Range	500 ohms	12.5 K ohms	12.5 K ohms	12.5 K ohms	70 K ohms
Input AC Sig. Range Amplitude, Freq.	0.6 V to 3 V RMS Phase Rev. 100 KC	0 to 3 V RMS Phase Rev. 3200 cps	0 to 3 V RMS Phase Rev. 2400 cps	0 to 3 V RMS Phase Rev. 800 cps	0 to 3 V RMS Phase Rev. 400 cps
AC Output Product Range	0 to 1 V RMS @ 100KC	0 to 1 V RMS @ 3.2 KC	0 to 1 V RMS @ 2.4 KC	0 to 1 V RMS @ 800 CPS	0 to 1 V RMS @ 400 CPS
Null at Max. AC Signal, Zero DC Sig.	15 mv RMS	10 mv RMS Max.	10 mv RMS Max.	10 mv RMS Max.	5 mv RMS Max.
Output Impedance	650 ohms	13 K ohms	12 K ohms	8 to 10 K ohms	15 K ohms
External Load	10K to 100 K ohms	50 K ohms	50 K ohms	50 K ohms	50 K ohms
Temperature Range	−55°C to +85°C	−55°C to +100°C	−55°C to +100°C	−55°C to +100°C	−55°C to +100°C
Null Drift over Temp. Range	0.1% of f.s.	0.1%	0.1%	0.1%	0.2%
Accuracy Variation over Temp. Range	±0.5%	±0.2%	±0.2%	±0.2%	1%
Hysteresis in % of Max. Input DC Sig.	0.1%	0.1%	0.1%	0.1%	0.25%
% Harmonic Dist. in Output Prod. Wave	Less than 5%	3%	3% to 5%	5% Maximum	5%
Overall Dimensions (in Inches)	$\frac{5}{8}$ x $\frac{25}{32}$ x $\frac{1}{2}$	$\frac{37}{64}$ x $\frac{25}{32}$ x $\frac{1}{2}$	$\frac{37}{64}$ x $\frac{25}{32}$ x $\frac{1}{2}$	$\frac{37}{64}$ x $\frac{25}{32}$ x $\frac{1}{2}$	$\frac{37}{64}$ x $\frac{25}{32}$ x $\frac{1}{2}$
Approximate Weight (in Ounces)	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.

The Circuit and Fundamental Principles of G/M Magnetic Multipliers are covered by U.S. Patent No. 2758162

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These dependable instruments are widely employed in flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas and thousands of control systems. Micro-circuit, miniature, subminiature, standard and specials available; request literature. Customized engineering, when required, performed on a no-charge basis.

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Circle 51 on reader service card

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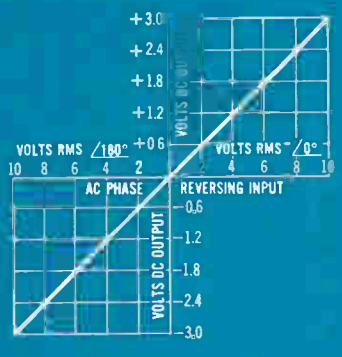

Amplitude Response Curve

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Illustrated literature and technical data will be sent promptly on request.

HIGH RELIABILITY PLUS! The new G/M Magnetic Demodulator is a solid state circuit for converting phase reversing AC signal voltages into phase detected polarity reversing DC voltages. The amplitude and polarity of the DC output are directly proportional to the phase and amplitude of the AC signal.

FEATURES

- High Reference Impedance Resulting in Very Small Reference Power Requirements
- Output as High as ± 10 V. DC in Present Units
- Very Low DC Offset Null Voltages (As low as 0.1% of full scale)
- Operation Over Wide Environmental Conditions
- Completely Solid State — No Moving Parts
- Signal and Reference Terminals may be Isolated
- Low Output Impedance
- Small Physical Size

SPECIFICATIONS DMD 1017-1 (TYPICAL UNIT)

TEMPERATURE RANGE	−55° C to +71° C
REFERENCE	115 V. — 400 CPS
REFERENCE IMPEDANCE LEVEL	>100 K
SIGNAL	0 to 10 V. RMS
SIGNAL IMPEDANCE LEVEL	>10 K
OUTPUT IMPEDANCE	<1 K
OUTPUT	±3 V. DC ±5% to a 2 K LOAD
FREQUENCY RESPONSE	40 CPS
NULL	<2 MV
DC POWER	28 V

The new solid state demodulators feature contactless switching for high vibration and shock resistance. Stability of performance and ruggedized construction mean they are the ideal solution to problems inherent in today's critical applications.

Other G/M Components

Also available is a complete line of magnetic modulators, magnetic multiplying modulators, high stability oscillators and relays. Order by bulletin numbers MM 101 Series Micro Magnetic Modulators, MM 102 Miniaturized Magnetic Modulators, MM 103 Standard Magnetic Modulators, MM 104 Miniaturized Multiplying Modulators, MM 105 Miniaturized High-stability Oscillators, MM 106 Micro Magnetic Multiplying Modulators, MM 107 Magnetic Relays.

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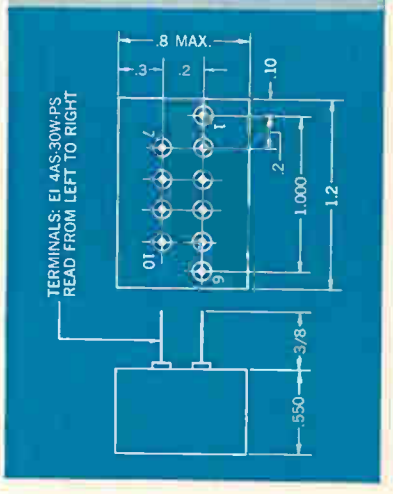
General Magnetics'

Micro-Miniature Solid State Magnetic Division Modules — ACCURACY OF 1% OR BETTER

NEW DESIGN CONCEPT—G/M Analog Division Modules employ a new concept which does away with high gain operational amplifiers and logarithmic circuitry previously used in electronic dividers. Elimination of these amplifiers means fewer components resulting in higher reliability, excellent stability, micro-miniature size and lower cost. The combination of magnetic and semiconductor circuitry results in analog division with accuracies of 1% or better over wide environmental ranges. The output is an AC sinusoidal signal which is the quotient of an AC numerator and a DC denominator.

These modules can be engineered to meet your most exacting requirements. Small physical size makes the new modules ideally suited for printed circuit use. If your problem is linear division, trig function conversion, automatic gain control combined with micro-miniature size, G/M Division Modules will solve it!

These new modules provide the quotient of two signals; an AC numerator of variable magnitude and phase, and a variable DC denominator.



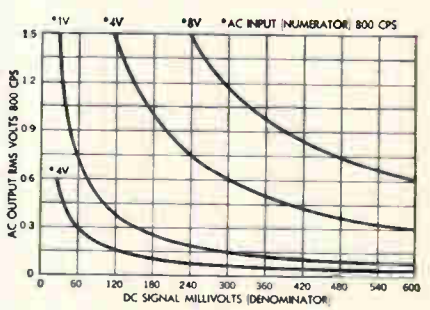
FEATURES

- Micro-miniature Size — Completely Solid State
- 1% Accuracy
- Low Power Consumption
- No Operational Amplifiers
- Wide Numerator and Denominator Ranges
- Isolated Inputs
- Low Output Impedance
- Operation Over Wide Environmental Ranges

SPECIFICATIONS—TYPE MDM 889-1*

EXCITATION (NUMERATOR):	0.4 V. to 8 V. @ 800 CPS
BIAS	+30 V. DC
OUTPUT LOAD	5 K
SIGNAL (DENOMINATOR)	30 MV to 600 MV
AMBIENT TEMPERATURE RANGE	0°C to +70°C

*Above specifications apply only to MDM 889-1 and may be changed to fit your exact requirements.



For Proven Reliability in Solid State Module Applications

These dependable instruments are widely employed in flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas and thousands of control systems. Micro-circuit, miniature, subminiature, standard and specials are available. The circuit and fundamental principles of G/M Magnetic Modulators, Multipliers and Division Modules are covered by U. S. Patent No. 2758162; additional patent pending.

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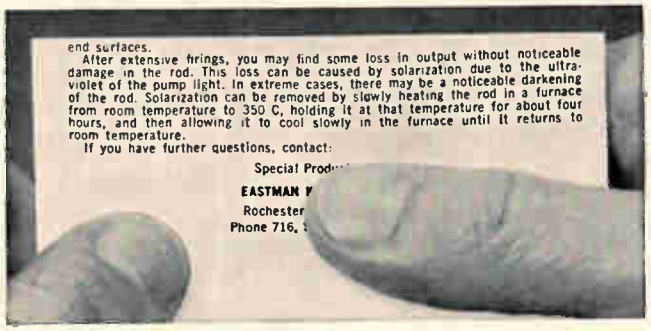
Kodak advertises laser glass that needn't return to the furnace

KODAK Laser Glass is famous for stupendous infrared pulses. That's because of the huge configurations in which we can put the mighty neodymium ion. As size goes up, so does the energy output per dollar. Since glass is amorphous, the output is unpolarized. The quality of this particular glass and of the optical workmanship we are prepared to put on it leads us to impressive undertakings in low beam divergence when the talk gets down to business. As for availability, on the shorter lengths of Nd-doped silicate glass we operate as close to immediate delivery as fast-moving paperwork will allow. This leaves us the time needed to work on the really big rods.

Note the following statement on the little slip we have been sending out with each rod:

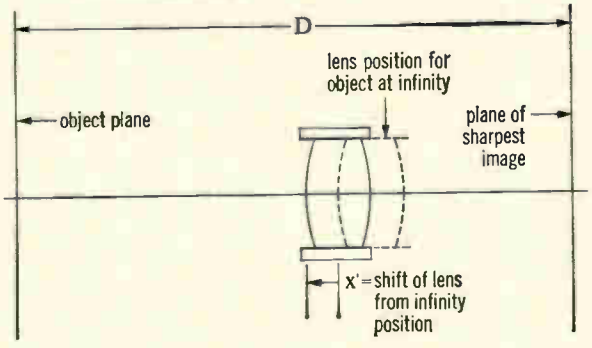


That statement now gets dropped. We have found a way to cut out the solarization without trading off anything in return.

Data and quotations from Eastman Kodak Company, Special Products, Apparatus and Optical Division, Rochester, N.Y. 14650 (phone 716-325-2000, ext. 5166).

Kodak advertises tables for setting lenses by

Very few of the facts and principles that readers of this magazine are paid to know had yet been dreamt of when the optical formulas that relate lens distances to focal lengths had already been understood for a century. This makes it all the more annoying when an electronics man gets himself in the ridiculous position of devoting the better part of a day to trial and error or a search through old textbooks to find out how to calculate x' in the following common problem:



We have put together a book of computer printout of x' for values of D from 500 feet to 3 inches and focal lengths from 5 millimeters to 18 inches. At $10 a copy we have sold a surprising number of these books to those whose own time is worth more. Orders are still being accepted by Publications Service, Eastman Kodak Company, Rochester, N.Y. 14650.

Price subject to change without notice.

Kodak advises those responsible for turning out important oscillograms

An unequivocal record of fact had better look the part. If you have been trying to get along without a KODAK EKTALINE Processor, give up and get one. Have your oscillographs loaded with KODAK EKTALINE 1729 Paper. That's a new paper. If you don't know about it, your contact has not been as close as it should be with Eastman Kodak Company, Instrumentation Products, Rochester, N.Y. 14650. The phone number is 716-325-2000, ext. 3257.

When this new paper is run through the EKTALINE Processor at 100 ft/min, you get a record that looks as clean and crisp as oscillograms were expected to look before the fad for traces that "pop up" without processing.

There *are* times when you want the image to appear without processing?

We were waiting for you to say that.

The point about this paper is that you can use it that way, too. Any time you wish.

After 130,000,000 diodes

1-amp glass rectifiers come easy

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For remote indication of resolver or synchro transmitters in system testing, North Atlantic's Angle Position Indicators (Figure 1) provide the advantages of low cost and continuous counter or pointer readout. These high-performance instrument servos are accurate to 4 minutes of arc, with 30 arc seconds repeatability and 25°/second slew speed. Dual-mode capability, multi-speed inputs, integral retransmit components and other optional features are available to match application needs. Priced from $895.

Figure 1. Angle Position Indicators are available in half-rack, quarter-rack and 3-inch round servo packages.

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Measuring receiver and transmitter performance to state-of-art accuracy is readily accomplished with North Atlantic's Resolver/Synchro Simulators and Bridges (Figure 2). Each of these dual-mode instruments tests both resolvers and synchros, and provides direct in-line readout of shaft angle, accurate to 2 arc seconds. Simulators supply switch-selected line-line voltages from 11.8 to 115 volts from either 26 or 115 volts excitation, and so can be used to test any standard receivers. Bridges have constant null voltage gradients, making them ideally suited for rapid deviation measurements. Simulators and Bridges each occupy only 3½ inches of panel height and are available in a choice of resolutions. They are priced in the $1500 to $3000 range.

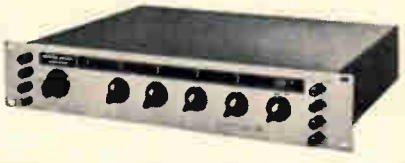

Figure 2. Resolver/Synchro Simulator provides ideal source for receiver testing.

Automatic Measurement And Conversion

Where systems require continuous or on-command conversion of resolver or synchro angles to digits, North Atlantic's Automatic Angle Position Indicators (Figure 3) handle the job without motors, gears or relays. These solid-state automatic bridges accommodate all standard line-to-line voltages and provide both Nixie display and printer output, accurate to 0.01° and with less than 1 second update time. Many variations, including 10 arc second accuracy; binary, BCD or decimal outputs; multiplexed channels and multispeed operation, are available for specific requirements. Ballpark price: $5900.

Figure 3. Model 5450 Automatic Angle Position Indicator. It measures shaft angles, converts them to digital data.

Measuring Electrical Characteristics

Combine a Resolver/Synchro Bridge and a Simulator with a North Atlantic Ratio Box, a Phase Angle Voltmeter and a test selection panel and you have an integrated test facility for determining all electrical characteristics of resolvers and synchros in component production or Quality Control. An example is the North Atlantic Resolver/Synchro Test Console shown in Figure 4. It measures phasing, electrical zero, total and fundamental nulls, phase shift and input current, as well as angular accuracy. Standard North Atlantic instruments are used as modules, making it a simple matter to fill the exact need. The unit shown sells for about $7500.

Figure 4. Model RTS-573 Test Console is a complete facility for the production line or in quality control.

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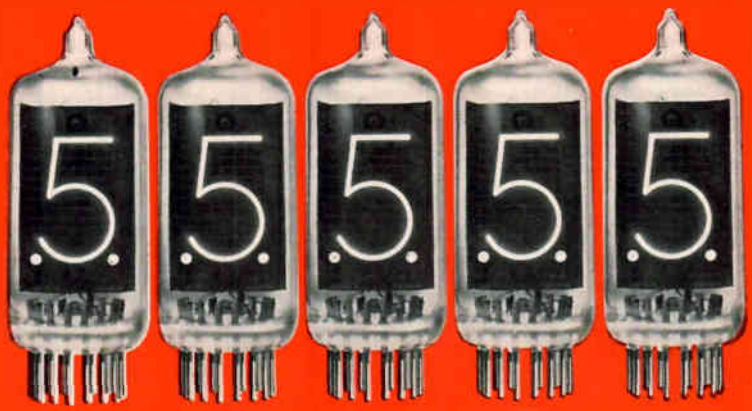

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Technical Articles

Dial any channel to 500 Mhz: **page 60**

A new frequency synthesizer, built of integrated circuits, has been digitized so it can select any of 3,500 channels in the military uhf band without tuning. By digitizing, the designers have eliminated electromechanical components.

Automatic diagnosis of engine ailments: **page 70**

By adapting techniques of biomedical research, Army engineers have produced a system that automatically checks a tank engine. A computer analyzes vibration patterns to warn of impending malfunctions. Automatic diagnosis is made possible by the development of a digital summing instrument that relates engine malfunctions to electrical vibration signals.

Special report—Communications satellites: **page 83**

The use of satellites for global communications is one of the most important technical developments of the twentieth century. For the cover, Art Dubinsky photographed a cutaway of the communications satellite TRW, Inc. is developing to be put into a synchronous orbit in 1968 as part of the Communication Satellite Corp.'s global network. The satellite can handle 1,200 two-way voice channels. On its top, looking like a chimney, is an antenna which is despun electronically.

1. Communications satellites: 1966 and beyond
2. Military's satellites will ring the earth
3. For a pilot over the ocean, a satellite link to home
4. Satellites to be airliners' traffic cop

Coming May 16

- **Firsthand report: How electronics perform in Vietnam**
- **Integrated circuits in an f-m receiver**
- **Transmission by optical waveguide**

Dial any channel to 500 Mhz

Monolithic integrated circuits program frequency synthesizers to select any of 3,500 channels in military uhf band without tuning, while reducing the size of the synthesizers and number of components in them

By Leon F. Blachowicz

Electronic Communications, Inc., St. Petersburg, Fla.

Frequencies up to 500 Megahertz (megacycles per second) are generated by a new breed of frequency synthesizers for ultra-high-frequency communications systems. A divider built with monolithic integrated circuits counts out the selected frequency. Any one of 3,500 frequencies can be programed in the divider.

Two voltage-controlled oscillators generate all the frequencies. The vco employed depends on the frequency selected. The vco output is controlled precisely by the digital circuitry, which compares the vco output with the desired frequency and generates the vco-control signal.

The combination of digital circuitry and traditional analog techniques eliminates electromechanical components and makes tuning and operating adjustments automatic. The synthesizer's output frequencies are all coherent with a single low frequency crystal reference.

As the key element in many communication systems, see the diagram at the top of page 61, frequency synthesizers provide any number of possible output frequencies with crystal stability and spectral purity. The requirements of modern military communication systems require that these synthesizers use no mixers or frequency multipliers which would otherwise result in spurious output frequencies and require tuned circuits. For use in uhf communications, the synthesizers should have a frequency range extending from 225 to 399.95 Mhz with channels every 50 khz. In addition, airborne units must make maximum use of integrated circuits to be as small as possible.

Until recently synthesizers were bulky and used a large number of electromechanical and mechanical components. The output frequencies were usually developed by combining the various harmonics of a single reference and, even with careful design, generated spurious frequencies close to the desired signal.

The frequency synthesizer developed by Electronic Communications, Inc., and for which patents are pending, uses the latest digital r-f and control techniques and provides 3,500 channels in the military uhf band. Future units promise about an order of magnitude size reduction—to approximately 10 cubic inches. In transceiver applications, the synthesizer provides a fixed difference between the transmitter and receiver frequencies—automatic frequency offset. The synthesizer, with very few component changes, could operate over any frequency band from 30 to 500 Mhz.

In the simplified diagram at the right of a digital synthesizer, the output frequency, f_0, of a voltage-controlled oscillator (vco) is divided by a fixed integer M and a variable integer N, resulting in a frequency f_0/MN at the input to the phase detector. The factor M is introduced by a prescaler circuit. This step is necessary to reduce the vco's output frequency enough to enable operation of the programed divider with integrated circuits. As advances in technology permit logic speeds compatible with the frequency of the vco, M will approach unity.

A reference frequency f_r, derived from a stable crystal oscillator, is used as the phase detector reference input. The detector's output is amplified,

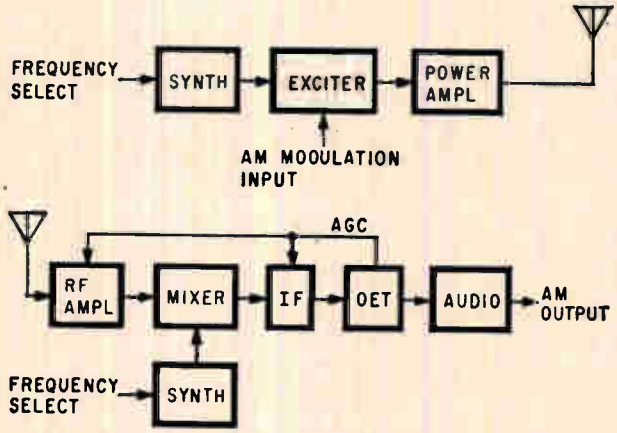
The author

Leon Blachowicz has been designing digital communications systems since 1960. He is now developing coherent phase-modulation techniques for high-speed microelectronic digital communication equipment.

filtered and used to control the vco, resulting in a phase-locked loop. When locked, the loop controls f_o so that $f_o/MN = f_r$, or $f_o = MNf_r$. If the quantity Mf_r is equal to the required output channel spacing, then the values of N may be selected to provide the required output frequency range. Binary logic signals control the division ratio, N, and may be derived from frequency selector switches. A coarse tuning system is provided to ensure that the vco's frequency is always within the acquisition range of the phase-locked loop.

Since no mixers or multipliers are used in the loop and the r-f output is taken directly from the vco, spurious output frequency components are minimized. The only tuned circuit in the synthesizer is the LC varactor resonator in the voltage-controlled oscillator.

This technique has additional advantages over other methods. For instance, the use of binary programing permits rapid and accurate frequency selection along with offset and preset channel storage. And, digital circuits made with monolithic integrated circuits result in lower cost and higher reliability.



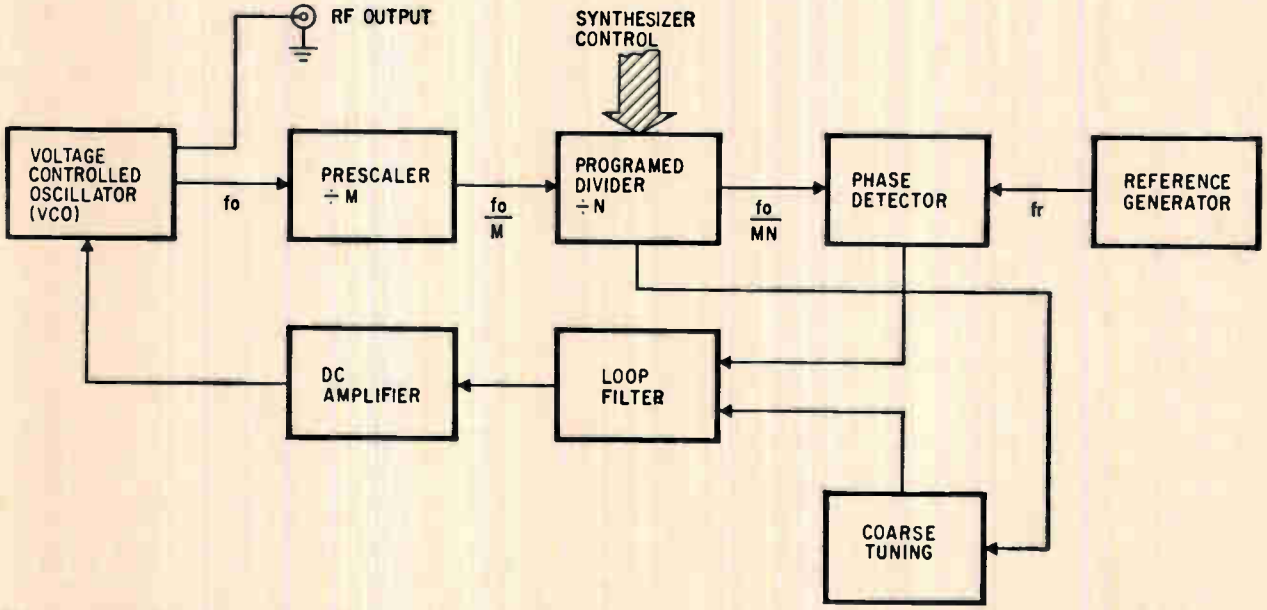
As the key element in many communications systems, a frequency synthesizer generates the basic frequencies needed in transmitters and receivers. Application in a typical amplitude-modulated receiver is shown.

Synthesizing ultrahigh frequencies

The functional block diagram of the uhf synthesizer developed is shown on page 63. Varactor-controlled tuned circuits and transistor r-f amplifiers produce vco's capable of being tuned from ap-approximately 190 to 400 Mhz. This synthesizer is used in a transceiver application. Therefore, even though the operating frequencies of the equipment range from 225 to 399.95 Mhz, the synthesizer must supply the receiver with a signal frequency offset by the first intermediate-frequency—30 Mhz. For receiving, the synthesizer tunes from 195 to 369.95 Mhz and for transmitting, it tunes over the frequency range of 225 to 399.95 Mhz.

The r-f amplifiers provide buffering for the vco's along with the main r-f output and the prescaler input signals. The prescaler (÷ M), provides a frequency division of 25:1 so that the maximum frequency at the programed divider input is approximately 16 Mhz.

The programed divider (÷ N), essentially a chain of programable counters, is constructed entirely with monolithic digital circuits. The division ratio N ranges from 3,900 to 7,999, and is programed by generating binary logic levels with frequency selector switches and applying these levels to the frequency control lines. The range of N corresponds to the output frequency range of 195 to 399.95 Mhz. When the transceiver is set to the receive mode, automatic i-f offset logic performs a full subtraction of 30 Mhz from the number programed with binary



Programed divider determines the desired output frequency by controlling the oscillator voltage level. The phase of divider's output is compared with that of a reference frequency in a phase detector and the error signal adjusts the voltage-controlled oscillator. The prescaler reduces the vco frequency so that the divider can be built of integrated circuits. Coarse tuning brings vco into loop's acquisition range.

Commonly used synthesis techniques

Frequency synthesis techniques may be divided into two broad categories—direct and indirect.

In the direct method, the output frequency is synthesized by combining various harmonics of a single reference standard and converting frequencies by mixing. This requires complex filters to eliminate the low-level spurious frequencies that are generated close to the desired signal. In the indirect method, the output is derived from an oscillator, which phase or frequency, or both, is controlled by comparison with a reference standard. In both methods, the long-term stability equals that of the reference.[1]

The diagram below and B show two variations of the direct method while diagrams C and D show indirect methods. However, the direct method becomes indirect if a phase-locked loop is used to remove spurious components from the desired output signal. The descriptions that follow do not differentiate those techniques in which the reference is a frequency standard, and those in which the reference is another synthesizer operating at lower frequency.

The first method directly synthesizes a given frequency by adding harmonics and subharmonics of the reference standard. The first nine harmonics of the reference are generated and made available on a set of crossbar switches.

The switches are set to correspond to each of the digits of the harmonic with the correct integer value. For example, if 6.82 Megahertz is to be generated, the synthesis begins with the least-significant digit, 2. The second, or 2-Mhz harmonic is selected from the crossbar. This harmonic is filtered, divided by 10, and added, by a process of mixing, to the second least significant digit, 8. The sum is filtered, divided by 10, and added to 6, the most significant digit, to yield 6.82 Mhz.

This technique can generate frequencies in arbitrarily small increments, because each selector switch, mixer, filter and divider increases the resolution ten times. However, the method is useless at frequencies in which wideband decade dividers are unavailable.

In the direct technique of diagram B, the output of a low frequency synthesizer is multiplied directly to a desired frequency. However, a wideband multiplier with low spurious output is necessary. Normally, the maximum multiplier bandwidth is approximately 10%, making multiplication by high order prime numbers difficult.

Other multiplier type synthesizers such as periodically phase-controlled oscillators (PPCO)[2] and specially-constructed traveling-wave devices are feasible, but do not provide spectrally pure outputs.

In the indirect synthesis method of diagram C, the frequency difference between a harmonic of the reference and the output of a voltage-controlled oscillator (vco) is compared with a desired difference frequency generated by a lower-frequency synthesizer.

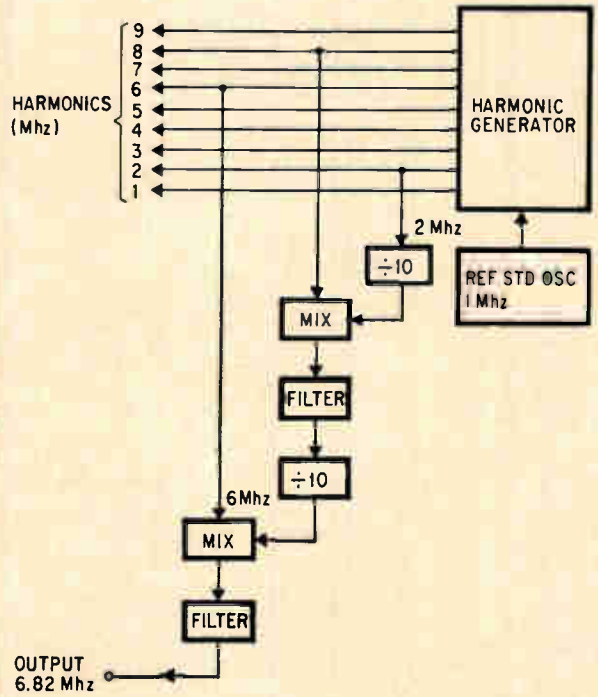
To get 6.82 Mhz, first the vco's output is mixed with the sixth harmonic of the reference standard. The difference in frequency is then compared with a desired frequency of 6.82 Mhz. From this comparison, an error voltage is generated which drives the vco to the correct frequency.

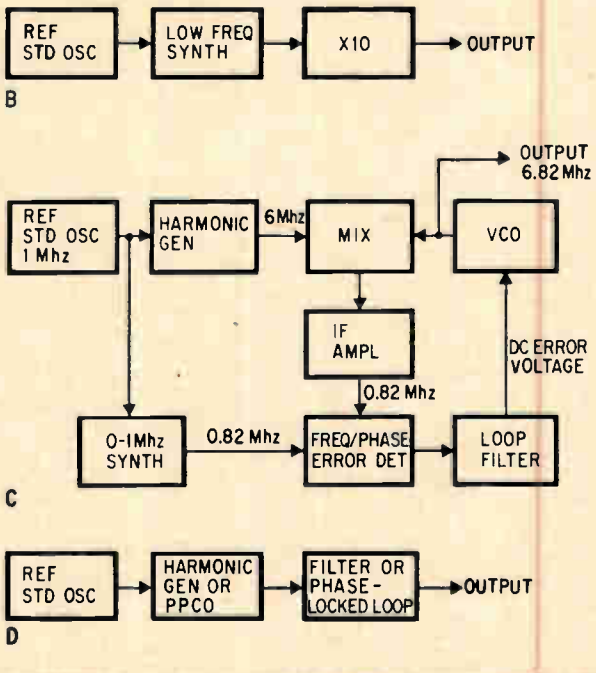
This method requires no wideband dividers or multipliers that would limit the maximum usable frequency. Also, the number of filters needed is minimum.

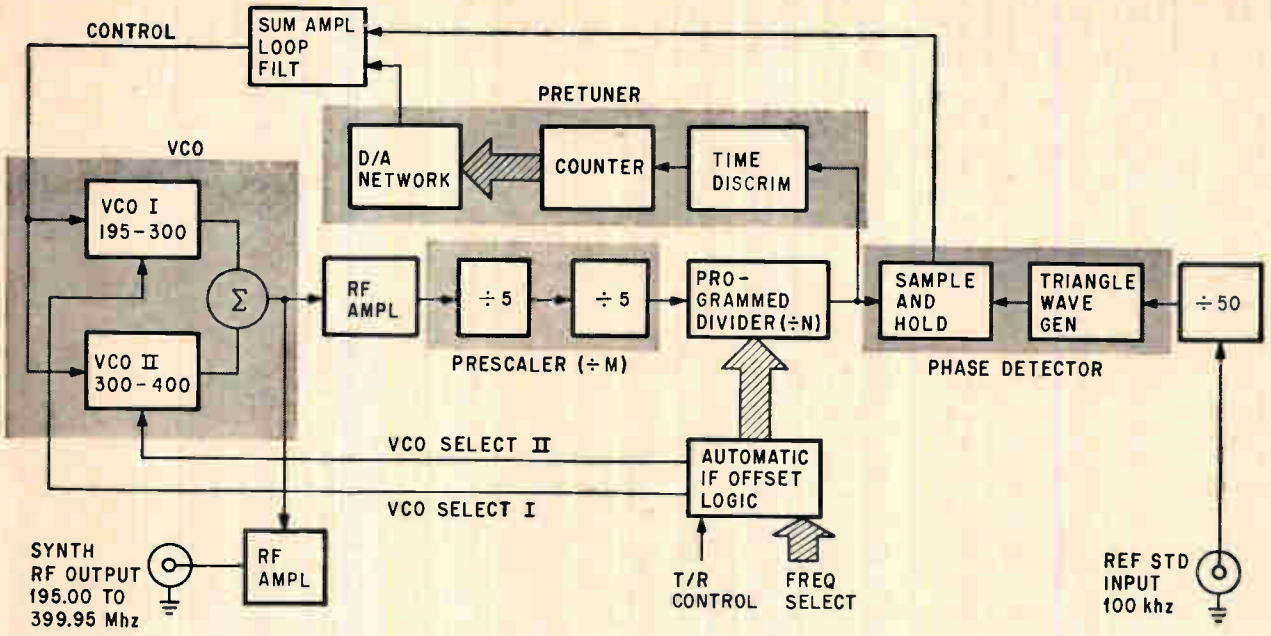
Method D employs a harmonic generator of the PPCO type to produce a frequency spectrum containing every desired output frequency. The correct frequency is selected by a phase-locked loop or filter network. This method becomes a simple one when the interval between output frequencies is large, but it is difficult to select a single frequency when the interval is small, say less than 2% of the desired frequency.

References

1. The Problem of Frequency Synthesis, Jour. Brit. IRE, Jan., 1961, p. 95
2. A Multichannel UHF Crystal Oscillator, Hahnel, Defense Documentation Center Document AD 29288







Digital synthesizer developed by Electronic Communications, Inc., incorporates two vco's to cover the frequency range from 190 to 400 Mhz. Since this instrument is designed for a transceiver, it includes automatic i-f offset logic to provide a frequency difference between the receive and transmit frequencies. When the transceiver is set to the receive mode, the logic subtracts 30 Mhz from the frequency programed in the divider.

logic levels on the frequency control lines.

The phase detector uses a triangle-wave generator and a sample-and-hold circuit to achieve a more noise-free output characteristic than possible with flip-flop detectors. The phase detector reference frequency of 2 khz is obtained by dividing down an external 100 khz standard. The d-c output of the detector is fed to a summing amplifier and filter where it is combined with a pre-tuning error signal for use as the controlling signal for the vco's. The pre-tuning signal is generated by a digital time discriminator. This signal pretunes the vco to a point where the small error signal from the detector enables it to acquire control of the vco. The synthesizer output from the vco summing junction feeds the transmitter exciter and the receiver's first local oscillator.

Q values

Good short-term stability of the vco is necessary to achieve a closed-loop bandwidth of a few tens to a few hundreds of cycles. A high degree of short-term stability requires first, that the vco's operate at the highest power level possible for a high signal-to-noise ratio, and second, that the vco's have the highest possible loaded Q in the oscillator's feedback loop so that any phase shift in the loop can be corrected by a very small frequency deviation.

Unloaded Q's of the order of 200 to 300 can be obtained in the 200 to 400 Mhz range with flat U-shaped inductors. However, the tuning varactors that are available at present have typical Q values between 25 and 50. Obviously this is the limiting factor in designing high-Q, LC voltage-tunable resonators.

The two transistors in the amplifier stage of the oscillator circuit on page 64 were chosen to obtain the uhf gain needed to ensure reliable starting. They are connected in a common base configuration, with the parallel LC varactor-tuned resonator across the collector and base. The small capacitors —3 to 5 picofarads—connected from the collector to the emitter provide the correct amount of feedback with the maximum gain. Their exact values are not critical and are established by experimentation. The main effect of the collector-to-base capacitor is to reduce the negative output impedance of the transistor to a value that will permit oscillations only in the desired frequency band with a fixed load impedance. The emitter-to-base capacitor forms a low-Q resonant LC circuit with the emitter lead inductance and shunt-peaks the amplifier.

The tuning varactors in the vco's are diffused-junction types. Their voltage-versus-capacitance characteristic follows a one-third power law. Operating reverse bias is never less than about two volts. This restricts the vco tuning range, but allows the peak amplitude of the r-f wave to approach two volts before the varactor becomes forward biased, and decreases the temperature coefficient of the varactor's tuning characteristic.

Two vco's are needed to cover the band from 195 to 400 Mhz. The oscillator not in use is deactivated by interrupting its supply voltage. The two oscillators do not cover the same percentage of the tuning range so the slopes of their frequency-versus-voltage curves differ, as do the voltages required to tune to the band edges.

The vco outputs are summed, through isolating resistors, at the input of a broadband amplifier. The input signal levels are between 30 and 70 millivolts at an impedance level of 200 to 300 ohms —about –20 ± 3 dbm. This signal level is amplified to approximately 3 to 10 milliwatts, +5 to

+10 dbm, at two isolated outputs. One of the outputs is limited with hot-carrier diodes and operates the uhf prescaler.

Four common-emitter stages provide the necessary gain. Each stage is shunt-peaked with small-value capacitors in parallel with the emitter resistors. These capacitors—3 to 5 picofarads—tend to decrease the gain at the lower frequencies in the band relative to the middle and high frequencies. This results in a flatter gain-versus-frequency characteristic than otherwise would be possible.

In the uhf prescaler, the fixed division ratio of 25:1 is achieved by cascading two divide-by-5 ring counters which consist of non-saturating current mode switches. The prescaler has an input impedance of 50 ohms over the 195 to 400 Mhz range. Its sensitivity is 2 milliwatts, ensuring reliable counting. The input and output waveforms for a 400 Mhz input signal are shown at the right. The output signal is no longer sinusoidal, but actually resembles a train of square-wave pulses.

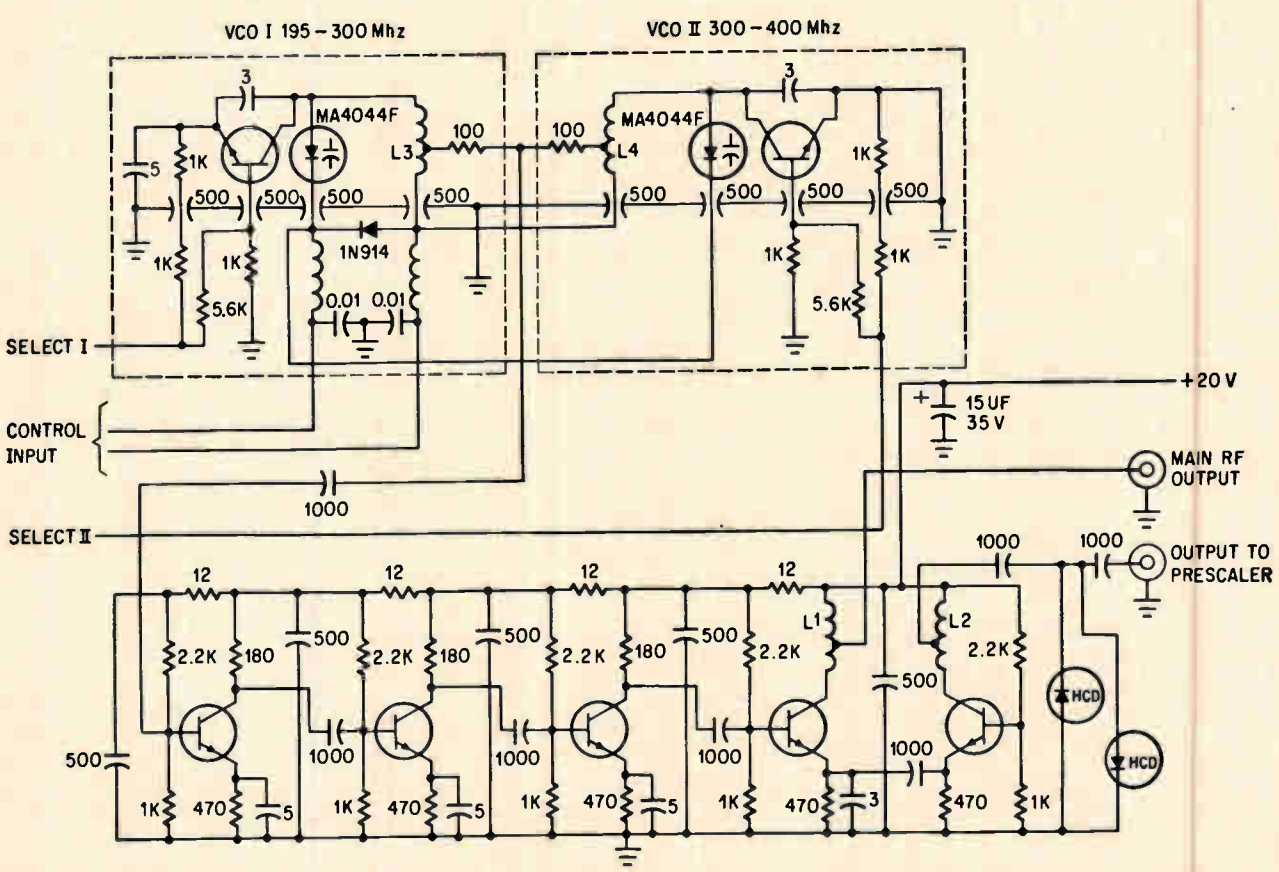
Programed divider

The output of the prescaler is the input to the programed divider. The signal frequency is divided by an integer from 3,900 to 7,999. The integer is selected by the 18 control lines that are activated by the frequency selector switches. The output of the programed divider in the closed loop is a train of 5-microsecond pulses at a frequency of 2 khz. These are supplied to the sample-and-hold circuit.

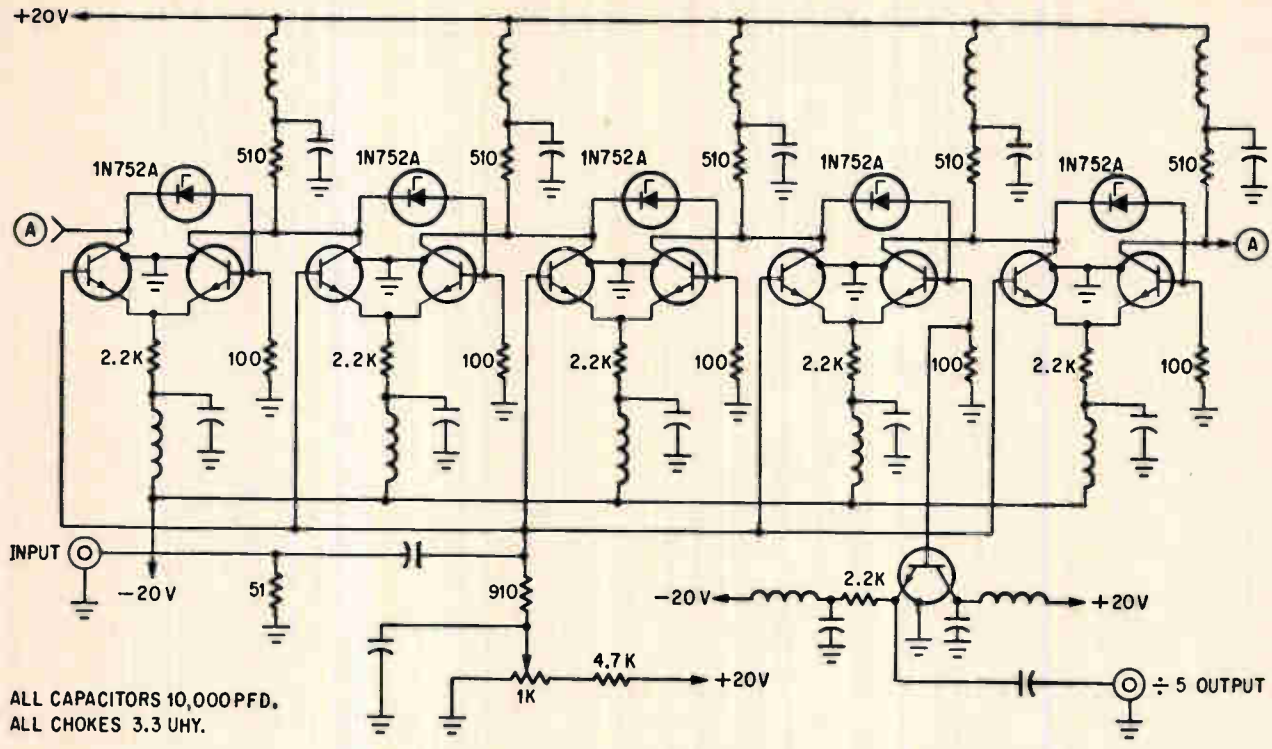
The programed divider consists of five cascaded stages: a divide-by-2, three divide-by-10's, and a divide-by-4, for a maximum input-output ratio of $2 \times 10 \times 10 \times 10 \times 4 = 8{,}000$. Desired division ratios less than maximum are derived by counting the input pulses from the prescaler and comparing them with the desired number as set on the 18 control lines. When correspondence occurs, a one-shot multivibrator is triggered. This generates a sample pulse for the sample-and-hold circuit and resets the counters in the programed divider.

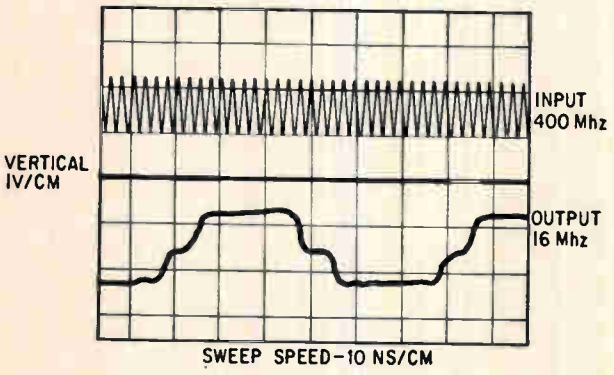
Two control lines regulate the comparator which generates the 100 Mhz decades in the output frequency; five lines control the comparators in the 10, 1 and 0.1 Mhz decades, and one controls the 0.05 Mhz decade. Use of a simple code system permits the desired input-output ratio to be developed with the connection of one of two logic levels to each of the 18 control lines. For example, if the two lines controlling the 100 Mhz comparator had a logical 1 and 0 on lines A and B respectively, this would represent a desired frequency at this point of 100 Mhz. A logical 1 on each line would be indicative of 200 Mhz.

A divider of this type normally would count the accumulated pulses, compare them to the desired count, reset the divider chain and begin counting



The tuning element of the voltage-controlled oscillators in the synthesizer are diffused-junction varactors. Each vco has a gain stage to ensure starting. The vco output signal is amplified by a broadband amplifier. The output to the prescaler is limited with hot-carrier diodes.





