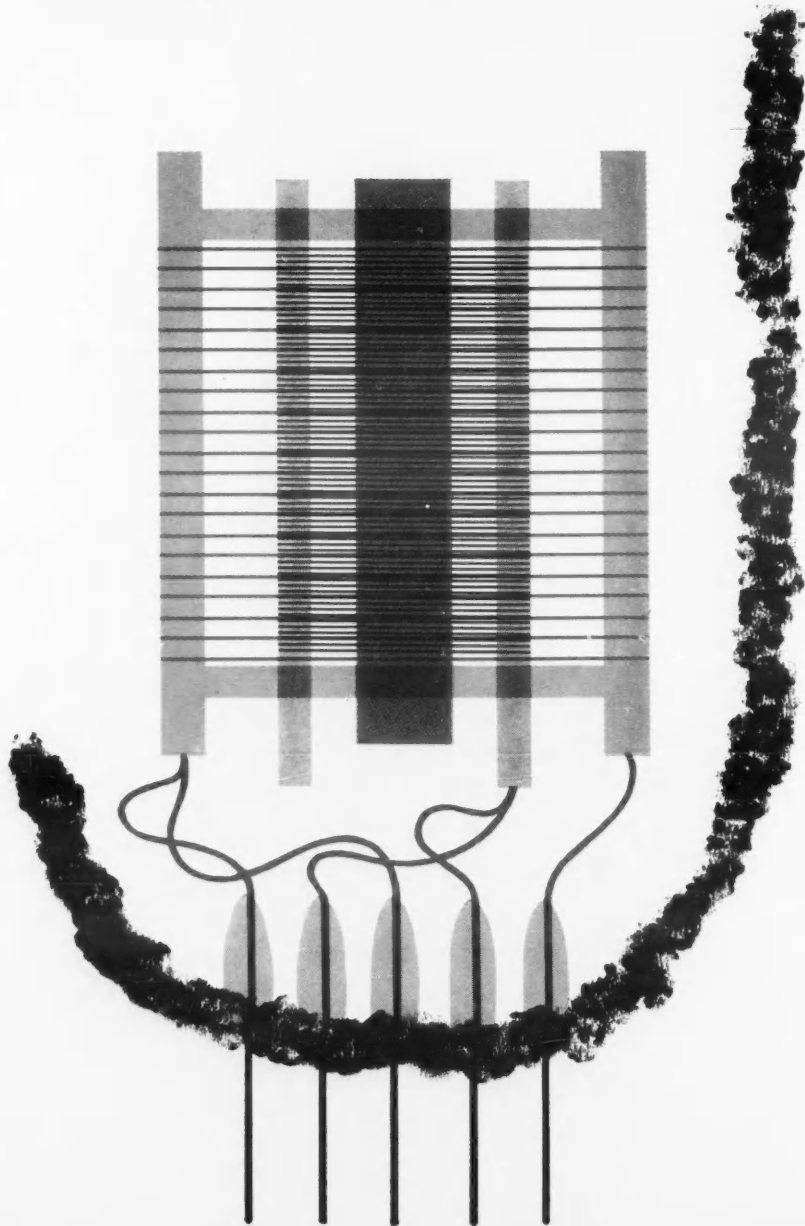


# ELECTRONIC DESIGN

APRIL 12, 1961



Double-frame-grid construction  
boosts pentode performance  
...p 56



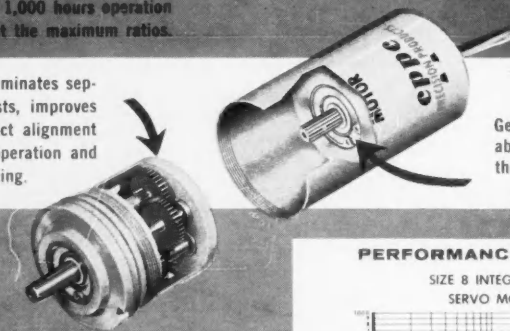
MICROWAVES...p 165

# NEW SIZE 8 INTEGRAL GEARHEAD MOTORS

## 3 Times Torque Load Capacity\* of comparable size 8 gearheads

\*Will sustain 20 in-oz torque load for 1,000 hours operation and 100 in-oz momentary overload at the maximum ratios.