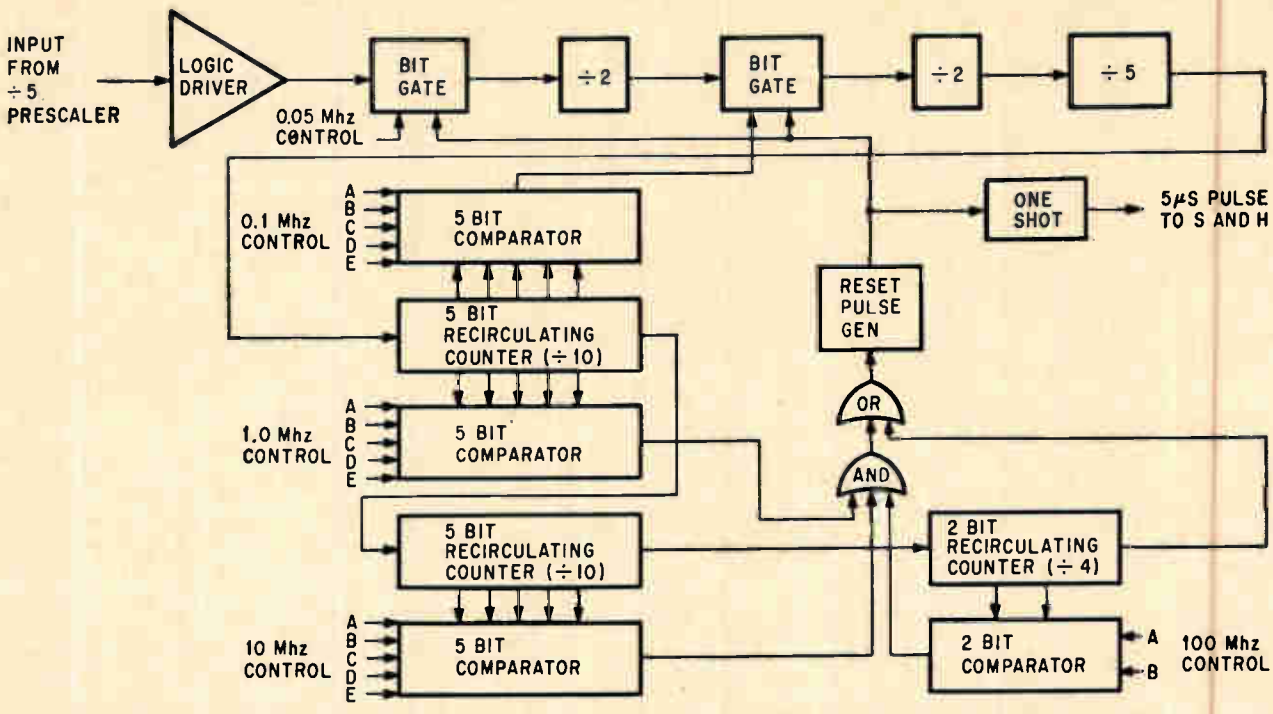
Two divide-by-5 ring counters are cascaded to form the prescaler. One counter is shown. Each stage acts as a nonsaturating current-mode switch. For a 400 Mhz input the output signal of the prescaler resembles a train of square-wave pulses at a frequency of 16 Mhz.

again. This method requires that the first bistable stage be capable of registering the last pulse, being reset and registering the first input pulse of the next count, all within one count period. This means that the bistable circuit must operate at twice the input frequency for one cycle. For example, if the maximum input frequency is 20 Mhz, the circuit would have to operate at 40 Mhz. Because this is beyond the capability of the integrated circuits used, a technique has been developed to eliminate the necessity of resetting those dividers that supply the two least significant digits—0.05 and 0.1 Mhz.

As shown in the diagram on page 66, the input from the prescaler is isolated by a logic driver. The resulting square-wave input is applied to the first bit gate. If the selected division ratio is an odd number, indicated by a logical 1 on the 0.05-Mhz control line, the first input pulse to the divide-by-2 circuit is gated out of the pulse train. If the division ratio selected is an even number, indicated by a logical 0 on the 0.05-Mhz control line, the input pulse train is passed unaltered to the divide-by-2 stage. This extraction of one input pulse per count period for odd ratios guarantees that the first bistable circuit always will be in the zero state at the end of every count period and will never have to be reset. The first divide-by-2's output is then N/2 pulses per count cycle for even numbers and (N-1)/2 pulses per count cycle for odd numbers.

The modified pulse train is then fed to the second bit gate which gates out every 10th pulse supplied to the cascaded divide-by-2 and divide-by-5 circuits. The gating of every 10th pulse continues until the number of the pulses gated out of the input to the divide-by-2 corresponds to the number represented by the code format present on the 0.1-Mhz control lines. The output to the divide-by-5 is then (N/2-M)/10 pulses per count cycle for even numbers or [(N-1)/2-M]/10 for odd numbers. M is the number represented by the code format present on the 0.1 Mhz control lines.

For example, suppose a ratio of 7,999 (399.95 Mhz) is desired. In this case M = 9. Thus, with the odd number equation, the output of the divide-by-5 circuit is [(7,999-1)/2-9]/10 or 399 pulses per count cycle. For a ratio of 4,446 (222.30 Mhz), M = 3 and the even number equation is used. The divide-by-5 output is therefore equal to (4,446/2



Programed divider consists of five cascaded dividing stages with a maximum input-output ratio of 8,000. Each significant figure in the synthesizer's output frequency is determined by the logic code set with selector switches on the corresponding control lines.

-3)/10 = 222 pulses per count cycle. It can be shown that for every integer from 3,900 to 7,999 (the range of desired division ratios) the number of pulses per count cycle out of the divide-by-5 stage is an integer with no remainder.

Counting and reset

The number of pulses to be counted at the output of the divide-by-5 stage is equal to the numbers which have code formats present on the 1, 10 and 100-Mhz control lines. Each of the dividers is monitored by a comparator. When the total count in the dividers corresponds to the three numbers represented by the codes, all three comparators generate simultaneous outputs to the AND gate. The resulting pulse signals the programed divider that the desired number of input pulses has been received and generates a reset pulse through the OR gate, restarting the counting process.

The reset pulse also may be generated by another input to the OR gate—the four-count from the two-bit recirculating register. The four-count indicates receipt of the 8,000th pulse by the programed divider and signifies an overflow condition. The reset on overflow is provided so that any disruption of the patterns recirculating in the five-bit register by noise or transients will be cleared at the end of that count period.

The difference between the phases of the reference signal and the programed divider output is converted to an error signal by the phase detector. Both the reference and programed divider signals —logic levels between –0.75 and –1.55 v d-c—are amplified in the detector. The reference signal is transformed from a square wave to a bipolar triangular wave with a peak amplitude of ±4 volts. The error signal is created by sampling the triangular wave, storing the sampled amplitude and using this stored voltage to control the voltage-controlled oscillator.

Voltage sampling

It can be seen in the diagram at the right that the storage element is a capacitor. Two metal-oxide-semiconductor (MOS) field effect transistors Q_1 and Q_2 are used as switches. Their leakage resistance is equal to or greater than 10^9 ohms. The first MOS transistor is a sampler switch and the second is connected as a source follower to provide a low impedance. The switch is turned on by the 5-microsecond sample pulse from the programed divider, and the storage capacitor is charged to the voltage level of the input signal. After the switch opens, the voltage on the capacitor remains constant until the next sample time.

A capacitive transfer, hold-sample-hold circuit prevents the pulse amplitude from following the triangular wave during the sample period. The capacitive part of this RC integrator is divided into two halves, separated by an MOS transistor (Q_1) series switch. The switch is normally closed. At the output of the second capacitor is a conventional sample-and-hold circuit with an MOS, Q_2, as a normally open switch. A third MOS, Q_3, provides an impedance transformation from 10^9 to approximately 1,000 ohms.

At the sample time, the first MOS switch is opened, allowing the second integrator capacitor, C_6, to retain its charge. This provides the second MOS, Q_2, with a constant voltage level which it samples for the third, or holding capacitor, C_8. During the sample pulse, the first integrator capacitor,

C_5, charges at twice its normal rate, so that at the end of the sample pulse, when the first MOS switch closes, charge equalization takes place and integration then proceeds normally until the next sample pulse. Therefore, the output of the detector is a stepwise-continuous voltage that is proportional to the phase difference of the input signals over a range of 180 degrees. This detector design improves the reference frequency rejection by 110 decibels over a flip-flop phase detector.

Voltage tuning

The reference generator consists of a sine-to-square wave converter and a divide-by-50 countdown chain. It provides a 2 khz reference signal from an externally supplied 100 khz source.

The pretuning voltage establishes an operating point for the vco from which the phase-locked loop can acquire phase lock. This voltage is generated by combining the pretuning signals from the pretuning network counter in a resistive network.

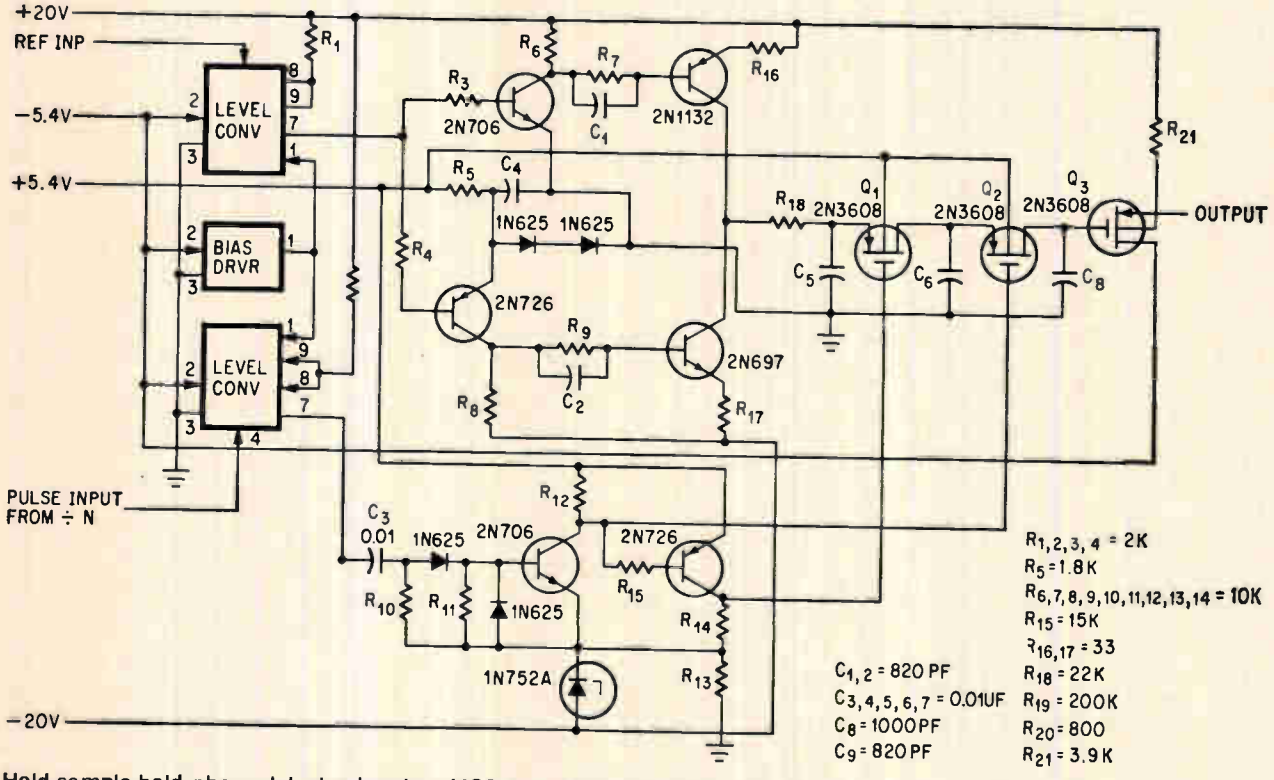
The error voltage from the phase detector passes through a low-pass filter before it is summed with the pretuning voltage for use as the vco control signal. The combining and filtering is done by the loop filter network. The composite signal is amplified to provide the proper drive level for the vco's.

Amplification is provided by an operational amplifier. Its feedback network is a simple resistor-diode combination that compensates for the sensitivity-versus-frequency characteristic of the vco's. In addition, a shunting capacitor acts as an RC filter to reduce the amplifier's high-frequency gain.

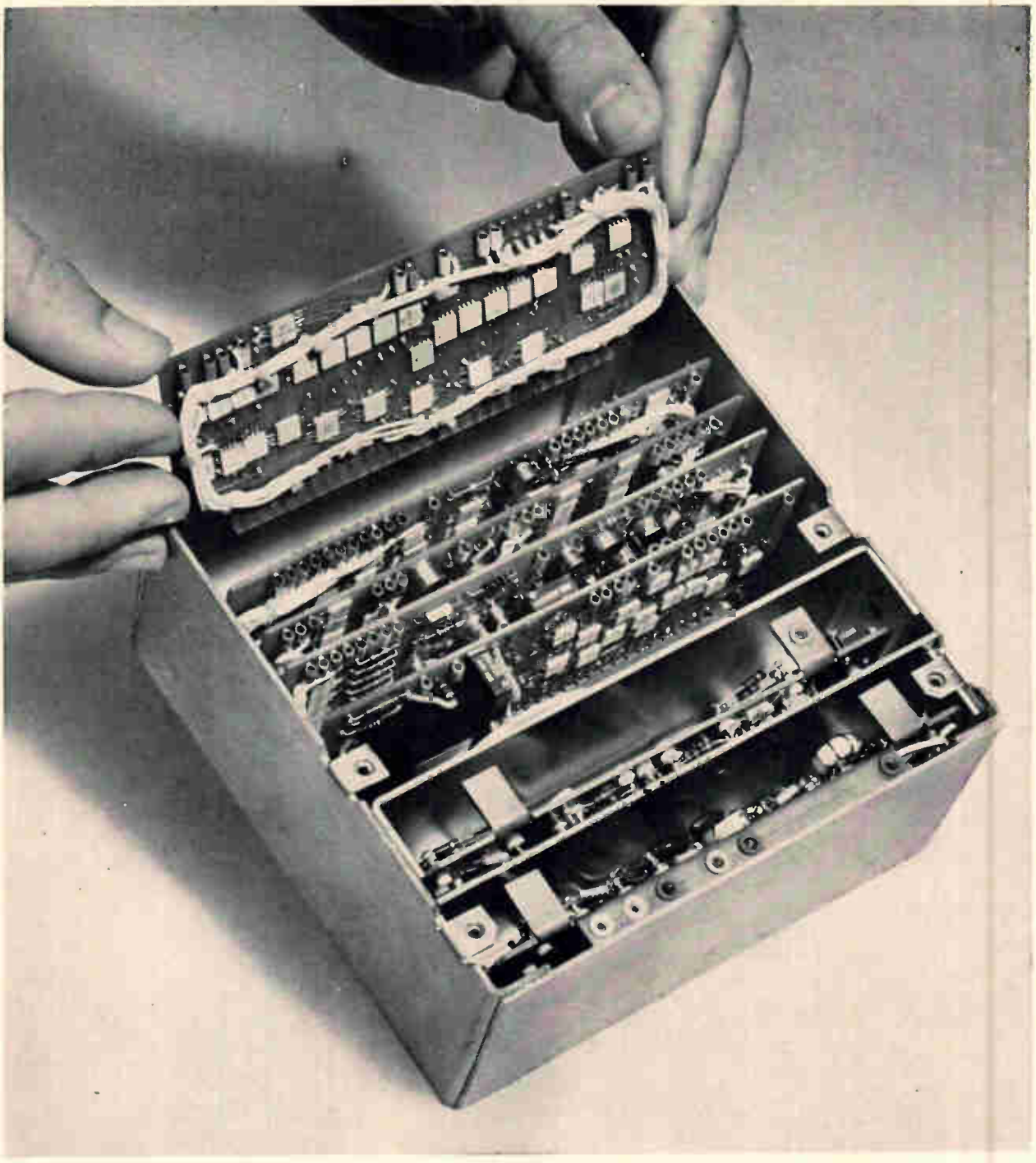
The pretuning network consists of a go no-go time discriminator and a binary ripple counter. The time discriminator determines whether the period of the pulses from the programed divider is within a predetermined region of the reference period—indicated by the time duration of the network's first multivibrator. The counter is used with a resistor network to generate the set of pretuning voltages. When the period of the pulses from the divider is not within the predetermined region of the reference frequency period, the pulses are gated to the counter, changing the pretuning voltage. When an acceptable voltage is obtained, the counting pulses are inhibited.

The time discriminator consists of two one-shot multivibrators. The first, a long-time delay multivibrator, is triggered by a pulse from the programed divider. When it returns to its normal state, it triggers the second, a window multivibrator. The window represents the acquisition range of the time discriminator. The timing is arranged so that the second unit is in the triggered state when the next output pulse from the programed divider will occur. As long as the period of pulses from the counter is close to that of the reference frequency, the second multivibrator inhibits the pulses to the pretuner counter.

For proper operation, the pretuning loop must have a pretuning voltage that covers the entire vco tuning range, the frequency error after the pretuning loop has acquired lock must be small enough to enable phase lock to take place, there must be enough pretuning voltage levels available and the



Hold-sample-hold phase detector has two MOS transistors as series switches and a third as an impedance transformer. Capacitors C_5, C_6 and C_8 are charged to voltages proportional to the phase difference between the programed divider's output and a reference signal. Voltages are summed with a pretuning voltage to control the vco.



The prototype of the digital synthesizer for use in the Navy's AN/SRC-27 (XN1) transceiver is made of a combination of discrete components and integrated circuits. One of the programed divider circuit boards is held out for view.

rate at which these voltages are swept must be slow enough to permit the pretuner loop to lock.

The range of the pretuning voltages is a function of the amplifier gain and offset; both of which may be adjusted as required. The frequency error present after the pretuner loop has acquired lock is a function of the width of the pulse from the window one-shot multivibrator in the pretuning network. This error can be made smaller by narrowing the window. But the stability of the multivibrator places a lower limit on the window width.

The number of pretuning voltage levels required is determined by the minimum frequency error detectable by the frequency discriminator. It is necessary to have at least one pretuning level which will maintain a frequency error which is less than the minimum detectable error for each programed output frequency. The number of pretuner levels possible is determined by the number of stages in the pretuner counter.

The maximum sweep speed of the pretuning voltages is limited by the phase lag in the open pretuner loop. These voltages must be swept slowly enough to keep the vco control voltage from pass-

Eventually, each of the discrete component subassemblies in the synthesizer will be reduced to an IC similar to the one-inch diameter disk shown above. This is the first of the microminiature circuits that are being developed for this unit. It is part of the prescaler—a divide-by-5 stage.

ing through the pretuner lock point before acquisition can occur. The number of stages in the pretuner counter and the frequency of the pulses gated to the counter control the sweep speed.

The phase-locked loop is designed to acquire phase lock once the pretuner loop has acquired lock. The digital operations in the phase-locked loop and the necessity to convert the sampled-data output from the digital portion of the loop back into continuous signals introduce a phase lag which affects the frequency response of the open-loop system. These effects must be considered in the compensation of the closed loop response.

The digital divider can be considered a device which samples the position of the vco zero crossings at a rate equal to the vco output frequency times the division ratio. The phase detector compares these samples with the phase of the reference oscillator's signal. The output of the phase detector is a pulse train which represents—in sampled-data form—the phase variations of the vco as a function of time. The effective average sampling rate of the detector—$1/T_s$—is 2 khz. The exact rate, however, varies with the vco phase. With a uniform sampling rate, the maximum frequency deviation rate which can be sampled and converted back into analog form without introducing a significant error is $1/2T_s$. With a non-uniform sampling rate and filtering, this maximum rate is reduced; and for random sampling, the maximum frequency rate is reduced to approximately $1/10T_s$. In this design, the maximum frequency deviation rate which can be detected at the output of the phase detector is less than 1 khz. Frequency deviation rates in excess of 1 khz are capable of introducing phase noise into the loop.

A zero-order data hold converts the output of the phase detector back into an analog signal. The data hold introduces into the loop a phase delay which increases linearly with frequency and a gain characteristic which allows zero transmission at the sampling frequency and its harmonics. The data hold does two things. First, because it suppresses the sampling frequency components at the output of the phase detector, it is not necessary to severely limit the loop noise bandwidth to reduce phase modulation of the vco at the reference frequency. Second, the phase lag introduced by the data hold must be considered when compensating the phase-locked loop.

It is possible to obtain a loop noise bandwidth of 1 khz through proper design of the loop filter. This is consistent with the maximum frequency deviation which is available at the output of the phase detector. Experience in the compensation of control loops in uhf synthesizers has shown that it is desirable to narrow the loop noise bandwidth beyond this point to minimize the effect of device noise and the noise introduced by power supply variations.

The introduction of phase lag in the loop is not attributable to this particular data hold circuit, but is introduced by the combination of the digital divider and the need for obtaining an analog signal to control the vco.

Digital testers, too

An immediate application of the synthesizer that has been described is in a 100-watt uhf-am transceiver being produced by ECI for the Navy. The equipment uses a digital synthesizer of the type shown on page 68.

Development of a uhf digital frequency synthesizer is a prime example of how current integrated circuit technology is forcing a reevaluation of classical problems in r-f design. The use of digital techniques to solve r-f problems is resulting in improvements in size, weight, cost and reliability that would not have been possible just a few years ago.

In a few years, virtually all tunable communication equipment will employ digital synthesizers, especially as cost and frequency limitations are reduced. It is easy to foresee digital synthesizers at frequencies to S band and higher in the near future.

Digital synthesis, however, is not limited to communications. It holds great potential for automatic ground support and test equipment considering how rapidly a uhf synthesizer can be programed over a wide frequency range for automatic receiver/transmitter testing and checkout. For example, a digital synthesizer could be programed to check the sensitivity of a 3,500-channel uhf receiver. It would take a skilled operator 10 hours to check all 3,500 channels—taking one complete measurement every 10 seconds, so a common expedient is to spot check some channels and assume the others are correct.

A digital synthesizer could check all 3,500 channels in only six minutes.

Automatic diagnosis of engine ailments

By adapting a biomedical research technique, computers analyze vibration patterns to warn of malfunctions that indicate impending failure of internal combustion engines

By Phil Hirsch,
Bethesda, Md.

Annual savings of almost $15 million in maintenance costs is what the Army anticipates from a system that automatically detects malfunctions in the engines of military vehicles. Now in operation at the Army's Letterkenny Depot in Chambersburg, Pa., is the first of these systems; this one designed to trouble-shoot tank engines. With it, mechanics can find problem areas, without costly engine overhauls, and correct them before they cause a breakdown in the engine.

The new check-out system was developed at Frankford Arsenal, Philadelphia. It is the first to employ digital summing—a technique widely used in biophysical electronics—to detect the impending failure of main and connecting rod bearings, worn and damaged oil rings, poorly timed valves, and related troubles. The development of a digital summing instrument has finally made it possible to relate engine malfunctions to electrical vibration signals.

Other automatic and semi-automatic systems for analyzing the performance of internal combustion engines are extremely limited in their ability to accumulate data from a number of points, to perform statistical operations on the information, and to make comparisons with norms representing proper engine performance. Usually these systems only evaluate performance in terms of component temperature and pressure; they do not sense important malfunctions in bearings until complete engine breakdown is imminent.

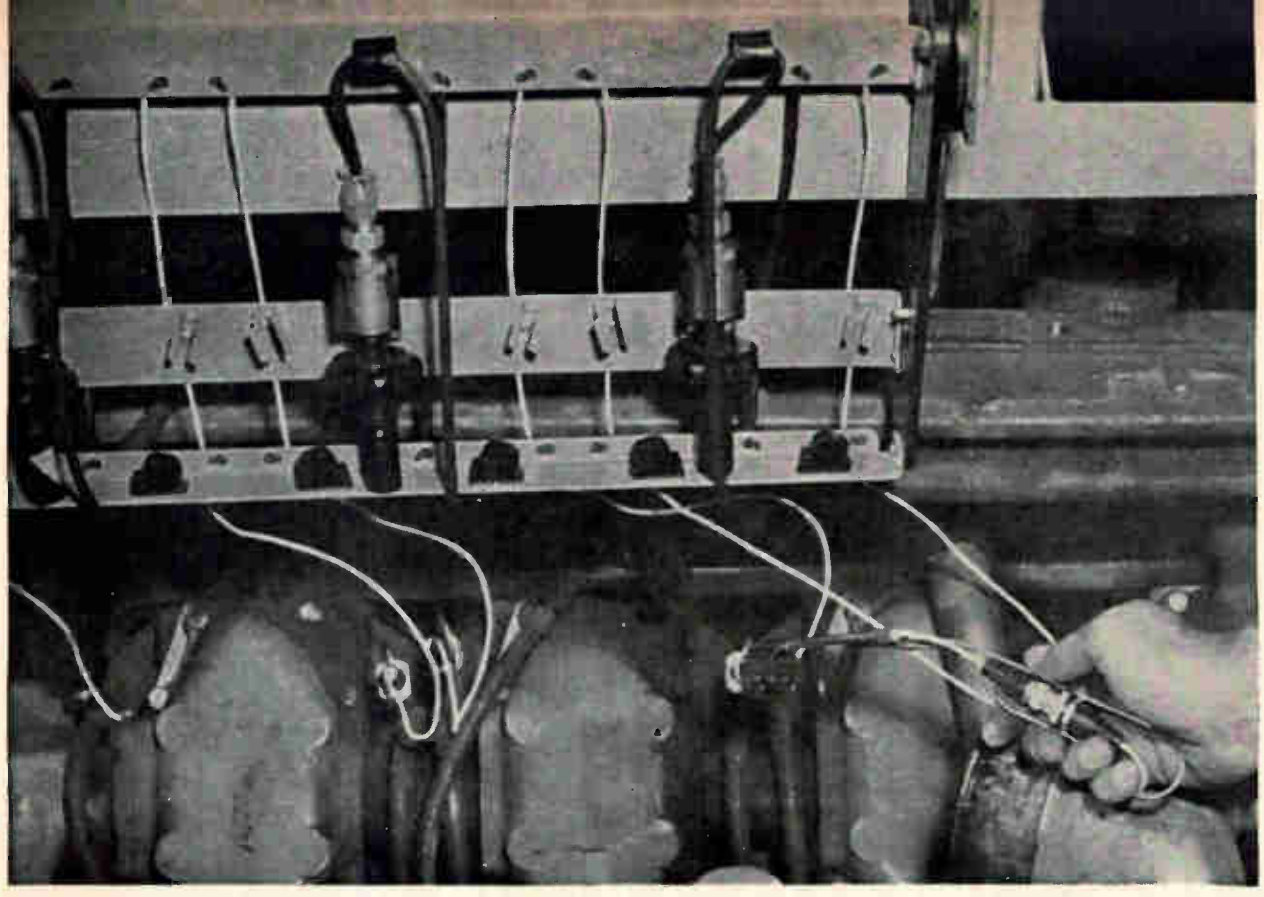
In addition to temperature and pressure, the Army's system measures vibration to determine the existence of malfunctions. The required data is sensed by 62 transducers positioned strategically on the engine block, crankcase, and inside accessible openings such as the oil dipstick tube.

While it is being tested, the engine rests on a dynamometer stand. The dynamometer is controlled by the diagnostic system in accordance with instructions stored in its test program. Tests can be made under load and no-load conditions. Ordinarily three runs are made under load, with the engine operating at 1,600, 2,400 and 2,800 revolutions per minute.

Data from each test is fed into a General Precision, Inc. Libratrol 500 computer for processing and comparison with previously stored information. The computer not only determines the over-all operating conditions of the power pack—the engine, transmission and cooling system—pinpointing specific weaknesses or failures, but also automatically produces a list like the one on page 72 describing each malfunction, its location and the stock number of the parts that must be replaced. If desired, the computer will list the points in the military supply system where the replacement parts can be found. With the automatic check-out, the entire test takes about one hour; without it, the same test would require several days work by a skilled mechanic.

The author

Free lance writer Phil Hirsch is the author of more than a hundred articles about the use of computers in accounting, industrial and research applications. He is now at work on a book that will examine the social implications of automation.



Spring-loaded temperature probe is held in position by a clamp that fits on the lower hexagonal nut of the spark plug. The actual measurement is made on the insert in the well. The probe is guided into position by slipping the clamp over the ignition harness wire.

Maze of data

Altogether, the computer receives data from approximately 430 different measurements during each test run which covers a checklist of 185 possible malfunctions. The data from the transducers is in the form of analog voltages; half of them are converted to digital data for direct use in the computer's arithmetic and logic circuitry. The remainder are time-varying signals which are fed first to a time-varying signal measurement (TVSM) complex for digitizing. Input address and relay sequencing sections of the diagnostic systems control the order in which the data is presented to the computer for analysis.

The frequency and period measurements for the analysis of certain engine conditions are provided by the TVSM complex, which consists of a one-megahertz (megacycles per second) oscillator, three differential amplifiers, a 16-stage counter, an 8-stage counter and several control flip-flops. Besides digital conversion of such measurements as liquid flow rates and crankshaft angular position, the TVSM provides control signals for logical sequencing and performance verification.

The output side of the system has 20 banks of 10 relays each. This is expandable to 32 banks if desired. Some of the relays perform an on-off switching function that activates special check-out, verification and malfunction control routines in the test program. In this mode, the relays switch each of the transducers out of the test circuit and substitute a known voltage for the signal. The computer then performs a self-check to verify that all its circuits are operating properly. Other relays control a resistor matrix that determines how much the dynamometer loads the engine during a test. Still other relays are linked to the Flexowriter which is used both for input address and test analysis readout. Such relays are needed to switch the Flexowriter between modes. The test analysis readout consists of both a tabular presentation and a punched paper tape record.

Setting the norms

The performance parameters used by the computer were established after extensive laboratory tests by the Army's tank automotive center in Detroit. This data, as well as the test program, is stored off-line on magnetic tape and is fed to the drum memory of the computer just before a test series begins. Off-line storage facilitates the use of the computer complex for tests of different types of vehicles, each of which may require different programs and performance criteria.

The new test procedure has been applied to a total of 50 M48-General Patton tank engines. No preliminary engine teardown or part removal is required. Although each of the engines checked out at Letterkenny was taken out of the tank, this step is expected to be eliminated when the existing test procedure is modified for field use. In this case, a special test cart would be positioned over the tank's motor; transducers, attached to spring loaded cables, would be pulled down from

Sample Output Format of Required Repairs

Malfunction	Code	Ord Stock No.	Fed. Stock No.	Man Part No.	Ord Part No.	Quan	Repair Ref.
Main/Con Rod Bearings Worn		G244-7744597 G244-7744598 G244-7767524	2805-774-4597 2805-774-4598 2805-776-7524	CO-301750 CO-302409 CO-301943	7744597 7744598 7767524	12 2 24	TM9-7009-1 Section VIII Par 103c, 104a pp. 190, 192
Con Rod #_____ Bent				CO-515453	8357878	12	TM9-7009-1 Section VIII Par 103c p. 190
Broken or Stripped Cooling Fan Drive		G262-8344515		CO-525255	8344515	2	TM9-7009-1 Section X Par. 112 p. 199
Pistons/Rings and Cylinder Walls Worn		G251-7346610	2805-734-6610	CO-515212 CO-518090	7403133 7346610	12 12	TM9-7009-1 Section V Par. 87 p. 163
Slipping Cooling Fan Clutch		G262-8344515		CO-525255	8344515	2	TM9-7009-1 Section IX Par. 108 p. 199
Defective Oil Pump		G244-7744620	2805-774-4620	CO-515652	7744620	1	TM9-7009-1 Section III Par 68 p. 132
Defective Oil Pressure Regulator		G244-7521-774	2805-752-1774	CO-516446	7521774	1	TM9-7009-1 Section III Par. 78 p. 151

Print-out of test results includes a description of the defect and the stock and manual number of the parts involved. It also directs repair personnel to the proper section of the appropriate repair manual.

an overhead boom on the cart and attached to the appropriate engine locations. A portable dynamometer would permit the engine to be tested under load.

Turning engine inside-out

Another modification of the existing test procedure being contemplated is in the method used to check out the combustion chamber and crankcase under vibration testing. At present, the restriction on opening up the engine, or even disassembling a part prior to the test run makes it difficult to obtain complete data from these inaccesible areas.

Two methods were explored in the search to expand the capability of the check-out system. In one, a high-speed frequency analyzer, originally developed for the study of human speech patterns, was tried. The other employed a special-purpose signal summing computer, Nuclear Data, Inc.'s Enhancetron. In both cases, the input consisted of the outputs of five piezoelectric accelerometers. These were attached to the crankcase studs, generally in the plane of the main bearings.

In an exploratory study for the Frankford Arsenal, the research and development center of the General Electric Co. analyzed tape-recorded vibrations from tank engines. The project was initiated with the collection of vibration data from ten 800-horsepower, 12-cylinder, air-cooled gasoline engines. The engines were randomly selected from a group that had been returned from the field for repair. The accelerometer outputs were recorded while the engine was run at three separate speeds. Measurements were also taken under varying conditions of acceleration. Frequency response was limited to 5,000 hertz by the tape recorder. All data was recorded using frequency modulation. In addition to the vibration data, an engine-timing marker was recorded once every engine cycle, every two revolutions.

After the tests were run, the engines were torn down and a detailed inspection was made of all parts. GE's task was to relate the malfunctions that were found with the recorded data. While it was apparent that the signals did tend to repeat engine cycle after engine cycle, there were slight variations. These were sufficient to prohibit direct analysis of the engine with oscillograms.

An attempt to produce clarified oscillograms from the data by high-speed spectral analysis and simple filtering merely clarified the nature of the data-reduction problem and established some parameters for further analysis. The problem of the cycle-by-cycle variations still remained and the GE engineers turned to the digital sum-

ming technique to generate the simple signature, or pattern, they sought. Such a pattern would represent engine performance as seen by any single accelerometer over the engine test period.

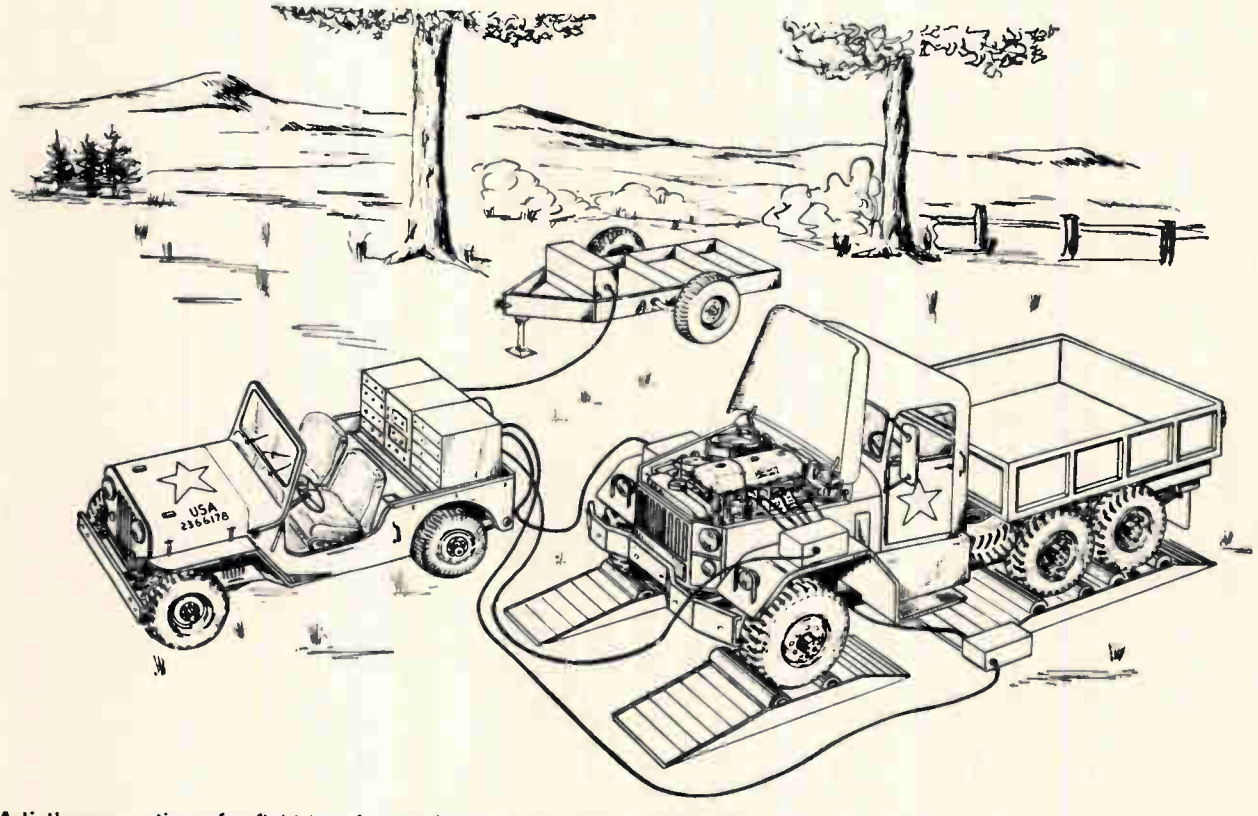
Digital summing

Before the study began, the GE and Frankford Arsenal engineers had reviewed trial analyses of the digital summing technique and hypothesized that it would be more effective than high-speed spectral analysis. The results demonstrated that while spectral analysis patterns could be correlated with many malfunctions—worn main bearings, cracked and broken piston rings, improperly closing intake valves, cracked manifold, damaged connecting-rod bearings and mistimed ignition—the summation technique detected many trouble spots, even some that were undetected by the more usual methods of engine analysis.

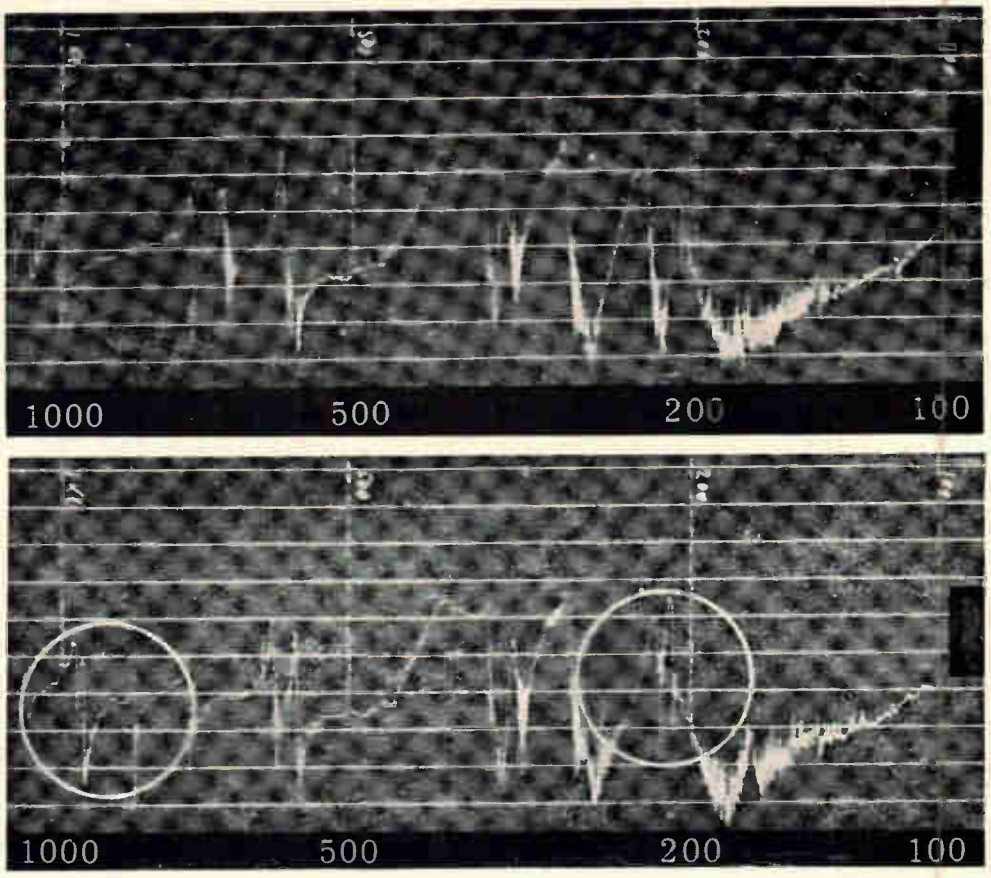
The Enhancetron samples a signal and measures its amplitude at several hundred points over a single cycle. At each point, the instantaneous voltage is compared with one or more internally generated voltages. If the input voltage is positive with respect to the reference, a single count is added to the Enhancetron's 1,024 channel magnetic core memory. If it is negative with respect to the reference, the stored count is reduced by one.

Since the repetitive portions of the input signal have the same polarity with respect to the reference at each corresponding point in successive cycles, the counts add or subtract linearly. Noise or other spurious components of the signal, however, are randomly positive or negative at each of these time points and add more slowly and even tend to cancel each other out. Thus, after a number of cycles, the stored information in the Enhancetron's memory for each of the 1,024 data points is the sum of the amplitudes observed at each point. The signal that is then displayed has an effective

Effect of piston ring malfunctions is to produce low-frequency modulation as shown in upper trace.



Artist's conception of a field test-facility for trucks. Installation includes portable dynamometer. Computer controller and all electronic subassemblies are mounted on the rear of the jeep. System power is supplied by generator mounted on the trailer which carries the dynamometer.



Passive systems can be analyzed by observing their mechanical signature over a frequency range. Upper curve is from a mechanically sound structure specially built for the tests. Lower wave was taken after two screws on the structure were loosened only two turns. The difference in the signatures is easily detectable.

signal-to-noise ratio considerably higher than that of the raw data.

Relating defects to signals

Raw data for the study, recorded on tape, consisted of about a 10-second segment of vibration data from each tank engine running at each of the test speeds. Six-track tape was used—five for vibration data and the sixth to accommodate time marker pulses that identify each engine cycle.

Each track was individually re-recorded with the timing pulses on nine-foot tape loops. These loops provided the basic input for the Enchancetron. Each was analyzed by the instrument for a period of five minutes.

Most engine malfunctions show up as high-frequency transients in the vibration signals that are detected by the acccelerometers. While the summing technique is responsive to amplitude variations and offers excellent resolution at the frequencies of interest, high-frequency transients did not show up in the first recordings. With digital summing alone high-frequency transients that are malfunction indicators tend to be cancelled out because of the minute changes in the phasing and timing of events in internal combustion engines. To capture the transients, full-wave rectification of the accelerometer signals was performed before summing.

After rectification, the data was simultaneously analyzed and displayed on a four-channel oscilloscope. The oscilloscope's sweep was triggered by the engine's timing-marker signal, but the Enhancetron was triggered by the scope since it required a trigger of greater magnitude.

It is possible to vary the sweep time of the Enhancetron—the time required to analyze one cycle of the input signal. A sweep time of 63 milliseconds was used for engine test speeds of 2,400 and 2,800 rpm. A sweep of 125 milliseconds was used at 1,600 rpm. In each case, slightly more than one cycle was digitized per sweep.

Passive possibilities

Much of the work being done at Frankford Arsenal and at GE may be of interest to operators of large truck and auto fleets and to large-volume commercial garages. The large computer system could be built at a cost of approximately $100,000. However, a portable system utilizing the components used in GE's vibration analysis study could be built at a lower cost. The estimated cost of such a system is about $20,000.

The system is not only applicable to engine testing, but the same basic techniques in use at Letterkenny could be used to troubleshoot passive systems. To demonstrate this principle, the engineers at GE's laboratory built a small metal U-shaped structure, with parts that could be removed or weakened to simulate structural changes or damage. The complete structure was first vibrated on a small shaker table to supply the initial vibration pattern, or signature. Afterward, minor changes such as loosening a screw two turns showed up in the waveforms as significant departures from the original signature.

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Audio discriminator measures large frequency changes

By Jean F. Delpech

Institut d' Electronique, Orsay, France

The circuit below produces a linear error voltage which is proportional to a frequency change of an input signal. If the signal is generated by a coil on the shaft of a small d-c motor, the error voltage can be used in a feedback loop to stabilize the motor's speed.

The circuit is useful in the measurement of drift, wow and flutter on recorder turntables and tape recorders, where the input signal originates from a prerecorded audio signal.

The circuit's first stage shifts the phase of the input signal in proportion to its deviation from a reference frequency. The second stage of the circuit is a phase-sensitive rectifier that produces a d-c error voltage proportional to the deviation. The center or reference frequency of the circuit can easily be adjusted by changing the RC time constant.

The transfer function for the RC network,

$$v_o = v_i \exp(2j \arctan RC\omega),$$

shows that when the input signal frequency varies, the phase angle of v_o changes but its amplitude does not. Therefore,

$$v_o = |v_o| \cos(\omega t + \phi)$$

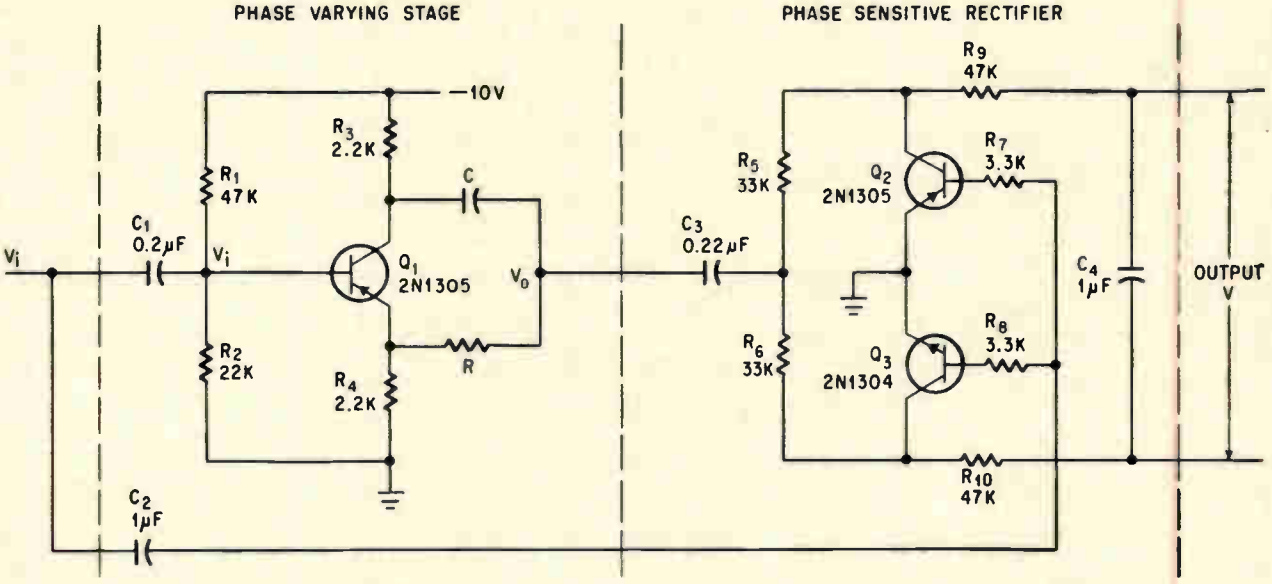
where $\phi = 2 \arctan RC\omega$.

The second stage compares v_i and v_o and produces an output voltage, V, proportional to their phase difference ϕ. Input voltage v_i is fed simultaneously through R_7 and R_8 to the base of the chopper pair Q_2 and Q_3, so that during each half cycle, one transistor is on and the other off. When Q_2 is off and Q_3 on, part of the signal v_o is fed to ground through R_6; part of the signal flows through R_5, R_9 and R_{10}, charging C_4. On the next half cycle, C_4 is charged through R_6, R_{10} and R_9.

The error voltage, V, appearing across C_4 is

$$V = k\, v_i \cos \phi$$

Since V must equal zero when the frequency of the input voltage $\omega = \omega_0$, the reference frequency, $\phi = 2 \arctan RC\omega = \pi/2$.



Two-stage audio frequency discriminator first shifts phase of incoming signal in proportion to its frequency deviation, then produces d-c voltage proportional to the phase shift. Varying R and C alters the center frequency.

Therefore, values for R and C are chosen so that $1/RC = \omega_0$.

With a calibrated nonlinear scale, it is possible to measure with good accuracy rather large frequency variations, of up to ±50%. For smaller deviations, a linear scale produces good results. For example, at a center frequency of 600 hertz (cycles per second), a deviation of ±60 hz can be measured within ±3 hz. The center frequency can be changed from several cycles to several hundred kilocycles. The stability is temperature dependent, but is better than 0.5% at room temperature.

Clip couples neon oscillators

By Robert F. Woody Jr.

Christiansburg, Va.

The clip of an octal tube grid placed around a conventional neon lamp converts the lamp into a three-terminal device that can be used to synchronize successive stages of neon lamp relaxation oscillators, overcoming their inherent instability.

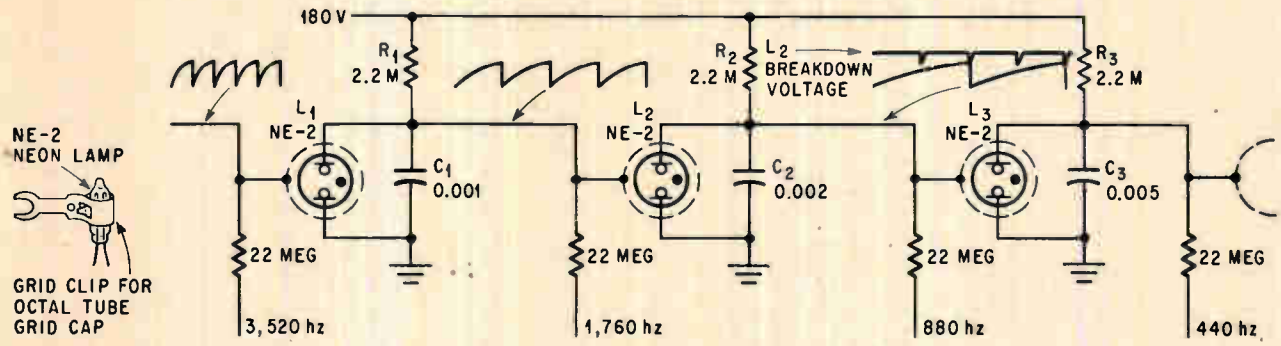
Negative pulses to the clip create an electrostatic field within the lamp and reduce its ionization potential, which, when exceeded, fires the tube

The circuit shown below is part of an electronic organ tone generator which uses the principle for frequency division. The diagram shows the clip as a shield (dotted lines) around each lamp in a conventional relaxation oscillator stage.

When L_1 fires, the voltage at A is made sharply negative. R_2 and C_2 are adjusted so that their effective time constant causes L_2 to be fired once for every two pulses from L_1, resulting in frequency division by two. The principle is applied to each stage in the frequency divider chain.

The divider can operate at any frequency from 100 hertz (cycles per second) to 4,000 hz.

No-load output voltage is 15 volts peak to peak.



Three stages of neon oscillators are synchronized by grid clip coupling between stages.

No moving parts in auto tachometer

By J.A. Irvine

Findlay, Irvine Ltd., Penicuik, Scotland

A reliable, accurate automobile tachometer circuit uses standard passive components with no moving parts, and may be built into any panel-type meter. The circuit on page 78 shows the tachometer to the right of the dotted line.

The top waveform on page 78 is the voltage across the coil, which is also the tachometer input. The waveform consists of a peak oscillatory voltage of about 200 volts—decaying rapidly as the spark plug fires—followed by a voltage step equal to the battery voltage when the breaker points close.

The center waveform is the voltage across C_1 and C_2. It shows the effect of D_1 conducting on the first positive excursion of voltage across the coil. C_1 and C_2 are charged to about 200 volts. The R_1C_1 and R_2C_2 time constants are chosen so that

the voltage across C_1 and C_2 decays more slowly than the coil voltage. In this way, D_1 does not conduct again until the points open once more.

The lower waveform is the voltage across C_2. Zener diode D_2 limits the maximum charging voltage across C_2. The decay of voltage across C_2 is governed by the fixed R_2C_2 time constant, resulting in constant area pulses.

With a four-stroke engine, the mean current flowing through the meter is calculated easily. If N = engine speed in rpm, n = number of cylinders and V = zener voltage, the number of current pulses per second (pps) flowing through the meter is

$$\text{pps} = \frac{N}{60} \cdot \frac{n}{2} \qquad (1)$$

The area of each current pulse

$$A = \frac{V}{R_2} \int_{t=0}^{t>>C_2R_2} e^{-\frac{t}{R_2C_2}}\, dt = VC_2 \qquad (2)$$

Therefore, the mean meter current is

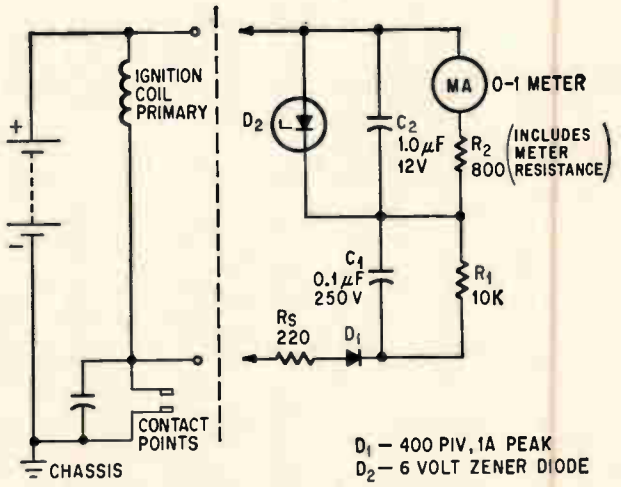
$$I = \frac{NnVC_2}{120} \qquad (3)$$

If full-scale meter deflection corresponds to 6,000 rpm and the motor has six cylinders, then full-scale deflection current from equation 3 is 6,000

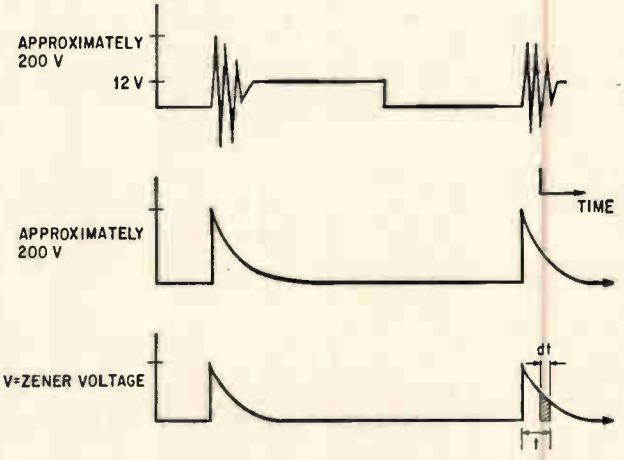
$$I_{max} = \frac{6{,}000 \times 6 \times 6 \times 1}{120} = 1{,}800 \text{ microamperes}$$

The pulse rate, calculated from equation 1, is 300 pps, corresponding to a minimum time interval of 3.3 milliseconds. If R_2C_2 is one-quarter of this value, then equation 2 is accurate within 2%. This means that the tachometer will follow the engine speed up to full scale with an error of less than 2%.

Calibration is not affected by C_1, R_1 or R_2. If a low temperature coefficient zener diode is used, the accuracy of the tachometer is the same as that of the meter over the normal temperature range.



Tachometer circuit, shown to the right of the dotted line, connects to the automobile circuit at the battery and the contact points.



Waveforms indicate voltage conditions that occur in the tachometer circuit. Top waveform shows the primary coil voltage; center waveform is the voltage across C_1 and C_2; the lower waveform shows the voltage across C_2.

Simulator circuit generates video or noise pulses

By Larry Turf

Airborne Instruments Laboratory, a division of Cutler-Hammer, Inc., Deer Park, N.Y.

In simulation, it is often necessary to generate a predetermined number of pulses; for example, to simulate the target returns of different types of radars. The circuit on page 79 provides a group of pulses with a fixed pulse repetition frequency—at the touch of switch S_1.

A pulse generator connected to input J_1 is set at the desired prf, pulse width and amplitude. With S_1 in the position shown and capacitor C_1 charged to the battery voltage, Q_1 is biased off while Q_2 is in the on condition. When S_1 is pressed momentarily, a negative trigger is applied to the base of Q_2, reversing the off-on states of Q_1 and Q_2. This produces a positive gate pulse at the collector of Q_2, the duration of which is controlled by R_8. This gate pulse is coupled to the base of Q_3, pro-

ducing bipolar output pulses which are coupled to the bases of Q_4 and Q_5. Their outputs operate the diode gate D_1, D_2, D_3 and D_4.

When S_1, is momentarily pressed, a predetermined number of pulses are gated out at J_2. The number of pulses depends on the duration of the gates at the collectors of Q_4 and Q_5.

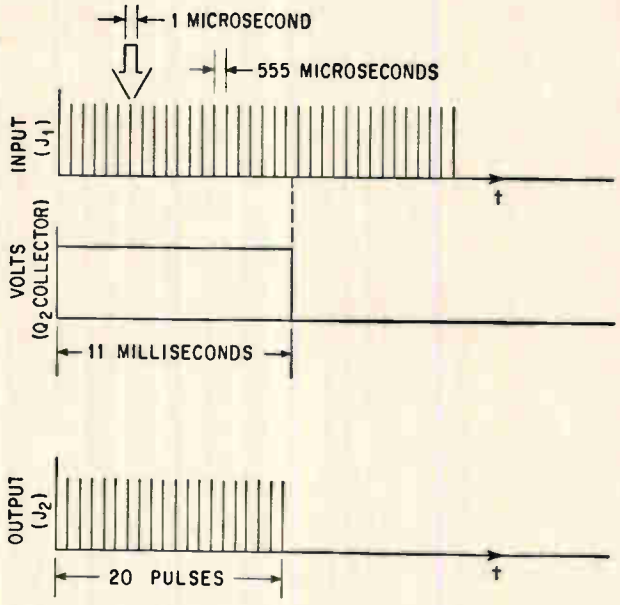
This is illustrated in the pulse diagram shown to the right. A pulse generator is set to a prf of 1,800 pulses per second, a pulse width of 1 microsecond and an amplitude of 1 volt, and connected to the input J_1.

If a pulse count of approximately 20 is required, then the pulse duration on the collector of Q_2—as set by R_8 must be 555 x 20, or 11 milliseconds.

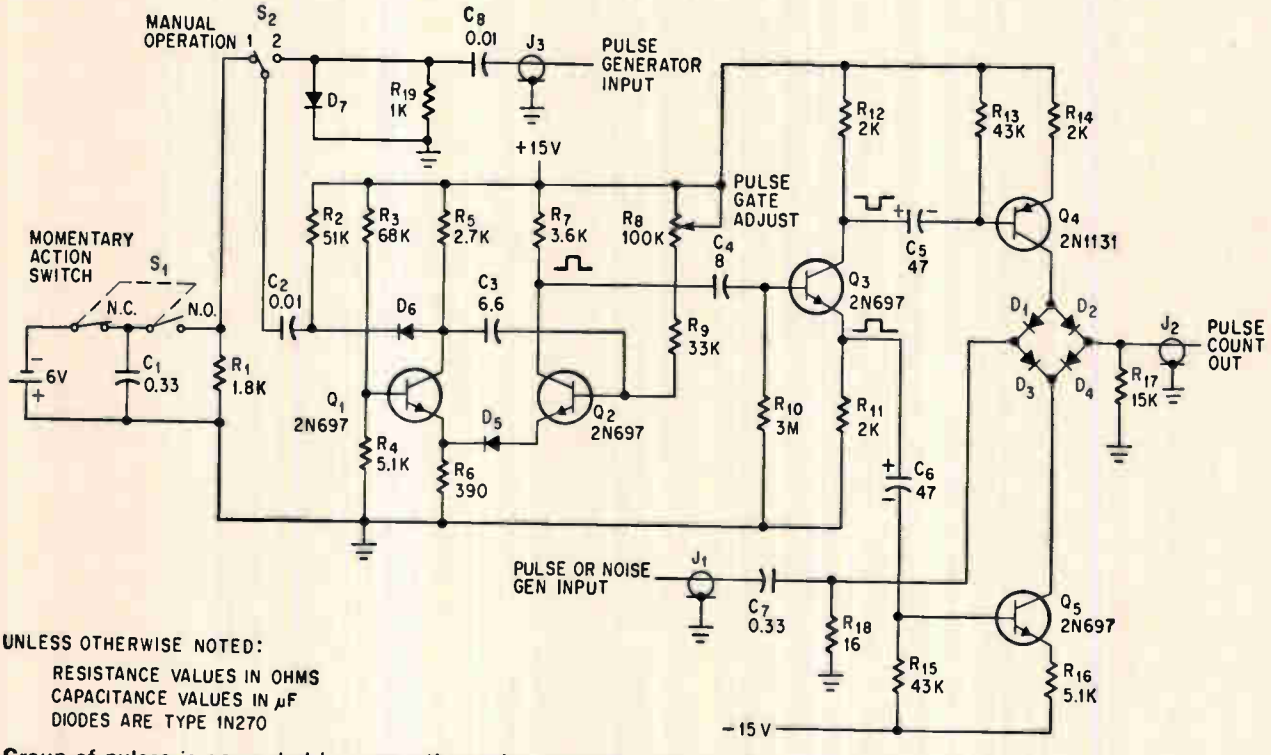
When pulse groups at a specific prf are desired, the pulse generator is connected to J_3 and switch S_2 is placed in position 2. The generator pulses are differentiated and these negative triggers produce a "bundle" of pulses at a specific prf rate.

Connecting a noise generator at J_1 and following the same procedures as outlined above will supply noise bursts when S_1 is pressed or at a specific repetition rate.

Either pulse or noise outputs can be used in conjunction with integrating techniques in counting and threshold devices. It is also possible to use this technique in signal to noise measurements.



Typical input and output pulses for a radar that has a prf of 1,800, a pulse width of 1 microsecond and an amplitude of 1 volt. If 20 output pulses are required at J_2, the duration of the gate pulse is set to 11 milliseconds by adjustment of R_8. To get a pulse count different from 20, potentiometer R_8 is adjusted to provide a different pulse duration. The pulse count is equal to the prf rate times the duration of the gate pulse.



Group of pulses is generated by connecting pulse generator to J_1 and momentarily pressing S_1. The number of output pulses at J_2 depends on duration of the gate which is set by R_8. Automatic generation of pulses at a specific prf is made possible by connecting pulse generator to J_3.

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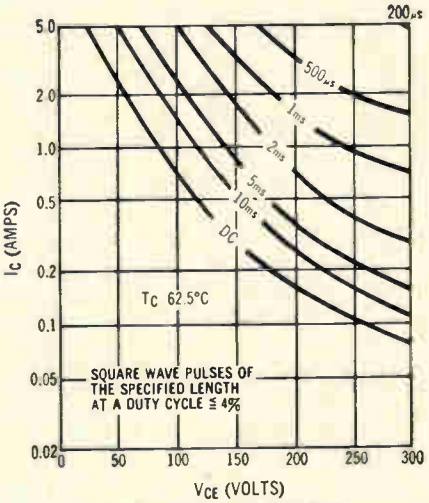
V_{CBO}	400V		
V_{CEO} (sus)		370	325
I_C	5A		
I_B	2.0A		
Junction Temperature	150° C		−65° C
h_{FE} (I_C=2.5A V_{CE}=5V)	35		15
h_{FE} (I_C=3.5A V_{CE}=5V)			10

TYPICAL SWITCHING TIMES:
Rise time —0.40 Microseconds
Storage time—0.45 Microseconds
Fall time —0.35 Microseconds



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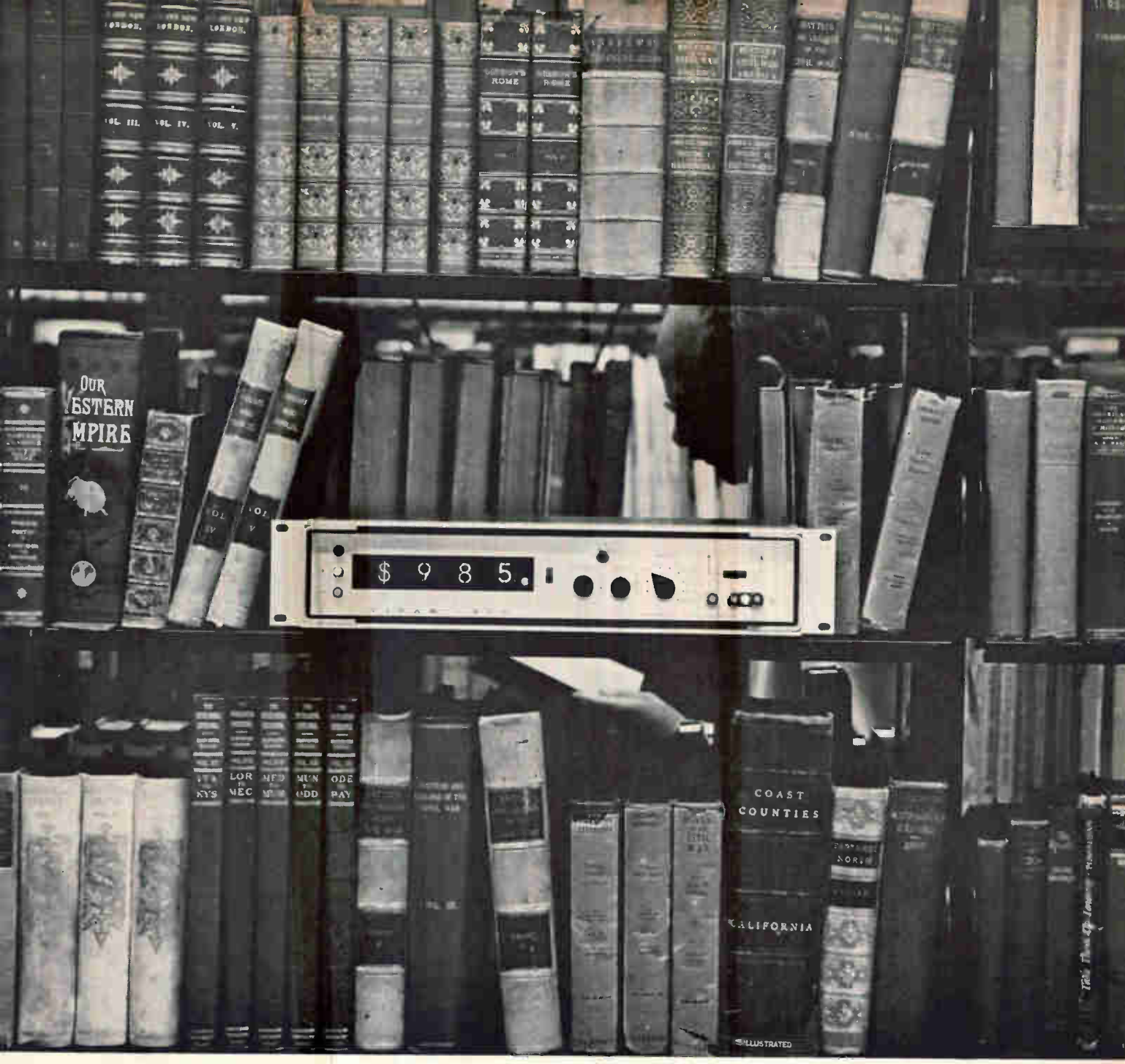

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Communications satellites: 1966 and beyond

Apollo astronauts, Pentagon generals and Japanese baseball fans will start using them this year; satellites talk in louder voices, live longer in orbit and soon will be able to listen to many ground stations simultaneously

By Robert Henkel
Space electronics editor

Satellite communications is making so swift a transition from developmental to operational systems that it is outdistancing even the most optimistic earlier estimates of its growth. As often happens in fast-moving technologies, forecasters underestimated the growth of satellite systems and overestimated the technical problems.

This year, a big one for operational communications satellites, will not produce a traffic jam 19,400 miles up but it will see production under way on three, or perhaps four systems. Also on tap for 1966 is:

- Launching of the first military communications satellites.
- Deployment of two Apollo support satellites.
- Offer of commercial satellite circuits over both the Atlantic and Pacific oceans.
- Probable start of construction on a very high-frequency communications satellite for aircraft.
- Initiation of design studies for a tactical communications satellite and a commercial multipurpose system.

This acceleration of space communications has been achieved despite formidable nontechnical obstacles. Not only was there foot-dragging and frequent changes in direction from military planners but there were pressures from political and vested interests inhibiting the growth of communications satellites.

Technically the field is shaping up well. The stationary satellite concept, for example, has proven even better than its proponents, once outnumbered, had expected. Originally dubious, the Communications Satellite Corp. now acknowledges this is the best way for it to go. Satellite reliability is proving to be better than first projected, station keeping in orbit can be handled, and time delay and echo are no problems on voice links.

"Technically, things have gone much faster than we thought," says Sidney Metzger, engineering manager for Comsat. Several key subsystems for advanced satellites will be demonstrated in flight tests later this year and early in 1967. Some of the important technical questions these tests may answer:

- Will the electronically despun, phased-array antenna provide the expected radiated power improvement in space?
- Can eight satellites be ejected by dispenser into a near-synchronous orbit on a single launch?
- Will the frequency division, multiple access scheme being designed into the first commercial global system perform as hoped in its first flight test?
- Will the gravity gradient system for stabilizing a satellite in orbit work effectively at higher altitudes?

Engineers riding bosun's chairs adjust 40-foot antenna on Mark-1B ground terminal for the Initial military system. Terminals like these, rather than flight hardware, will be big business.

I. Blossoming commercial systems

Engineers at the TRW Systems Group of TRW, Inc., in Redondo Beach, Calif., have been hard at work recently on eight different communications satellite proposals. TRW's competitors are busy too. It seems that everyone—from the Mormon

church to the petroleum industry—is taking a close look at using satellite communications.

The hardware builders are confident of their ability to turn out communications satellites. "In terms of the technology required, it's here—and it's been here," declares H.T. Hayes, manager of TRW Systems' Communication Laboratory.

But technical ability is not the problem, says the head of the communications satellite program at another company. He points a finger at those interests whose existing communications plants and equipment are being written off on obsolescence schedules as long as 20 years. Such extended write-off periods could slow the use of satellites.

True, nobody is waiting to buy time on Early Bird, Comsat's first commercial satellite. Only 75 of the bird's 240 channels are leased currently. Since there are about 50 underwater cable circuits still idle between the United States and Europe, Comsat explains, their owners are reluctant to buy satellite time until the cables are filled. But with transatlantic traffic increasing by 20% annually, Comsat believes Early Bird will start filling up after the cable circuits reach capacity later this year.

It was only 10 years ago that the first transatlantic telephone cable was laid. By the end of last year total investment in such overseas voice-grade cables passed the half-billion-dollar mark. But telephone cables may soon join high-frequency radiotelephone and overseas telegraph cables in a retreat to obsolescence, as satellites enter the picture and bring down circuit costs.

Comsat in control

As far as the commercial communications satellite business goes in this country, the Communications Satellite Corp. has a virtual monopoly under the 1962 Communications Satellite Act to provide such circuits. Incorporated in February, 1963, the publicly held company currently owns 55.35% of the International Telecommunications Satellite Consortium, and is manager for developing the space segment of the Intelsat global systems.

The biggest shot in the arm to Comsat business, however, could be the recent bids to use satellite communications domestically by the Western Union Telegraph Co. and American Telephone & Telegraph Corp. Both companies have asked Comsat to talk about putting up domestic satellites and chances are good that such satellites will go into use within the next two to three years. By requesting such service, both companies tacitly acknowledge Comsat's right to own domestic satellites.

AT&T is talking about one large-capacity synchronous satellite for domestic service to supplement its interstate cable and microwave links. Informally, it is discussing satellites with circuit capacities ranging from 3,000 to 12,000. The company is ready to pay the full cost of the satellite but says other domestic communications carriers could use it if they paid their share of the cost. Western Union has been considering the use of up to eight ground stations for domestic satellite service.

Communications satellites

Satellite	Deployment date	Builder	
Early Bird (303)	April, 1965	Hughes	First commercial system, put up by Comsat over the Atlantic. Currently operational.
IDCSP (Initial)	June, 1966	Philco	First military system; 22 to be launched into a 18,400 nautical mile near-synchronous orbit by three Titan-3C boosters.
303-A Blue Bird (Intelsat-2)	September, 1966	Hughes	Two Comsat satellites (over Atlantic and Pacific) to provide commercial channels, and links for NASA Apollo network.
Aerocom	Mid-1967	Not selected	Aeronautical services satellite, planned by Comsat to provide vhf voice relay to aircraft over Atlantic. Evolution to global system possible.
Global (Intelsat-3)	Early 1968	TRW Systems	Multiple access, 1,200 channel-satellite; Comsat plans to launch several in a system to cover world.
Multi-purpose	1968–1969?	Not selected	Comsat to select contractors shortly for preliminary design.
ADCSP (Advanced)	1969?	Not selected	Six studies now being evaluated by DOD.
Tactical	1968–69?	Not selected	Request for proposals expected this summer from DOD on military system.

This is potentially big business for Comsat since domestic interstate communications account for between $3 billion and $4 billion in annual revenue. U.S. international telecommunications business, by comparison, amounts to about $200 million a year.

Comsat must decide also whether it will try to provide the domestic satellites alone or in conjunction with Intelsat. It could go either way.

Big decisions

One question that has to be answered soon is whether Comsat will be the only U.S. company to put up and operate communications satellites, domestic as well as global systems. The earlier-than-anticipated move by AT&T and Western Union to use satellites for domestic service is being interpreted as an attempt to block their customers from putting up their own satellites.

The television networks, led by the American Broadcasting Co., have done the most talking about their own systems. ABC last year proposed a television distribution system, using a synchronous satel-

lite, to the Federal Communications Commission but a decision on this is not expected for several months at the earliest.

The important FCC ruling on the ABC filing, which some feel will come this year, will also have international implications. If Comsat is given the sole right to domestic satellites, the U.S. could take the lead in maintaining a single organization (the International Consortium) in the international communications satellite field.

The interim agreement on global communications satellites comes up for review in 1969 by the 48 member nations of Intelsat. Comsat would like to see the interim terms continued in a new agreement and the inclusion in the consortium of more nations, especially the Soviet Union. One worry is that the Russians, who have already launched communications satellites, may put up a global system of their own.

Comsat is pushing hard to get its full-fledged global satellite system operating before the 1969 Intelsat meeting to dissuade other nations or blocs of nations from putting up separate systems. More than one system could mean operational conflict and inefficiency. The Intelsat agreement calls for joint ownership of the satellites by member countries. Each member country owns its own ground stations.

But even if individual nations put up their own domestic communications satellites such systems would not necessarily interfere with global communications networks or communication links of nearby countries. The Hughes Aircraft Co., which has conducted a number of studies in this area, says Japan, for example, could put up its own satellite and not illuminate China or even the Philippines with its signal.

Several countries and some foreign companies are thinking along domestic system lines. Hughes expects to begin a study soon on a television broadcast distribution satellite for a Mexican television network. Also talking about putting up their own communications satellite systems are France and a group of European nations.

Fast job for NASA

Coming up next on the Comsat schedule is the rush job to deploy an uprated Early Bird, the Hughes-built 303-A, which is also being called Intelsat-2 and Blue Bird. Providing the urgency and initial channel demand for Blue Bird is NASA's need of a reliable communications link with six of its remote Apollo tracking stations.

Two Blue Birds are scheduled for fall launching —one over the Atlantic by September and the other over the Pacific by October. Besides six voice/data circuits for NASA, Blue Bird will open commercial links in the Pacific with nearly 180 channels and augment Early Bird's existing 240 channels in the Atlantic with another 100. Comsat already has a commitment to transmit the World Series to Japanese baseball fans.

Although heavier (155 versus 85 pounds in orbit) and more powerful (15.5 decibels above 1 watt versus 14.5 dbw) than Early Bird, Blue Bird is rated at the same 240 channels because its antenna beam width has been increased from 10° to 15° in order to cover more of the earth. Six voice/data channels will be provided NASA and each channel will use 27 times more power than a North Atlantic channel through Early Bird. This is because Apollo tracking ships will have only 30-foot antennas and a receiving system noise temperature of 170° Kelvin, compared with the 50° K noise temperature of the 85-foot dish systems used with Early Bird.

Bandwidth has been increased to about 125 megahertz (megacycles per second) on the Blue Bird by using a single conversion transponder that includes a four-stage tunnel-diode amplifier and four 6-watt traveling-wave-tube amplifiers which can be operated in parallel.

Hughes is past the half way mark of a "tough" eight-month delivery schedule on four satellites. Says Richard M. Bentley, program manager: "It will cost us $5,000 every day I'm late with each of the first two spacecraft." The first one is due July 12 and the second three weeks later. Hughes can also earn incentive payments on the satellites for up to 48 months of orbital operation.

Bentley, who was running two weeks behind schedule half way through the program, says his toughest problem was getting components such as capacitors and 1% precision resistors. He was concerned about 20 "problem components" out of a total of some 650 different parts in Blue Bird.

The Blue Bird has a rated three-year operational life and will fill the time gap between Early Bird and the upcoming global system (Intelsat-3) for international television and telephony links. If necessary, a Blue Bird will replace Early Bird, now in its 13th month of commercial operation over the Atlantic.

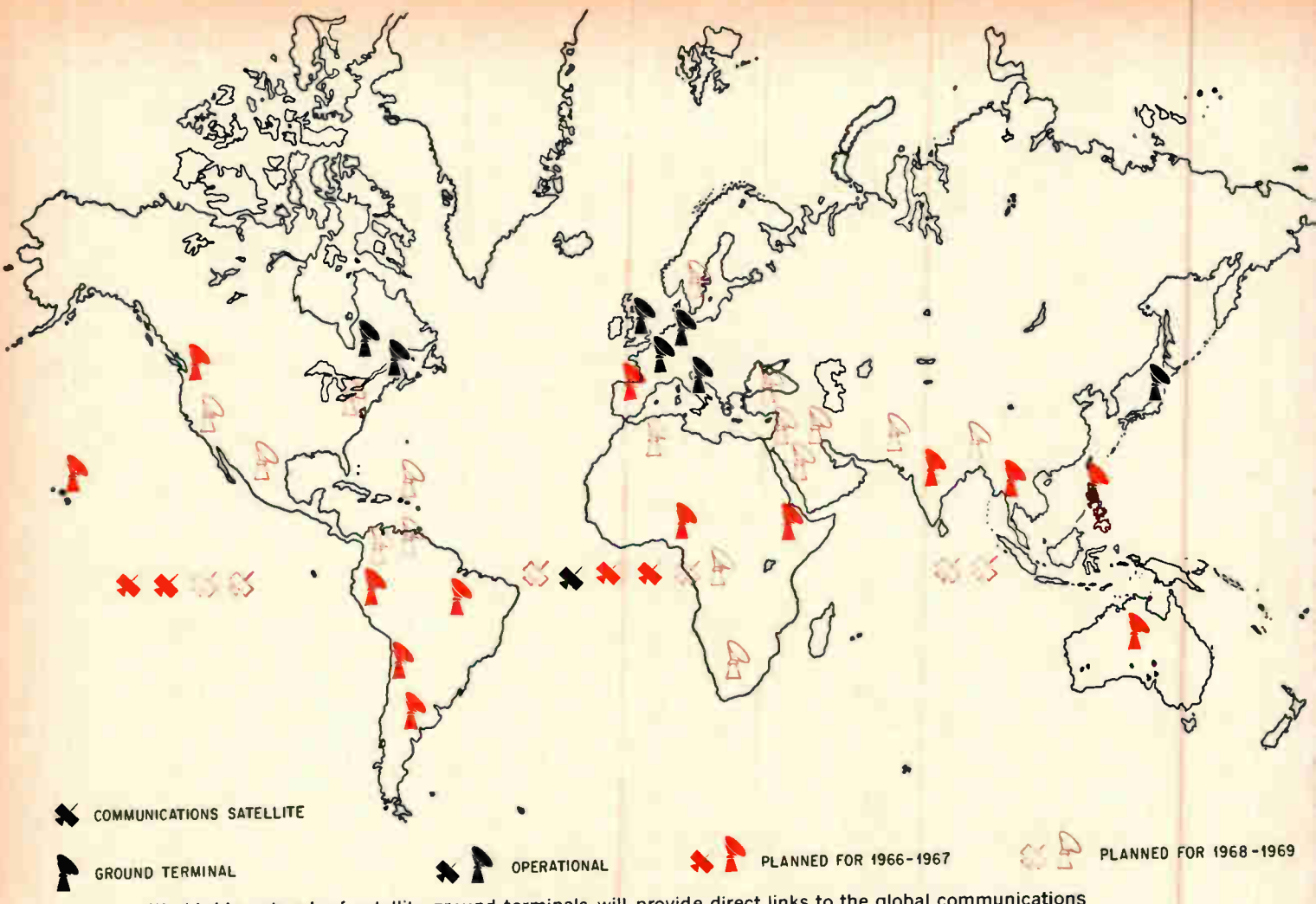
Synchronous global system

Comsat is now shooting for early 1968 for the deployment of its global system, designed to handle projected telephone circuit needs through the early 1970's, says Spencer W. Spaulding, manager of Comsat's Systems Analysis division.

A delayed decision finally was made in March to go to synchronous altitude with the system. Ironically, the longtime champion of the higher orbit, Hughes, had already lost out on this contract to TRW Systems, which had originally proposed a medium altitude phased orbit system. The final design specifications on the spacecraft were written so that either orbit could be used.

So, instead of a production order of some 24 satellites for the medium altitude system, TRW Systems' first contract calls for six spacecrafts for a four-satellite stationary system (two over the Atlantic, one each over the Pacific and Indian oceans, and two in reserve).

Negotiations on the fixed-price contract, dragging on since last November, were expected to be completed this month. Although TRW Systems denies



Worldwide network of satellite ground terminals will provide direct links to the global communications satellite system now being developed for the 48-nation International Consortium (Intelsat) by the Communications Satellite Corp. Ground stations shown are based on current Comsat estimates; satellites include those operational, being built or in the planning stage.

that the decision to go synchronous means a substantial amount of redesign work on its spacecraft, it has been said that about the only thing TRW salvaged from its medium altitude phased system studies in 1964 for Comsat was a linear repeater. The repeater, incorporating tunnel diodes, was designed by the International Telephone & Telegraph Corp. and has a bandwidth of 225 megahertz. Two will be used on each satellite.

The spin-stabilized 260-pound satellite, measuring 56 by 37 inches will have an erp (effective radiated power) of 22 decibels above one watt. This allows for 1,200 to 1,500 or more two-way telephone circuits, the exact number depending on channel bandwidth. Solar cells will put out 160 watts of raw power for the repeater, which will drive Sylvania Electric Products Inc.'s electronically despun, phased array antenna.

Foreign builders? Not yet

Competition to build flight hardware for satellite systems is heating up, at least among companies in the United States. Until last November, Hughes was in the driver's seat with its early gamble on synchronous satellites paying off. But when Comsat selected TRW Systems instead to build the global system, one of the major reasons for its choice was said to be the corporation's need of more than one production source for flight hardware.

U.S. firms are supplying nearly all the hardware presently. Comsat, with a nudge from some of its foreign consortium partners, was interested in bringing in overseas manufacturers on the global system work. In its original proposal, TRW said it would build some of the satellites entirely overseas, but the picture has changed in the shift to synchronous and the resulting lower requirement for flight vehicles. TRW now says it will build the satellites overseas only if more than six satellites are built. Comsat was also disappointed recently when it received no responses from overseas manufacturers on its request for proposals to design a multipurpose satellite.

Traveling salesmen

Despite their setback on the global system, Hughes satellite salesmen are having a busy spring. They are proposing an uprated 303-A Blue Bird they claim is "comparable to the global system." A Hughes team has been on the move throughout Europe contacting members of the consortium's interim committee. In talking up the uprated 303-A, they have been promising the first satellite 13 months from a go-ahead at a price about two-thirds of the TRW model. Contrasting with the early 1968 deployment schedule for the global system, Hughes

maintains that the first two uprated Blue Birds could be launched in the August-September, 1967 period, if it got a fast go-ahead.

Hughes sees the improved Blue Bird not only as a possible second source on the global system but also as a way to upgrade the Apollo support satellite it is now building for Comsat. It has already proposed its improved Blue Bird to upgrade the two-satellite systems in 1967 from an equivalent 240 channels to 1,000 channels per satellite. This could mean retrofitting the two reserve Blue Birds now being built and producing two new uprated models.

User requirements may also call for a second Blue Bird satellite to be launched into a Pacific station next year, mainly to service an expected increase in military traffic. Although the Pentagon is ready to start launching its own system for secure communication links, it is also expected to become a heavy user of commercial circuits for routine traffic.

The improved 303-A would use an electronically-despun phased-array antenna to up Blue Bird's 15.5 dbw of effective radiated power to 25 dbw. An improved transponder was also proposed as part of the 303-A upgrading. It would quadruple the 303-A bandwidth from 125 megahertz to 500 Mhz.

Help coming for pilots

This month, the uprated 303-A probably will also be proposed to Comsat for an aeronautical services satellite (Aerocom).

Because of the great interest shown by the airlines and the Federal Aviation Agency, Comsat is planning to put up Aerocom as soon as possible to experiment and gain operational experience.

Planned for launching in the middle of next year, the 210-pound synchronous aeronautical satellite will provide voice communication relay to commercial aircraft over the Atlantic where currently used links such as high frequency are least effective. This means working with lower performance terminals, the use of vhf and very low gain aircraft antennas.

Initially, two transportable ground stations with 42-foot antennas would be used, with Comsat guaranteeing two communication channels.

Once this initial aeronautical satellite proves out, Dick Bentley of Hughes believes it will "take off and expand quickly into a global system." Such a system could provide to transoceanic flights such services as aircraft location, traffic density information and in-flight telephone hook-ups for passengers. Airline reservations and ticketing could also be done via the satellite for international traffic, eliminating the "endless telephone calls and days of waiting" ticketing now takes, he says.

Due to get under way shortly for Comsat are several four-month preliminary design studies for a large multipurpose satellite that may well end up providing both aeronautical (air traffic control as well as communications) and television distribution as early as 1968 or 1969. Launched by an Atlas-Agena vehicle, the satellite would weigh about 800 pounds in orbit. It may have as many as three narrow beam antennas and 10 to 12 repeaters to accomplish its varied tasks. With a planned 500-Mhz bandwidth and erp of 40 dbw, the satellite will have a capacity of about 5,000 to 6,000 two-way telephone circuits.

Data via satellite link

The list of potential users for commercial communications satellite circuits is nearly endless when applications beyond the near-term are considered.

One of the most exciting applications, to Comsat and hardware producers alike, is the potential of data transmission by satellite. It's hard to say when computer-to-computer hookups via satellite will be big business, but Bentley of Hughes forecasts that data transmission one day will be "the biggest source of revenue from satellites."

Some of that revenue will come from the military. He predicts, for example, that in two or three years, when more satellite circuits are available, data on all military logistics between the Pentagon and Vietnam will flow through satellite links. Satellite wideband circuits will facilitate the use of faster data rates needed by the Defense Department. One high speed rate of 40,800 bits per second requires a bandwidth equivalent to 12 voice circuits.

As larger numbers of satellite circuits become available and long-distance rates decline (rates will not be based on distance and time as they now are, but solely on the amount of time used), business usage of data transmission will expand rapidly. It will then become practical, for example, for many companies to handle their inventory control in real time from a central location for as many as 30 to 40 different plants scattered around the country.

Satellite-to-home television

Comsat believes direct television broadcast from satellites to home receivers is at least 10 years away commercially, but the kind of distribution the ABC television network is proposing could come much earlier. Tv distribution would mean transmitting frequency-modulated network television programs down to local tv stations directly from a satellite in place of ground links from the originating point.

Comsat's multipurpose satellite is being designed with this application in mind, but the corporation has been making a study on providing an interim tv distribution service. Should a need develop for such interim service, Comsat says it could adapt one of its presently planned satellites to begin this kind of service in "late 1967 or early 1968."

Disagreeing with Comsat's timetable on direct tv broadcast is Bentley of Hughes, who thinks broadcasting to home receivers will come "in the early 1970's—1970 or 1971." Because of power limitations on the satellite this would be restricted to a single country or region. Tv transmission to network commercial stations via satellite or educational television to schools on a statewide basis, for example, will be in use by 1969, the Hughes

communications satellite manager predicts.

Hughes, which did the tv-distribution study on which ABC based its application to the FCC, spelled out a system incorporating a synchronous satellite and ground receiving terminals for individual local stations. Bentley says 30- to 40-foot fixed dishes could be installed for about $40,000 to $50,000 each, and would include "fairly good receivers with tunnel-diode front ends."

In the ABC study, Hughes estimated the cost of the over-all system at about $5.9 million per year, including a replacement period of five years for the satellite, 200 30-foot receiving terminals, two 60-foot originating terminals, an experimental receiving station and a telemetry and command station. The estimated total is half the current land microwave lease payment of $11.9 million annually made by ABC to AT&T. Hughes "leaned over backwards to be conservative" in its estimates, Bentley says, and indicates the total could be lower.

If detailed design studies were started now, the Radio Corp. of America believes it could demonstrate large-area telecasting into home receivers by 1969. RCA would use a synchronous satellite with a single tv channel capacity. This practical demonstration would be made at a frequency of 800 Mhz, which is channel 69 in the uhf band. Using a 40-foot dish antenna and transmitter power of 5 kilowatts on the satellite would provide an acceptable signal for home receivers modified by an outside antenna and booster amplifier, both costing under $100, according to the RCA in-house study.

Hughes' plan for a tv broadcast distribution satellite for educational television would use the company's proposed HS307 satellite. This nine-foot diameter synchronous satellite, also used in the ABC study, would weigh about 1,550 pounds and would be launched by the Atlas-Agena vehicle. Using an intermediate-frequency limiter repeater with a 25-Mhz bandwidth, an effective radiated power of 40 dbw could be obtained for the single tv channel and 20 voice channels.

Hughes has considered larger satellite configurations than the 307's nine by eight feet and con-

What happens to international cables?

On the eve of routine global communications by satellite, international cables are being installed at an unprecedented rate.

Submarine cables are being laid this year between Hong Kong and Singapore, Guam and Australia, the Virgin Islands and Venezuela, and Portugal and South Africa. Another cable between the United States and Puerto Rico is planned. Additional cables to the Far East and South America are being considered.

International common carriers say they would not be investing heavily in cables if they believed that satellites would rapidly replace them. On the contrary, carriers expect to install cables for at least five to 10 more years—and probably for a longer period on short, heavily used routes.

At the same time, however, the carriers are developing and financing communications satellite systems, through such agencies as the Communications Satellite Corp., and privately, by installing satellite terminals in other countries.

The carriers expect satellites to open up huge new markets in international communications. Satellites should shine, to cite two examples, in transmitting digital data at high speed between computers in the world's commercial centers and in establishing high-quality communications between these trade centers and areas which cannot be served economically by cables. The international transmission of television by satellite has already begun.

There are two reasons for the expected longevity of cables—and for ground-based, international radio communications as well. First, the world's hunger for more and better communications seems insatiable. Second, it usually pays to maintain existing facilities when they are doing a good job, they add.

The introduction of coaxial submarine cable in 1956 immediately stimulated overseas telephoning because coaxial cable offered higher-quality voice communications than high-frequency radio and more rapid data transmission than h-f radio or d-c telegraph cables. The radio channels are still crowded, but outmoded d-c cables will be discarded and new ones will not be installed.

The international carriers won't discard coaxial submarine cables, which are economical to maintain, as long as keeping them saves the leasing fees for satellite channels. They will use the satellites when, as will often be the case in the future, the satellite fees are less than ownership expenses.

The cables being built this year have 80 to 360 voice-grade channels. They fill customer needs that satellites cannot yet satisfy, the carriers say.

Forecasts generally agree that the number of voice-grade channels will have to approximately double, from 3,500 now to about 7,000, in five years and triple within 10 years. About 70% of the new channels will terminate in areas with heavy communications traffic—the type of situation which is said to favor cable.

New 360-channel cables will cost less than satellites per channel until the early 1970's. Proposed 720-channel cables and 1,280-channel cables being developed will be even less expensive than satellite systems.

Nevertheless, the carriers concede that by 1970 there will probably be 30 or more nations interlinked by communications satellites.

Filing a minority report on the view that satellites will make cables obsolete are representatives of the common carriers. Their opinions, combined in this article, express the belief that satellites will not replace cables but, instead, will supplement existing communications facilities.

cluded the improvements gained don't seem to be worth the increase in size. By doubling the satellite length to 16 feet, an effective radiated power of 43 dbw was calculated. But the improved output (compared with 37 dbw) isn't worth the required size increase, Bentley says.

As far as Hughes is concerned, the 307 is a plateau in communications satellite size over the next 10 years. The Hughes design approach will be toward special-purpose systems. During this decade, Hughes plans to stay with already proven launch vehicles such as the Atlas-Agena booster.

Weather and the Mormons

Another job for communications satellites will be to collect meteorological information from a worldwide network of weather observations stations—from ocean buoys to aircraft—and feed this data into a master computer complex to obtain the world weather picture. The analysis and forecast in turn could be distributed to cities and towns throughout the world by the same satellite network. Three or four synchronous satellites could pick up virtually all weather stations, excluding only the polar areas. Hughes is beginning to talk to users about such a satellite network, which would also take pictures of cloud cover over the earth in the manner of the Nimbus and Tiros meteorological satellites.

The petroleum industry is also interested in communications satellites to transmit data on core samples from off-shore drilling platforms to a central laboratory, for example. And recently making inquiries about a satellite radio relay was the Mormon church, which could literally talk to the nation from one pulpit.

Where the dollars are

While much of the prestige and excitement in the communications satellite business is concentrated on the flight hardware, this is not where most of the dollars for such systems will be spent in the electronics industry. For manufacturers, the big business ahead is in the ground terminals.

Telephone services

Cables have caused a growth in telephone traffic as large as 75% a year. How supply influences demand is illustrated by the U.S.-to-Puerto Rico cable. In 1960, International Telephone & Telegraph Corp. and American Telephone & Telephone Co. installed 48 channels, which were increased to 84 in 1962 by time sharing. Another 138 channels were added in 1964 and a 720-channel system will be needed next year.

The cables don't rule out satellites in the future. In fact, permission to install both satellites and cables when additional facilities become necessary has been requested from the Federal Communications Commission. Satellites will augment cables on many other routes, because most of the existing cables have insufficient channels during peak telephoning hours.

Satellites also will fill the need for high-quality telephone service to areas not connected by cable because costs are too high. A satellite can do the work of many long, individual cables, thus slashing costs. In this market, satellites will be competing with h-f radio, not cables.

H-f radio is now the cheapest form of long-distance communication and carries a large portion of world-wide traffic. However, it is subject to ionospheric fading and the average link is limited to four voice-grade channels because of a shortage of spectrum space.

Satellites are not expected to reduce the number of radio facilities. They will still be needed as a low-cost backup. Any h-f channels dropped from international service will probably be snapped up for communications in undeveloped countries.

The spectrum crowding that hampers h-f radio may in time have its counterpart in satellite communications. Cables don't have this problem, because they do not depend on radiated signals. This is still another reason why carriers say they will retain existing facilities.

Data transmission

Satellites should win a major share of the developing market for high-speed data transmission by making this type of communication inexpensive.

Telegraph cables usually transmit less than 100 bauds (code elements) a second. H-f radio is usually restricted to 1,500 bits a second, per voice-grade channel. A coaxial cable channel can handle 2,400 bits a second. The limiting factor in voice-grade channels is bandwidth, 3 kilohertz in most coaxial cables. It pays the carrier more to use these channels individually for telephoning than to devote the bandwidth of several channels to raise data speed.

Microwave-frequency satellite channels will have 10 times the bandwidth of channels in the most advanced cables being designed, and will carry data at a correspondingly higher rate. In addition, satellites will make more data channels available than cables.

The military forces are developing satellite data links and once businessmen learn how to take advantage of commercial links, satellite data traffic will boom. Under favorable conditions, the annual growth could be 50% a year for the next five years, says an ITT source.