CPPC one-piece gearhead housing eliminates separate gear plates and fastening posts, improves and maintains accuracy through exact alignment of gear clusters, assures smoother operation and more expedient inspection and servicing.



Gearhead and motor are selectable, individual parts enclosed in the same common motor housing.

Clifton Precision, pioneers in postless gearhead construction, introduces the finest in gearhead design—cage-type, one-piece gearhead housing machined from a single block of metal. In these units, exact duplication of gear centers is accomplished through simultaneous boring of permanently integrated bearing plates (patent pending). Positive and permanent alignment of gear clusters composed of AGMA precision Classes II and III hardened-steel gears integral with shafts journaled at both ends in ABEC class 5 bearings, minimize deflection and backlash, maximize torque load capacity, insure smoother operation and continued reliability of performance beyond normal endurance life requirements. Cage type construction facilitates inspection and lubrication while gearhead is mounted simply by removing motor. CPPC motors will stand greater heat than ever before due to the use of new materials. See box at lower right.

Write for our free pamphlet which gives detailed specifications of our entire gearhead motor and motor-tachometer line, sizes 8, 10 and 11.

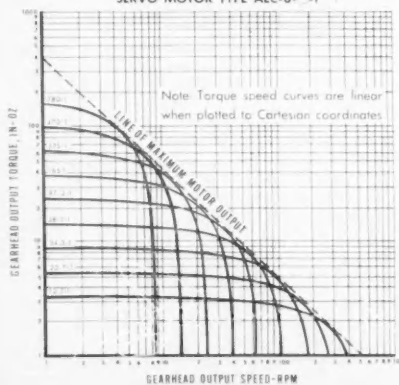
### STANDARD TYPES

RATIOS		No. of Clusters	Dir. of Rotation
Size 8	Size 10		
12.09	19.98	2 (3 pass)	reverse
20.63	32.19	3 (4 pass)	direct
34.26	58.28	3 (4 pass)	direct
58.44	93.89	4 (5 pass)	reverse
97.07	169.97	4 (5 pass)	reverse
165.58	273.84	5 (6 pass)	direct
275.02	495.74	5 (6 pass)	direct
469.15	798.70	6 (7 pass)	reverse
779.22	1445.92	6 (7 pass)	reverse

Notes: 1. Any ratio ( $\pm 3\%$ ) is available within the limits of the ratio range at additional cost and may require longer delivery time.  
2. Max. backlash = 30 minutes at 2 in-oz reverse gauge load in above units. Inquire if special tolerance is required.

### PERFORMANCE CHARACTERISTICS

SIZE 8 INTEGRAL GEARHEAD MOTOR  
SERVO MOTOR TYPE ALC-8-1



### MOTORS

The following CPPC standard motors, electrical characteristics of which can be found in the current CPPC Rotary Components catalog, are offered with our gearheads:

#### SIZE 8

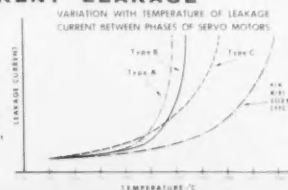
ACH-8-□-1 AMH-8-□-3  
ACH-8-□-4 ALC-8-□-1  
AMH-8-□-1 ALC-8-□-4

#### SIZE 10

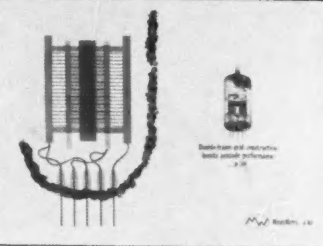
ACH-10-□-1 ALH-10-□-1  
ACH-10-□-4 ALH-10-□-5

### CURRENT LEAKAGE

Superiority of insulation in CPPC motors is illustrated by actual comparative curves shown at the right.