Undeveloped nations

Satellites will cause a revolution in communications with underdeveloped nations, once the problem of establishing ground stations and local ground networks are solved. Besides providing better telephone service, satellites will make practical such services as data links with remote computers. Communications within continents also will be improved. Countries in Latin America, Southeast Asia and Africa that cannot afford extensive microwave or cable systems will find satellite systems an inexpensive substitute. As soon as technology allows many small ground stations to share access to a communications satellite, these countries will leapfrog into the satellite era.

Even though Hughes has captured much of the commercial satellite hardware, it doesn't expect to exceed $20 million to $30 million a year in communications satellite sales until the 1970's, when this volume might double. The company wouldn't even begin to forecast ground station sales.

Activity is beginning to pick up in this area. Hughes is now putting the finishing touches on a ground station with an 85-foot antenna it built with its own money in Caddo Gap, Ark. It plans to fly a group of foreign potential customers to the station later this month for a demonstration.

TRW Systems reportedly will team up with another company and enter the ground station business with an 85-foot steerable dish model. The first opportunity for it to bid on a station may be for the Australian ground station for Comsat's global system. An announcement on this joint venture is expected shortly.

Comsat also is predicting a big upturn in ground station construction. By the end of 1967, some 15 to 20 countries are expected to have ground stations completed, or well under way, for operating with the global system. By then, Comsat expects to have three or four stations in the U.S., and possibly another in Puerto Rico. By 1969, Comsat is predicting that 30 to 40 countries will be linked into the global system.

The Arkansas ground station was put up by Hughes as a prototype of equipment that it hopes to sell at from one-third to one-half the cost of earlier ground stations. Much of the savings comes because a tracking capability in the antenna is unnecessary with stationary satellites. The stations at Goonhilly Downs, England, and Pleumeur Bodou, France, were said to have cost more than $10 million each, while AT&T's Andover, Maine, station represents an investment estimated at between $15 million to $20 million. The Arkansas station is also a Hughes prototype for multiple access by ground stations into the satellite.

II. Technical confidence grows

Much of the credit for the fast moving technical pace of the communications satellite field goes to the success of the three satellites now in orbit—Syncom 2, Syncom 3 and Early Bird. Probably even more successful than their builder, Hughes Aircraft, expected, the three had chalked up a total of 1,670 days in orbit by the end of 1965. Out of nearly five years, less than 24 hours were unavailable for communications because of satellite malfunctions.

NASA's two Syncom satellites are now being operated by the Air Force as military communications links to the Far East, while Comsat's Early Bird, launched in April, 1965, is the first commercial satellite between the U.S. and Europe.

The only electronics failure so far was a pnp silicon alloy transistor (2N2185) that suffered a collector-to-emitter short on Syncom 2. The device served as a commutator switch in one of the two telemetry encoders. This failure, of course, didn't interfere with the satellite's primary job as a communications repeater.

In making lifetime predictions on these satellites, the limiting factor was the traveling-wave-tube amplifier, but none of the six twt's flying on Hughes satellites have failed so far. Engineers were worried about twt life four or five years ago, but now Hughes engineers don't know what the practical limit on tube life will be. Tube designers are now talking about 200,000- and 300,000-hour lifetimes on the 6-watt twt's.

Based on Early Bird and Syncom performance, Hughes engineers are gaining more and more confidence in predicting satellite lifetimes. For example, they are now predicting five-year lifetimes with a 70% confidence factor. "And it won't be long before we will be predicting, quite accurately, satellite lifetimes of 10 years," says Dick Bentley of Hughes. He even sees the day, perhaps 10 years away, when predicted lifetimes of communications satellites will be 20 to 30 years. This long a lifetime would be based on nuclear power supplies and considerable circuit redundancy.

R-f power in parallel

While considerable work is being done currently on higher power twt's for communication satellite transponders, Hughes is taking a different tack to increase the r-f power output of the satellite in order to retain high reliability—keep the reliable 6-watt Early Bird tube and operate several in parallel.

When the 303-A Blue Bird is launched this fall, it will operate four of the 6-watt tubes together to get 24 watts of r-f power. In about a year, as its solar cell power system degrades, Blue Bird will switch down to three tubes in parallel to emit 18 watts.

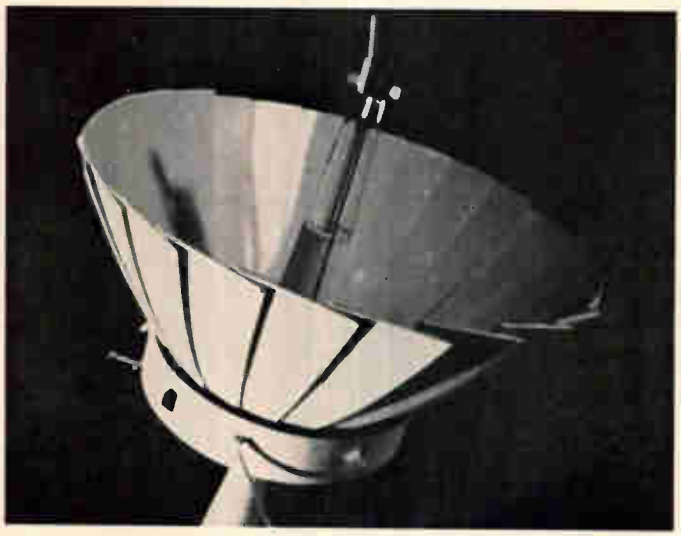
By staying with low-power devices in its parallel approach, Hughes engineers believe they can reach the 100- to 200-watt range of r-f power in one satellite. And if one of the small twt's quits working, there is a modest degradation of power, not the complete outage that would result if a single high-power tube failed.

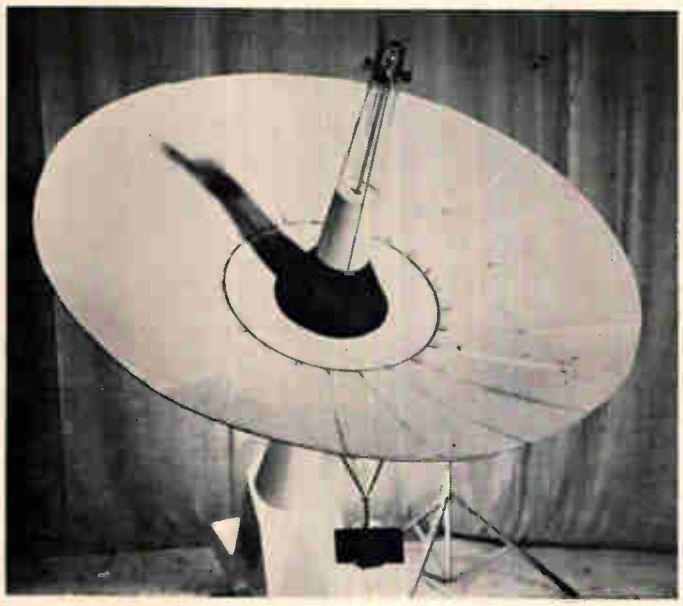
Hughes has come up with a new transmitter—antenna system that it claims has operated at a new high in effective radiated power for a satellite system. Tested earlier this year on the firm's antenna range, the system had an erp of 36 dbw or 4 kilowatts, according to Boris T. Subbotin, senior scientist at the Hughes Communications Satellite Laboratory. This is a factor of 20 greater than the 22.5 dbw specified for Comsat's global system.

Subbotin, commenting on the large amount of power generated by the system, notes "the first time it was turned on, the output exceeded the acceptable safety tolerance level of r-f microwave energy for man."

Beam size was nominally 17° by 21°. The band-

Sunflower antenna





High-gain antenna, opening like a flower, has been proposed by TRW as a 15-foot dish for a tactical communications satellite. Taken from earlier company work on a 30-foot solar collector called Sunflower, this 8-foot model shows how antenna would unfurl.

width of 300 megahertz was obtained without any attempt to redesign the frequency limiting portions of the equipment which were Applications Technology Satellite components.

The ATS phased-array system used is made up of 16 stacks of radiators arranged circularly around the spin axis. They are driven in proper phase to form a pencil beam, which is despun electronically to cancel out the satellite spin. There are no moving parts to limit operating life.

In the new system, "multiple" parallel twt's (Hughes wouldn't say how many) are driven and phased to form the beam, each twt driving its own part of the antenna array. Outputs of the tubes are not combined, since Hughes is minimizing the hardware and the distance between the r-f source and the radiating elements.

"We're not only picking up the sum of the r-f power but also the losses within the previous 303-A system. There the phase shifting is done ahead of the twt. In the test, the spin ripple, which should be as small as possible, was a 0.3° variation in the erp."

Before the test, some people were worried about phase differences in the new antenna system, says Bentley, but this has not proven to be a problem. He doubts if anyone is going to come up with a more practical approach to increasing power without getting into new technology.

Boom from multiple access

Communications satellites, so far, have operated as a relay or cable replacement in a trunk system where one ground transmitter uses the entire satellite.

But the real growth in satellite communications will come with multiple access, which means that a satellite can be used by many ground stations simultaneously. By sharing a single satellite repeater among many users, service costs can be reduced and small and large ground terminals with differing communications requirements can participate at the same time.

The first Applications Technology Satellite (ATS-B) will test the multiple access technique Comsat is using on its global system—frequency-division multiplex. The test will be from the ground to the satellite using single sideband modulation —this uplink capable of carrying 600 two-way circuits. The experiment will have from 12 to 24 active circuits plus noise loading to simulate all-channel use. These signals will be converted into phase modulation of a single carrier in the spacecraft and retransmitted to all stations.

Comsat hopes multiple access by frequency division will satisfy most of its needs for at least several years. However, it is not the most efficient technique from the standpoint of frequency spectrum conservation and probably is not the best way to have multiple access among large numbers of small inexpensive stations such as ships, aircraft and automatic weather stations. Comsat also is currently looking into time-division multiplexing.

One of the penalties paid for multiple access, particularly for frequency division, is that it takes more bandwidth. And the radio-frequency spectrum is already so overcrowded that commercial communications satellites must operate in the same bands used by line-of-sight radio relay systems on the ground. This has led to a limitation on the amount of power that reaches the ground from satellites in these shared frequency bands; a limitation which prevents the use of higher power satellites already technically feasible for communications with small inexpensive earth stations.

Pacing power systems

One of the pacing technologies in building practical communications satellites has been the power system. But surprisingly enough, most specialists, including those from Comsat, agree that for the next five to 10 years, possibly even longer, these satellites will use solar cell or photovoltaic systems. The prosaic solar cell—written off time and again in recent years by engineers for large power sources in space—is now being seriously considered for systems in the kilowatt ranges. For 1975 flight hardware, 40- to 50-kilowatt photovoltaic systems are being called practical and realizable by engineers from TRW and RCA.

Engineers at Hughes foresee "several kilowatts" of power out of deployable arrays that unfold or expand in space, but then worry about the structural dynamics of these solar cell assemblies. "It seems an uncertain way to go," says Hughes communications satellite programs manager Bentley, who maintains that such mechanical deployment configurations have not proven to be reliable up to now. One of the reasons why the Syncom and Early Bird satellites have demonstrated good reliability has been the use of only skin-mounted solar cells.

Hughes is now getting 6 watts per pound out of its solar array (structure materials, solar cells, and diodes) to the unregulated bus. Any nuclear power source will have to compete with the solar cell's cost and watts per pound, as well as assuring that safety requirements can be met. The Early Bird power system, with a 3% degradation annually on its n-on-p cell supply (based on normal solar-flare activity) has a calculated 14-year lifetime.

The company has been proposing its 307 satellite with 550 watts of d-c power, but it says it can increase the power to 700 to 800 watts still using only skin-mounted cells. And by going to advanced deployable arrays such as one that extends outward 100 feet in accordion fashion, one to two kilowatts of raw power can be produced, Bentley believes, on the 307.

Learning from OGO

Existing solar cells mounted on lightweight, deployable structures of rigid foldable panels "will be the way to go," says Alfred Krausz, assistant manager of TRW Systems electric power laboratory. "Using today's technology, we should be able to build large, oriented solar-cell arrays producing 10 to 50 kilowatts of power." Such an array could be as large as 5,000 square feet or more of solar cells. This technique would give "better than 20 watts" per pound of raw power (exclusive of conditioning) in synchronous orbit or 50 pounds per kilowatt.

Tests have been conducted successfully at lower altitudes with this deployment scheme, according to Krausz. Directly applicable to communications satellites is an improved version of the Orbiting Geophysical Observatory (OGO) solar power subsystem. This TRW-built array, based on a four-year-old technology and putting out 600 watts, can be made lighter and assembly costs reduced, he says.

One problem is temperature variation. But solar cells can take a –150°C to 100°C excursion, and by proper design, temperature variations, deployment loads and stresses during launch can be allowed for, he feels.

The biggest problem is not in conversion of solar energy though, but in structural dynamics. Large arrays have to be verified in flight tests, although feasibility was demonstrated in the Pegasus satellite. Aerodynamic drag won't bother such a system until it is down in a 300-mile orbital altitude. Krausz said structural demonstration of foldable rigid panel deployment can be shown in a couple of years, and "the rest is pretty much in hand."

"We don't have to wait for thin-film solar cells. Today's single crystal cells are suitable. I'm convinced that for the next seven to 10 years, these cells will be cost competitive with future devices," Krausz says.

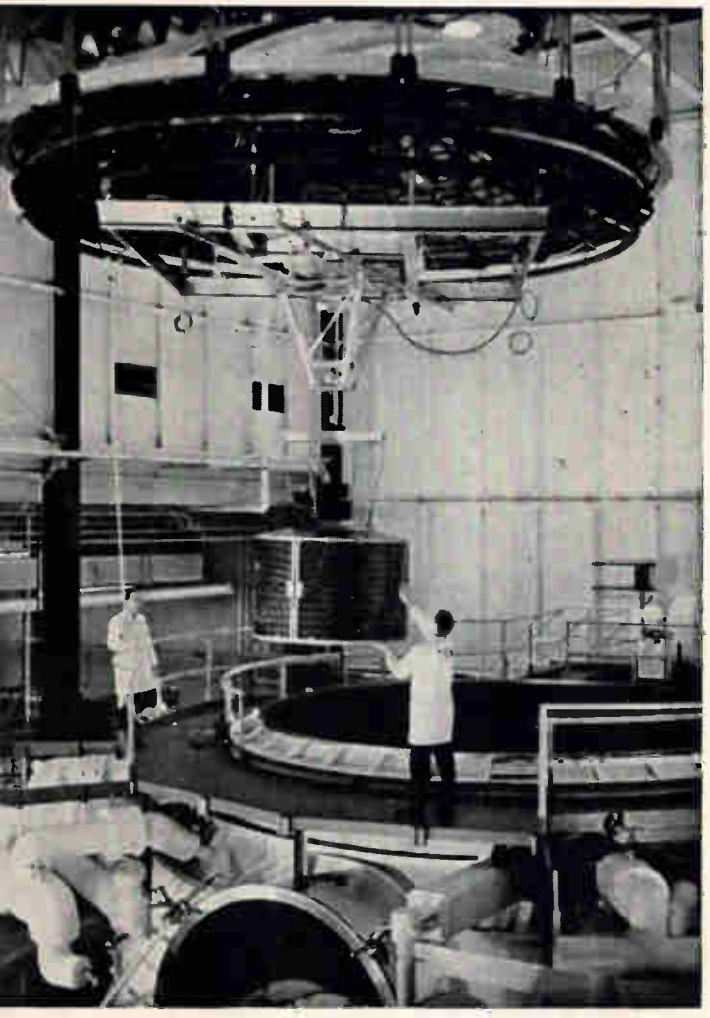
Pneumatic deployment of arrays

One approach with such foldable rigid panels would be to unfold them one by one, latching each time a panel unfolds.

TRW is investigating a proprietary approach "which looks like a usable scheme," he says. It's the use of pneumatic rather than electrical power to deploy the panels. A rolled nylon casing is stiffened by compressed nitrogen gas. The force can be closely controlled when stiffening the nylon case so that the folded panels can be unfolded, in sequence, and then locked into place one at a time.

In its in-house studies on the proposed synchronous tv-broadcast experimental satellite, RCA would need 12 kilowatts of raw power to operate its 3-kw spacecraft, and it too favors photovoltaic supplies. RCA believes a 3-kw conventional solar array system will be available by 1968; it uses 8-mil thick silicon cells (2 by 2 centimeters) with both contacts on the back of the cell and with a conversion efficiency of about 10%. With 3-mil thick glass covers for thermal control and protection from low-energy particles, flight hardware arrays on honeycomb paddles would weigh out at 15 to 20 watts per pound.

The solar power system expected by RCA for the 1970 state of the art would be a "trampoline



Out of the tank comes a model of Comsat's global systems satellite following thermal vacuum, solar energy and reflectivity tests. The stationary satellite, also shown on the cover, is being built at TRW Systems for a 1968 launch date.

array" having no metallic substrate, but with dendritic or thin single-crystal cells assembled directly to a dielectric sheet 2 to 4 mils thick. Such an assembly could then be stowed in rolled form, or stretched in a metal frame, to get 25 to 30 watts per pound. Thin-film techniques could even double this watts-per-pound figure by 1975, according to a number of RCA engineers.

In addition to array development, there must be a continued effort to cut weight in power-conditioning circuits since the weight of such circuits could offset the advances expected in array technology, according to RCA.

Continuing advances in photovoltaic technology will hold the field, and nuclear power systems will not overtake solar types during the next 10 years, predicts Richard B. Marsten, spacecraft electronics manager at RCA's Astro-Electronics division. He suggests that a 20-kilowatt photovoltaic supply with conversion, regulation and distribution circuits could be made, with total weight of 1,000 pounds, for an operational telecasting spacecraft to be launched at the end of 1975.

III. Military systems: limited and late

Military satellite communications systems, long recognized by Pentagon planners as a significant way to improve their worldwide command and control traffic, have been under intensive study by the services since 1958. However, today—eight years and some $400 million later—there is still no operational system.

The only system actually being built by the Defense Department is the Initial Defense Communications Satellite Project, or IDCSP. With a design based on 1962 state of the art (because of the initial requirement for an early operational date) the system not only is marginal operationally but is even considered by some to be a high-risk program.

One scientist closely involved in this type of work comments that the military approach to communications satellites has been "completely befuddled by the many changes in management thinking." This, he says, goes all the way back to the ill-fated Advent synchronous satellite program, canceled in 1962, which had "too many managers in the act."

The Initial system is an outgrowth of a medium altitude system called MACS, which was to have 12 to 28 satellites circling in an uncontrolled random polar orbit 5,000 nautical miles up. An Atlas-Agena was to have launched them seven at a time into a global system.

MACS went into what some Air Force planners called a "holding mode" in 1963 while the Defense Department and Comsat tried to get together on a joint military-commercial system. Failing at that, the Pentagon did another switch and decided to use research-and-development launches of the Titan-3C for its communications satellite system. This way the program got a "free ride" since the Defense Department saved money by eliminating the cost of the Atlas boosters, but the free ride changed the program completely.

Another plan to use both boosters and combine the polar medium-altitude satellites with the near-synchronous equatorial orbiting units at 18,200 nautical miles—"giving distinct advantages in coverage"—was scuttled by a political decision to use only the Titan-launched higher altitude orbits to handle long-haul traffic only.

Initial system on for June

The spin-stabilized 97-pound satellites making up the Initial system are the same ones designed for MACS by the Philco Corp.'s Western Development Laboratories, but with antenna changes.

The initial launch of the Initial satellites, targeted earlier for February, is now on for early summer, probably in June. It was delayed not only by the Titan-3C booster but by problems faced by Philco in going from the design and development phase into production. This transition was called a "rough one" by a senior Air Force officer in the program. The Air Force's Space Systems division

is handling the space portion of the system for the Pentagon.

But the program does provide one of the rare instances when a satellite can be built on a production line (Lockheed Missiles and Space Co. also has done this with its military satellite program). This gives Philco a "real opportunity to mass produce and get the problems ironed out," the Air Force officer comments.

Philco is producing some 35 satellites, including 22 flights sets and 13 qualification and engineering models. The first launch will be followed by two more at about two month intervals. The Air Force wants to get all 22 satellites into orbit.

The satellite, because it was designed for polar orbit is "far from optimum," one communications satellite engineer says, and it is "marginal all the way." Because the satellite does not have the erp for the designed bandwidth, the Air Force has been forced to reduce capacity.

The change to the higher orbit, though, simplifies one giant problem, the ground-based computer and control system. This very complex system was to have provided position and signal data for the satellites in the medium altitude environment to the AN/MCS-46 (Mark-1B) ground terminals, being built for the Army Satellite Communications Agency by Hughes. Going to the near-synchronous equatorial orbit removes the need for the complex computer system. Instead of just a couple of hours visibility over one ground station, the satellite at near-synchronous altitude will be visible for five to six days at a time.

The channel capacity of the Philco satellite with the Mark-1B terminal, for example, dropped from the seven commercial voice channels or 15 tactical voice channels at 5,000 miles to two commercial or five tactical quality voice channels for the near-synchronous orbit.

Advanced military system

System definition studies for the follow-on or Advanced system are presently being reviewed at the Pentagon. The hope now is to start launching the Advanced satellites in 1969, although 18 months ago the Pentagon specified its goal as late 1967 or early 1968. It now plans to launch replenishment satellites in 1968 to tide over the Initial system, "if necessary," until the Advanced is ready.

Six companies bid on the Advanced system studies and the Defense Communications Agency ended up by giving contracts to all of them. DCA, which runs all long-haul point-to-point circuits for the Defense Department, is amalgamating the six study inputs into a single request for proposals on the Advanced system. This is "impossible," one satellite engineer insists. Such an approach, he feels, could cause the ADCSP or Advanced system to grind to a halt. Such an operational long-haul, secure system though will probably consist of different satellite types and possibly will be stationed at different altitudes and orbits.

Depending on how successful the first launchings are, there is a good chance the Initial system could grow into the Advanced system, some company planners believe. An Air Force officer deeply involved in the military communications satellite program agrees, saying "we've always felt the Initial system could evolve easily into the Advanced program—and it would be fairly logical."

Richard M. Bentley of Hughes: "It won't be long before we will be predicting, quite accurately, satellite lifetimes of 10 years."

The Initial system could be replenished gradually with modestly improved satellites—flying a couple of experimental satellites on each launch. The General Electric Co., for example, presently is building a satellite to test a two-axis gravity gradient stabilization system in a near synchronous orbit later this year. This satellite is externally comparable with the Philco satellites and uses the same ejection spring mechanism.

If gravity gradient stabilization proves out at higher altitudes, it could be an "extremely attractive approach" for the military system, the Air Force officer said. This way of aligning a satellite, which is based on the fact that a long object in space will align itself vertically with the earth, has successfully been tested in 500- to 600-mile altitudes, but no one knows for sure yet whether the technique is practical at higher altitudes.

The reason is that the gravitational force tending to orient the satellite vertically decreases rapidly with altitude—at a synchronous altitude of 19,400 nautical miles it has only 1/200th the pull it has at 500 to 600 miles.

But if gravity gradient techniques are practical for satellite control at the higher altitudes, the Pentagon could go to a steerable horn antenna which is not as complex as a despun array system.

Next year, one of the Initial system satellites will be flown with an electronically despun array an-

tenna (built by Sylvania Electric Products, Inc., as a subcontractor to Philco). If it works, the Air Force will probably put this antenna on all satellites on follow-up launches. Using the electronically despun antenna would improve the satellite's effective radiated power by "an order of magnitude," an Aerospace Corp. spokesman says, the exact amount depending on beam width and control.

Unlike other despun antenna systems now being developed, the Air Force will use two instead of one—one to transmit and one to receive. Adding the despun antenna on the receiving end will allow tactical-sized ground stations to communicate with the satellite. There is a factor of 10 tradeoff with power and antenna gain here, the Aerospace official says. The present satellite power system can handle the despun antennas.

The Initial satellite is using traveling-wave-tube amplifiers with 3-watt output—two for reliability on each satellite, each from a different manufacturer. The design approach is more sophisticated than on currently operating communication satellites, he notes. "We're pushing for the last decibels in the system—tighter frequency stability, for example."

The frequency translation repeater operates at X band (8 gigahertz receive and 7 Ghz transmit), with exact frequencies classified.

Twt improvements are another evolutionary step being cranked into the system. The Air Force plans to change the present 3-watt twt to a 6-watt tube. It also has picked up a development program previously started on a 35-watt twt and a qualification model has been completed. With this size twt, however, "We're talking about primary raw power of 150 watts off the solar cell power system, and we couldn't gain that much from the present size satellite. If we could go to this powerful a twt, we'd have to resize the satellite," an official in the program says.

Another improvement would be to go to a tunnel-diode front end in the satellite receiver. The noise temperature of 10 db on the front end could be improved by 3 to 5 db, or by factor of two. Then the Air Force could work with a three-foot dish on the ground or something that could be carried by tactical forces.

Designed without batteries to achieve longer life, the Initial satellite has a 7,808 solar cell array with an initial 43-watt raw power output. The basic solar cell power system, however, is still the limiting factor in satellite lifetime. "It now looks like a five-year life for the communication subsystem which uses 22.5 watts," the program official for the IDCSP says.

Three kinds of military traffic

The Pentagon now sees its satellite communications traffic breaking down into three categories: leased channels on commercial satellites for use in long-haul, point-to-point unsecure administrative traffic; the Initial defense communications satellite project for long-haul command and control secure communications (followed by some sort of advanced system); and a tactical communications satellite system for use by aircraft, ships and troops in the field.

The Air Force Space Systems division, Los Angeles, which would handle development of the "Tacsat," is now awaiting a decision on the system approach from the Pentagon. The plan is to get the request for proposals out to industry by mid-1966 for the development of Tacsat, but SSD's communications satellite office has been hurt by transfers—there are a lot of empty desks right now. This could slow things down a bit.

While many people appear to be leaning toward the synchronous altitude orbit, there are those who are pushing the lower orbits. A synchronous satellite is a "sitting duck in a military situation," says an official at TRW Systems. "There are good reasons why you might not want others to know where the satellite is in a military situation—it could be shot down."

An Air Force officer high in the military satellite business says he "can't deny they can be shot down. But in the case of the Initial system, for example, that can get pretty costly. With up to 22 in orbit it would be a hell of a lot of cost involved for anyone." It would mean a complete missile launch for each satellite someone might want to knock down, and the kill rate would have to be high, he notes.

A tactical satellite "belt"

TRW has been pitching its "Minicom" proposal to the military for a tactical satellite. Studies have been made on the feasibility of putting up as many as 100 of TRW's tiny piggyback satellites in a low orbit to communicate with low-power ground equipment. The TRW proposal is based on its tetrehedral environmental research satellites built for customers for noninterference piggyback launching.

Three models of the low-cost satellite weigh from 1.5 pounds to 7.5 pounds, with volume ranging from 26 to 135 cubic inches. Power from skin-mounted solar cells goes from 0.8 watt to 2.4 watts regulated.

Customers have doubts about this approach, however. One Air Force officer in communications satellites points out there are a "great many problems in this approach to overcome; coverage is limited and the satellite has a small capability."

An area of growth necessary in military systems will be in antijamming capability and message security—possibly by using data processing in the satellite. Two future possibilities are direct signal processing, which means extracting the signal from jamming and noise; and commanded antenna switching, permitting a transmitter to make the satellite aim high-gain beams at particular localities. There is a trade-off though between the technical improvement and the additional complexity; direct signal processing, for example, would require thousands of added parts compared to less than a thousand now in a simple repeater.

Military services' satellites will ring the earth

Launch of eight satellites this month begins a system which is the forerunner of an exclusive communications network

By Jay J. Cohen

Defense Communications Agency, Washington

The Defense Communications Agency expects to launch its first series of communication satellites this month. In addition to increasing the Defense Department's long-distance communication capability, the satellites will provide information for the design of an advanced military communication satellite network to be launched in 1969.

The preliminary satellites are part of the Initial Defense Communications Satellite Project, which is a research and development phase of the Advanced Defense Communications Satellite Project.

The Defense Department eventually hopes to attain a worldwide command and control network. The system would provide the military with exclusive access to the satellites; secure, high-speed transmission; uninterrupted communications during a nuclear blackout of high-frequency radio; and protection against jamming.

With the satellites in place, tactical and control communications could be set up rapidly anywhere in the world. In addition, the versatility and flexibility of the satellite network would eventually diminish the cost of providing long-haul communications by reducing the number of expensive ground-based communication links, such as tropo-scatter systems and submarine cables, that would otherwise be needed.

The initial network will provide a relatively small channel capacity between a large number of stations rather than follow the commercial long-haul approach of supplying a large trunking capacity between a few stations. The satellites—one is shown on page 97—were developed and produced by Philco Corp.'s Western Development Laboratories division in Palo Alto, Calif., assisted by the TRW Systems Group of TRW, Inc., of Los Angeles.

Random orbits

The initial satellite-communication network will consist of a worldwide network of ground stations and 15 to 22 satellites randomly spaced in near-synchronous equatorial orbits. In a random arrangement the distances between the satellites constantly varies. The satellites will be at several altitudes in the vicinity of 18,300 nautical miles. In contrast, a satellite such as Early Bird, which appears stationary in the sky, operates at a synchronous altitude which is about 19,400 nautical miles (22,300 statue miles) above the earth.

Since the initial defense satellites are not at synchronous altitude, they will drift slowly across the path of an earth station at a rate of about 30° per day. At this drift rate, an earth station located at 35° latitude would view the same satellite for about 4½ days.

In addition, since the satellites are at different altitudes, their orbit periods will vary, causing the spacing between satellites to vary with time. As a result, the satellites will also drift past one another. However, the orbital parameters have been chosen so that the satellites will never bunch.

Because of their high altitude, the satellites will view about a third of the earth's surface, just as

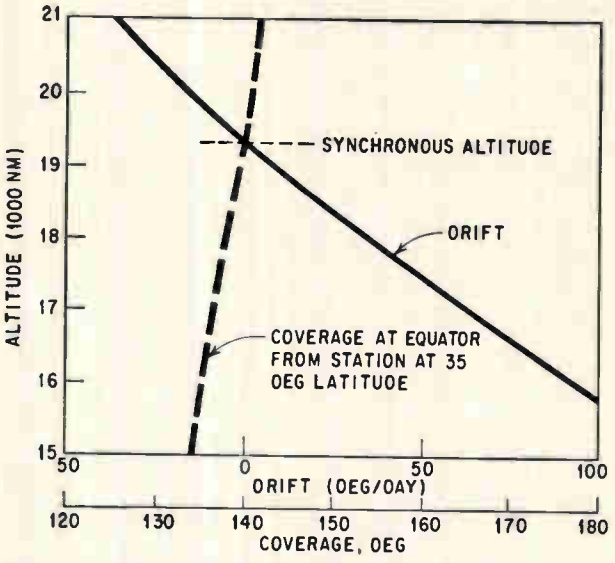
The author

Jay J. Cohen, as technical advisor to the deputy director of the Communication Satellite Project Office, is responsible for all technical aspects of the satellite program. During 1960 to 1963 he also served as technical director for the Navy on phases of the Advent and Syncom satellite programs.

a synchronous satellite does. Actually there is only a small difference between the coverage angles at altitudes from approximately 15,000 to 23,000 nautical miles. At altitudes between 17,600 and 21,800 nautical miles the drift will be less than 50° per day. Drift and coverage as a function of altitude are plotted on the graph at the right.

The random orbital configuration has two important advantages. First, it assures that if one satellite malfunctions, another satellite will eventually be in place to provide communications capability. Secondly, the satellites can operate without station-keeping controls, thereby preventing an enemy from changing the orbit of the satellites and disrupting communications.

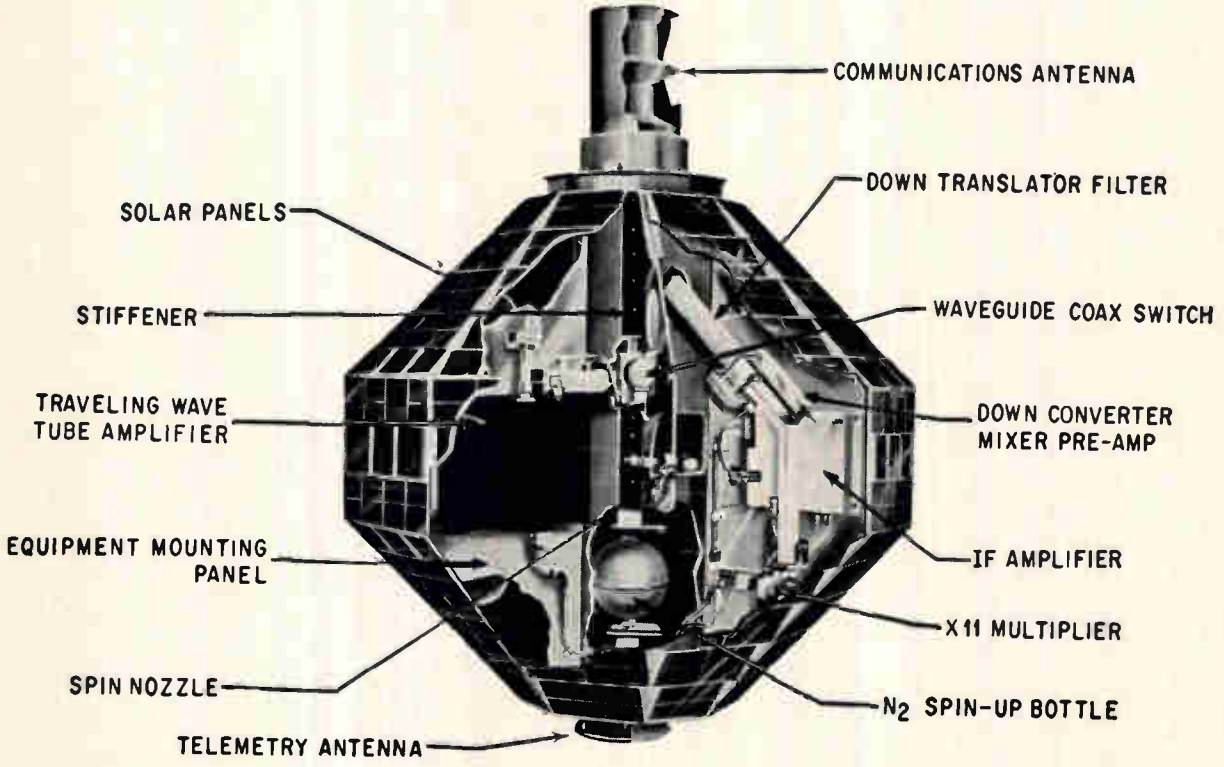
Station keeping refers to techniques that are used to correct the satellite's orbit. For example, a system employing stationary satellites requires that each satellite remain in a precise equatorial orbit. It is necessary to periodically adjust each satellite's orbit to compensate for perturbations caused by solar and lunar gravitational forces, solar pressure, and variations in the satellite's distance from the earth. This requires on-board thrusters which are generally controlled by telemetery signals received from the ground. These station-keeping controls are not needed in the random-orbit system.



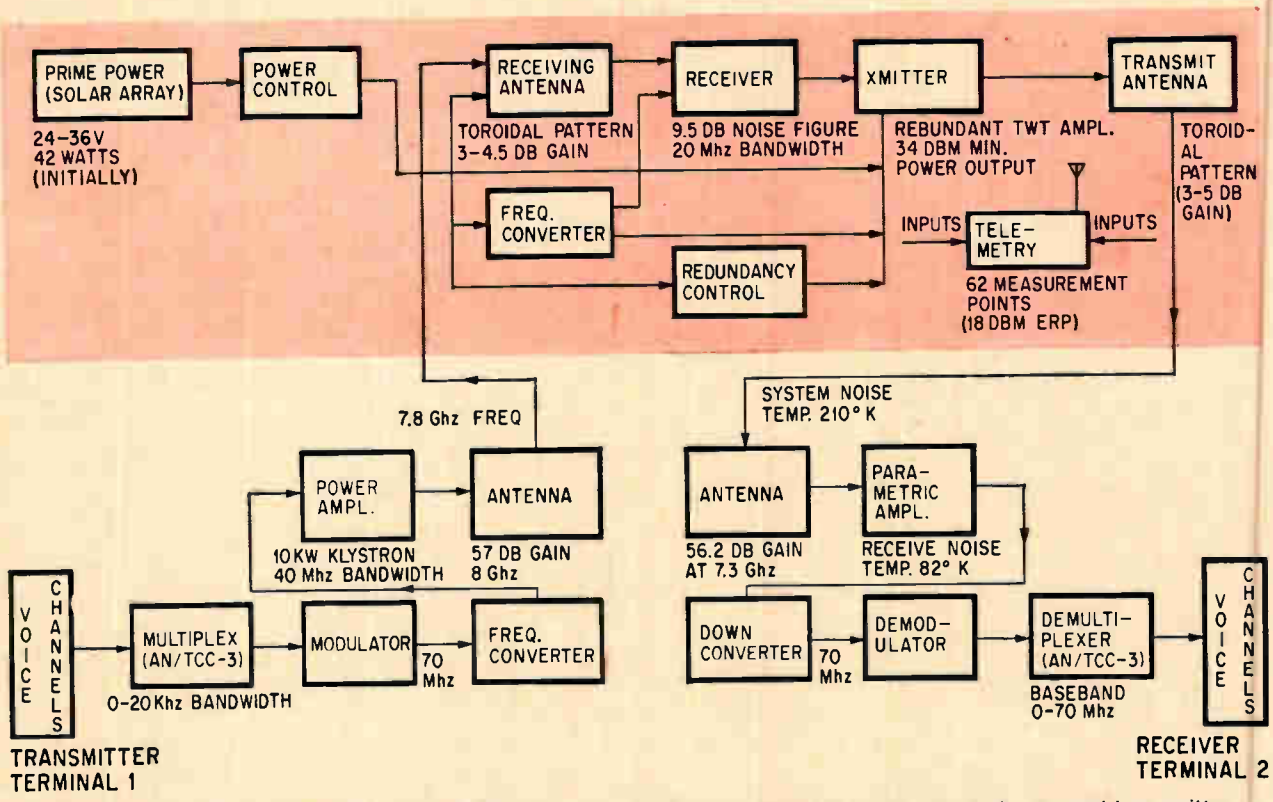
Coverage of the earth and the drift of a nonstationary satellite are functions of altitude. The coverage only varies slightly for altitudes near a synchronous orbit. The satellite will drift less than 50° per day at altitudes from 17,600 to 21,800 nautical miles.

Communication reliability

Reliable communications between ground stations will depend heavily on the number of satellites in orbit. Reasonable reliability will be attained with 15 satellites. Eight will be placed in random orbit during the first launch. The launch of eight more, planned two months later, will also contain one experimental satellite that is not considered part of the network.



Military communications satellite will operate as a repeater, retransmitting the signals that it receives. Nitrogen gas will spin the satellite to stabilize its attitude in space and keep the antenna pointing to earth.



Block diagram shows a communication satellite (in color) linking two Mark 1B terminals. At the ground transmitter of one terminal, voice signals modulate a 70-Mhz (megacycles per second) carrier. The modulated signal is converted to a frequency of about 8 Ghz and is then transmitted to the satellite. In the satellite the signal is converted to a frequency of about 7.3 Ghz and then retransmitted to the other ground terminal. In the receiver the radio-frequency signal is demodulated to recover the voice signals. A telemetry system within the satellite monitors critical circuits and transmits the information on a 400-Mhz carrier to the ground terminal.

Three months after the second launch, during which time the satellites will disperse around the world, a link such as Helemano, Hawaii, to Camp Roberts, Calif., can operate almost continuously—its communication reliability will be almost 100%. A longer link, such as Fort Dix, N.J., to stations in Western Europe, will have 93% communications reliability. The Camp Roberts and Fort Dix stations will be the principal terminals for communication links to the Pacific and to Europe.

Because the satellites drift past one another, a ground station will generally have more than one satellite in view at any one time. For example, statistical studies of the orbit configuration indicate that if communications are possible 98% of the time, then one satellite will be in view 98% of the time, two satellites will be in view 90% of the time and three will be in view 80% of the time.

As the number of satellites declines, some of the longer links will lose more of their communication reliability than the shorter links. If a satellite should malfunction a communications break (outage) may not occur for weeks or months, but when it does occur, it may last for hours or days at a time. A replenishment launch is scheduled in 1967.

Communication repeaters

The satellites (one is shown on page 97) will operate as real-time repeaters, receiving signals at some classified frequency in the band between 7,975 and 8,025 megahertz (megacycles per second) and transmitting the signals back to earth at a frequency between 7,250 and 7,300 Mhz (see the block diagram above). Since these bands are exclusively reserved for satellite communications, there will be no interference to communications networks on earth.

Communication signals received by a dual-bicone antenna on the top of the satellite will be down-converted to an intermediate frequency of 70 Mhz and subsequently upconverted to the transmitting frequency. The intermediate frequency bandwidth is about 20 Mhz. A traveling-wave tube amplifies the signal, developing about 2.5 to 3 watts at the antenna terminals.

The antenna is omnidirectional and has a 25° beamwidth which is sufficient to spread the energy over about a third of the earth's surface. Spin stabilization will maintain the satellite's axis normal to the plane of the orbit and consequently a portion of the antenna beam will always be directed toward earth. However, since the antenna is omnidirectional around the spin axis, a large portion of the energy is also radiated into space.

To see whether this radiation loss can be eliminated, one satellite with a despun antenna will be orbited. The despun antenna will be an electronically scanned array whose unidirectional beam is rotated oposite to the spin of the satellite. As a result the beam will remain stationary with respect

to the earth. Since it will be unidirectional, it will radiate more power toward earth.

The satellite will require 26 watts of power. Over 8,500 solar cells mounted on the surface of the three-foot-diameter satellite will initially supply about 42 watts. The solar cell's efficiency will slowly decrease with time.

The satellites permit multiple access by a number of ground stations. However, no ground station can use a satellite unless it is scheduled.

An interim satellite control center will study network scheduling, coverage, outages and the transferring of signals from one satellite to another—called handover. A related problem, replacing satellites that go out of service, will also be studied.

After two successful launches and deployment of five or six ground stations, the system will be tested and subsequently phased into the Department of Defense's communication network.

Ground terminals

Ground stations exist at Fort Dix, and Camp Roberts. They are being prepared in Helemano, which is near Honolulu; in the Philippines, West Germany and Ethiopia.

For a specified effective radiated power at the satellite's antenna, the channel capacity of any particular communication link is primarily a function of the size of the receiving antenna at the ground terminal. Larger dishes result in increased signal levels, which permit a ground terminal's channel capacity to be increased.

In the initial defense network, earth stations will have antennas diameters ranging from 6 to 60 feet. Channel capacity will vary from 1-voice channel in a 6-foot dish to 4-voice channels in a 40-foot dish. Although the 60-foot dish would permit larger capacity, at this time the terminal equipment is similar to that on the 40-foot dish.

Terminals with 60-foot diameter antennas are located at Fort Dix and Camp Roberts. Originally built for the Advent satellite program, the terminals, AN/FSC-9, have been used for several years as part of the ground system for the Syncom communications satellite. For the Defense Department's satellite program, the operating frequencies will be changed and new modulation and demodulation equipment will be installed.

The AN/MSC-46 or Mark 1B, developed by the Hughes Aircraft Co., of Fullerton, Calif., is the first ground terminal developed specifically for the initial satellite project. Consisting of operating vans and a 40-foot diameter dish, the station can be transported by air and set up on a prepared site by a 27-man station crew in 48 hours. The Cassegrian antenna contains a four-horn feed that permits the terminal to track the satellite's signal by simultaneous-lobing (monopulse) techniques.

The Mark 1B terminal can transmit or receive at least four high-quality voice channels and four teletypewriter messages. A high-quality channel has a signal-to-noise ratio (snr) greater than 53 decibels. The capacity permits data transmission at a rate of 38,400 bits a second or equivalently 16 channels at 2,400 bits a second. Two Mark IB's will be installed in Hawaii for communication with the mainland and with bases in the Western Pacific. The terminal is under the control of the U. S. Army Satellite Communications Agency (Satcom).

A more portable terminal that uses a four-dish cluster with a total outside diameter of about 15 feet is in development. These antennas are also able to track a satellite. Designated AN/TSC-54's, or more informally, Mark V's, these terminals are being constructed by Radiation, Inc., Melbourne, Fla., for Satcom. Each terminal can be air lifted and set up by a six-man crew in about 2 hours with a minimum of site preparation. The terminal is valuable in remote areas and for emergency operation and will provide one tactical quality voice channel (snr = 30 db), 64 duplex telegraph channels or four vocoded-voice channels. A vocoder reduces the voice bandwidth by transmitting only those frequencies in the speech signal that will allow the speech to be reconstructed at the receiver.

Hughes Aircraft is also building shipboard terminals with six-foot diameter dishes. These smaller terminals will handle eight teletypewriter channels and possibly one tactical-quality voice channel.

Multiple access

A number of ground terminals will simultaneously be able to use the same satellite. For example, four Mark 1B terminals transmitting standard frequency-modulated signals could communicate with one another through the satellite. Similarly, 50 ground stations could use one satellite to establish 50 independent telegraph links.

Ground terminals will be able to transmit frequency-modulated signals as well as more complex spread-spectrum signals. These spread-spectrum signals provide a multiple-access capability that is not possible with conventional frequency-modulated signals.

By using spread spectrum signals with different coding schemes it will be possible to actually overlap signals at the same frequency and further increase the multiple access capability. The signals will be separated at the receiver by correlation detection.

Other tests

One of the satellites in the second launch will be stabilized by gravity-gradient rather than by spin stabilization in order to test a second stabilizing technique. This satellite will not be used for communications but will provide some data for determining the configuration of the Advanced Defense Communication Satellite antennas.

In another test launch that is scheduled for 1967, the Titan booster will carry a satellite with a despun antenna as described on page 98. This too will be evaluated for possible use in the Advanced Communications Satellite Project.

For a pilot over the ocean a satellite link to home

Airlines plan to communicate through satellite relays by 1968; voice and data tests begin late this year

By Frank C. White

Air Transport Association of America, Washington

When synchronous satellites are parked in orbit above the earth, pilots passing over empty stretches of land or water can forget their worries about long-distance communication.

The satellites' radio system will relay at very high frequency (vhf) voice and data between the pilot and far-away ground stations. At the moment, a pilot can reach a ground station on vhf only within line of sight—about 300 miles. Farther away, he must switch to high frequency, which has a much poorer quality.

Satellites will change all this. Pilots and ground stations will communicate on vhf during the entire flight by transmitting over a line-of-sight path to a satellite for subsequent relay. Vhf is relatively noise-free because it is much less subject than h-f to atmospheric and ionospheric interference. The result will be error-free communications between aircraft and ground terminals over distances as great as 7,000 miles.

The airlines plan to use satellites for communications as early as 1967 or 1968. Certainly, when the supersonic transports begin flying the Atlantic in the early 1970's, all the anticipated problems should be solved. Pilots will talk with the ground via satellite whenever it is necessary.

The author

Frank C. White is manager of Communications-Data Processing for the Air Transport Association. He is responsible for airline air traffic control, company communications and related data-processing systems, including air-ground, and point-to-point systems.

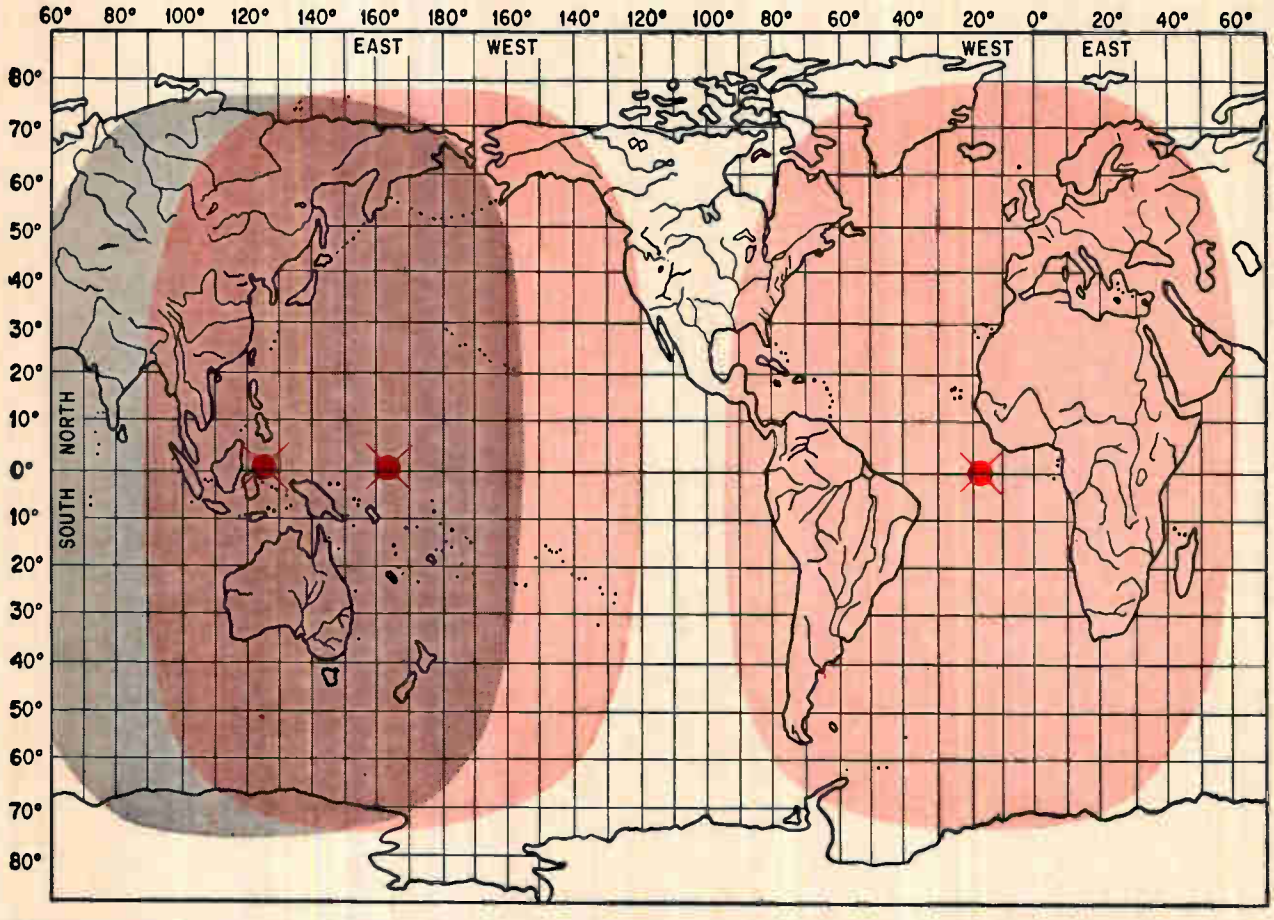
On station

A radio beam from a satellite in synchronous orbit can cover one-third of the earth's surface. Therefore, one satellite sitting over the equator at about 12° west longitude will provide communications coverage for all transatlantic flights except those near the north geodetic pole. Likewise, a second synchronous satellite at about 170° west longitude will cover most transpacific flights (diagram at right). If it is worthwhile to cover the less-traveled polar routes as well, three satellites in a synchronous orbit that is inclined with respect to the equator may be used. Each of the satellites' orbits would describe a lazy-eight pattern (due to the inclination of the orbit) and be spaced equidistant from one another, so that at least one satellite is above some minimum latitude.

Technically feasible

The technical feasibility of satellite communications for aircraft was proven in January, 1965 when a Pan American World Airways, Inc., jet in scheduled flight out of Hong Kong established two-way communications with Camp Roberts, Calif., via Syncom III. Syncom III, above the Pacific, radiated less than one watt of power into space on a vhf telemetry channel at 136.47 megahertz (megacycles per second). The channel was used to exchange slow speed (60 words-a-minute) teleprinter signals between the ground and the aircraft. The signal received by the aircraft had a power level of less than −140 dbm (decibels below 1 milliwatt reference).

The aircraft had on board an RA-21 standard airline vhf receiver which had been modified by the Bendix Radio Corp. to receive Syncom III frequency-modulated signals at 136.47 Mhz. Bendix also supplied two 200-watt vhf transmitters (149.22



Three possible locations of aeronautical communications satellites have been proposed by E.J. Martin of the Communication's Satellite Corp. Satellite at the right provides coverage (indicated by color) for all transatlantic routes, except polar routes. At left are satellite locations for coverage of transpacific flights.

Mhz) with a phasing unit to permit a combining of the power of the transmitters to provide horizontal, vertical or circular polarization. The radome in the airplane's nose housed a vertically and horizontally polarized Yagi antenna pair designed and supplied by the Boeing Co. A teleprinter, capable of operating in aircraft and handling variable data rates, was supplied by the Federal Aviation Agency.

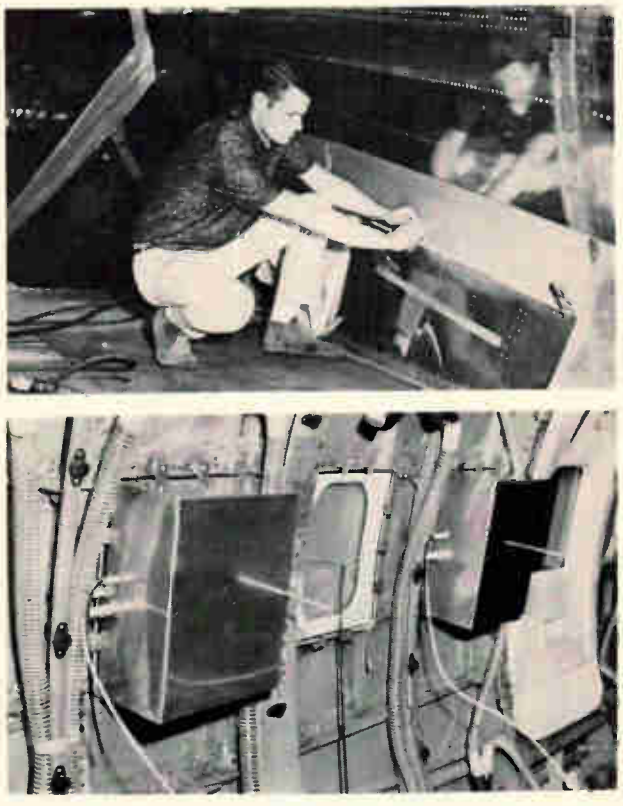
Once it was established that satellites could provide vhf air-ground communications, the airlines had to find out the needs of a practical system. During the past year the airlines have been testing the reception, in the air and on the ground, of signals from both Syncom III and the Communication Satellite Corporation's Early Bird.

When the National Aeronautics and Space Administration launches ATS-B (Applications Technology Satellite-B) later this year, the airlines and the Federal Aviation Agency expect to get a great deal of information from experiments with the satellite's vhf transponder. The transponder will receive signals on 149.2 Mhz and transmit on 135.6 Mhz. Its antenna will be an eight-element phased array. Transmitter power output will be 3.75 watts per element. The ATS-B's vhf transponder has a total effective radiated power output of 200 watts, making it suitable for both voice and data experiments.

Aeronautical Radio, Inc., owned by the airlines, will work with the National Aeronautics and Space Administration on the ATS-B tests. Aeronautical Radio will attempt to isolate and solve voice and telemetry communications problems unique to aircraft-satellite-ground communications systems and also any problems created by the coexistence of satellite-relayed communications and existing air-ground communications in the same vhf spectrum.

Turning in space

If it were not for the atmosphere, signals to and from a satellite would retain their original polarization. The plane of polarization of a signal passing through the ionosphere, however, will be rotated proportionally to the integrated electron density and the square of the wavelength. This phenomenon is known as Faraday rotation. For average situations, rotation at aeronautical vhf frequencies is 6 to 7 radians. Two to three rotations may be observed at a ground station during a 24-hour period. The polarization rotates clockwise about 2½ revolutions in 12 hours and then unwinds the same amount. This creates a need for an aircraft antenna capable of receiving signals that have a



Technician fits a wing-body (top photo) antenna for air-satellite communications test on a Boeing 707. Trans World Airlines, Inc. aircraft with such antennas have been conducting tests with the Communications Satellite Corp.'s Early Bird Satellite. Below, special antennas have been mounted in the passenger windows. Two boxes are 136-megahertz (megacycles per second) cavities.

slowly rotating plane of polarization.

The solution to Faraday rotation is to make the antennas insensitive to signal polarization. A circularly polarized antenna fills this requirement. Such antennas can be used on the satellite, or at the earth and airborne terminals and preferably in all three locations. ATS-B, like its predecessors in the family of synchronous communications satellites, will be spin stabilized. It is difficult to design circular polarization into a spinning satellite, but not impossible. Several manufacturers believe they can produce circularly polarized antennas for spinning satellites. The antennas would have about 10-decibel gain. Subsequent ATS spacecraft will test gravity-gradient stabilization. If this proves effective, then circular polarization aboard the satellite with even higher-gain antennas, about 18 decibels at vhf, will be feasible.

Designers must concentrate on the antenna of the airborne terminal. The ground terminal design is no problem. Satellite-communication paths are most intolerant of antenna nulls. There are no excess decibels available to waste. Thus, to communicate with satellites, the antennas on the aircraft must be either: directional—and selective as to direction of flight; or, provide null-free hemispherical coverage, with selectable polarization, or preferably circular polarization.

Boeing has built, and both Pan American and Trans World Airlines, Inc., have flown, antennas that provide both horizontal and vertical polarization with more than 8-db gain. These antennas can be combined to provide a single circularly polarized antenna. The flight tests are continuing as antenna designs are improved. In the most recent test, a Trans World aircraft monitored vhf signals from Early Bird Oct. 20, 1965.

These antennas provide almost ideal coverage for all of the North Atlantic routes between New York and London or Paris terminals. They look "abeam" of the aircraft, toward the satellite which is parked in the mid-Atlantic over the equator. They are not difficult to retrofit into jet airliners. Four separate antenna elements are required: a vertically polarized antenna in the fillet area of each wing root, and a horizontally polarized antenna above each wing. The four elements combine to provide two side-looking circularly polarized antennas. With these antennas and an effective radiated power in the satellite of less than 50 watts per channel, it is possible to have perfect, noise-free, vhf voice or high speed (1,800 to 2,400 bauds per second) data communications.

Interference from multipath signals is another problem that affects antenna design. A signal from a satellite can either travel a direct path to the aircraft, or can be reflected from the surface of the earth. The reflected signal from smooth water can be nearly as strong as the direct signal. The problem may be partially solved by a good antenna design. The Boeing antennas, for example, look upward slightly and normally do not receive signals reflected from the earth's surface. Circular polarization of all antennas would be of value since reflection from the water changes a signal's rotation to a direction opposite to signals arriving by the direct path. Circularly polarized antennas will receive signals rotating right or left, not both, and thus can be designed to receive only signals arriving from the satellite.

Side-by-side

Coexistence of satellite signals and ordinary vhf aeronautical communications signals in the same vhf spectrum may present a problem. Current plans call for use of a portion of the present air-ground vhf band (118 to 136 megahertz) for satellite communications. Plans by the Federal Aviation Agency and by the International Civil Aviation Organization call for channels spaced every 50 kilohertz throughout the band. Present airline equipment can use channels separated by 25 kilohertz. Thus adequate spectrum is available, particularly if the channel separation by 25 khz is utilized in the future. Studies are underway by airline radio engineers to determine whether frequency-modulated communications via satellite should be on the same channels as those used for the air-ground, amplitude-modulated communications. Alternate possibilities are to interleave the two kinds of communications on the "in-between" channels, or give

Plugging air-communications gap

The first day-to-day use of satellites for transoceanic aircraft communications of voice and data will come later this year when the National Aeronautics and Space Administration puts up the Applications Technology Satellite-B. The first operational system is expected to be the Aerocom synchronous satellite, which the Communications Satellite Corp. expects to launch next year. Aerocom will play a dual role—filling in the communications gaps that now exist on the transatlantic air routes and providing operational and technical lessons that can be applied toward the global aeronautical communications systems of the future.

The specifications for Aerocom's communications subsystem, in the table below, are still loose. For example, Comsat asked for power options that would allow the number of voice channels to be increased to four from the basic pair of two-way channels. To pilots, the important thing is that Comsat plans to provide airliners with long-range vhf communications. Pilots consider vhf the only practical solution to their over-ocean communications problems.

Circuitous and unreliable routes often must be used to contact airliners flying the North Atlantic. If the air traffic controller at Kennedy airport wanted to reach a plane that had left for Europe three hours before, to warn the pilot of a newly discovered storm, he would have to send the message to Gander, Newfoundland, which would then attempt to reach the airliner by high-frequency radio. The attempt might not succeed.

On the longer routes in the Pacific, the problem is greater. The communications roundabout that hampered the rescue of the Gemini 8's crew in March illustrates what can happen when a plane has to contact the United States in an emergency.

The rescue plane, south of Japan, had to contact a ship over the horizon. The ship transmitted the message to Okinawa, where a ground station relayed it by h-f radio to the U.S.S. Kingston, a satellite communications ship in mid-Pacific. The Kingston sent the message to Hawaii via the Syncom III satellite. From Hawaii, the message traveled 5,000 miles by cable before it arrived at the Manned Space Flight Center in Houston.

If Syncom III were the kind of satellite that could directly relay messages from an airplane, many anxious moments would have been saved.

—W. J. Evanzia

Aerocom communications subsystem characteristics

Communications frequencies		Effective radiated power	Carriers
Ground-to-satellite	6 Ghz	11 dbw min.	4
Satellite-to-ground	4 Ghz	11 dbw min.	4
Aircraft-to-satellite	118–136 Mhz	25 dbw min.	4
Beacon	4 Ghz		

Transponder bandwidth		Max. amplitude variation	Translation stability (khz) 1 month	3 years
6 Ghz to vhf link	400 khz	1.0 db	±6	±60
Vhf to 4 Ghz link	200 khz	1.0 db	±8	±80
6 Ghz to 4 Ghz link	20 Mhz	1.0 db	±2	±20

Antenna polarization

Vhf transmit and receive: left-hand circular

6 Ghz receive and 4 Ghz transmit: linear

each communications service its own channels.

The signal level received at the earth's surface from a synchronous satellite 22,300 miles away is very low. Even a comparatively high-powered satellite like the ATS-B (200 watts effective-radiated power) will deliver a signal to ground terminals of less than —140 dbw. This signal is far below the level required for most receivers working in the 118- to 136-Mhz band.

Introducing satellite comunications into the existing air-ground spectrum also creates a probable need for changing the signal modulation. Normal air-ground vhf aeronautical communications today is a-m, while f-m is desirable for satellite communications. Power limitations of the satellite repeater (which depend on solar cells) require the use of constant-amplitude signals (f-m) to assure efficiency.

More jobs

The airlines are interested in the use of satellites for both air traffic control and operational control, and data acquisition. The Federal Aviation Agency will probably contract with Comsat for satellite communications for air traffic control. The airlines hope, through their communications corporation, Aeronautical Radio, to be able to contract directly with Comsat for services. The airlines feel Aeronautical Radio should be an authorized user of Comsat satellites, eliminating the step of contracting through a common communications carrier. The major issue is not a difference in prices; it's whether the airlines and Aeronautical Radio, which became licensees of aeronautical frequencies in 1933, have the right to deal directly with the supplier of services.

The entire question of whether Comsat should be limited to serving as a "common carrier's carrier" is under study by the Federal Communications Commission. A decision is expected soon.

If the decision is in the airlines' favor, they may wish to contract with Comsat for satellite services and with common carriers for point-to-point ground communications.

Satellites to be airliners' traffic cop

Airliners flying the Atlantic are often isolated from ground stations for as long as an hour. Soon, if Comsat orbits a satellite over the ocean, pilots will have a link to home base

By Nathaniel Braverman

Federal Aviation Agency, Atlantic City, N. J.

Communication is only one of the many functions that satellites eventually may perform in air traffic control systems, but it is the most important function. And, it is the most pressing need in the heavily traveled North Atlantic air routes. Thus, a proposal a few weeks ago by the Communications Satellite Corp. to put a communication satellite into orbit over the North Atlantic was good news to pilots flying the busy routes.

Comsat has filed proposals and specifications with the Federal Aviation Agency and the Federal Communications Commission for orbiting a satellite to be used exclusively by the FAA and the airlines for communications between transatlantic airliners and air traffic control centers in the United States and Europe. [Specifications for the satellite communications subsystem are in the preceding article.]

Aircraft now depend on high-frequency radio for long-range communications with ground stations. Because of the unreliability of h-f radio, some aircraft are out of touch for as long as an hour. Comsat plans to put the satellite, called Aerocom, into a synchronous orbit over the mid-Atlantic to relay messages between planes and air traffic control centers at very high frequency and microwave frequencies.

Comsat's proposal calls for two 2-way voice channels. This limited service will alleviate some of the existing communication gaps on the North Atlantic route but by the 1970's more channels will be needed.

Beyond communications

Air-traffic studies show that the second most pressing need in transoceanic air travel is surveillance—the process of determining and keeping track of aircraft positions. There is no reliable over-the-ocean surveillance system for commercial air travel at present. For traffic control purposes, air traffic surveillance is the determination of an aircraft's position by means external to the aircraft and without aid of the aircraft's own navigational systems.

Although the satellite proposed by Comsat would have only communication capability, a combined-function satellite which would provide both communication and surveillance would better serve the needs of the FAA and the airlines.

Most of the so-called navigation satellites that have been proposed are actually air traffic control surveillance satellites.

A navigation system that would actually guide or navigate aircraft is a third possible use of satellites but it is not vital at present. More and more transoceanic aircraft are carrying good self-contained navigation aids, such as doppler radar. Other improved systems—including doppler-inertial and inertial guidance systems—are coming into use.

True navigation satellites appear to offer competitive advantages only as an aid in detecting large errors in airborne navigation equipment and for in-flight updating of self-contained airborne navigation systems. This navigation—assistance capability, however, is automatically available if the aircraft's position can be determined at a ground station and a reliable communication link to the aircraft exists through the satellite. The position of each aircraft does not have to be determined continuously to check or update airborne navigation

The author

Nathaniel Braverman, technical advisor to the Chief of Test and Evaluation at the National Aviation Facilities Experimental Center, has been with the Federal Aviation Agency since 1958. He has been working on the analysis and planning of navigation, traffic control, and communication systems since 1945.

systems, or for air traffic control surveillance. Doppler systems have to be updated only about once every 400 miles and inertial systems will require even fewer position corrections.

A fourth possible function of an air traffic control satellite system is the collection and transmission of weather data. The meteorological satellite system being completed by the U. S. Environmental Science Services Administration and the National Aeronautics and Space Administration already has proved to be a valuable aid to air traffic control. FAA traffic control centers make routing decisions based on the most up-to-minute weather information available and pilots take off with Tiros satellite pictures of the weather along their route.

Two satellites or one

Two basic types of synchronous satellite techniques are being considered by the FAA for over-ocean surveillance. In one, the distance and direction from one satellite to an aircraft are determined simultaneously. In the other, the distances between two satellites and an aircraft are found simultaneously.

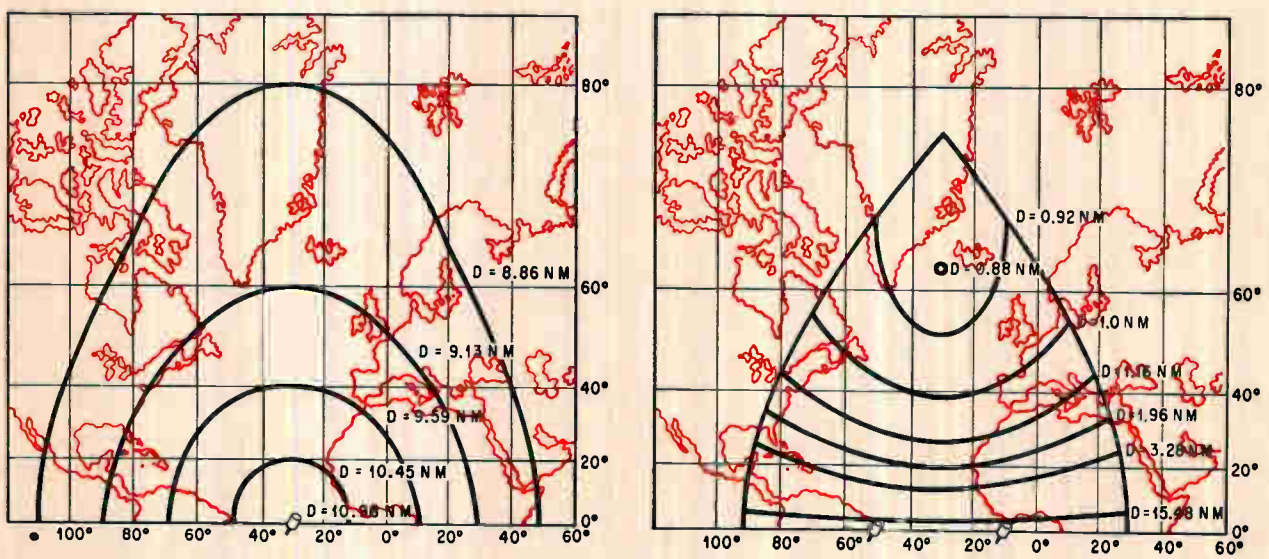
The Westinghouse Electric Corp. is studying a one-satellite system. A gravity-gradient-stabilized satellite would be in a synchronous orbit over the equator. The satellite would have two orthogonal interferometer arms and the system would be capable of measuring distance. A c-w or pulse-coded signal would be initiated at a station on the ground and relayed through the satellite to the aircraft. The plane would retransmit this signal to the satellite. The satellite's interferometer system would determine the angle of arrival of the plane's signal and retransmit the returned signal to the ground station. The distance from the aircraft to the ground station could then be determined after conventional pulse or c-w techniques derive time-of-transit. The angular errors of the interferometer arms determine the precision of the method not the small errors in the distance measurement.

The drawing at the left below shows the accuracy that can be obtained and half the area covered by a one-satellite system. The assumed standard deviation of the angular error is 0.2 milliradians. This accuracy has been determined experimentally at the National Aviation Facilities Experimental Center in Atlantic City, N.J., for a ground-based system, with a 125-foot inferometer. Aviation accuracy requirements are about three times greater. It is not known if a one-satellite system will be accurate enough. A two-satellite system should be able to meet the accuracy requirements.

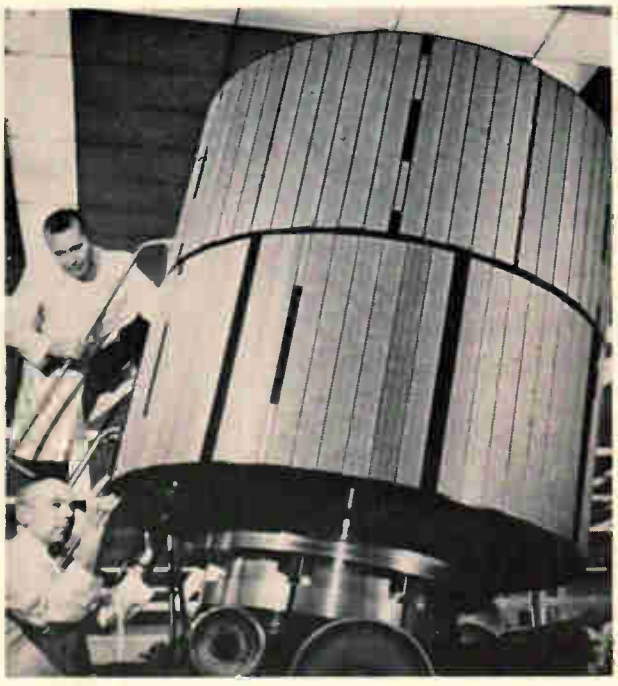
Research on two-satellite systems

The University of Michigan and the General Electric Co. both have studied two-satellite techniques. Both methods are basically alike. Two satellites would be put in synchronous orbit in the equatorial plane (at 0° latitude) but would be separated by about 30° to 70° longitude. A c-w or pulse-coded signal from a ground station would be relayed through one satellite to the aircraft. The transpender aboard the aircraft would retransmit the signal to both satellites which would then return the signal to the ground station. Transit times are measured and then the distances from the aircraft to each of the two satellites can be derived.

A study by the FAA shows that a two-satellite system is very accurate except for the area near the equator. The drawing at the right below shows half the area which would be covered by satellites stationed at 10° to 50° west longitude. The lines of constant error (isograms) show the coverage of the satellite; D, which is equal to $2d_{rms}$, is the magnitude of the errors which would not be exceeded in at least 95% of all position determina-



In the one-satellite surveillance system (left), the probability is greater than 0.95 that a measured position is within D nautical miles of the aircraft's true position, (assuming an input angular standard deviation of 0.2 milliradians.) With a two-satellite system (right), the position of aircraft in the North Atlantic can be determined more accurately than by the one-satellite system.



Communications, range and range-rate determination techniques will be studied when NASA's Application Technology Satellite-B is orbited later this year. The satellite is being built by the Hughes Aircraft Co.

tions. The standard deviation of the error in aircraft-to-satellite distance and aircraft altitude is assumed to be about 1,200 feet.

Other surveillance systems

Two other ways to determine position of aircraft with synchronous satellites have been proposed. One is to mount microwave radars on anchored floating ocean platforms or ships. The radar data from the platform (radar position in relation to the platform's fixed location) would be relayed by satellite to a land-based traffic control center.

Another system would take advantage of a worldwide radio navigation system under development by the Navy, called Omega. Very low frequency signals from Omega would be received and processed by equipment in the aircraft. The position information would be relayed to a control center by a communications satellite. The d_{rms} accuracy of the basic Omega system is reportedly about one nautical mile in the daytime and two nautical miles at night under normal conditions.

Another proposal is to use automatic airborne receivers to detect the doppler frequency shifts in the signals from four Omega stations. Four stations instead of the usual three, are needed to solve the position equations.

NASA also has proposed to use the Omega-satellite systems to pinpoint weather disturbances. Weather balloons would carry a vlf receiver tuned to the frequencies of the Omega system ground stations. The vlf signals would be converted to a vhf frequency and transmitted through the satellite to a ground-based center which would determine the position of the balloon.

A look at the future

A practical satellite system for both communications and air traffic surveillance could be an adaptation of a communications satellite system. The need for polar area coverage and fail-safe communications redundancy has increased the interest of Comsat and others in an inclined-orbit multiple synchronous satellite system.

In this proposed system, three or four phased satellites would appear to move in a figure "8" over a point centered on the equator. This system could be modified by placing four phased satellites in orbit so that two figure "8" patterns are formed, with two satellites in each pattern. The two patterns could be separated by 30° to 70° longitude. Such a system would allow a two-satellite method of air traffic surveillance and provide full communication coverage.

The scheme would eliminate the loss of accuracy in the small region near the equator. Since four satellites are involved, the required channel capacity per satellite is lower. Also smaller booster rockets are needed to put satellites into inclined orbits and multiple-launch techniques may be used. These factors can mean big savings.

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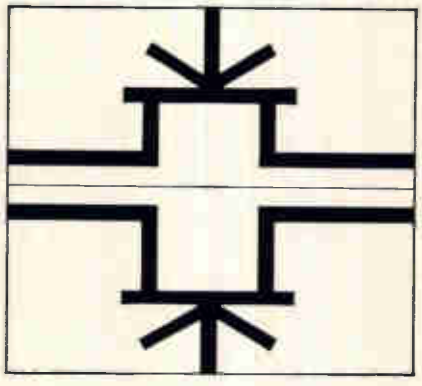

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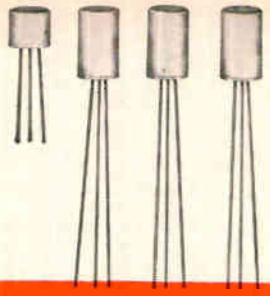

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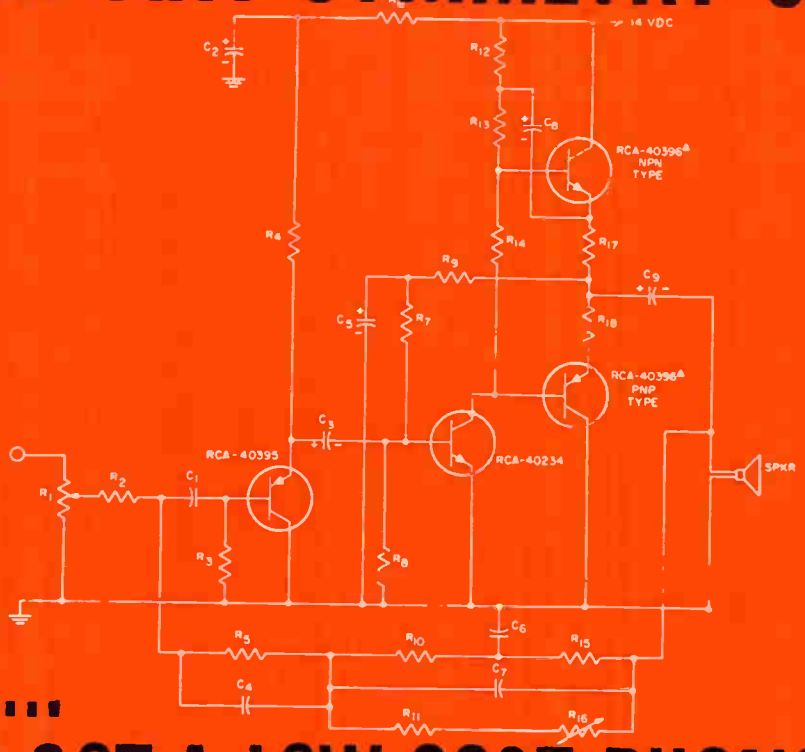

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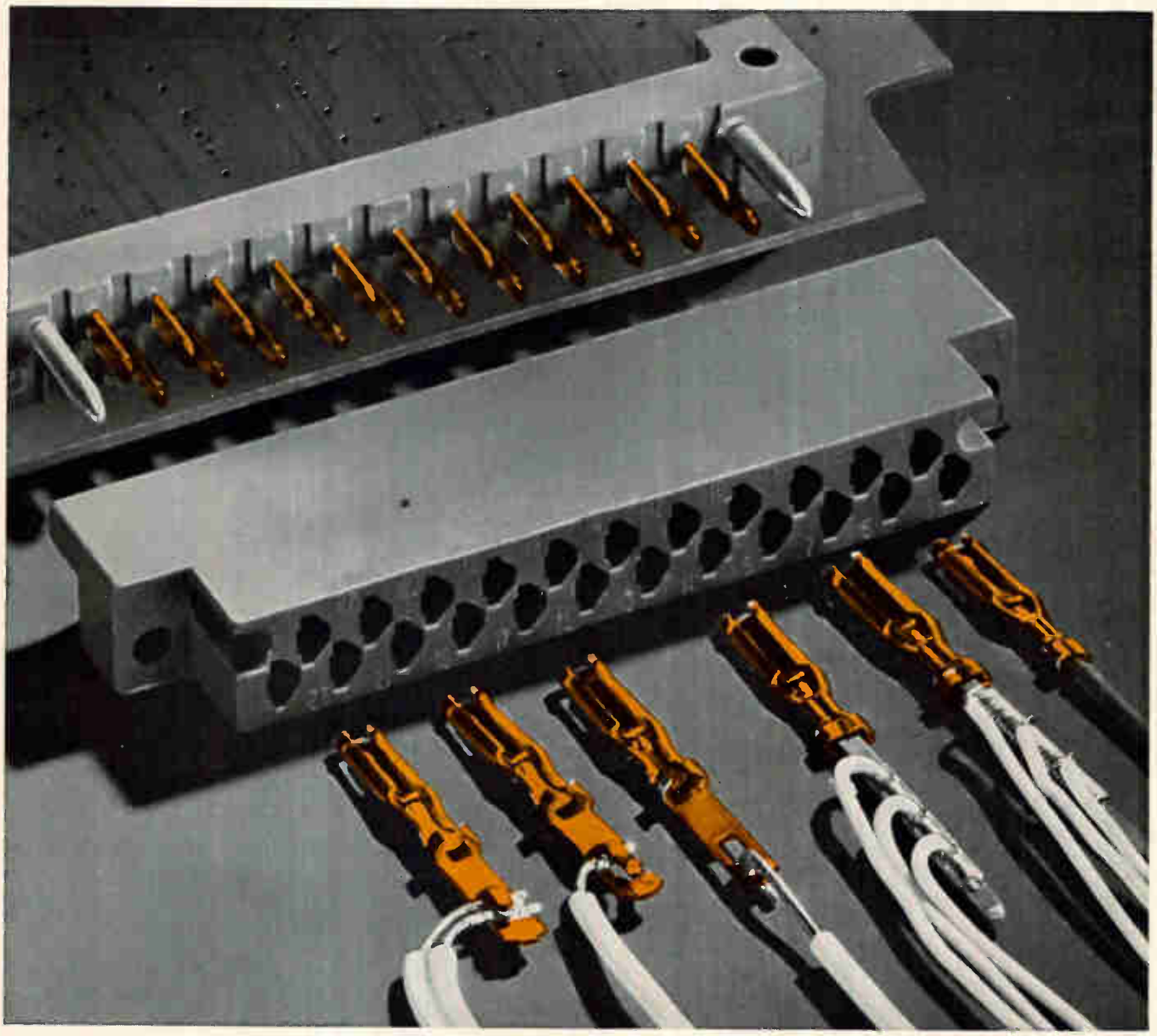

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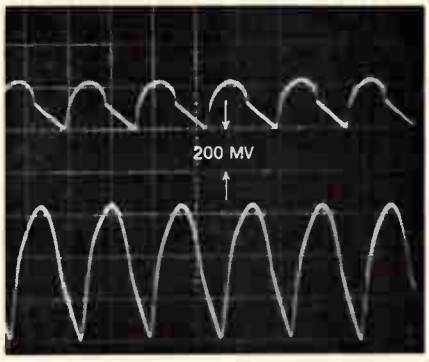
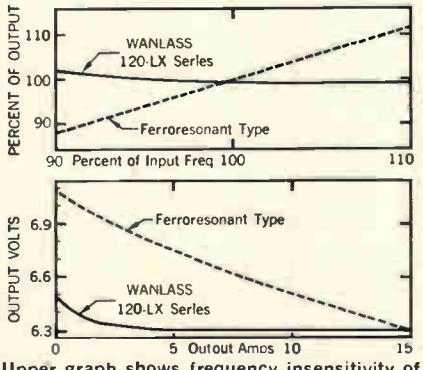


Unretouched dual scope photo shows WANLASS LX ripple output (above) vs. typical ferroresonant unit under identical conditions.



Upper graph shows frequency insensitivity of Wanlass LX Power Supplies vs. ferroresonant units. Lower graph, compares load regulation.

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Probing the News

Systems engineering

New discipline defies definition but the industry wants more of it

Top companies are selecting their brightest engineers for rotational work programs and back-to-school training in ambitious effort to put systems engineering concept to work

By Walter Barney
Los Angeles Regional Editor

At the Autonetics division of North American Aviation, Inc., a radar engineer packs up his slide rule and his pentel pens and moves to another office for a six-month stint on computer design. An engineer at the Hughes Aircraft Co.'s Aerospace Group, having completed six months of work in guidance control, shifts to space systems. A full-time graduate student at the Massachusetts Institute of Technology opens his mailbox to get his regular paycheck from the Bell Telephone Laboratories. An engineer walks out of North American's Space and Information Systems division and braves the Los Angeles freeways to attend a class leading to a special master's degree at the University of California at Los Angeles.

Because all of these young electronics engineers have demonstrated interest and ability in a wide range of engineering fields, they are being trained in one of the newest—and vaguest—disciplines, systems engineering.

Even though there's disagreement on definition for systems engineering [see box], there is unanimity on the need for systems engineers. "We are doing more complex things in terms of the number of variables to be considered," says Simon Ramo of TRW Systems, a TRW, Inc. group. "More men and a lot more money are involved, and we can't afford trial and error any more."

Most systems men grew into their jobs more or less haphazardly, but there is a growing realization among companies doing systems work that the chance method won't fill their needs in the future.

"The only way to get a good systems engineer right now is to steal him from another company," says Philip M. Oliver, director of industrial relations at the Philco Corp.'s Western Development Laboratory. But there are indications that the situation is changing. Companies—Philco included—are turning more and more to the training of their own systems engineers, either through rotational job programs or support for advanced academic work or both. And the universities, feeling the pressure for more courses in systems work, are setting up special curriculums and are even offering systems courses on an undergraduate level.

I. View from the top

A ballistic missile or any avionics package or a communications satellite is made up of a number of subsystems that are distinctly not modular in conception or function. Change one black box and the odds are that every other black box will have to be modified. And then you

A rose by any other name

No one has yet come up with a definition for systems engineering that can be repeated without exhaling. E.G. Christiansen of North American's Space and Information Systems division cites this definition, for instance:

"The technique and administrative process that organizes and integrates concepts, resources, and technologies into the development of total systems, maintaining technical integrity over all elements of the system, including hardware, software, procedural data, facilities, and personnel requirements. It encompasses such activities as systems definition, systems analysis, functional analysis, reliability analysis, test analysis, maintenance analysis, and system integration."

There is probably a one to one relationship between the number of systems engineers and the number of definitions of systems engineering. "Systems engineering is best left to an intuitive concept," says John G. Brainerd, throwing in the towel. The remark is interesting because of the source; as director of the Moore School of Engineering at the University of Pennsylvania, Brainerd put aside the problem of defining systems engineering to organize a graduate program in it.

may find that these additional changes nullify the initial change.

The systems engineer, then, has to make sure that the total system works properly. His task is optimization; if a transmitter is built with more power, will the gain be offset by the increased size and weight, or cost? On a more commercial level, will each subsystem be ready at the right time so that the contractor can meet his deadline? Will the individual subsystems be compatible?

Personnel directors and training program administrators are unanimous in saying that the engineers best fitted to learn these tasks are those with solid technical ability and far-ranging interests, plus a gregarious nature and an ability to communicate.

"The best systems men I've hired were guys who took the initiative and moved around from structures to propulsion to computers to design to marketing," says Philco's Oliver. "We try to make a generalist out of a man who is a specialist on one or more disciplines," says E. G. Christiansen, head of manpower development for S&ID. "We won't take a man who has spent 15 years in vibration and flutter analysis and try to make him a systems engineer; he has to have displayed some breadth."

The choice of the trainee is vital; in fact, says Ramo flatly, "selection is more important than training."

Since the primary reason a company trains systems engineers is to provide itself with a stock of them, the benefits of such programs are obvious; but there is some fallout, too. Christiansen puts it most succinctly: "a systems engineer will be a better designer." He explains that a man trained in systems engineering will, even when working on a subsystem, analyze his entire mission before he begins to design. "Too many engineers begin to design right away," Christiansen says.

II. Masters of all trades

Strictly speaking, some of the rotational work programs aspire only to this modest goal of providing the engineer with a broader background. Autonetics, for instance, calls its plan a "systems engineer development program" but, ordinarily, the radar engineer who works successively with computers, missiles and booster controls, and inertial navigation, say, will return eventually to his old job in radar. The company believes that a man will do a better job of radar design if he has a solid technical knowledge of the entire system in which the radar will eventually be placed.

Stepping up. Yet inevitably, because it is the cream of the young engineers who are selected for the program (they already have their master's degree, plus three to five years experience in which they have demonstrated exceptional ability) some of them step into supervisory positions.

Autonetics makes no commitments about promotions. "Still, if we can't provide the opportunity, we know that others will," remarks Earl H. Schaefer, the executive director of research and engineering at the company. (Most firms with extensive training programs wonder if they can hold on to the finished product; the evidence from companies like Hughes and the Bell System, which have had such programs for years, is that they can.)

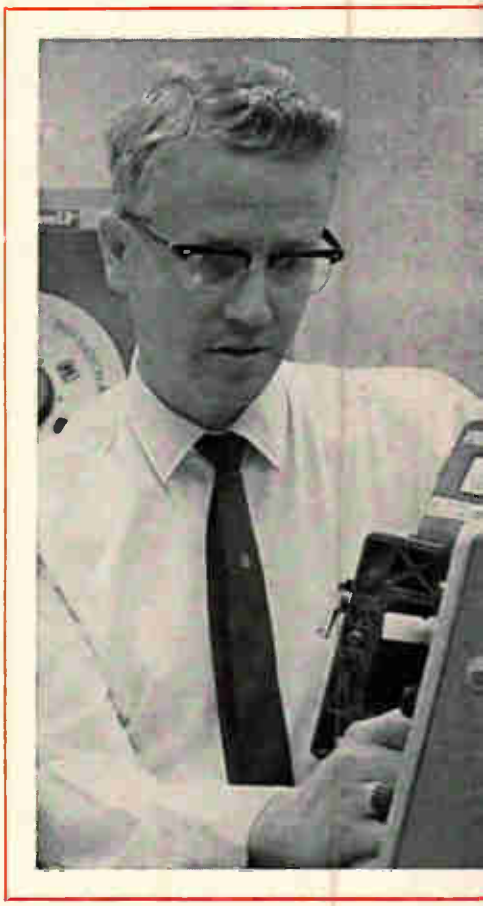
The entire Autonetics program was thrashed out at the chief engineer level before the company put the first 15 candidates into orbit a year ago. Some section heads were apprehensive about losing their most talented young men for a 12- or 18-month period, and possibly forever; they were mollified by the assurance that for every bright young man that they lost, they would gain another from a different section.

"And," emphasizes Schaefer, "the man who is switched to a new section is expected to do a job. He's not there to kibitz."

Off the campus. Hughes, with about 17,000 engineers, has a somewhat more ambitious program than Autonetics'. At any given time, more than 100 men will be on the merry-go-round. Hughes picks them off the college campus; its rotation has a double goal. Some men, the company hopes, will acquire systems capabilities, while others will learn—through doing—exactly which field they wish to specialize in. About 15% to 20% do wind up in systems work, Hughes says.

Although the Hughes program, which began in 1964, is open only to newly minted graduates, the company is beginning a professional career development program in which men with from two to eight years experience with other companies will participate.

Philco has a ranking system to grade its engineers in terms of their contributions to the company. The top 25% will be rotated through various subsystems and emerge, the company hopes, as systems men. In addition, its Western Development Laboratory division is negotiating for 36 June graduates, most of whom will start their rotation immediately. They will work



in eight categories: design, test, quality assurance/reliability, management planning (such as budgeting and pert theory), interfacing, hydraulics and structures, computer programing, and sales and marketing.

WDL's Oliver figures that it takes about six years to make what he calls a "journeyman" systems engineer, which he defines as "a man who knows every aspect of a system and can talk like an engineer to engineers and like a salesman to a customer."

III. Back to school

It is axiomatic that a skill which can be learned can be taught, and it is not surprising, therefore, to find that a number of companies are growing their future systems engineers in the classroom. Company-sponsored educational programs, even elaborate ones, are not new, of course, and they offer a ready-made framework for the development of systems men.

Until recently, there were no formal curricula in systems engineering, only isolated courses which might have some bearing on the discipline. Now, however, a number of graduate schools offer masters' degrees and even doctorates with emphasis on systems engineering. In many cases, these academic programs have been set up in cooperation with industry. UCLA, for instance, worked closely with S&ID in constructing its program, which is supposed to be ready in the fall of this year. Brooklyn Polytechnic Institute got help from the General Electric Co.

The UCLA curriculum is built around four "core" courses in the synthesis of engineering systems, techniques of system optimization, the dynamic elements of operational systems, and system simulation, with additional electives in decision theory, computer-aided design, information theory. Brooklyn Polytechnic has seven required courses —in the theory of differential equations, probability, theory of linear systems, selected topics in transients, logic circuits, synthesis of linear feedback systems, and stochastic processes—plus 10 hours of electives and a master's project.

At MIT, some 60 to 70 graduate students go through the preliminary design aspects of a complex system just as company engineers would. The program has included the design of a weather satellite system, a vehicle for a manned Mars mission, and a Northeast corridor (Boston to Washington) transportation system. The University of Pennsylvania has 90 students currently working on masters' degrees or doctorates in systems engineering, and several other universities, such as the University of Florida, Johns Hopkins, and Cornell, also have systems curricula.

The Bell Labs, where systems engineering has been a common term for a generation, has, predictably, one of the most elaborate educational programs. "Actually," says John N. Shive, Bell's director of education and training, "we won't hire anyone who doesn't want to further his education."

A new Bell employee interested in systems engineering may spend an entire year on salary at Penn, Cornell, Johns Hopkins or MIT, fulfilling the academic requirements for the master's. Then he attends in-house classes one day a week at Bell, working the other four days; and finally, after eight months of this regime, he enters a program of rotational work assignments.

Hughes, too, has a program of masters' and doctoral fellowships under which a new employee may attend graduate school full or part time, and many of the trainees in the rotational program mentioned above are also master's candidates. (At one period, of 139 engineers in the rotational program, 113 were master's fellows.) These men are paid a prorated salary for 24 hours of company work a week, plus a stipend which typically brings their income up to $6,500 a year.

All expenses paid. S&ID, which plans to send 25 men a year to UCLA for the master's degree, requires its men to carry a full work load, but it does take care of all expenses.

GE, another company with a full educational program (its 15,000 working engineers took 12,000 semester hours of courses last year) gives its trainees a carefully balanced mix of practical experience and classroom work. Brooklyn Polytechnic gives academic credit for the company's three-year program, under which engineers attend a four-hour lecture one day a week. In the summer, about 100 of the top men are sent to the Brooklyn campus to work on advanced degrees. More than half of these men, says Dolph Ebeling, GE's director of technical education, are systems engineers.

"We could have just sent these men back to school," says Ebeling, "but we didn't want that; we wanted to make sure that we gave them a good combination of practical and academic work."

IV. Theory and practice

Which method makes the better systems engineer—classroom work or practical training? Should a company put most emphasis on grounding its trainees in probability theory and stochastic processes, value theory, information theory, computers, game theory, and modeling, or should it stress strong technical background in subsystems?

Most training directors say that there should be a judicious mixture; the problem comes in deciding what is judicious. "If you want to do systems work, you better get into a big system," says Ebeling.

"You can't legislate a systems man; you need a man with competence in depth in subsystems," agrees Schaefer of Autonetics.

But Simon Ramo believes that there are actually two types of systems engineers. "One has very broad technical and executive experience," he says, "and attacks the problem of the whole. He is alert to the link between technology and science, and to the economic and social aspects of a system. He is an

Quick returns

Autonetics' rotational job-training program has long-term goals, but the company got a short-term dividend before the plan had been in effect a year.

One engineer, 40-year-old S.F. "Jack" Higgins, had been shifted from data systems to research and engineering and then to the company's Advanced Programs and Marketing division, where he was assigned to antisubmarine warfare projects. He was sitting in on a meeting to see if there were any antisubmarine applications when one speaker described some communications receiving equipment.

Higgins felt that a systems approach, taking into account commonalities of equipment, could simplify the receiver considerably. He suggested certain design changes which Autonetics has breadboarded. The company expects that change to bring in an extra million dollars in gross profits. Figuring a rough profit margin of 7%, that means $14 million in extra business.