## ELECTRONIC DESIGN



COVER: A dual view of a new Amperex pentode tube. At left, artistic design of the tube's double-frame-grid construction. Right, photo of the tube, showing a structural cutaway of its inner portion. For a full description of the tube, turn to p. 56.

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CLIFTON HEIGHTS, PENNSYLVANIA



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## Sidelights of This Issue

### The Battle of the IRE

Covering a news event as big as the annual IRE International Show and Convention can be fun, but for most electronics journals a more appropriate descriptive word might be formidable.

How, amid the welter of booths, products, meetings, speeches, claims and counter-claims, is a journalist to cut through the confusion and mirror the action meaningfully for his readers?

ELECTRONIC DESIGN has always approached the industry's biggest event like a general facing his biggest battle. Long before the IRE Show opened at New York's Coliseum, the high command at ELECTRONIC DESIGN began planning the strategy for full coverage.

Once again ED's ELECTRONIC DAILY troops were called up from the reserve ranks, this year under command of General—beg pardon—News Editor Bob Haavind. Day-by-day staff meetings were held as long as two weeks in advance of the Show.

On the eve of IRE's opening day, a full conference was held between ED and the DAILY's staffs. Then the precision shock troops—reporters, to you—were turned loose.

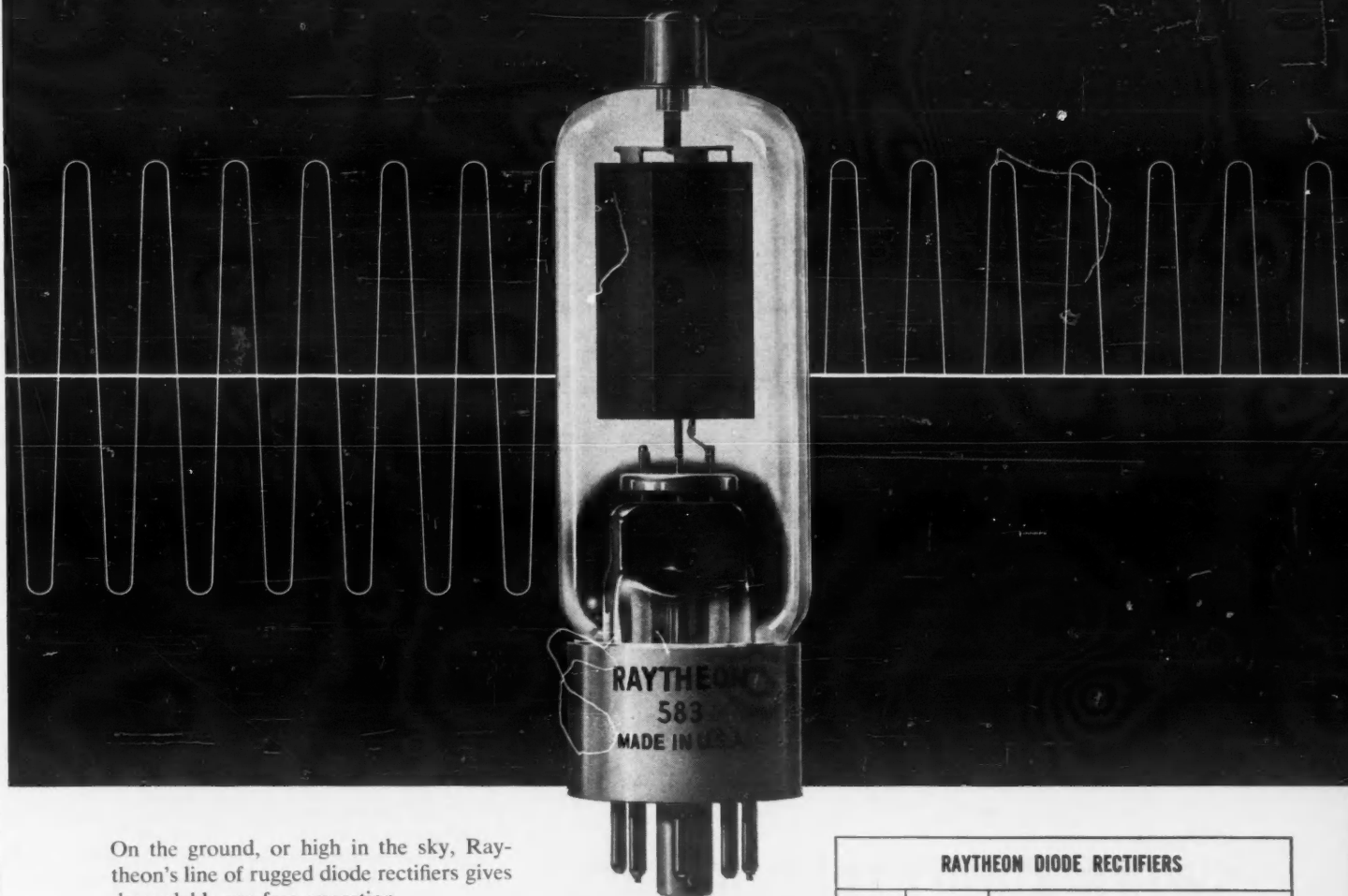
For three days they assaulted the front lines at the Coliseum and at technical sessions in various hotels. Intelligence was collected and evaluated, both at the ELECTRONIC DAILY office at the Show and at ED's main office. Steady bulletins were printed by the DAILY.