Higgins has been with the company for three years. He's a 1950 graduate of the University of California at Berkeley.

integrator who is expert at tradeoffs and optimization.

"The other type of person is a specialist in the tools of systems engineering. In any complex system of men and machines, someone is needed to make reasonable analytic estimates of the whole. He is a specialist in random stochastic phenomena—a physicist, say, whose knowledge of quantum or wave mechanics has led him to think in terms of probability functions."

Technological infancy. Ramo, who is not afraid of the definition problem, adds: "engineering is the application of science to society, and systems engineering is closer to the nub of what engineering really is. The trouble is, systems engineering is not very well done yet; it's now at the stage of electrical engineering in Steinmetz's time. [Charles P. Steinmetz, the discoverer of magnetic hysteresis and the developer of a simple notation for a-c circuits, died in 1923.]

"Social problems," Ramo continues, "are still not taught properly. We teach an engineer the humanities to make him a better citizen: we should teach the humanities so as to make men better engineers. Otherwise you're operating in a vacuum and it's like telling a medical student all about drugs and nothing about the human body."

That problem, incidentally, is recognized in Brooklyn Polytechnic's undergraduate program; the catalog notes that because human factors are vital parts of most systems, "the new curriculum provides a strong core of humanities and social science courses, including new presentations of material in the behavioral sciences and in aspects of economics that are relevant to the systems field."

The increasing demand for systems engineers, and particularly the skimming off of the brightest young men for systems training, is likely to improve the practice of systems engineering rapidly. We may soon see the development of a general theory of systems engineering, something which is lacking at present.

It's even possible that someone will come up with an acceptable definition for the discipline. But that may be expecting too much.

Technicians hold the trumps

Bidding goes up as technicians grow scarcer; qualified technicians are in the army now

Electronics recruiters who are finding it difficult to sign up engineers aren't having any better luck hiring technicians. A booming economy—spurred by Viet Nam—is creating the greatest demand for technicians since the Korean war. At the same time, the armed services are siphoning off manpower and paying large bonuses to keep their trained technicians. The electronics industry is caught in the middle. Hard pressed to find qualified engineers [Electronics, March 7, 1966] the industry finds itself stepping up recruitment campaigns to attract production workers.

"Technical people are harder to find than engineers," says Edward Barr, personnel manager of Honeywell Inc.'s Electronic Data Processing division, Wellesley Hills, Mass. "The technical applicant has the market in the palm of his hand," says Robert Gillette, general employment supervisor at Sanders Associates, Inc., Nashua, N. H. In Chicago, Frank Delay, personnel director of Zenith Radio Corp., says "yes, we're having trouble getting ahold of electronics technicians; everybody in the industry is."

Ben E. Jeffries, employment manager of Collins Radio Co. in Dallas, says the general situation on technicians is tighter now than he has ever seen it. Joseph Malone, manager of plant employment at the Fairchild Semiconductor division of Fairchild Camera & Instrument Corp., San Francisco, says "because of the market shortage, we're in the same position we are with engineers—there isn't enough to go around" and so it goes . . . The drive for more technicians is going full steam.

▪ Texas Instruments Incorporated in Dallas, reports it will need 1,000 electronic technicians this year and Tom Dudley, corporate director of personnel, says it will be "quite a scramble to find all we will need, but we think we will be able to recruit enough to meet these needs."

▪ The Florida State Employment Service at Cocoa polled aerospace contractors serving Cape Kennedy and the Kennedy Space Center and reported an estimate 195 to 255 openings for electronics technicians. And the service forecast a need for an additional 1,400 for the balance of the year.

▪ A spokesman for International Business Machines says IBM will need 3,000 technicians nationwide in 1966.

▪ Radio Corp. of America says it will need 2,000 technicians.

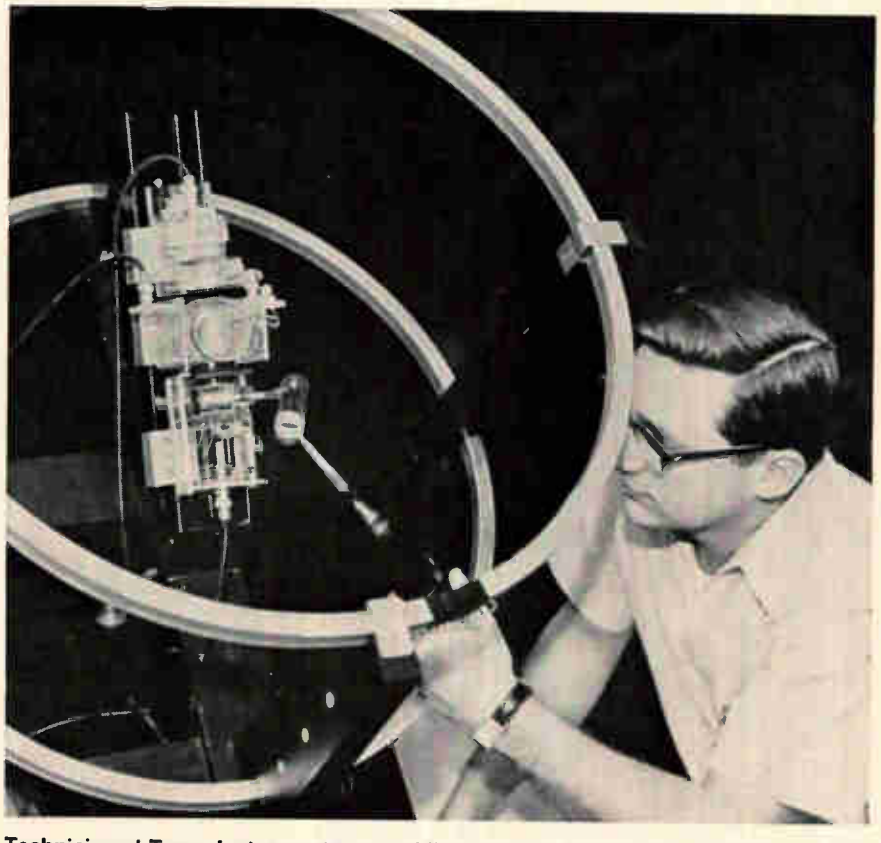
▪ General Dynamics in Fort Worth, Tex., needs 65 technicians "in the near future."

▪ Collins Radio needs 60 to 70 technicians in its Dallas division.

▪ Fairchild Semiconductor is seeking about 50 technicians for its San Francisco plant.

▪ Grumman Aircraft Engineering Corp. is looking for about 300 technicians for its Long Island, N. Y. facilities and for field work.

▪ Sanders Associates needs 108 technicians and the personnel manager says that for the first time in seven years, the company is paying employment fees for technical help. Sanders Associates is not alone in stepping up its recruitment drive. Salaries are rising, firms are increasing their placement advertising, fringe benefits are being added and relocation fees are being



Technician at Texas Instruments assembling the prototype of a metastable helium magnetometer. The shortage of such electronics technicians has caused a talent search as hectic as that for engineers.

paid in some instances.

Airborne Instrument Laboratory, a division of Culter-Hammer Inc., held an open house at its Deer Park, Long Island plant in an effort to get technicians to come in and browse around. Airborne is seeking about 50 technicians.

I. They're in the army now

The basic reason for the technician shortage is the familiar story of the well running dry just as the need for water increases. Electronics firms have depended on three major sources for trained technicians; the armed services, technical schools and on-the-job training—either at their own facilities or a rival company's.

The increased draft is grabbing off many technical school graduates as soon as they leave school. And many technical graduates are deciding to continue school to get their engineering degree—some went to avoid the draft but many would have continued anyway. In San Francisco, Lenkurt Electric Co.'s employment manager Don McGuire reports, for example, that many students resent the "second-class status" of technicians and think "If I can be a technician, why don't I go on and become an engineer?" Fifty per cent of this year's graduating class at Wentworth Institute in Boston plans to continue school. This compares with 31% last year and 22% the previous year.

Settling for 6 months. The draft also is making it difficult for companies to hold young technicians. Gillette complains that at Sanders Associates it is difficult to get a supervisor to approve hiring "draft bait." He says, "if I can get six months out of them, I'll consider myself lucky."

The armed services are further complicating the problem by going all-out to keep the technical people they have, thus drying up another major source of technicians. In the past six months, the Army has increased its reenlistment bonuses to the point where some servicemen with specialist ratings, including technicians, have received reenlistment bonuses of $6,000 to $7,000. The amount varies with length of service, rank and speciality.

Well is running dry. With the normal sources of supply drying up, companies are turning more and more to "recruiting" from other firms or developing their own training programs. Texas Instruments, for example, usually gets about 30% of its technicians from graduates of military service. And it has depended heavily on 32 accredited technical institutes, hiring an average of 15 graduates per school. In the past, the company has been recruiting primarily in the Southwest and Midwest, but now reports it has to "go farther afield."

Gillette, of Sanders Associates, says one result of the technician shortage is that companies are now robbing Peter to pay Paul. "Companies are all pirating technicians. Everybody takes from each other," says Gillette.

W. E. Meyer, recruitment and training manager of the Guidance and Control Systems division of Litton Industries, Woodland Hills, Calif., says the technician "shortage is now so severe that we are going back to the Midwest to recruit experienced electronic technicians. We're picking up their moving expenses, too."

William Towne, technical manager at Snelling & Snelling employment agency in Boston, says he has 140 to 160 requests a week for technical help. He says the companies "are hiring people they wouldn't look at two years ago. Anybody with a certificate from a legitimate technical school is in great shape."

Warm bodies. George McKay, chairman of the Electronic Technology dept. at the University of Houston, says many companies call asking "for just a warm body and we'll do the rest."

Clarence Pope, of the New York State Employment Service, says he has standing orders from some firms for technical manpower and if a person will relocate and has credentials, he can be placed. Salaries range from $100 to $175 a week depending on experience.

II. Train your own technician

Many firms report that they are increasing their own on-job training programs both to increase the number of technicians and upgrade the quality of those already employed.

Training is an expensive item. Elmer Noonan, director of indus-

trial relations for Northrop Corp.'s Nortronics division, Palos Verdes Estates, Calif., says "We have had training expenses running in excess of $1 million dollars a year for assemblers and technicians." Nortronics is not running any training programs at present, but it has an initial $20 million contract for the navigation system for the C-5A transport aircraft and will need 175 to 225 additional electronics assemblers and technicians this year.

Job Corps. Many companies are hoping that eventually the Job Corps training programs will help ease the shortage of young trained assembliers and technicians. However, the electronics program started in May, 1965 and the Corps is aiming at a two-year training program. Control Data Corp. began programs earlier this month to train 30 computer technicians and 60 electronics draftsmen under a Manpower Development and Training Act contract award. The courses last six months.

In the meantime, companies are stepping up their own on-the-job programs. For many companies free tuition plans, or part-payment plans are also fringe benefits in their battle to attract trained technicians. Douglas Aircraft Co., Inc., of Santa Monica, Calif., for example, in February began an apprenticeship program for electronics technicians with the International Association of Machinists. About a dozen apprentices enrolled are working 40 hours a week at the firm and going to night school. Starting pay in the program is $2.24 an hour; that climbs to $3.54 during the last six months of the four-year course.

Sanders Associates has set up a drafting apprenticeship program. One student in the course is 43 years old. He says he's always wanted to be a draftsman.

Itek Corp., Lexington, Mass. plans more internal training programs for technicians who are academically qualified but have had no experience. IBM looks for—and tests—people to determine natural ability and even academically qualified technicians are sent through training couses.

Eliminating English. Texas Instruments has various in-plant schools, primarily to up-grade technicians, and is planning a program to train potential technicians. Details are to be worked out, but the basic idea is to cut the time required for a normal technical institute in half by having students attend classes eight hours a day. The curriculum would eliminate such courses as history, English, etc., required at most institutes. One question to be settled is whether the students will be hired by the company and then trained, or vice versa.

III. Job shoppers are back

The acute shortage of technicians has also led to a return of the so-called "job-shopper" and growth of consulting firms which supply technicians to companies which need help for short periods of time. A spokesman for Lehigh Design Co. Waltham, Mass., a design consultant firm, says the basic attraction of this type of work is a higher pay scale.

Companies use the service to fulfill short-term contracts and avoid layoffs after the contract has expired. Lehigh has 12 offices from Boston to Los Angeles with a permanent work force of about 1,500 people. As an example of its contract, Lehigh has supplied 400 to 500 technical people, including designers, engineers, and technicians, to IBM over the past two years to work on the new 360 series computers.

The future looks promising for the well-qualified technician. Although Tractor Inc., at Austin, Tex., does not need any technicians now, William Avrett, director of personnel, says the company is in dire need of 60 to 70 engineers. And he explains, "Since we use technicians primarily to assist engineers, we can't afford to hire technicians until we have sufficient engineers to back them up."

The Atlanta area now reports that there is no acute shortage of qualified technicians, although most companies say they are continually on the lookout for good, qualified people. A spokesman at Lockheed-Georgia Co. notes that next spring the company will be into the C-5A program and "will probably need more technicians". The spokesman says the company needs engineers now. When engineers get going; technicians can't be far behind.

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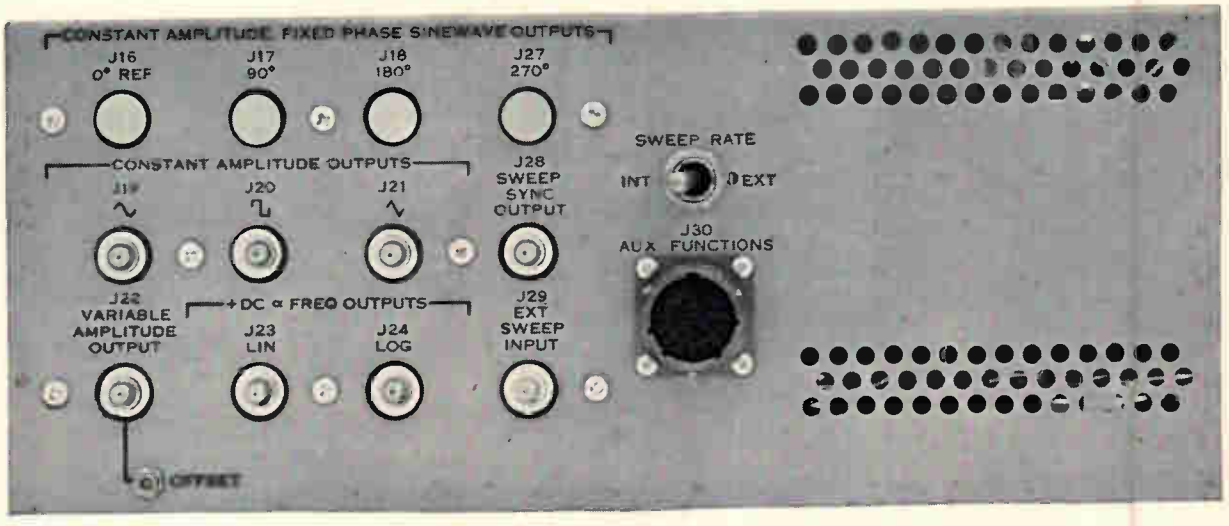

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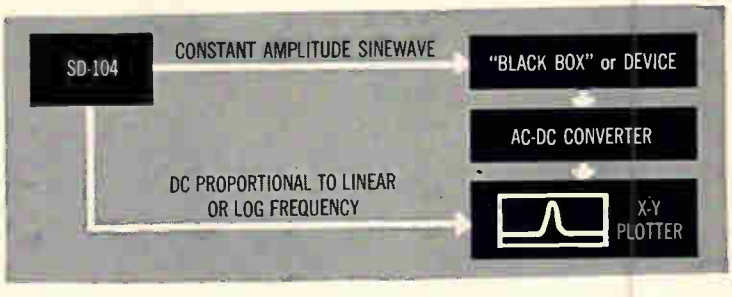

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Consumer electronics

Solid state device woos housewife and homeowner

Market growing for silicon controlled rectifiers for food blenders, washers, ranges, drills, saws and other appliances for home and workshop

By Jerome Eimbinder

Solid State Editor

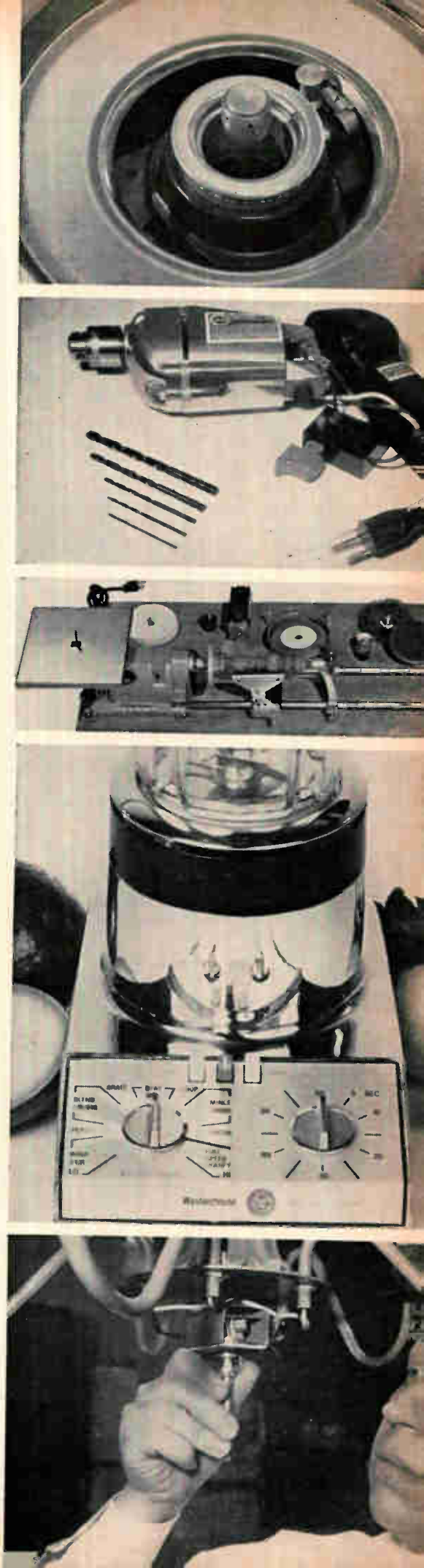
When mother goes to the kitchen, a tiny but versatile solid state device called the silicon controlled rectifier will be waiting to help her with the dishes, dispose of the garbage and wash those delicate things by machine. Mother's newest helpmate has been around for several years, but only recently have reduced costs allowed scr's to take their place in household appliances from food blenders to drills. Despite the fact that the scr's still tend to increase the cost of an appliance, manufacturers have discovered mother will pay a little more for their advantages.

The scr makes a nearly ideal power switch; having only two stable states, on and off. It is almost as efficient as an electromechanical switch, is much faster and has a longer life. In a typical scr control circuit, a variable resistor sets the voltage supplied to a capacitor. The scr is triggered when the charge is sufficient. To increase or decrease the motor speed, the resistor value is adjusted to control the instant at which the scr is triggered during a positive half cycle of the supply voltage. If heavy loading causes the motor to slow down, its counter-electromotive force drops. The change in voltage is fed back to the scr input, causing it to be triggered into conduction earlier in the cycle. This, in turn, causes the motor to speed up, compensating for the heavier loading.

I. Scr—the housewife's friend

C. E. Burnett, vice president of the industrial tube and semiconductor division of the Radio Corp. of America, predicts that solid-state controls eventually will go into 75% of all home appliances. RCA expects sales of solid state devices for home appliances and hobbyist tools to exceed $100 million a year by 1970. The bulk of this will be for scr's. This optimistic outlook for proliferation of solid state circuitry in tools and appliances is largely because of a reduction in scr prices in the past two or three years. In early 1965 the Electronic Control Corp. of Detroit tried to sell a solid state control unit to the Rival Manufacturing Co. for use in a food blender, and Rival reportedly gave their salesman the horselaugh because the price asked for the unit was unrealistically high. Eight months later, Electronic Control was able to cut the price of the unit by 50% because of a drop in the cost of scr's, and Rival bought the unit.

Diamonds to doughnuts. The difference in the cost between the first scr's commercially available and their cost today is like the difference in the cost between diamonds and doughnuts. When the General Electric Co. introduced them in 1957, scr's cost $300 each. Many scr's now cost less than $1, and GE recently announced an scr for 35 cents, about half the cost of the cheapest previously available. The



Appliances using scr's. Top to bottom: range with electronic pilot light; drill with scr control unit; Versitool, a home workshop tool; food blender; and light fixture.

Advantages with scr's are worth the extra cost

Semiconductor Products division of Motorola, Inc., says that those who buy in volume can now get all the components they need to build a 1300-watt control circuit for under $2.50. This includes two 8-ampere type MCR2304-4 scr's, the MT32 diode, two capacitors, a 100,000-ohm potentiometer, a resistor and a pulse transformer. A few years ago, a similar set of components would have cost at least double the price.

Scr cookbook. Typical of the success of an appliance with an scr circuit is a food blender Westinghouse Electric Corp. began marketing last month. Distributor orders for the variable-speed blender, model HA40, greatly exceed orders for its conventional counterpart, the HA20, even though the conventional blender, which has seven speeds, lists for $22 less than the solid state model.

The Waring Products Co., a division of the Dynamics Corp. of America, published a cookbook four years ago for use with its conventional blender warning that no blender could beat egg whites for meringues or whip cream as well as a hand beater. Waring eliminated this warning when it published a cookbook for its new solid state blender last year. The new blender, capable of operating with high torque at low speeds, could do these jobs and many others previously not possible, such as neatly shred apples, dice onions, chop eggs and gently stir mayonnaise and puddings.

Waring's earlier models operated at 12,000 revolutions per minute (low) or 20,000 rpm (high). Operating at speeds under 10,000 rpm would have caused stalling under heavy loads and possibly damaged the blender's motor. In the new model, an scr control circuit also makes it possible for the blender to operate at 3,000 rpm.

More blenders. The Westinghouse Electric Corp. and Rival are currently selling a solid state blender; the Ronson Corp. will have one on the market in June; and Knapp-Monarch Co. and the Hamilton Beach Co. division of Scovill Manufacturing Co. have units under development.

The Rival model contains only four components: a bidirectional semiconductor switch, a potentiometer, a fixed resistor and a capacitor. The bidirectional switch is essentially two scr's connected back-to-back (sometimes known as a reverse parallel connection).

The configuration of the bidirectional switch allows generation of a full wave output. The device can be triggered by either a positive or a negative signal at the gate electrode. An extra benefit of the device is an immunity to damage from potentially destructive voltage surges. If a large transient voltage accidentally is applied to the device, it is merely triggered into conduction, whereas a conventional scr might be destroyed.

A magic word. Scr's are also being used in washing machines, gas ranges, floor polishers, drills, sabre saws and lighting fixtures. Frank Rosen, chief engineer for product development with Dominion Electric Corp., a manufacturer of small kitchen appliances, explains that with scr's "you can get slower speed without losing power, and you can control power from full-on down to full-off in a stepless manner."

Robert Gundaker, marketing manager of the portable appliance division of Westinghouse, points out that in addition to the improvements to induce additional consumer spending, "the name—'solid state'—itself is like a magic word" to the consumer.

II. A slow drill is an scr drill

The reduced costs of scr's also has stimulated their use in drills. Scr's were introduced in drills in 1961 to provide low-speed reliability, but only in the last few years has the market reached significant proportions. Today at least eight companies offer a hand drill with scr circuitry.

Carl Amrein, an engineer at the Black & Decker Manufacturing Co., says that the ability "to work at low speeds without stalling is the most significant reason for using scr's in drills." Also important, he says, is the ability to select the right speed for a particular job. Using scr circuitry increases the cost of a drill by about 25%, says John Roods, plant manager of the Bersted manufacturing division of the McGraw-Edison Co., "but the advantages are worth the extra cost."

Slower speeds make it possible to start a hole without a center punch and reduces the possibility of the drill bit moving off-center, thus scarring a piece of work. Amrein says that the scr-controlled drill also makes it possible to use a drill as an automatic screw driver.

III. Don't wash by hand . . .

A need for low-speed reliability also was the incentive for trying out scr circuitry in washing machines. Two years ago, the Hotpoint division of the General Electric Co. began to worry about the growing number of garments sold with tags calling for hand-washing. Hotpoint discovered these garments could be washed safely by machine if lower spin and agitation rates were used. To provide the high torques needed at the required low-operating speeds, Hotpoint developed a washing machine with solid state controls. Besides an scr, its circuitry includes a conventional pnp transistor, a unijunction transistor, nine conventional semiconductor diodes and a zener diode.

Hotpoint's washer has been available since October and sells for about $350. Montgomery Ward & Co. will soon market a solid state machine for about $340 to compete with the Hotpoint washer. According to a recent survey, the average retail price for conventional automatic washers is $225.

Got a match? The various uses for scr's in appliances seem unlimited. For instance, Sears Roebuck & Co. is selling a gas range that uses scr igniter circuits instead of conventional pilot lights. The electronic match, made by the Wilcolator Co., a subsidiary of Ranco, Inc., lights the gas by a spark gap that is energized by a capacitor discharge. An scr switches current to the capacitor when the knob of the range is turned to a "light" position [Electronics, Feb. 7, pp. 47-48]. Wilcolator says the savings in fuel costs from not burning a pilot light pays for the scr unit in a few years, and that the electronic match

circuits don't heat kitchens the way conventional pilot lights do and eliminate the danger of a spontaneous explosion from a gas leak.

Other products will soon be using scr's: The Ronson Corp. will introduce what it calls "a food preparation center" later this year that will use scr circuitry. The device will blend liquids, extract juices, grind meat and coffee, shred vegetables and crush ice. Magic Chef, Inc., is developing an scr food waste disposal unit; the Bersted division of McGraw-Edison is manufacturing a home workshop tool using scr's that will be able to be used for sawing, sanding, spinning, grinding and polishing; and Northern Electric plans to come out with a thermostat containing an scr in the next six to 12 months.

Several other companies, such as the Sunbeam Corp. and the Cory Corp., are developing small scr-controlled kitchen appliances. Sunbeam officials say, however, they are not convinced yet that low priced scr's can perform as well as component manufacturers claim and will not yet commit themselves to solid state circuitry. Cory expects to put scr's in some of its products next year; its diversified product line includes coffee makers, humidifiers and knife sharpeners. GE predicts that sewing machines, movie projectors, food warmers, hair dryers, darkroom exposure controls, humidifiers and sump pumps soon will be made with scr circuitry.

Also, scr's have been used since the late 1950's for industrial speed and power controls in steel, paper and textile mills; today, their use in industry is so widespread they are considered commonplace.

It has been predicted that total sales of scr's will reach $39 million this year—$6 million more than last year's sales—and reach $59 million by 1969 [Electronics, Jan. 10, p. 135].

Adam J. Lappin, the president of Waring, says there is no doubt that "solid state is changing our thinking. When we brought out a conventional blender in the 1950's," he says, "we didn't expect to redesign it for five years. Now, it will probably be necessary to retool at least once a year to take advantage of the latest solid state advancements."

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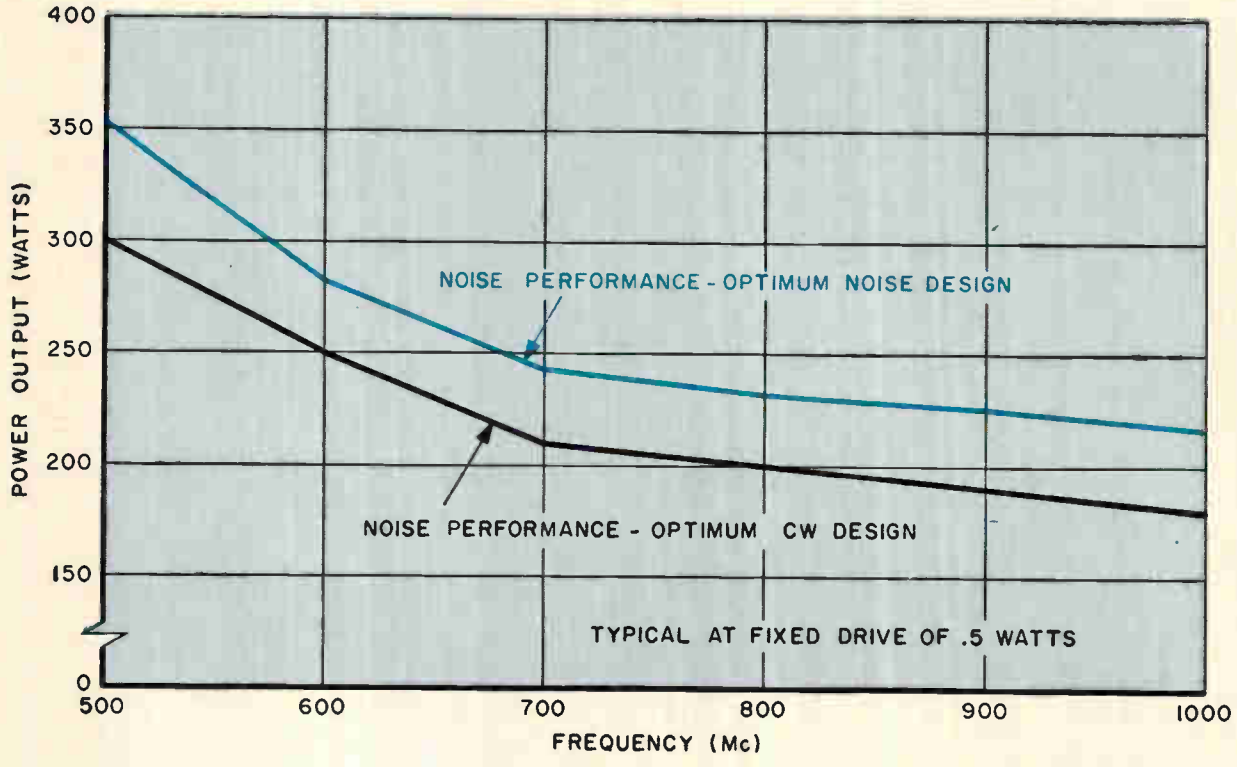
JOYFUL NOISE

How Sperry uses design to replace de-rating of TWTs for ECM systems



For the ordinary CW traveling wave tube, amplifying noise is hard work. If you've been specifying tubes for ECM systems, you probably know the old rule of thumb . . . pick a likely looking CW tube and de-rate it about one-third if the application calls for amplifying noise.

Now the rule of thumb is out of date. System designers who order noise amplifiers from Sperry are replacing degraded performance with designed performance. They no longer buy more CW tube than they need. They achieve their specified noise level with a Sperry traveling wave tube that's customized and rated for optimum noise performance. Naturally such tubes improve system size, weight, and over-all efficiency.

Sperry's growing proficiency in high-noise design is a result of extensive studies in that area of traveling wave tube technology. Noise amplification requirements have led to serious investigation of the "capture effect" . . . the tendency of low frequency noise to utilize a disproportionate share of the tube's output at the expense of noise amplification near the high edge of the band.

Significant improvements in noise performance (see curve above) have resulted from such techniques as helix tapering, controlled over-voltages and variations in perveance. These techniques have been fully proved during high-production runs.

For your next high-noise application, Sperry suggests this: tell us all about your noise source and send us a sample, if possible. We'll go to work on design refinements that will give you joyful noise . . . not the degraded performance of a tube designed for CW work.

Engineering details of Sperry's high-noise discoveries are available in a new technical paper. For your free copy, write today to Sperry, Gainesville, Florida.

Design refinements to fit changing system requirements . . . that's the big bonus from Sperry's Storehouse of Knowledge. For high-noise applications or other system demands requiring state-of-the-art TWTs, klystrons or BWOs, always start with Sperry.

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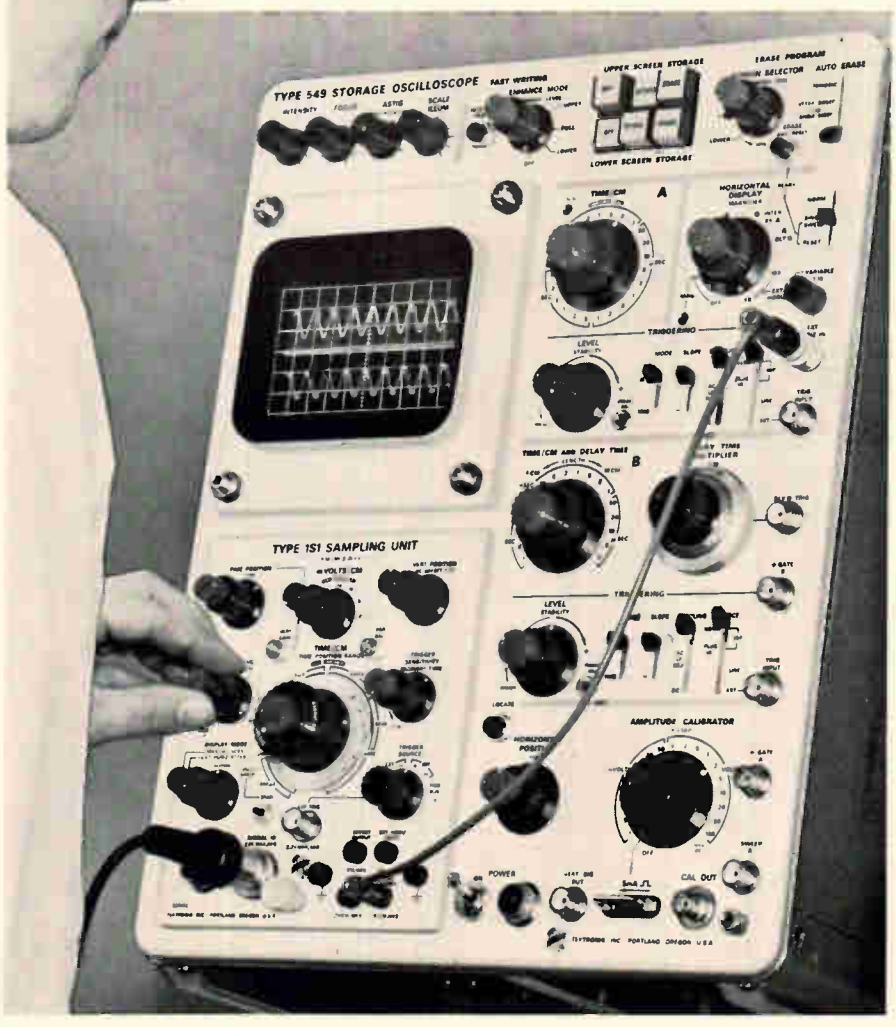
Circle 127 on reader service card

DC-to-30 MHz performance AND THE versatility of 20 plug-ins with split-screen storage



TEKTRONIX Type 549

split screen permits simultaneous operation as a storage and conventional oscilloscope

Split-screen storage offers a distinct advantage to the user in waveform-comparison applications — by permitting quick comparison of dynamic signals appearing on one half of the crt with a reference trace stored on the other half, or the Type 549 can be used for full screen storage or full screen conventional displays.

SAMPLING AND STORAGE

The storage capacity of the Type 549 provides easy-to-study displays—and with a Type 1S1 Plug-In adds new convenience to sampling applications. With this new dc-to-1 GHz sampling unit, you need no pretriggers or external delay lines—the 1S1 has internal triggering with a built-in delay line. The Type 549/1S1 combination gives a stored display that is steady and, because more samples can be displayed, there is high resolution of the sampled information.

storage features:

Unparalleled Writing Speed — up to 5 cm/μs, with enhancement.

2 Independent 3x10 cm Display Areas — with separate upper half and lower half controls.

Bistable Storage.

Automatic Erase — with selectable viewing times from 0.5 seconds to 5 seconds. Erase can be selected for recurrent or after-sweep operation.

Erase-and-Reset — with push-button control for erasing display and rearming single sweep. Erase-and-Reset can be controlled remotely, if desired.

other features:

Precision Sweep Delay—from 1 microsecond to 10 seconds.

Wide Sweep Range — 5 s/cm to 0.1 μs/cm (Time Base A) and 1 s/cm to 2 μs/cm (Time Base B). 5X Magnifier extends fastest sweeps to 20 ns/cm (Time Base A) and to 0.4 μs/cm (Time Base B).

Single Sweep — manually, automatically, or remotely.

Full-Passband Triggering — with flexible, easy-to-use facilities.

Simplified Trigger Logic — with lever control of trigger functions.

Size and Weight — dimensions are 17″ high x 13″ wide x 24″ deep; net weight is ≈ 67 lbs.

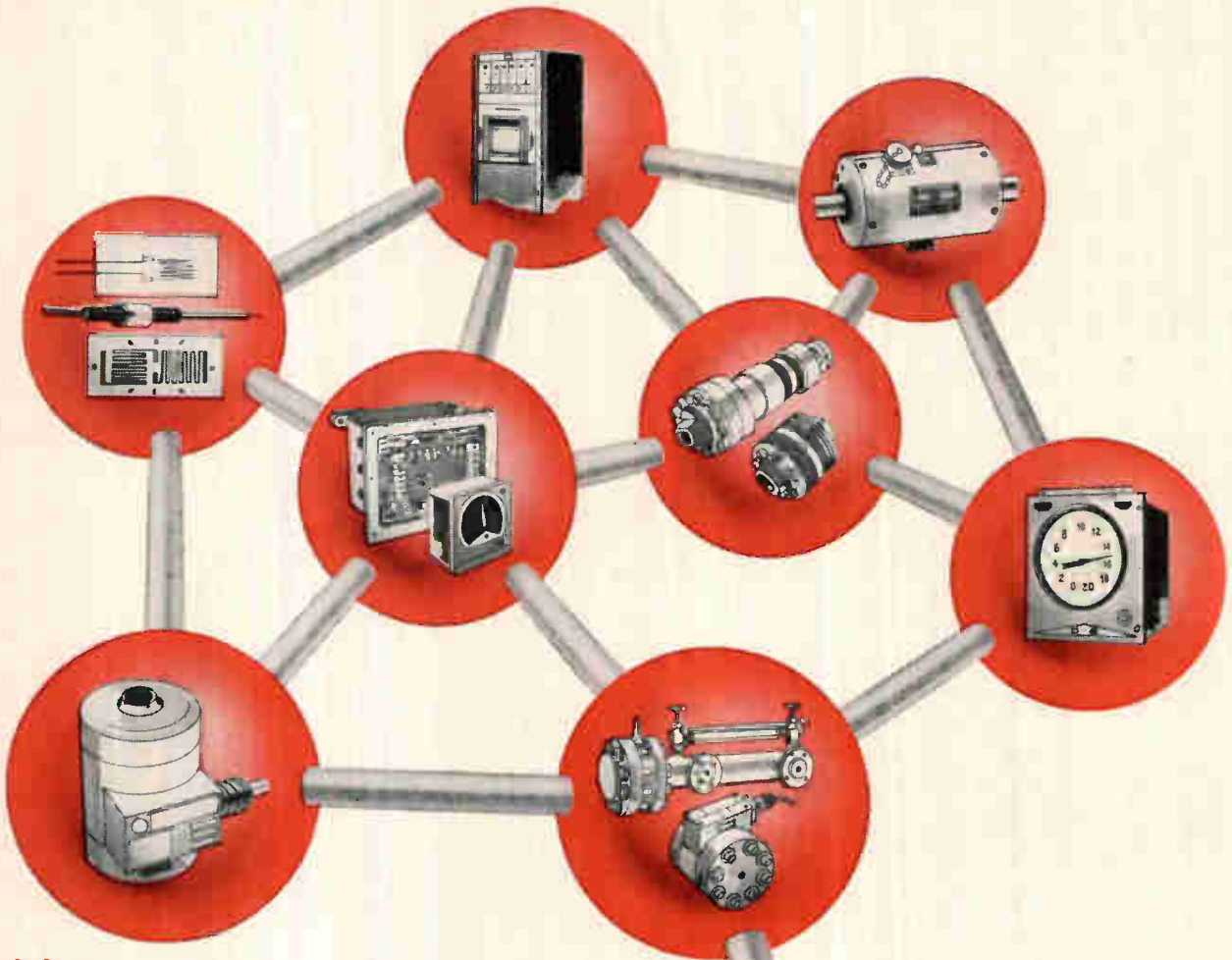
Type 549 Oscilloscope $2375
(without plug-ins)

The plug-in units range in price from $145 (B high-gain unit, K fast-rise unit) to $1100 (1S1 sampling unit, illustrated).

U.S. Sales Prices f.o.b. Beaverton, Oregon

For more information call your Tektronix Field Engineer.

Tektronix, Inc.



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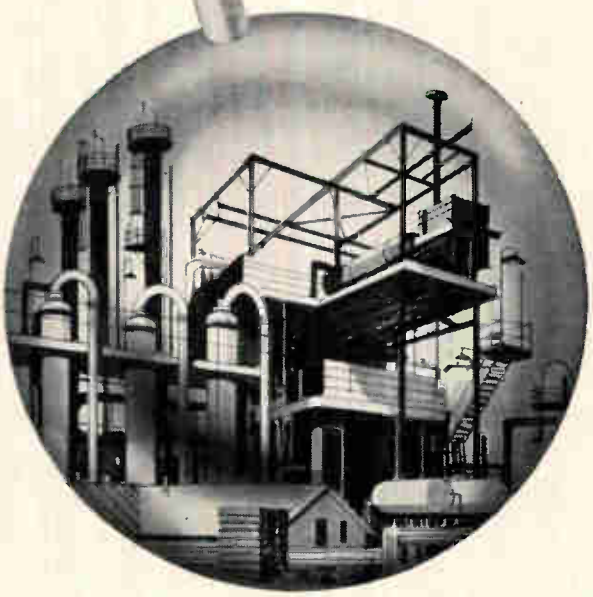

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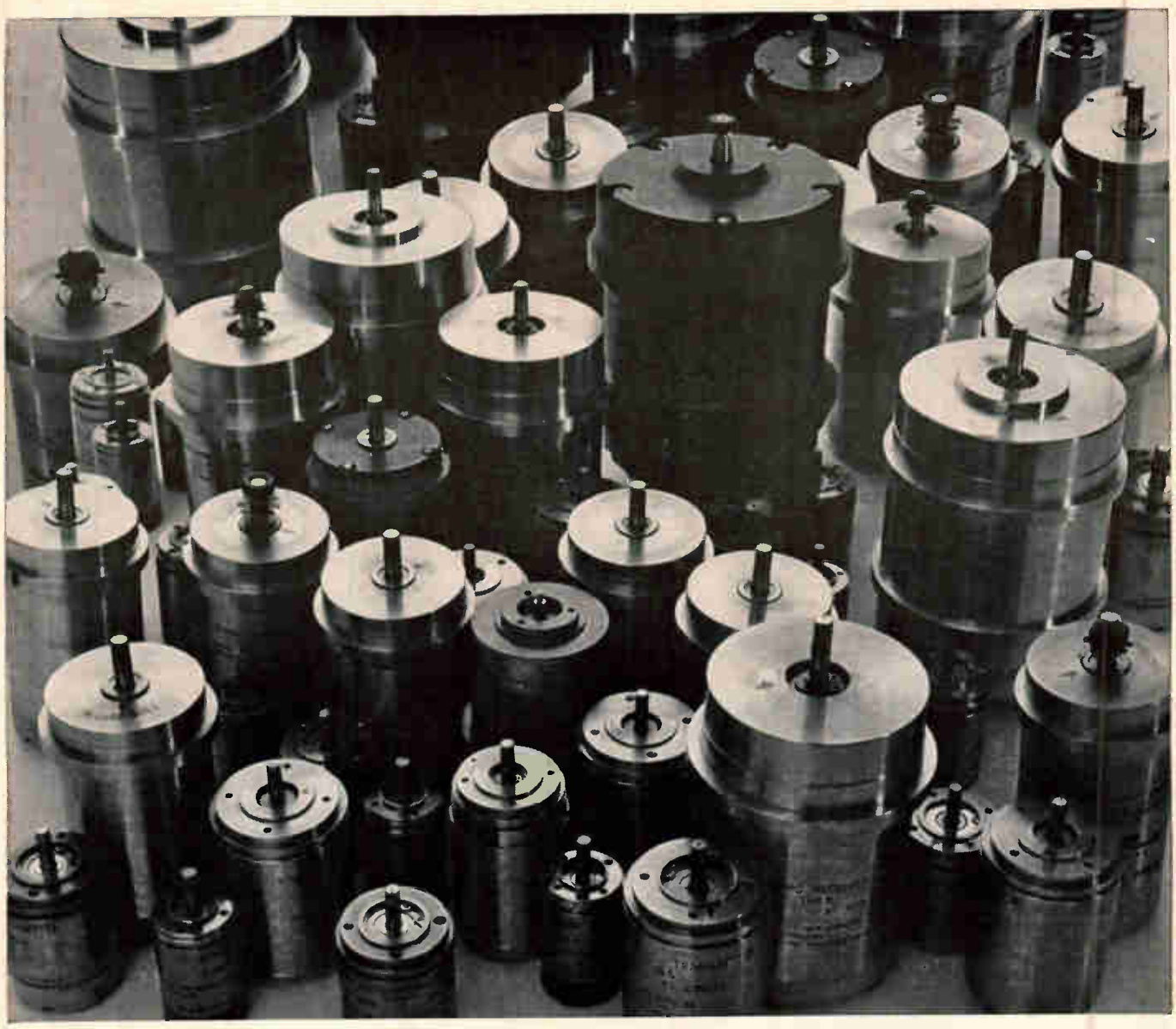
Circle 129 on reader service card 129



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Bendix® Mil-Spec synchros total 107 different synchro models—cover 11 major military specifications—and include nine primary sizes, ranging from the dwarf Size 08 (our most recent addition) to Size 37 (see chart for both).

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Size	Max. Diameter (In.)	Typical Weight (Oz.)	No. of Models
BuWeps 08	0.750	1.6	3
BuWeps 11	1.062	4.4	10
BuWeps 15	1.437	9	19
BuWeps 18	1.750	17	16
Ordnance 23*	2.250	21	20
BuWeps 23	2.250	31	20
BuWeps 30	2.962	99	2
BuWeps 31	3.100	65	10
BuWeps 37	3.625	124	7

*MIL-S-12472, 16892, 20708, 2335; MS-51080, 51081, 51082, 51083.

Montrose Division

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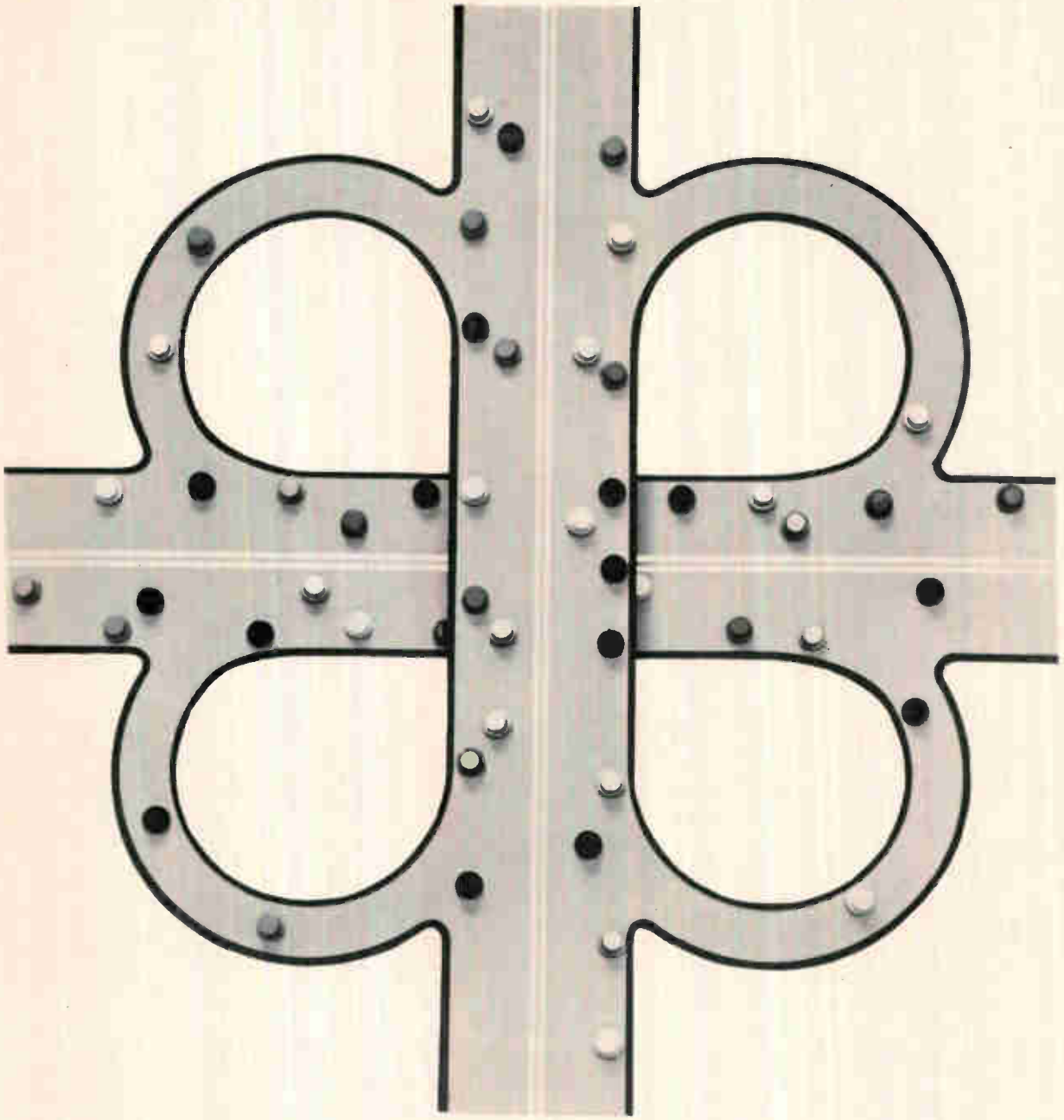

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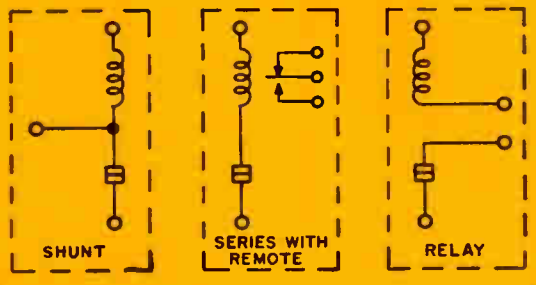


AP113

AP4

AP12

AP114

AIRPAX ELECTRONICS incorporated Cambridge, Maryland (301) 228-4600

Voice link cuts telemetry cost

Voltage-controlled oscillator steps up low-frequency signals from sensors so they can be transmitted over voice channels

Data can now be gathered inexpensively at many points along a polluted river with a pair of telemetry units introduced by M F Electronics Corp. The company says the price of its voltage-controlled oscillator and demodulator—$99 for the pair in lots of 50—is one-tenth the cost of previous units.

The key to the low price is the use in the units of capacitive (a-c) coupling instead of resistive (d-c) coupling. A-c coupling was made possible by limiting the response to sensor outputs having a frequency of 0.5 hertz (cycle per second) or higher, thereby eliminating much of the cost of providing the drift compensation required for d-c coupled circuits. The company points out that in the majority of applications the sensor frequencies are not d-c. In addition, the a-c coupled circuits operate on low-voltage power supplies—even on batteries—which don't require precise voltage regulation over a wide temperature range.

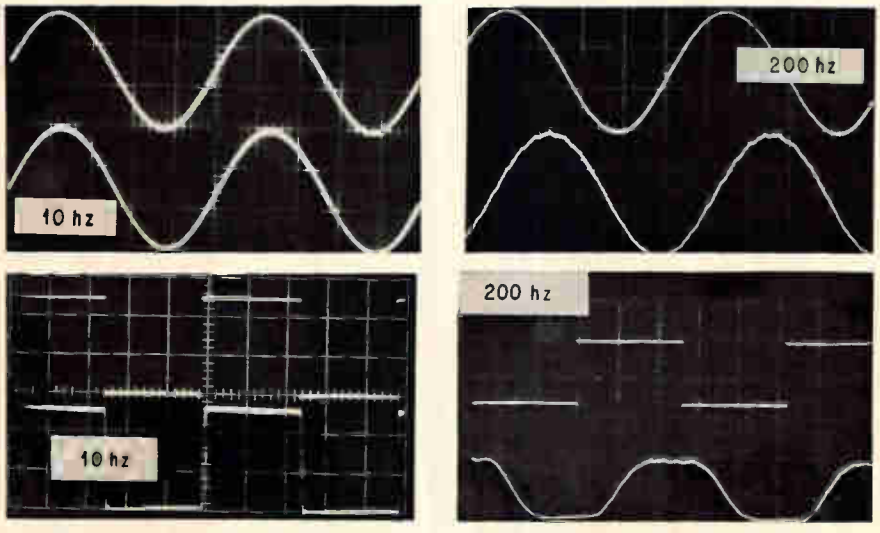
The model 310-1 vco converts low-frequency signals from such sensors as flowmeters, seismometers and hydrometers to frequencies suitable for transmission by radio, telephone and microwave communications links which carry voice messages (300 to 3,000 hz) on higher-frequency carriers. The signals can also be recorded directly on conventional voice-grade magnetic tape.

The model 410-1 demodulator, which can be miles from the signal source, decodes the signals, producing a replica of the original data. The replica is suitable for display, recording or further processing.

The output of the vco is a 2,500-hz sine-wave carrier signal. Input data may vary from 0.5 to 200 hz with amplitudes up to 1 volt root mean square. The input signals modulate the vco carrier frequency by as much as 10%. An emitter-follower provides the high input impedance needed to preserve the vco's low-frequency response. The square-wave output of the vco circuit is converted to a sinusoidal waveform by a low-pass filter. The output is amplified so that the 1-volt rms signal can be fed into a 600-ohm load, making it compatible with standard communications system.

The demodulator's operation is based on pulse-averaging techniques. The f-m input signal triggers a one-shot multivibrator which delivers an output consisting of constant-width pulses at 2.5 khz, plus or minus the data frequency. The pulses go through a filter which passes only the variations in the average level of the multivibrator's output voltage. A power amplifier boosts the level of the recovered data signals which can then be fed into a 600-ohm load.

Monitoring dirty rivers is not the units' only possible use. M F Electronics sees applications wherever multiple data-gathering instruments are needed or where the vco's may be ruined in the process of collecting information. Typical applications are in oceanographic research, weather forecasting, air-pollution control, water conservation and geological exploration.



Oscilloscope traces show the over-all response of voltage-controlled oscillator-demodulator pair at frequencies of 10 and 200 hz, and for sine- and square-wave input signals. The upper trace in each photo is the vco input and the lower trace is the demodulator output. At 200 hz the phase shift of the demodulator becomes evident, since the higher harmonics of the input signal are missing from the reproduced square wave.

Specifications

Nominal vco output frequency	2,500 hz
Deviation for 1-volt rms vco input	±10% around center frequency
Over-all linearity (vco input to demodulator output)	±0.5 db of 1:1 ratio over input amplitude range of 0.05 to 1 v rms
Over-all frequency response (zero demodulator load)	±0.5 db from 0.5 to 200 hz
Over-all phase response (zero demodulator load)	±5° of straight line from 4 to 200 hz
Distortion	Less than 5%
Input power	10.5 to 14 v d-c at 25 ma per unit
Price (per pair)	1-4, $120 each 50 and up, $95 each

M F Electronics Corp., New York, N.Y. 10010
Circle 350 on reader service card

←Circle 132 on reader service card

Water-cooled projection tube

A projection cathode-ray tube shaped like a watering can, which the manufacturer claims will produce double the light output and last 20 times longer than standard cathode-ray projection tubes, has been announced by the Raytheon Co.

The tube's phosphor screen is cooled by a removable heat exchanger, making it possible, Raytheon says, to bombard the phosphor with high-energy electron beams for longer periods than with standard projection tubes, and also provide more light energy. The heat exchanger, which is not provided, should have a cooling capacity sufficient for 40 watts maximum heat dissipation at 70°F. For equal light outputs, the CK1419P31 is said to require only half the anode voltage that a standard projection tube needs, and only half the video grid-driving voltage. An external lens focuses the image onto the projection screen.

The tube was originally developed for the Air Force, which required a 3- by 4-foot projection screen image with a white peak brightness of 15 foot-lamberts. Because the tube was built to military specifications, with rugged construction, it can go into mobile image projection systems.

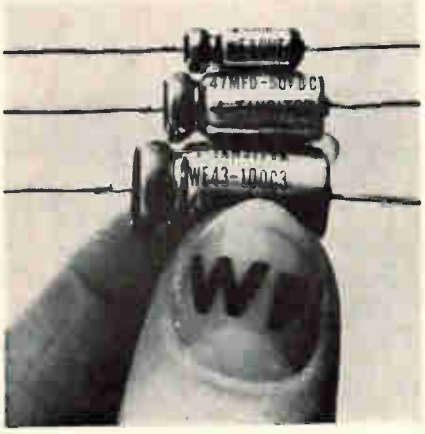
Raytheon feels that the new tube will find application in large display systems with a tv format and raster scan, such as closed-circuit theater television, management displays and stock quotation boards. It can also be used in scan conversion systems to display a radar plan position indicator image which has been converted to a tv format.

Specifications

General data	
Bandwidth	10 Mhz
Phosphor	31
Phosphorescence	Green
Persistence	Medium
Focusing method	Magnetic
Deflecting method	Magnetic
Deflection angle (approx.)	38° maximum
Heater characteristics	
Heater voltage	6.3 ± 10% volts
Heater current	0.6 amp
Characteristics with cooling system operating	
Anode voltage	40,000 volts
Grid #2 voltage	±600 volts d-c
Grid #1 voltage	−100 to 200
Resolution	600 lines
Light output	38,000 foot-Lamberts
Life	500 hours minimum
Delivery	6 to 8 weeks
Price	$2,000
Heat exchanger data	
Type of coolant	Esso univolt 30 or equivalent
Flow rate	5 gal per minute minimum

Raytheon Co., Industrial Tube division, Quincy, Mass. [351]

Tantalum capacitors eliminate acid damage



High-capacitance tantalum capacitors are comparable to wet slug types, but use a neutral electrolyte, which completely eliminates the possibility of damage by acid leak-

New Components

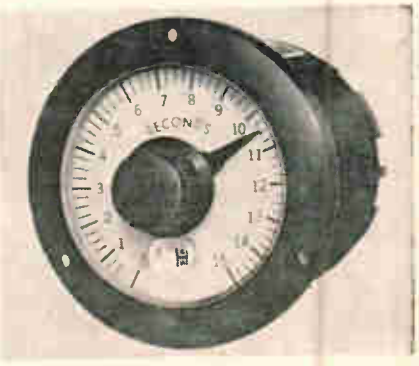
age. Type WF capacitors are in every way equal to MIL types CL64 and CL65 as listed in MIL-C-3965 except that sintered slugs are not employed in their manufacture. In addition to their acid-free construction, the units offer voltage ratings up to 300 v d-c at 85°C, and up to 200 v d-c at 125°C, where 150 and 100 v d-c were previously considered the upper limits.

The WF capacitors are of polar construction, with an outer insulating sleeve if required. They are available in three case sizes. Capacitance ranges are from 0.1 to 560 μf. Standard capacitance tolerance is considered to be $\pm 20\%$, with other tolerances available upon request.

The units successfully withstand 2,000 hours life test at rated voltage and temperature while subjected to a vacuum of 10^{-5} mm of mercury without signs of electrical degradation, mechanical damage or electrolyte leakage. They may be adapted for use in space fields, computer applications, navigation, communication, control equipment and low-voltage transistorized circuits such as filtering and storage.

Tansitor Electronics, Inc., West Road, Bennington, Vt. [352]

Time delay relays for industrial use



Industrial time delay relays are offered for control of processes, electrical and electronic equipment, and machine tools. Units are panel-mounted and have an easily read dial, a convenient adjustment knob,

and a time-remaining indicator. Load switches are two 15-amp, single-pole double-throw, snap-action type, and two 10-amp, open-blade, solenoid operated. Series designation is K41300.

Any one of 14 time ranges can be specified from 0 to 6 sec. to 0 to 60 hr; 6, 12, 24, 115 or 230 v a-c, 60 or 50 hz (cycles per second) operation; and any of three control wiring modes to meet requirements. Reverse clutch operation can also be furnished if desired.

Timing accuracy is ±0.5% of dial scale. Maximum reset time is 500 msec. Over-all bezel diameter is 3¾ in.; case diameter is $3\frac{1}{16}$ in.; over-all length is 4¾ in.

The A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. [353]

Directional couplers feature low loss

Two to 32 Mhz (megacycles per second) bidirectional couplers are said to offer a combination of low loss, high directivity and coupling flatness not previously attainable. Two models are available. They are similar except for the coupling factors which are 17 db for model CD-917 and 20 db for model CD-920.

Used in h-f systems for measurement of incident and reflected power, and the determination of load vswr, the couplers have precisely controlled characteristics that remove many former limitations. For example, a coupler may be left in a system at a cost of less than 0.2 db in main line power. Coupling flatness of ±0.25 db over the band eliminates the need for output calibration vs frequency. Vswr is less than 1.1 on all ports. Incident power measurements may be made to 0.25-db accuracy, and the deviation from true match is

New Components

less than 1.05 when reflected power reads zero.

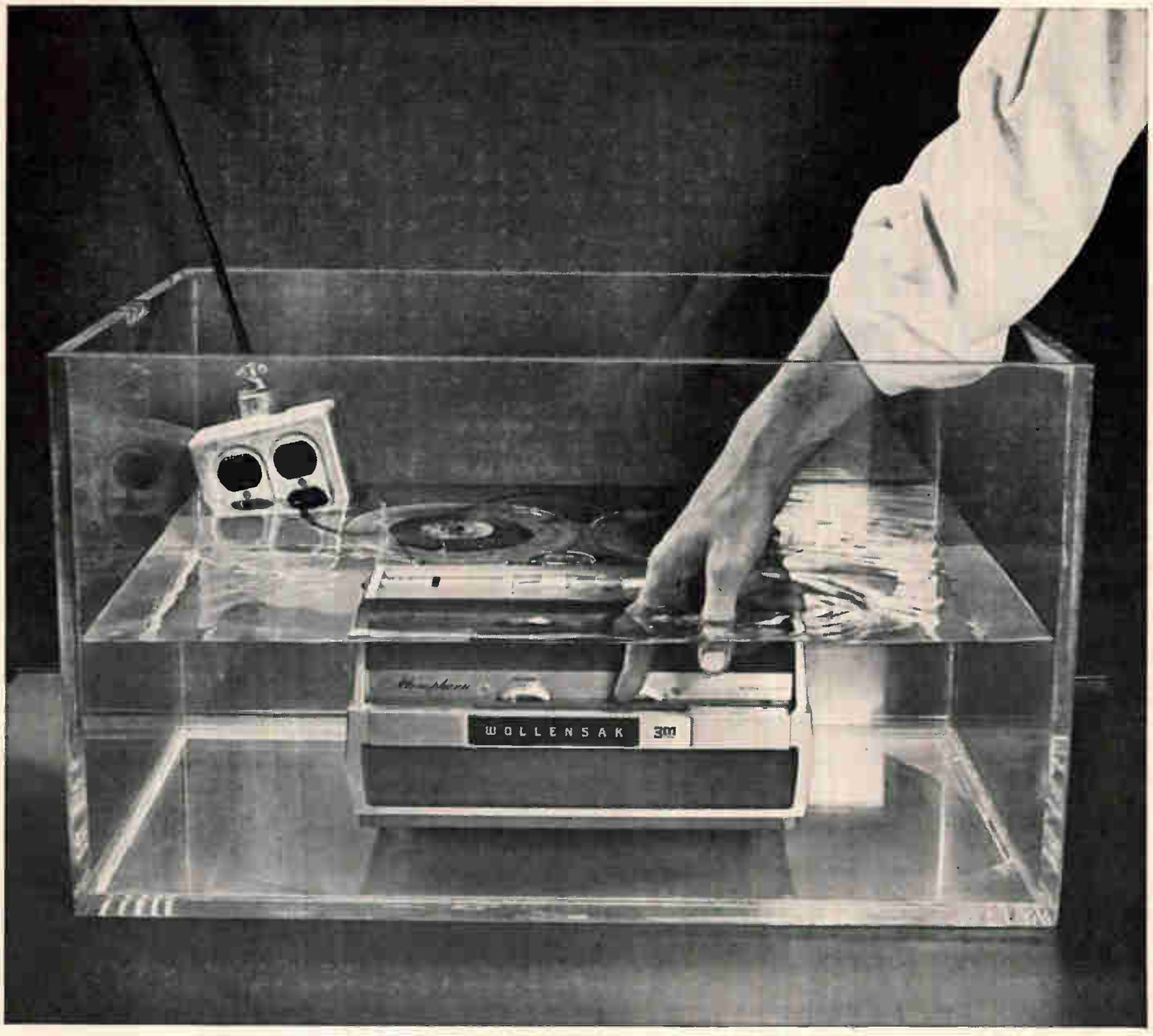
The couplers measure 1¼ in. × 1¼ × 2½ in., excluding connectors. Type N, TNC or BNC connectors are offered. Weight with TNC or BNC is 5.5 oz.; with N, 7.6 oz. Price is $130 with N connectors, $10 additional for TNC or BNC. Delivery is stock to 4 weeks.
Anzac Electronics, Inc., Moody's Lane, Norwalk, Conn. **[354]**

Push-button switch for high-density use

A compact, momentary-action push-button switch features a rugged molded plastic box body. The HI-D switching device occupies only a 5/8-in. square space which suits it to high-density packaging applications. Its insulated unitized body offers protection on all four sides, providing mechanical and electrical reliability and minimizing leakage and capacity between contact springs. HI-D switches are especially valuable for multichannel, multifunction equipment, such as automotive and marine testing equipment, public address and intercom devices and a wide variety of radio transmitters and receivers.

They may be mounted on matrices on 5/8-in. centers through 3/8-in. holes in panels up to 3/32-in. thick. Only 1 3/32-in. depth behind panels is required. The molded plastic body of the switch keys internal contact springs and keeps them from shifting and shorting.

Integral, silver-plated contact springs are constructed of a special alloy of nickel silver. Four of the most commonly used contact forms (1-A, 1-B, 1-C or 1-D) may be specified for the HI-D switch.
Switchcraft, Inc., 5555 North Elston Ave., Chicago, Ill., 60630. **[355]**



WHAT IS A TAPE RECORDER DOING IN FC-77 COOLANT?

Playing!

This traffic-stopping demonstration of the completely inert dependability of FC-77 coolant has been featured at several national electronic trade shows. An ordinary "right-out-of-stock" tape recorder is lowered into a tankful of FC-77, plugged into an electrical outlet and a hand reaches in and pushes the button to start a practically continuous concert that plays during the show.

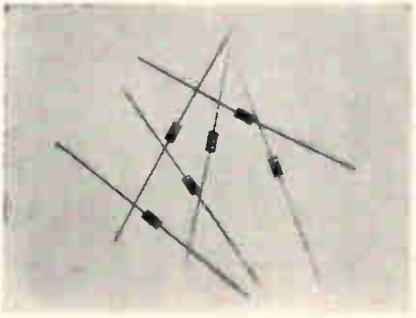
All this time, recorder parts of steel, copper, chrome, plastic, rubber, elastomers, glass, nylon, adhesives, as well as recording tapes are directly immersed in FC-77 coolant. Nevertheless the recorder plays on. When at the end of a show, the player is removed from the tank none of its components are affected. How's that for "inertness"!

All members of 3M's fluorochemical coolant family have this exceptional compatibility with most materials (even at temperatures above the maximum permissible with other dielectric coolants). This "easy-to-get-along-with" coolant, incorporated into your system can bring about better reliability. *Want more?* These coolants have wide liquid ranges, excellent electrical properties, thermal and chemical stability, are non-flammable, non-corrosive, non-toxic. Write and ask about them, particularly our new, economical FC-77. 3M Company, Chemical Division, Dept. KAX-56 St. Paul, Minn. 55119.

Chemical Division 3M COMPANY

New Semiconductors

Voltage-variable capacitance diodes



Low-cost plastic packaging and the superior performance of abrupt junction epitaxial construction are combined in these voltage-variable capacitance diodes.

The SV-1748 and SV-1650 series feature minimum Q of 150 and 200 at 50 Mhz and guaranteed tuning ratios from −1 to −15 volts exceeding 2.6. These units are designed for use in automatic frequency control, voltage-variable tuning and modulator circuits at frequencies to 1 Ghz. Capacitances ranging from 6 to 56 pf at 4 volts bias are available.

Price is $1.50 each in 100 quantity lots; availability, from stock.
Somerset Electronics Corp., P.O. Box 115, Manville, N.J., 08835. [361]

Plastic encapsulated unijunction transistor

A plastic-encapsulated unijunction transistor is priced at 72 cents in quantities of 100 to 999. The manufacturer claims the TIS43 offers 20 times lower leakage than silicon-alloy unijunctions in the TO-18 package currently selling at greater than twice the price.

The manufacturer also claims that vibration and shock resistance have been increased threefold over alternative silicon-alloy unijunctions through the use of planar construction and a solid, one-piece Silect package. Test results show the TIS43 will withstand 60,000 g constant acceleration without damage. In operating life tests, planar unijunction transistors from the same process have logged 155,000 transistor hours without record of a failure.

Low leakage characteristics are important for precision timing circuits and also permit the use of smaller, less expensive capacitors.

Applications include oscillators, voltage and current-sensing circuits, multivibrators, wave-form generators, and astable and bistable circuits. The TIS43 also is an economical triggering device for scr's.

Principal electrical characteristics include: emitter reverse current, 10 nanoamps maximum at 25°C; standoff ratio, 0.55 minimum, 0.80 maximum; inter-base resistance, 4 kilohms minimum, 9.1 kilohms maximum; emitter-to-base one breakdown voltage, 3 volts minimum.

The Silect plastic package meets the JEDEC TO-92 outline.
Texas Instruments Incorporated, 13500 North Central Expressway, Dallas, Tex. [362]

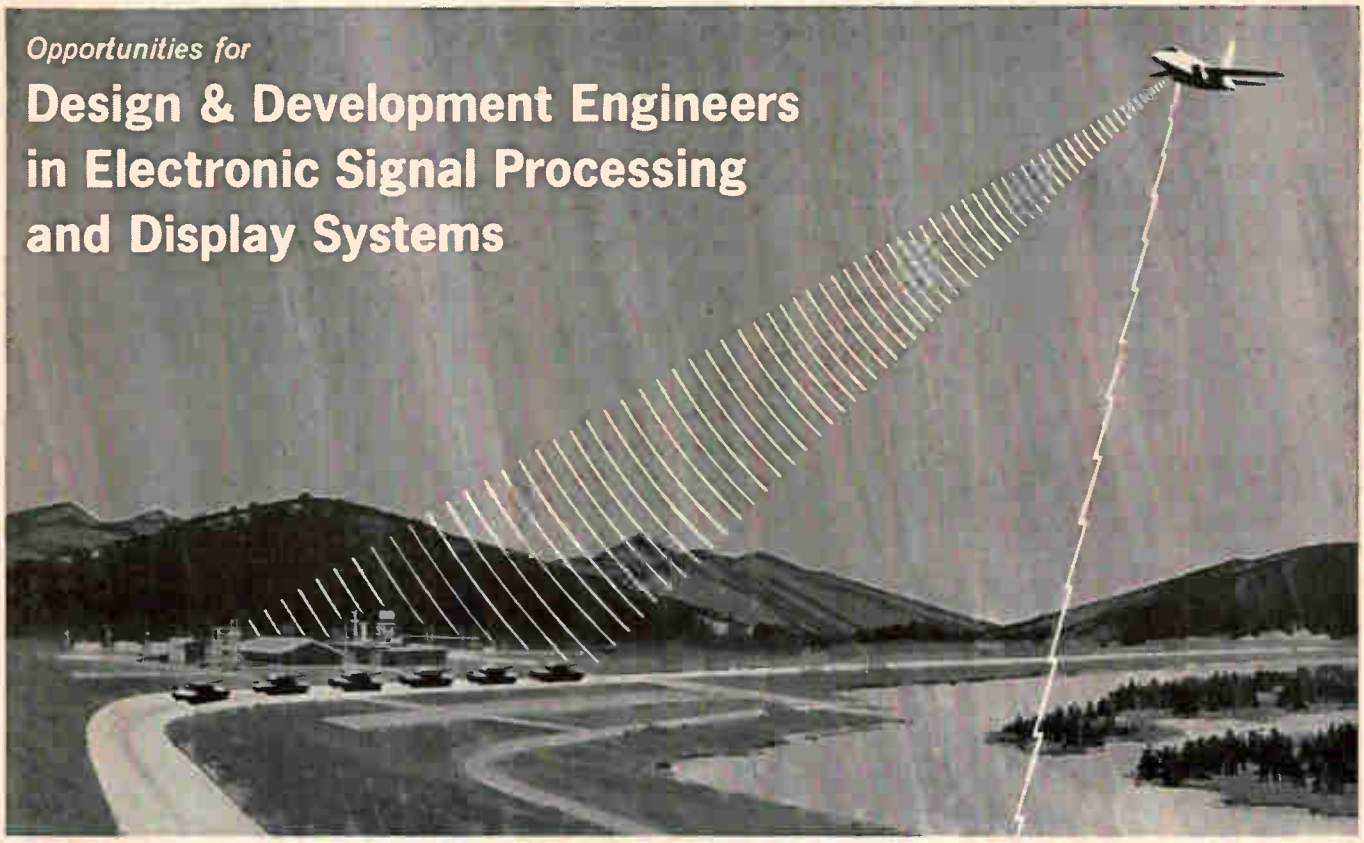
Integrated circuit wideband amplifiers

The SL500 series of monolithic, silicon, IC wideband amplifiers is announced. The units are intended for use in i-f strips operating between 10 and 60 Mhz (megacycles per second) and have current gains of ×20, an upper cut-off frequency of 100 Mhz and a noise figure of about 6 db.

Featured in the circuits are supply line decoupling networks and wide-range automatic gain control facilities. The circuits operate over the full military temperature range of −55° to +125°C.
Semiconductors Limited, Cheney Manor, Swindon, England. [363]

Opportunities for

Design & Development Engineers in Electronic Signal Processing and Display Systems



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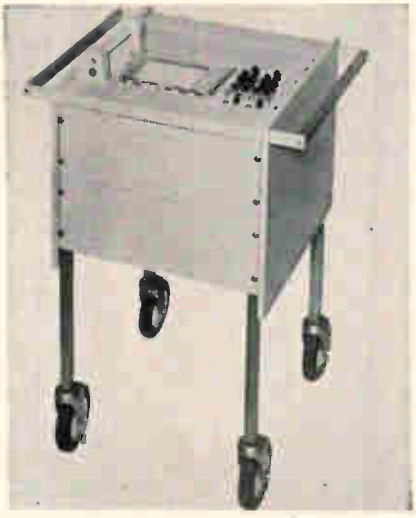
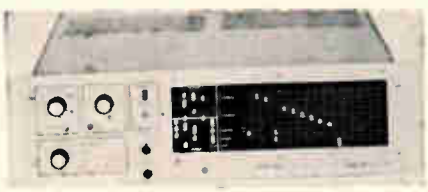
Solid-state, 2-channel mobile oscillograph



A solid-state, two-channel, direct writing recorder has been announced. Model 7702A thermal writing oscillographic recorder features 50-mm chart widths, four push-button selected chart speeds as standard with four more optional, a choice of several solid state 8800 series plug-in preamplifiers, and availability as a portable unit for rack-mounting or in a mobile cart. Frequency range of the 7702A is d-c to 125 hz; linearity, 0.5%; sensitivity, depending on preamp used, 1 μv to 5 v/division. Basic system costs $1,675, plus preamps.

Sanborn Division, Hewlett-Packard Co., 175 Wyman St., Waltham, Mass., 02154. [371]

Digital-output drive unit



Type 642 is a digital-output drive unit that can be used universally for the control of output writers, tape perforators, magnetic tape instruments, punch card instruments, etc. The input levels have been laid out in such a way that most digital instruments such as counters, digital voltmeters and a-c converters can be connected to the unit.

The sequence of the parallel information output can be selected on the pin board of the unit. Additional characters may be intercalated in the punch-out for the control of data processing computers.

Borer Electronic Co., 4500 Solothurn, Heidenhubelstrasse 24, Switzerland. [372]

Indicator measures angular position

Model 2035 angle position indicator is a servo instrument intended primarily for test equipment to measure the angular position of synchros and resolvers. The special features of this instrument include a digital read-out in degrees and minutes. It is a half-rack package. Flexibility of design permits modification for specific requirements.

Specifications include a range of 0° to 360° continuous rotation; accuracy of 6 minutes; repeatability of 30 seconds; slew speed of 25° per second; power requirement of 115 v, 400 hz (cycles per second), ½ amp. Over-all dimensions are 9½ in. x 1¾ in. x 9 in. deep.

Occo Mfg. Corp., 8 Romanelli Ave., South Hackensack, N.J. [373]

Pressure transducer sized for space

A microminiature pressure pickup, the series 400-P, is said to be the smallest in the industry. Weighing 0.8 gram, with a volume of 0.01 cu in. in a stainless steel case, the unit meets space and airborne conditions where small size and ac-

cessibility are critical.

The performance of the 400-P is the highest available per unit of size and weight, according to the manufacturer. Charge sensitivity is 25 picocoulomb/psi. Dynamic pressure range is from 0.1 psi to 1,000 psi. Frequency is 0.1 to 8,000 hz. The unit is 0.250-in. high with a 0.250-in. x 32-thread mounting stud.

Series 400 is compatible with the company's series of charge amplifiers and is equipped with a detachable cable.

Columbia Research Laboratories, Inc., MacDade Blvd. & Bullens Lane, Woodlyn, Pa. [374]

Tape recorder for airborne use

An airborne magnetic tape recorder will provide laboratory quality instrumentation performance under extremes of temperature, vibration or noise. Model M-201 recorder meets MIL-E-5400 and MIL-I-6181 environmental and rfi specifications. It is available with 250 khz or 1 Mhz bandwidths at 60 inches per second tape speed.

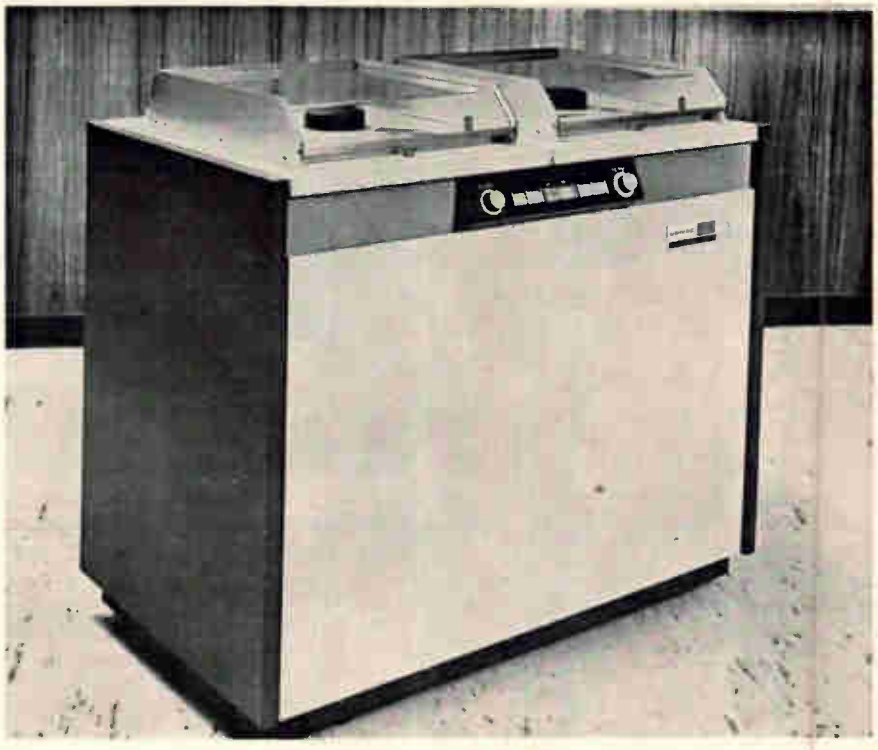
Weighing less than 110 lbs, the M-201 series is designed to handle a variety of airborne instrumentation assignments. All electronic circuits are solid state, with easy-maintenance modular construction.

The unit features 0.5% maximum peak-to-peak flutter at 3¾ ips from d-c to 1 khz. It records 14 IRIG tracks on one-inch tape, uses 10½-in. NAB reels, and includes reproduce monitor electronics for preflight check-out and calibration. Input power requirement is 400 hz, 115 v, 3 phase.

Astro-Science Corp., 9700 Factorial Way, S. El Monte, Calif., 91733. [375]

New Subassemblies and Systems

Mass memory for small computers



Users of small computers often need mass random-access storage units. The Univac division of the Sperry Rand Corp. has developed a simple storage device for users of the Univac 1004 and 1005 computers. It looks like a pair of big record players on which disk cartridges can be placed manually. Up to one million characters can be stored on each side of the disks, which can be flipped over and "played" on either side.

The Unidisc has two unusual features that simplify the programs of the 1004 and 1005—data-search command and Fastband indexing. When a data-search command is encountered in the computer program, the Unidisc consults the Fastband index on one track of the disk. The index identifies the track in which the desired data is stored. A read/write head then moves to the proper track and reads the data into a buffer storage unit, for transfer into the computer. With hardware, therefore, the Unidisc can execute with one computer instruction ("data-search") a series of operations that would take other storage units three or more instructions: "determine the address," "find the track" and "read the data."

For this simplified program, the user must pay a price—in restricted data organization and in additional hardware. The data on the disk must be in some prearranged order, as numerical or alphabetical, because the Fastband index records only the location of the last record on each track. Applications of the Unidisc, furthermore, are assumed to be such that updated information can be stored in the same location as the original data, so that the read/write head does not move again before rewriting. However, if the user wants to rearrange his data on the disk, he must also rearrange the Fastband index. The trade-off is that if data were stored completely at random on the disk, the user would have to keep track of it by some method other than Fastband.

The additional hardware cost of executing three instructions in one is offset by the design of the magnetic read/write head, which is in contact with the disk. In other disk storage systems, a film of air

"floats" the read/write head to prevent wear, but requires expensive manufacturing techniques to maintain tolerances. The Unidisc read/write head is made of special proprietary wear-resistant material.

Up to six Unidiscs can be used at once with a single 1004 or 1005. The disks are mounted on one master handler and five slave handlers. The master handler controls all six disks, and has a buffer storage unit through which all data passes between any disk and the computer. Two handlers are mounted in a single module, as shown in the photograph on page 144.

Specifications

Disk diameter	14 in.
Disk speed	1,200 rpm
Disk capacity	1 million characters each side
Average time to locate track	110 msec
Average rotational delay	25 msec (½ revolution)
Leading rate after seek	200 khz
Number of tracks	100
Rental/purchase price	$500/$18,000
Delivery	Spring, 1967

Univac division of Sperry Rand Corp., 1290 Avenue of the Americas, New York, N.Y. 10019. **[381]**

Single decade counter designed as a module

Series 444 Unidec is a single decade electromagnetic counter that provides a count frequency of 60 hz (cycles per second), which is said to be considerably faster than comparable devices. Its over-all size is a compact 1.68 in. high x ¼ in. wide x 4.22 in. deep. Printout capability is also featured.

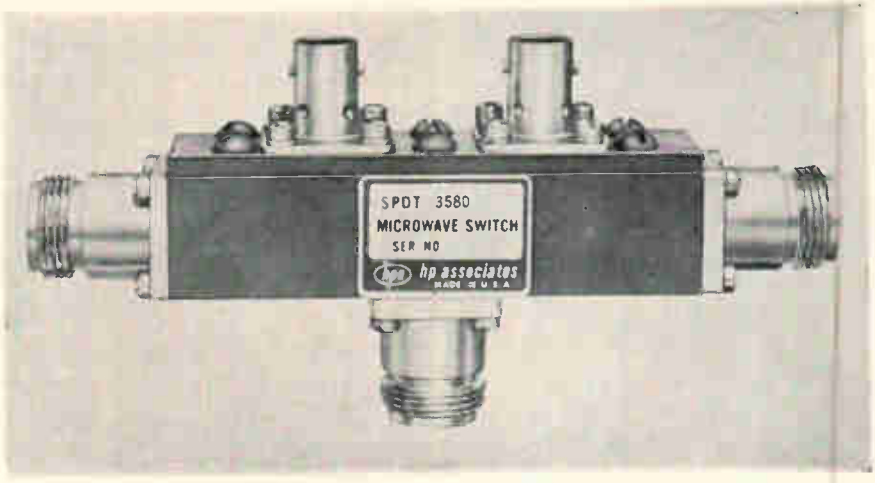
Designed as modules, the counters can be grouped to provide a high-speed counter with any number of digits or used individually for control purposes. The single decade counter is fitted with all necessary internal contacts to enable groups to be driven in either serial or parallel form, to be remotely reset to zero and to provide an electrical readout.

In addition to being used as an indicating counter, the series 444 Unidec can perform as a programable switch.

ENM Co., 5304 W. Lawrence Ave., Chicago, Ill., 60630. **[382]**

New Microwave

Diode switch offers 90-db isolation



As much as 90 decibels of isolation between input and output is achieved in a solid state coaxial switch developed by HP Associates, a division of the Hewlett-Packard Co. The switch provides this high degree of isolation while keeping the insertion loss to less than 2.5 db. Isolation varies from 70 to 90 db over the switch's frequency range of 4 to 8 Ghz (gigacycles per second). The company claims that the switch's lowest value of isolation is at least 30 db higher than any comparable switch on the market.

The HPA-3580 switch moves from open to closed position in less than 20 nanoseconds; it goes from closed to open in 10 nanoseconds. It consists of a series of diodes in a 50-ohm coaxial microwave structure, which also contains the filtering, by-passing and blocking elements needed in biasing the diodes. In its closed position, the switch permits energy to flow from one of the two input ports to the common output port. In the open position, the input port is isolated.

The single-pole double-throw unit can safely switch two watts of continuous-wave power at 25°C. In point-to-point microwave relay links, it can rapidly switch standby equipment onto the line whenever operating equipment malfunctions. The HPA-3580 is suitable for antenna-lobing circuits. In addition, it can operate as a pulse or amplitude modulator and as a transmit-receive switch.

Specifications

Frequency range	4 to 8 Ghz
Isolation (minimum)	70 to 90 db
Switching speed (maximum)	
Open-to-closed	20 nanoseconds
Closed-to-open	10 nanoseconds
Insertion loss (maximum)	1.6 to 2.5 db
Power	2 watts continuous-wave
Voltage standing-wave ratio (maximum—switch on)	2:1
Temperature range (operating and storage)	—55°C to 125°C
Shock	30 g for 3 milliseconds
Size (excluding connectors)	0.875 x 0.750 x 3.0 inch
Price	$495 (1 to 9 units)
Delivery	2 to 4 weeks

HP Associates, 620 Page Mill Road, Palo Alto, Calif. 94304 [391]

Microwave receiver features YIG filter

A microwave receiver is now available with a yttrium iron garnet (YIG) filter, which screens out unwanted signals. The versatile electronically tunable receiver, designated R-31, can be set either to a specific frequency, or to sweep its entire bandwidth as it seeks a signal.

The R-31 is available in six radio-frequency bands covering the range of 0.25 to 18 Ghz (gigacycles per second). These include 0.21 to 1 Ghz; 1 to 2 Ghz; 2 to 4 Ghz; 4 to

8 Ghz; 8 to 12 Ghz; and 12 to 18 Ghz. All bands are controlled by a single demodulator unit.
Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., Mountain View, Calif. [392]

Traveling-wave tube for the mm-wave region

A c-w traveling-wave tube is announced for the 6 to 7 millimeter band. This power amplifier offers over 17 db of gain in the range of 45 to 51 Ghz (gigacycles per second). Maximum c-w output of 600 mw has been obtained in this band.
Oki Electric Industry Co., 202 E. 44th St., New York, N.Y. [393]

Broad-band video detectors

A series of three video detectors combine high tangential sensitivity with broad r-f and video bandwidths. Model TV11 has a tangential sensitivity of —53 dbm over the full r-f bandwidth from 2 to 4 Ghz with video bandwidth greater than 17 Mhz. Sensitivity variation over full band is less than ±1.5 db.

Weighing less than 1 oz and occupying less than 0.75 cu. in., the video detectors meet Class 4 environmental requirements of MIL-E-5400 and MIL-T-5422. All three models can be operated with self-bias, or an external bias may be applied through the video output connector.

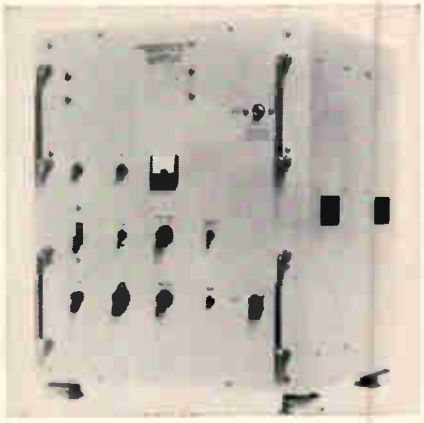
Detectors available off-the-shelf in small quantities have OSM coaxial connectors for r-f input and miniature coaxial connectors, or

New Microwave

solder terminals for video output. Special models with other form factors, connector types, and higher tangential sensitivities and less bandwidth can be provided. Detectors can also be packaged with the company's other microwave integrated modules or custom Tri-Plate strip transmission line circuits.

Sanders Associates, Inc., Microwave Division, 95 Canal St., Nashua, N.H. [394]

Microwave amplifier offered in 4 bands



Self-contained 100-watt c-w microwave amplifiers are available in four bands: 1 to 2 Ghz, 2 to 4 Ghz, 4 to 8 Ghz, and 8 to 12.4 Ghz. The amplifier is a traveling-wave-tube type exhibiting 30 db small signal gain and 35 db noise figure in each band. Type N r-f connectors are standard. Protective circuits include helix current overload and twt collector temperature cut out.

Twt's are interchangeable, permitting one amplifier to cover all bands with only minor adjustments. Power input is 105 to 125 v a-c, 60 hz. Size is 22¾ in. high x 19 in. wide x 21 in. deep. The amplifier utilizes solid state low-voltage circuits.

Units are available with the following options: 400-hz input, airborne packaging, bench mount adaptors, special r-f connectors, internal load isolator, and internal power monitor.

Alto Scientific Co., Inc., 4083 Transport St., Palo Alto, Calif., 94303. [395]

NEW *all-solid-state PHASE LOCK SELF-TUNING NARROW BANDPASS FILTER*

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Circle 505 on reader service card

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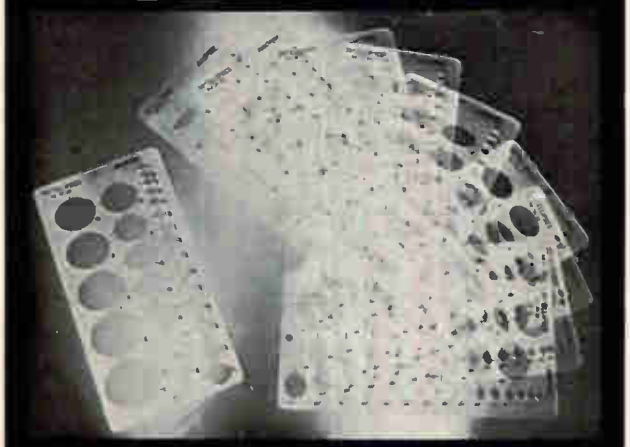

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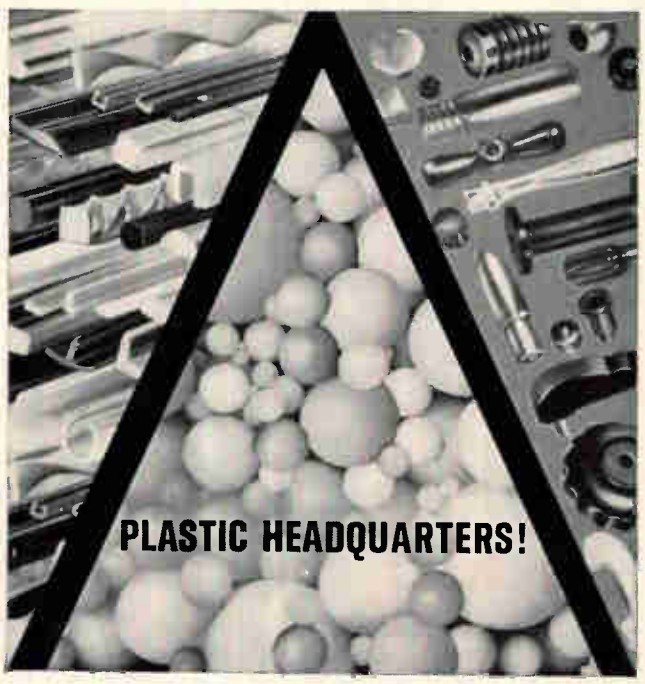

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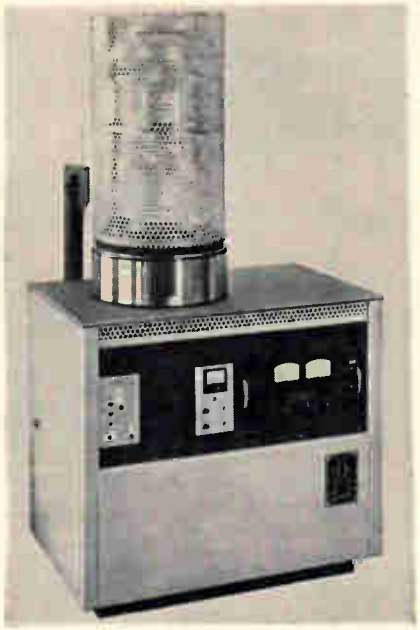
Circle 149 on reader service card

New Production Equipment

Bell jar system offers versatility



A bell jar system announced by the High Vacuum Equipment Corp. can be used for vacuum evaporation, thin film studies and deposition, degradation and thermal studies under varying environments, and shadow casting for electron microscopy. Accessories further increase the unit's versatility.

The pumping system consists of a five-stage, six-inch diffusion pump. After pumping the standard 18-x-18 inch pyrex bell jar to the 10^{-8} torr range, the system may be repeatedly evacuated from atmosphere to 5^{-7} torr in approximately three minutes. Pumping speed at the baseplate inlet is about 600 liters per second, with ultimate bell jar pressures of 2×10^{-8} torr.

In addition to the pumping station, other components of the model ST-6600 include a matching aluminum body gate valve and a 6.4-liter liquid-nitrogen trap. Vacuum gauging consists of a combination of thermocouple ionization gauge control, providing full-scale readings from atmosphere to 10^{-9} torr.

Optional equipment includes glass or stainless-steel bell jars of 12-, 24- and 30-inch heights; automatic liquid nitrogen controllers and audible or visible alarms to indicate excessive pressures. Automatic programing controls and special gauges are also available for completely automated operation.

Specifications

Pumping speed baseplate inlet	600 liters/sec
Bell jar	Standard 18 x 18 inches
Bell jar hoists	Electromechanical
Cabinet size	44 x 28 x 38 inches high
Baseplate	19 dia. x 3/4 inch stainless steel
Voltage requirements	5 kva, 230 volt, 1 phase, 60 hz
Water	1 gpm
Air	60 to 90 psig
Floor space required	36 x 48 inches
Net weight	1,800 pounds

The High Vacuum Equipment Corp., a subsidiary of Robinson Technical Products, Inc., 2 Churchill Road, Hingham, Mass. [401]

Squeeze-plier tool for production lines

A light-weight, semiautomatic squeeze-plier air-operated hand tool is especially adapted to increase production line efficiency in the handling of miniaturized electronic circuits.

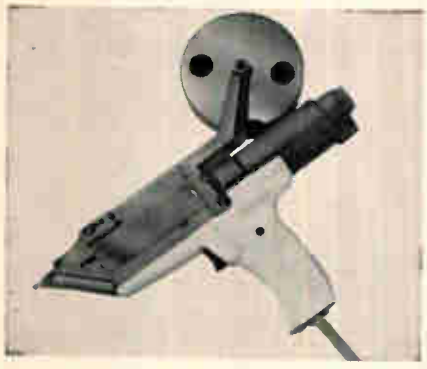
Particularly useful for straightening diode wires, cutting them to length and bending them to special configurations, the new tool is designed to handle diodes at a rate of up to 8 a minute. Formerly, with

hand operation, the time for completing the same processes ran as high as 3 minutes.

As with all of the manufacturer's squeeze-plier tools, the new unit may be quickly adapted for other production line uses by means of easily interchangeable heads.

Simonds Machine Co., Inc., 102 Main St., East Woodstock, Conn. [402]

Hand tool speeds up clip-to-post wiring

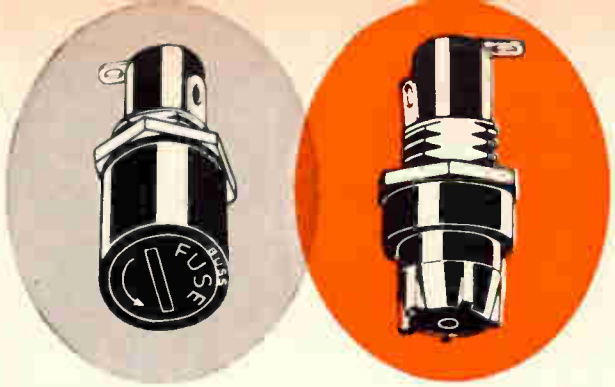


A split-cycle pneumatic hand tool provides many operational advantages for the point-to-point wiring industries. Lightweight alloys and plastics combine with functional design to reduce operator fatigue and increase production speeds. It balances comfortably in the hand and facilitates wire lead insertion and accurate positioning on the terminating post.

Termi-Point clips and unstripped wire are fed from reels mounted on the tool. The actuating trigger is squeezed twice during the split cycle; once to strip and position the manually inserted wire end, and again to terminate it on the post via the pressure clip. Depth of penetration is adjustable for terminating clips up to four-high on the post. Waste insulation from the stripped wires is automatically delivered to a hollowed area in the tool handle which can be emptied at the operator's convenience.

The hand tool consists of three basic assemblies: power pack, clip feed assembly, and mandrel assembly. In addition, a wire-cutter assembly for use with bulk wire is available as an option. The tool is adaptable to all A-MP posts that accept solid or stranded wires from No. 18 through No. 29 Awg.

AMP Inc., Harrisburg, Pa. [403]



Screw type slotted knob that is recessed in holder body and requires use of screwdriver to remove or insert it.

Screw type knob designed for easy gripping, even with gloves. Has a "break-away" test prod hole in knob.

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Fuseholder only 1⅝ inches long, extends just 29/32 inch behind front of panel Takes ¼ x 1¼ inch fuses. Holder rated at 15 ampere for any voltage up to 250.

Military type available to meet all requirements of MIL-F-19207A.

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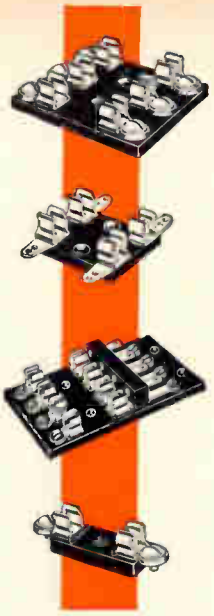
Circle 153 on reader service card



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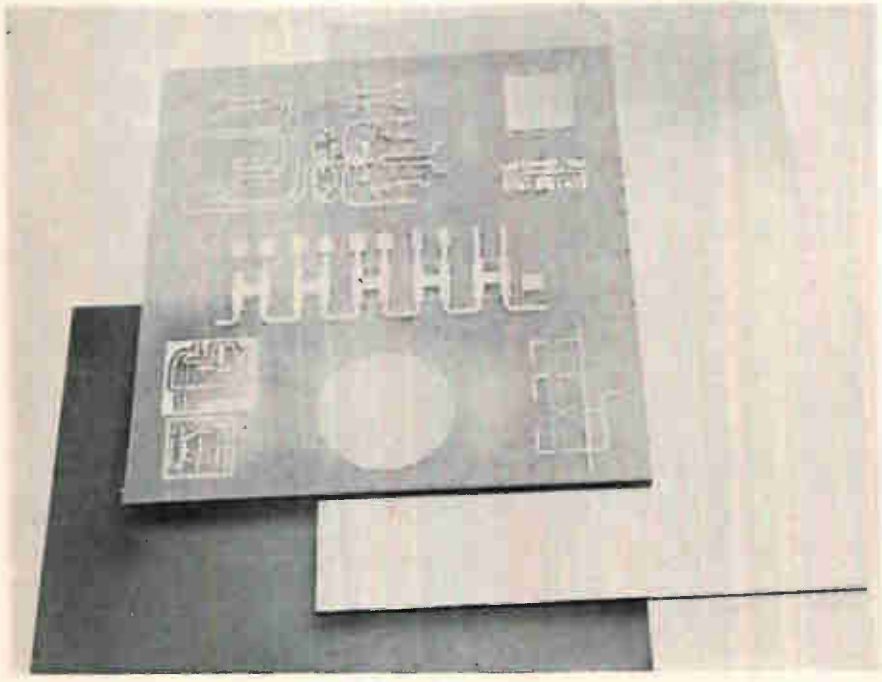
Circle 507 on readers service card

Heat-resistant substrate



Requirements for the substrates used in strip-line circuits are great strength, rigidity, thermal and dimensional stability, and low electrical loss. The Polymer Corp. of Reading, Pa., is offering an electrical grade thermoplastic, polyphenylene oxide, which the company says possesses these properties.

Called Z-tron "G," the new material is produced with little induced internal stress, eliminating much of the warping and dimensional changes that occur when a circuit is etched. Polyphenylene oxide comes in sheets up to 16 by 24 inches and in thicknesses of 0.0625 to 0.250 inch, and can be ordered copper-clad or unclad.

"The mechanical strength of Z-tron "G" is higher than that of any other available substrate. Electrically, Z-tron "G" is comparable

New Materials

to any," claims William I. Huyett, electronic products manager. As for copper-clad material Huyett says, "the strength of the bond between the substrate and the copper is three to five times better than is available in other types of bonded substrates." The cladding is bonded to the substrate without adhesive. Since there is no need to remove adhesive, undercutting during etching is reduced. The company has applied for a patent on the bonding process.

The new material has a linear coefficient of thermal expansion of 2.9×10^{-5} in./in./°F, about one-half that of any other type of substrate, according to Huyett. Thermally induced stresses, rupture of copper circuitry, and loss of bond do not occur within the material's thermal operating range of −270°F to +375°F.

Because of its rigidity and high heat resistance, it can be worked with standard high-speed drills and cutting tools, without being softened by the heat of friction. Sheets of Z-tron "G" have a thickness tolerance of ±0.001 inch.

Specifications

Impact strength notched Izod 1/8-in. bar	1.2-1.6 ft lbs/in. of notch
Tensile strength, 73°F	10,500
257°F yield	6,000
Tensile modulus, 730°F	3.9×10^5 psi
257°F	3.5×10^5 psi
Creep (10,000 hrs at 3,000 psi at 73°F)	1.0%
Flexural modulus, 73°F	3.8×10^5
Heat deflection, 264 psi	380°F
Coefficient of linear expansion	2.9×10^{-5} in./in./°F
Dielectric strength, short time (1/8 in.)	500 v/mil
Volume resistivity	10^{17} ohm-cm
Dielectric constant (60 hz to 3 Ghz)	2.55
Dissipation factor at	
1 Mhz	.0007
1 Ghz	.0009
3 Ghz	.0011
Delivery	4 to 6 weeks
Price, 10-25 ft² 1/16-in. thick, copper-clad on both sides	$30.00/ft²
100 ft², 1/16-in. thick, copper-clad on both sides	$18.00/ft²

The Polymer Corp., Reading, Pa. [406]

Gold epoxy solder for lead attachments

A gold-filled, one-component, heat-curing epoxy compound is electri-

cally conductive. Designated E-Solder No. E3205, it is a thermosetting material used in applications requiring the specialized properties of noble metals.

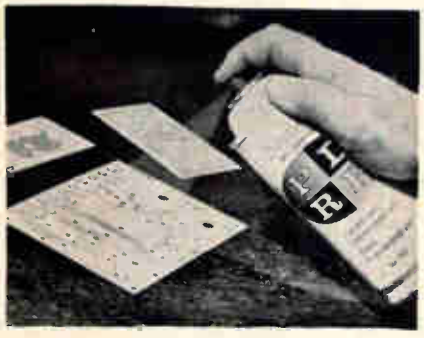
The solder requires no mixing and cures at temperatures as low as 125°C. It may easily be applied by dip, brush or bonding wheel.

This material is used for lead attachments in diodes, transistors and other electronic components. It exhibits excellent adhesion to a variety of surfaces including ceramics, glass and metals. Volume resistivity is approximately 0.01 ohm-cm.

A 5-gram sample kit of E3205 is available from stock for $20.

Epoxy Products Co., Inc., division of Allied Products Corp., 166 Chapel St., New Haven, Conn., 06513. [407]

Spray forms film to seal out moisture



An aerosol known as No. 707 PDRP (penetrant, demoisturant, rust preventative) is said to prevent malfunctions in electrical and electronic equipment caused by moisture and corrosion.

With very low surface tension and very high capillary action, Sprayon PDRP forms a continuous molecular film that penetrates the innermost recesses of motor windings, etc., and penetrates the smallest pores and crevices of a metal surface. This film acts as barrier to moisture and oxygen without interfering with functions or tolerances.

Non-toxic and non-irritating, the spray prevents corrosion on bare, painted or plated metal. It is harmless on virtually any surface, including rubber and fabric.

Sprayon No. 707 PDRP is supplied in a 16 oz aerosol can.

Industrial Supply division, Sprayon Products, Inc., 26300 Fargo Ave., Bedford Heights, Ohio 44014. [408]

New Books

Probability

Probability, Random Variables, and Stochastic Processes
Athanasios Papoulis
McGraw-Hill Book Co., 583 pp., $12.75

The author opens with any introduction to probability theory, including the evolution of its definition from early studies of games of chance to the modern axiomatic concept of probability spaces.

The book's second part, although called "Stochastic Processes," deals only with the first- and second-order properties of the processes. Primary emphasis is placed on harmonic analysis and the second-order properties of random functions. A special discourse on transients in linear systems and two-dimensional Fourier transforms is lucid and worth reading.

In general, the subject matter is well organized and enriched by a number of good examples and problems.

Numerous typographical and conceptual errors mar the book. Some subjects are treated so superficially—the Markov processes, for one—that the material is almost useless. Many of the integral equations and equalities that appear should be prefaced with the statement "almost everywhere" or "almost surely" or "almost certainly."

A number of misconceptions result from the author's diligent effort to avoid a description of probability based on the measure theory. In the preface, he writes that "the book is neither for the handbook-oriented student nor for the sophisticated few who can learn the subject from advanced mathematical texts." The degree of mathematical sophistication required to understand the book's discussion of harmonic analysis, however, is adequate for an understanding of measure theory. If the intent of the book was to restrict the mathematical detail, then the measure-theory concepts should have been stated, their implications detailed, and references made to literature where proofs could be obtained. Throughout the text measure-theory concepts arise; their appearance without the proper foundation destroys the coherency of the subject matter.

For a full understanding of stochastic processes, other books are much better. In conjunction with other books, this book would be useful, however, to someone working in harmonic analysis. It's a good supplement.

William R. Joy
Logistic Systems Management, Inc.
Washington, D. C.

Microwaves

Microwave Tubes
Proceedings of the Fifth International Congress on Microwave Tubes, Paris
Academic Press, 528 pp., $50

A detailed account of microwave devices is given in the papers of the biannual International Congress on Microwave Tubes held in Paris in September, 1964. The scope is broad, covering low- and high-power tubes and advanced studies, including plasma and quantum devices. A few solid-state devices are also discussed.

The section on low-power tubes provides an excellent discussion of traveling-wave devices, including type-O backward-wave oscillators, resonant O-BWO's and traveling-wave tubes.

The high-power section deals extensively with klystrons. The high-power crossed-field portion primarily concerns magnetrons, injected-beam, crossed-field amplifiers and continuous-cathode, crossed-field amplifiers.

Of special interest are papers on beam plasma interactions describing several amplifiers that display surprisingly high gain and efficiency.

The papers are directed at engineers and scientists working with microwave devices and, on the whole, are fairly sophisticated. Since the chief value of the papers was that they contained state-of-the-art information, it is unfortunate that their publication took more than a year. It is also unfortunate that about one-quarter of the papers, in French and German, were not translated into English. The exceptionally high price will

probably restrict this excellent reference book primarily to industrial and institutional libraries.

Burton H. Smith
Raytheon Co.
Waltham, Mass.

Switching circuits

Pulse, Digital, and Switching Waveforms
Jacob Millman and Herbert Taub
McGraw-Hill Book Co.
958 pp., $18.00

This book was originally planned as a second edition to "Pulse and Digital Circuits," published by the authors in 1956. However, because about half the topics in the book are new and the subjects retained have been rewritten, a new title was selected. The overhauling of the original edition is illustrated by the switch in emphasis from vacuum tubes in the original version to transistors.

The book describes circuits and systems used in such applications as computers, timers, counters, digital instrumentation, radar and telemetry. Basic circuits treated include differentiating circuits, clippers, comparators, clampers, pulse generators, pulse amplifiers and multivibrators.

Recently published

Electromagnetic and Quantum Properties of Materials, Allen Nussbaum, Prentice-Hall, Inc., 424 pp., $15

Tropospheric Radiowave Propagation Beyond the Horizon, International Series of Monographs in Electromagnetic Waves, Vol. 8, Francois Du Castel, Pergamon Press, 236 pp., $11.50

Nonlinear Electron-Wave Interaction Phenomena, Joseph E. Rowe, Academic Press, Inc., 591 pp., $18

Random-Process Simulation and Measurements, Granino A. Korn, McGraw-Hill Book Co., 234 pp., $12.50

Zone Melting, Second Edition, William G. Pfann, John Wiley & Sons, Inc., 310 pp., $11.75

Electrical Phenomena in Gases, R. Papoular, American Elsevier Publishing Co., 198 pp., $9

The Electrochemical Society, Inc., Spring Meeting, Cleveland, Ohio, Extended Abstracts, Vols. 2, 3, 4, 14 and 15, The Electrochemical Society, Inc.

Transistor Electronics, Karl-Heinz Rumpf and Manfred Pulvers, Pergamon Press, 282 pp., $10

CATV System Engineering, William A. Rheinfelder, Tab Books, 206 pp., $9.95

Modern Electronic Components, Second Edition, G.W.A. Dummer, Sir Isaac Pitman & Sons, Ltd., 516 pp., $8.82

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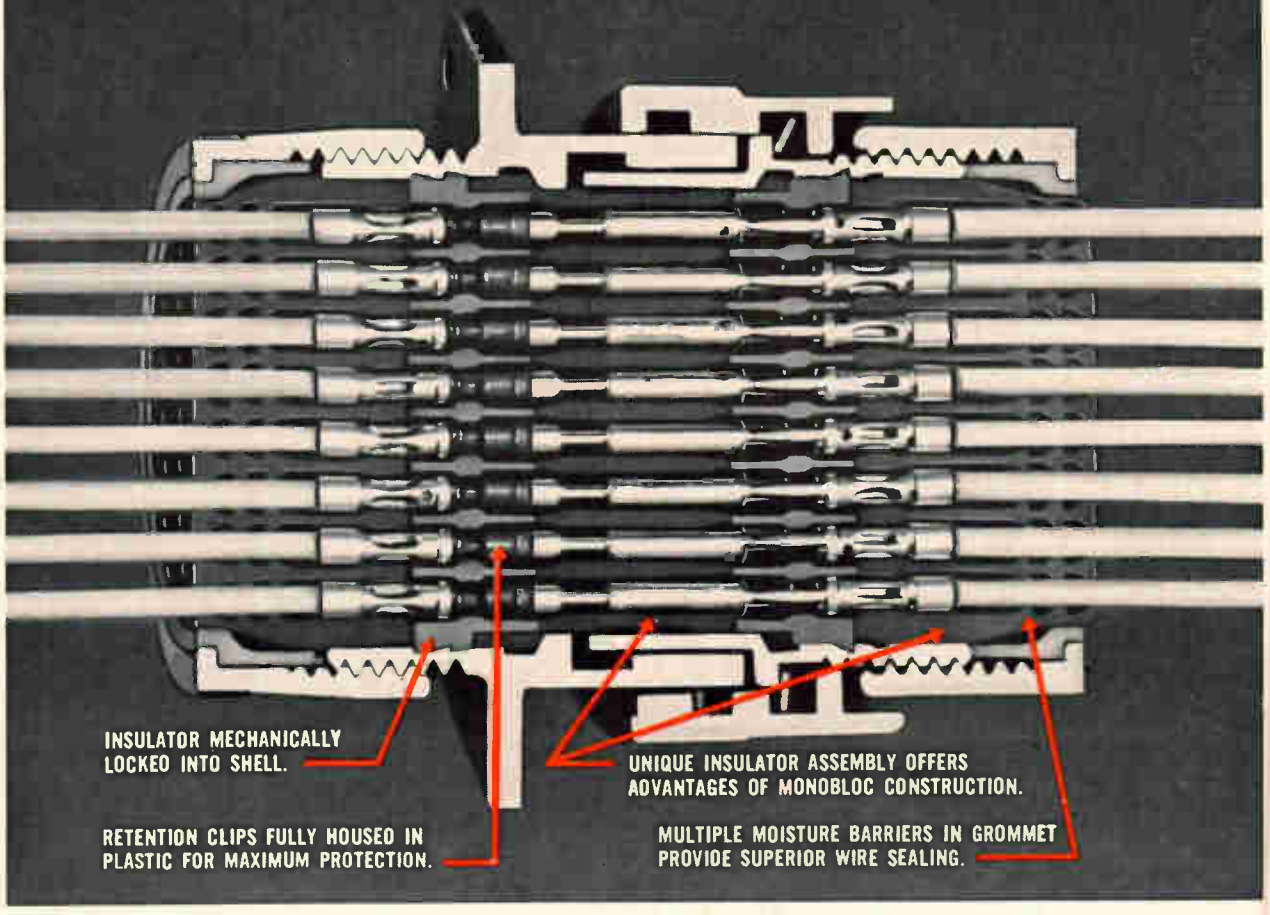


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The unitized construction of the elastomers and plastic wafer, which comprise the KPSE insulator assembly, eliminates separate bonding operations . . . no voids or contamination to cause electrical failures. The insulator is held in the shell by a mechanical plastic-to-metal lock which prevents axial movement under pressure. Contact retention clips are completely surrounded by plastic instead of rubber to provide maximum clip protection against possible damage from front release tool.

KPSE connectors with crimp, snap in contacts use standard MIL-C-26482 hardware, thus intermating with any solder or crimp 26482 connector. They are available in eight shell sizes, six service types and accommodate up to 61 contacts. There's one for your use in aircraft and missile applications, electronic subsystems and ground support systems.

These new environmental connectors are available from ITT Cannon Authorized Distributors.

For more information, write to the world's largest and most experienced manufacturer of reliable electrical connectors: ITT Cannon Electric, 3208 Humboldt St., Los Angeles, California. A division of International Telephone and Telegraph Corporation.

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Technical Abstracts

Kilowatt servo

A high-performance a-c position servo using a d-c motor
P. M. Will and Murray Zeldman
Research and Development Division, American Machine and Foundry Co.
Springdale, Conn.

Until recently hydraulic systems have controlled servomechanisms that have high horsepower and short time constants, especially in applications where system weight is critical. With careful choice of motor and drive circuitry, a complete electromechanical servosystem was built at a cost that was less than the price of a good quality hydraulic servo valve. The system design objectives were a d-c output level in the kilowatt range, bidirectional output power, direct use of 60-cycle line power and a cost limit of $50 for the complete amplifier circuitry.

The crux of the design lies in choosing a prime mover that has sufficient power and bandwidth. The motor choice is critical if hydraulic system performance is to be obtained from an electromechanical drive: the motor must have low inertia and high torque-speed characteristics. A d-c printed circuit motor was chosen.

A serious obstacle to using a printed motor here, especially since bidirectional rotation is required, is that the device has a low impedance and therefore a high armature current. The impedance typically is 2 ohms and thus the armature current for a 1 horsepower motor will exceed 22 amperes. If a conventional d-c servoamplifier were used to control the motor, the amplifier would require an expensive ±50-volt, 20-amp regulated supply.

A different design approach was needed, one which would allow the amplifier to operate off line power so that a power supply was not needed. A simple half-wave approach was chosen. Silicon controlled rectifiers (scr's) rectify the incoming a-c line power to operate the d-c motor. Each scr is fired by a unijunction-transistor circuit. To get bidirectional operation two unijunction-transistor circuits were used in parallel, each firing one scr and operating during different half-waves of the line voltage. Changes in error signal changed the scr firing angle, changing motor speed accordingly.

Presented at the 1966 IEEE International Convention, New York City, March 21 to 25.

Microwave test set

A precision d-c potentiometer microwave insertion loss test set
C.T. Stelzried, M.S. Reid and S.M. Petty
Jet Propulsion Laboratory
Pasadena, Calif.

Small insertion losses of coaxial and waveguide components must at times be measured with greater precision than commercial test equipment normally provides. A test set has been developed that has a measuring error of less than 0.0001 decibels, discounting the error due to the connectors. The instrument's frequency range of 10 megahertz (megacycles per second) to 40 gigahertz can be extended to 90 Ghz with slight performance degradation.

The test set is a d-c potentiometer. The signal level is sampled with power meters at two points and the d-c outputs are compared on a null indicator. A precision divider is used to obtain a null before and after inserting the microwave component to be measured. The difference in the divider ratio—converted to db—is a measure of the insertion loss.

The power meter (HP431B) has an output which is proportional to the square root of the applied power. A squaring circuit provides a linear output with respect to power. Signal-source modulation is not required; this eliminates possible errors from double moding a klystron signal source and modulator instability. As an example of the set's performance, a right angle WR112 waveguide section was measured eight times and found to have an average insertion loss of 0.0282 db. The average deviation of all the measurements was 0.0008 db, which includes the nonrepeatability of connecting and disconnecting waveguide flanges.

Presented at the 1966 IEEE International Convention, New York City, March 21 to 25.

New Literature

Electronic multimeter. Trio Laboratories, Inc., Dupont St., Plainview, N.Y., has published a two-page technical data bulletin on its model 313-2031 multimode transistorized a-c/d-c voltmeter.
Circle 420 on reader service card.

Automated soldering systems. An eight-page brochure from Electro-Mechanical division, Electrovert, Inc., 86 Hartford Ave., Mount Vernon, N.Y., 10553, describes and illustrates the many automated soldering systems available to meet the various requirements of the printed-circuit industry. Compact, low-volume processing to high-volume processing as well as systems for special applications are described. [421]

Polycarbonate capacitors. General Electric Co., Schenectady, N.Y., 12305. Bulletin GEA-8102 on polycarbonate film-foil capacitors provides easy reference to performance characteristics and catalog information. [422]

Microelectronics tools. Hammel, Riglander & Co., Inc., P.O. Box 222, Village Station, New York, N.Y., 10014, has issued a 12-page catalog covering a line of specialized hand tools for microelectronics. [423]

Vacuum components. Jennings Radio Mfg. Corp., subsidiary of International Telephone & Telegraph Corp., 970 McLaughlin Ave., P.O. Box 1278, San Jose, Calif., 95108. Short form catalog No. 100 illustrates and lists specifications for a line of vacuum components. [424]

Permanent magnet material. Thomas and Skinner, Inc., 1120 E. 23rd St., Indianapolis, Ind., 46207. Illustrated with demagnetization and energy product curves, bulletin M304-A lists the typical magnetic and material characteristics, and points out the specific features of Alnico 9. [425]

Preset counter. United Computer Co., Palo Verde Industrial Park, 930 W. 23rd St., Unit 8, Tempe, Ariz., 85281, has published a bulletin on a small, lightweight preset counter (model PR-40) that is built with integrated circuits. [426]

Phase shifter. Scientific-Atlanta, Inc., Box 13654, Atlanta, Ga., 30324, announces a preliminary product information sheet giving description, applications and specifications data for the model 223-1A reciprocal latching phase shifter. [427]

Flip-flop circuit card. Sparton Electronics division, Sparton Corp., Jackson, Mich. Product data sheet 23 contains a description of and typical specifications for a new flip-flop digital solid-state circuit card, product No. DFF-S-1. [428]

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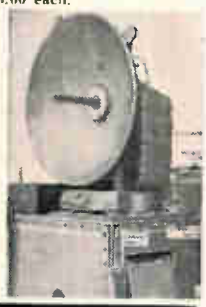

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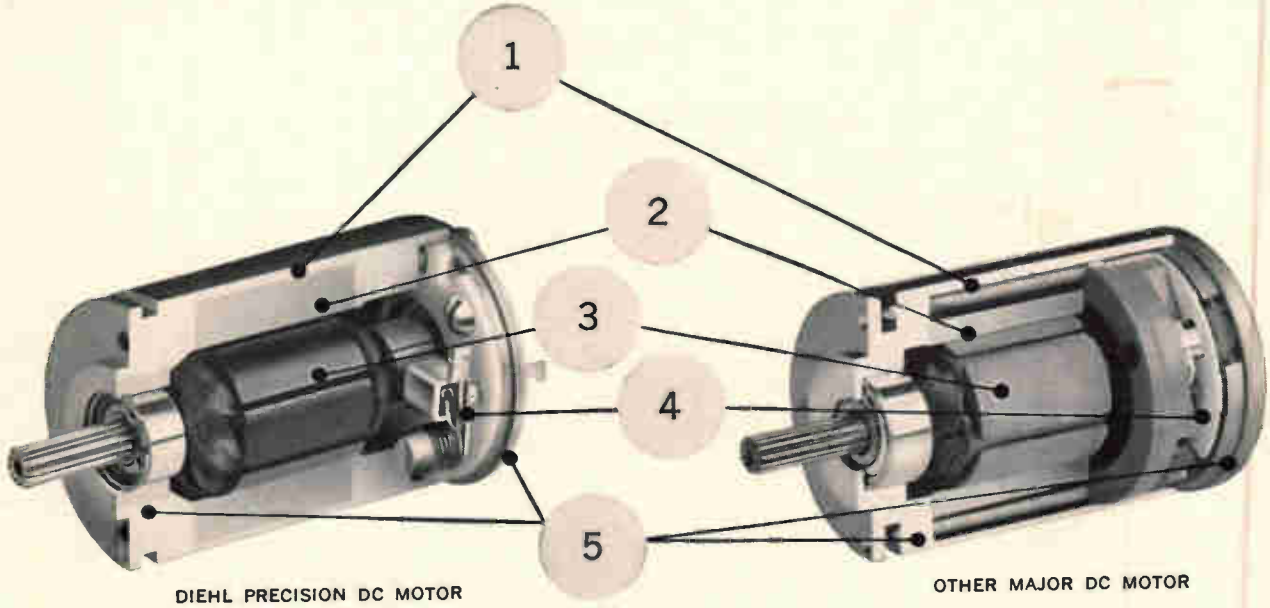

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May 2, 1966

Electronics Abroad

Volume 39
Number 9

Japan

Good mixer

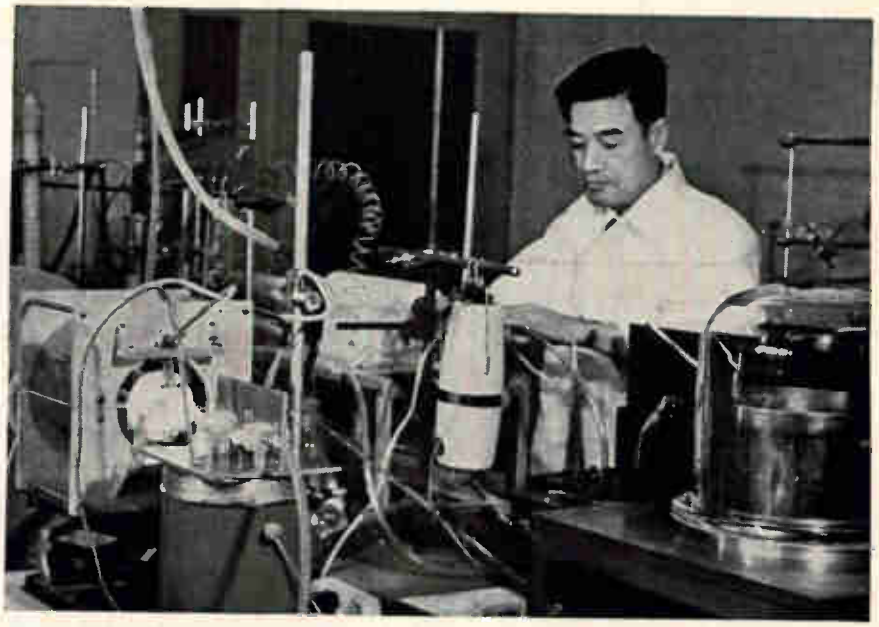
Decades after its theory was first figured out, the Schottky barrier diode has started to come into its own as a microwave mixer at frequencies too high for silicon junction diodes. An added push for the late-blooming device now seems in sight from Japan.

The Matsushita Electronics Corp. has developed a molybdenum-silicon Schottky diode, says it will be produced as a discrete component at prices competitive with point-contact germanium diodes. It can also be built into integrated circuits.

As far as cutoff frequency and reverse recovery time go, Schottky diodes are in a class by themselves. In the United States, Bell Telephone Laboratories and other companies have pushed cutoff frequency in experimental diodes to higher than 500 gigahertz (gigacycles per second). Microwave Associates Inc. has in development a 200 Ghz microwave mixer. Reverse recovery times for Schottky diodes run well under 1 nanosecond, compared to about 4 ns for typical fast silicon computer diodes.

Matsushita Electronics, a joint venture of Matsushita Electric Industrial Co. of Japan and Philips Gloeilampenfabrieken NV of the Netherlands, can't yet match the cutoff frequencies reached in the U.S. The molybdenum-silicon diodes Matsushita has made so far operate at frequencies up to 15 to 20 Ghz. But Shigetoshi Takayanagi, head of the group that developed them, says he's confident their frequency performance can be boosted substantially. What's more, the fabrication technique can easily be adapted to mass production.

Hot and fast. Like all Schottky diodes, the molybdenum-silicon devices derive their high-frequency capability from majority-carrier action. When the diode is forward-biased, the Schottky barrier lowers. Hot electrons from the n-type semiconductor than diffuse over the barrier and into the metal layer of the diode. When the bias is reversed, the barrier rises and the hot electrons cannot pass over it. Operating in this way, the Schottky diode virtually eliminates minority carrier storage. Reverse flow of stored carriers is what slows down silicon junction diodes.



Shigetoshi Takayanagi leads research group that developed a chemical deposition process for making molybdenum-silicon Schottky doides.

The American physicist Walter Schottky described the theory of barrier rectification before World War II. But it wasn't until the early 1960's that devices became practical with the advent of pure semiconductor materials and epitaxial construction techniques. Bell Labs was one of the first to succeed with a gold-silicon diode in 1963. After came diodes fabricated with tungsten, palladium, vanadium and many other metals.

Takayanagi and his group turned to molybdenum because of its relatively low work function, a determining factor in the height of the Schottky barrier. Its height, in turn, determines the forward and reverse current characteristics. The early Matsushita diodes have forward current flow of 30 to 40 milliamps for a 1-volt drop across the diode. Reverse current runs about 5 microamps at 20 volts.

Matsushita fabricates its Schottky diodes by reducing molybdenum pentachloride with hydrogen gas at the surface of a 5-micron epitaxial silicon layer deposited on low-resistivity n-type silicon. During the process, hydrogen chloride gas forms to clean the surface.

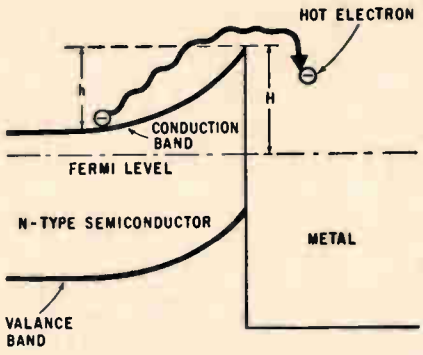
Double pass. However, a straight pass of molybdenum pentachloride and hydrogen over heated silicon won't work. If the temperature of the silicon is higher than 550°C, molybdenum silicide forms on the surface instead of pure metal. On the other hand, clean films can't be deposited on the silicon at lower temperatures because the pentachloride isn't completely reduced and lower chlorides are mixed in with

the molybdenum metal.

Takayanagi's group got around the drawback by first passing the molybdenum pentachloride over a carbon mesh heated to 700°C. This first pass preactivates the reaction. A pure film of molybdenum then forms on the surface when the partially reduced chlorides and the hydrogen pass over the silicon at a temperature between 390°C and 500°C. Diodes produced in this fashion have a barrier height of 0.57 electron-volt, very close to the calculated height, and uniform from batch to batch.

After the molybdenum is deposited, wafers are etched to obtain mesas of either 70 or 100 microns diameter, then diced. The finished diodes have the customary gold ohmic contact at the bottom, and a ball-pressure contact on top.

On the way. Early diodes fabricated in this fashion with 100-micron mesas showed cutoff frequencies higher than 15 Ghz and reverse recovery time faster than 1 nanosecond even though their unsophisticated mounts added shunt capacitance and series inductance. Takayanagi says that diodes with better packaging, smaller mesa and 1-micron-thick epitaxial layer are on the way and will improve performance by a factor of at least 10. And he sees possible applications for the molybdenum-silicon diodes in integrated circuits; the diodes can be fabricated with planar masking as well as mesa etch.



Band model of Schottky diode. Barrier (h) drops when diode is forward biased and hot electrons from n-type semiconductor diffuse into metal. With reverse bias, electrons can't get back over high barrier (H).

Great Britain

Landlubber computers

Time was when British instruments and control makers expected their country's proud maritime tradition would one day mean for them a thriving market in ship automation. Instead of the hoped-for trade winds, though, the forecast now is for a calm sea.

At a recent conference on electronics in ships and shipbuilding held at Glasgow, cost-conscious ship owners quashed earlier optimistic forecasts of electronics companies for big upcoming markets in shipboard controls. Computer makers, especially, left the meeting with the impression that their best maritime market will be in ports rather than on ships.

At sea. After a hard-headed analysis, reported J. and J. Denholm (Management) Ltd., one of Britain's largest ship operators, it appeared that the economic investment in automation systems in a 50,000-ton bulk carrier couldn't run much higher than $55,000. The only systems that would pay for themselves in savings over a 15-year ship life, in this operator's opinion, are four—an automatic fuel system, simple data-logging and alarm equipment, a recorder for engine maneuvers, and an autopilot. Even for the simple 20-point data logger, the economic investment was pegged at $19,800 and this is far below current costs of data-logging systems.

The dismal outlook for big-ship automation, however, is slightly offset by a trend to automatic operation during the night on smaller ships like trawlers. Here, the savings to shipowners are indirect; improved working conditions help keep officers and crewmen going to sea rather than turning to easier jobs on land. And to better match the vessels to their work, some deep-sea trawlers have been fitted with 20-point data loggers to record torque, thrust, and speed of propeller shaft. The data is destined for simulation studies that will give a good idea of what size and power a trawler needs to do various jobs. A follow-on to this optimization program will aim at improved routing techniques to get trawlers from their British ports to Atlantic fishing grounds.

Safe in port. The Glasgow conference, however, pointed to a solid future for computers in British ports. Already at London's Royal Victoria Docks, the Blue Star Line has installed an automatic meat-handling system with an integrated-circuit computer controlling the sorting process.

As the meat passes out of the ship's hold on a conveyor system, inspectors code into the computer the type and grade of meat. Truck drivers come to the docks with prepunched order cards. From the information on the cards, the computer assigns the truck to an available loading bay. Once there, the driver signals his arrival to the computer operator, who in turn instructs the computer to allocate the order to the bay.

Another computer-controlled system under development by Davy-Ashmore Ltd. will automatically unload about 70% of the coal in the hold of a collier. The system also will make life easier for the human operator who handles the unloading of remaining 30%.

What complicates the system is the pendulum-like behavior of the grab bucket. The effective length varies with the tide, the size of the collier, and also changes as coal is unloaded. The computer calculates these factors so that the bucket can discharge on the fly and then swing back to drop into the hold. In addition, the system controls the grab so that it unloads evenly from all of the hold.

Although shipbuilders in Britain lag behind their Scandinavian competitors in the use of numerically controlled machine tools for cutting plates, two British firms are pioneering with automatic equipment to bend rolled profiles into ship frames. Ferranti Ltd. and Hugh Smith Ltd. described at the conference an NC machine they are developing that forms frames with

two hydraulic rams working against a central anvil. Digitizers at the end of the frame measure its shape as it is formed. This digital input is compared to the design dimensions, fed in on a five-channel paper tape. The comparison signal controls power servos for the rams. A special servo system checks for elastic recovery after bending and calculates the amount and direction of any further bending needed.

Hungary

Shortcut to NC

Sharp-eyed showgoers at this week's machine tool exhibition in London will stop short when they reach the stand of Technoimpex, the Hungarian government's machinery export agency. On the stand will be a small, numerically controlled lathe that can take workpieces only up to 200 millimeters long, itself an oddity. More surprising will be the nameplate on the NC hardware—Grundig.

The unusual combination is not the result of a willy-nilly slapping of Grundig NC gear onto a Hungarian-built lathe. The West German industrial giant Fried. Krupp, whose big plants dot the Ruhr Valley, based the idea of a small lathe on a survey that showed 60% of all turned parts could be handled on a machine with 200 mm lathe swing and 200 mm distance-between-centers. When Krupp found that West German machine tool builders weren't interested in building an NC short-bed lathe, it decided to let the Hungarians develop it.

A cut. The deal Krupp made with Technoimpex would make any hard-core Marxist cringe. In return for its NC knowhow (Krupp is West Germany's largest user of NC machine tools), Krupp cut itself in for a piece of any profits Technoimpex makes on sales of the lathes in Western markets. And Krupp gets a pair of added benefits under the arrangement. Instead of canned foods, low-grade steel, light bulbs and the like, Krupp can take as barter payment in return for heavy equipment supplied to Hungary small lathes it can use in its own plants. Then, too, added foreign currency flowing into Hungarian coffers from sales of the lathes should mean more cash business for Krupp in Hungary.

Although Hungary badly needed Western knowhow to catch up with East Germany, Poland and Czechoslovakia in NC, the country's Marxist planners dawdled for a year before they accepted Krupp's offer of knowhow in exchange for a profit cut. After the deal was signed, Krupp brought in Grundig as a subcontractor for the NC hardware. The lathe uses standard Grundig two-axis, eight-channel, solid state circuitry.

For the Hungarians, developing the lathe in collaboration with Krupp and Grundig has been a shortcut to NC. Later this month at the annual Budapest Fair, a Hungarian NC radial drill will be shown. It was designed and built by Csepel, the country's largest industrial complex, which also manufactures the small lathe for Technoimpex.

Denmark

Money maker

Many a United States company has fought its way into computer production hoping for profits only to find losses. Denmark's sole computer maker, ironically, twists the tale—it started out as a nonprofit organization but fared so well it finally went public.

A/S Regnecentralen found a money-making niche for itself in the highly competitive computer business through a mix of manufacturing and services. It produces computers and peripheral equipment, develops software programs, runs four data-processing service bureaus in Scandinavia. During the first 15 months after it went public in January, 1964, the Copenhagen-based company chalked up sales

Niels I. Bech, managing director of money-making Danish computer company.

of $2,875,000 and a gross profit of $142,950. Today it has 400 employees and grows 5% monthly.

Success story. Regnecentralen's success story started in 1955, when the Danish Academy of Technical Sciences set it up as a nonprofit organization. "We didn't mean to make a profit in the computer field when we started, but it turned out that way," says Oscar Lund, the company's sales director.

By 1957, Regnecentralen had built its first computer. In 1960, the company went on the market with a transistorized machine originally developed for the Danish Geodetic Institute. The GIER, as the machine is called, has binary parallel operation with a cycle time of 6.6 microseconds. It turned out to be a best seller by Scandinavian standards. Computer sales bounced up from $45,000 in 1960 to $405,000 in 1961 and by 1963 had reached $690,000. All-in-all, 35 GIER machines have been installed or ordered.

The company's income from service bureaus showed the same solid growth, climbing from $165,000 in 1960 to $585,000 in 1963. With total yearly income well over a million dollars, the company went public two-and-a-half years ago.

World-class reader. Along with its successful GIER computer, Regnecentralen has put on the market some world-class peripherals. Its

tape reader, at 2,000 characters a second, rates as one of the fastest anywhere. It's notable for the way it eliminates the start-stop character-reading action found in most other tape readers.

In the Regnecentralen unit, characters are read continuously and fed into a buffer store that empties, character by character, into the computer. A register system and a digital-analog converter keeps a constant check on the buffer. When the buffer starts to fill too fast for the computer, the checking operation sends a signal to a servo system that slows down the motor in the tape drive. That way, reading speed is continuously matched to the rate the computer can handle.

For the future, Regnecentralen expects its main activity will shift to software operations. It has developed a specialty, for example, in Algol compilers. But the company doesn't intend to phase out its hardware operations completely. It has under development a complete data converter system, modular data logging systems, an integrated-circuit 24-bit floating point computer and will supply a process control computer for a Polish chemical plant next year.

Italy

Automation by Fiat

The Italian industrial giant Fiat is best known for the hundreds of thousand of passenger cars it sells every year at home and abroad, but over the years the company has built up considerable electronics know-how for its own use and when it sees a market, tries to move in.

Fiat hopes to make a splash at sea with automation equipment for ships. Although the market hasn't turned out to be as lush as many controls makers once thought it would, Fiat recently scored with its first major contract—an automation system for a refrigerator ship under construction in Italy for the Soviet Union. Fiat's system will control the 8,400 horsepower main-propulsion diesel engine, the ship's electrical power plant, its auxiliary systems and part of the refrigeration equipment.

When it puts to sea early in 1968, the Russian reefer will be run with an engine-room crew of nine instead of the usual 13 to 16 men. Speed-change commands, with the automation system, can be fed in from the bridge through the conventional engine-order telegraph or through a typewriter linked to the control console in the engine room. In the case of telegraph orders, signals are digitized in a converter that also formats all system inputs.

Once formatted, command information passes to a transistorized logic coordinator, essentially logic routing circuits plus a small digital computer. The coordinator separates the orders and shoots them to the proper machinery. In the engine room, for example, outputs are fed to two servo systems. One controls the throttle, the other the engine-reversing system. The transistorized coordinator also transmits to a data logger the information it sends to ship machinery. The information is printed out both in the engine room and on a small console on the bridge.

Lights and whistles. The data logger is the heart of the alarm system tied in with the automatic ship controls. When a parameter in the main engine, electrical power plant, auxiliary systems, or refrigeration system strays outside its normal limits, the alarm equipment flashes a light and sounds a whistle to alert the crew. It then prints out a code that shows what the trouble is and what equipment caused it.

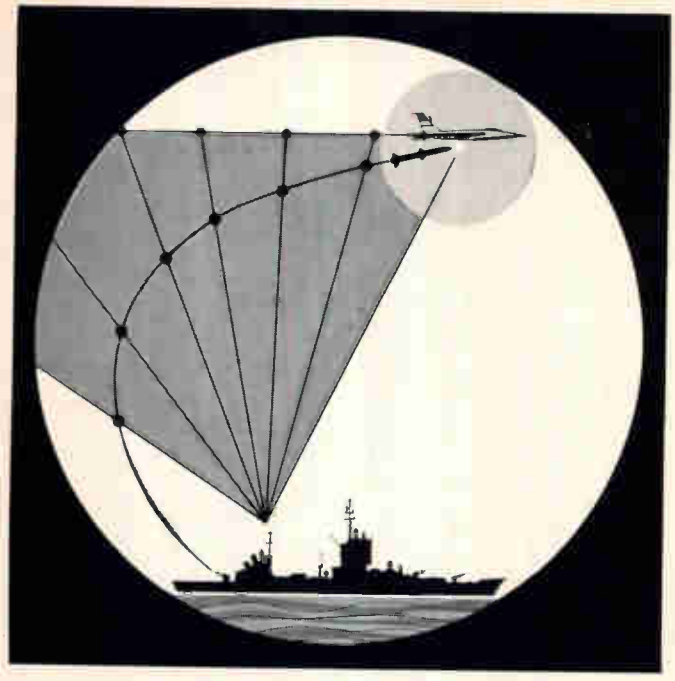
Inputs to the data logger's alarm-comparison circuits come from three main devices. One continuously scans 34 crucial parameters—shaft rpm, cooling water pressure, and the like—essential to keeping the ship running. A second scanner makes periodical checks on 70 other important—but not vital—parameters like main bearing and oil temperature. The third input device comes into play during speed changes. Along with feeding in data for recording maneuvers, it signals the two scanners when an ordered maneuver—like an emergency burst of flank speed—will cause abnormal engine conditions. That way, the scanners don't trip the alarm system during emergency maneuvers.

Around the world

West Germany. A new material under test by Siemens and Halske AG of Munich may challenge the dominant position of yttrium-iron garnet in microwave isolators and delay lines.

At the recent International Conference on Magnetics at Stuttgart, Siemens reported promising results in tests on calcium-vanadium-bismuth (CVB). It had the lowest field losses among eight different materials, including substituted and unsubstituted YIG, in tests on plates at temperatures down to 4.2°K. The tests showed that for isolation of 4.2 gigahertz (gigacycles per second) ruby masers, unsubstituted YIG is adequate. But for low-temperature circulators, CVB discs had the best performance—insertion loss of 0.2 decibel and isolation of 20 db.

Soviet Union. The Soviet bloc of countries will be lined up solidly behind the French Secam system at next month's meeting of the International Radio Consultative Committee (CCIR) in Oslo where a final attempt will be made to adopt a single color-tv standard for Europe. The Soviets earlier this year proposed changes to the French system that would have made it very much the same as its chief rival, the West German system PAL (phase-alternation-line). But a fortnight ago a mixed commission of Soviet and French tv officials agreed to adopt the so-called Secam-3 system which transmits frequency-modulated chrominance signals. The Russian NIR variant had amplitude and phase modulation for the color signals, as has PAL. Both France and Russia plan test color broadcasts late next year. Network color programs will begin in 1968.



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