Early on the fourth day—the last day of the IRE event—there was another full parley between ED and the DAILY. Progress to date was established, false leads and booby traps pinpointed, and a final push mapped.

By the time the Show had shut, ED was in possession of a triumphant collection of facts. These were distilled behind the lines, and the hard significance of the IRE event is now available in a white paper.

To read it, turn to p 4.

CIRCLE 2 ON READER SERVICE CARD ▶



On the ground, or high in the sky, Raytheon's line of rugged diode rectifiers gives dependable arc-free operation.

Example: Raytheon 583, one of six Raytheon half-wave rectifier types. Operating as a clipper diode at altitudes to 36,000 feet, maximum ratings are 15,000 volts PIV, 8 amperes peak plate current. Arc-free clipping action makes sure a magnetron can be fired once *without* re-firing automatically or uncontrollably!

The reliability of Raytheon diode rectifiers is the result of exceptional care in design and manufacture . . . with no compromise in quality control. Gold-plated plates and zirconium coatings assure reliable operation at high voltages. Cathodes are heliarc welded. Higher exhaust temperatures mean less gas and longer life. For more information on Raytheon's growing line of dependable diode rectifiers, please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

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ARC-FREE  
DIODE  
RECTIFIERS**

RAYTHEON DIODE RECTIFIERS						
TYPE	SERVICE	HEATER		MAX. PLATE RATINGS		
		VOLTS	AMPS	PEAK INVERSE (VOLTS)	PEAK CURRENT (AMPERES)	AVERAGE CURRENT (AMPERES)
583*	H. W. RECT. (to 36,000 ft.) CLIPPER DIODE (to 36,000 ft.)	2.5	4.9	17,000	0.250	0.065
		2.5	4.9	15,000	8.0	0.240
3B24W 3B24WA*	H. W. RECT. (HALF FIL.) (FULL FIL.)	2.5	3.0	20,000	0.150	0.030
		5.0	3.0	20,000	0.300	0.060
3B26	CLIPPER DIODE	2.5	4.75	15,000	8.0	0.020
3B29	H. V. RECT. (OP. 1) (OP. 2) (OP. 3) CLIPPER DIODE	2.5	4.9	16,000	0.250	0.065
				7,700	0.300	0.080
				5,000	0.300	0.095
		2.5	4.9	10,000	8.0	0.018
4B31*	H. W. RECT. CLIPPER DIODE	5.0	5.0	16,000	0.470	0.150
		5.0	5.0	16,000	12.0	0.060

\*Mil-Std-200E Preferred Type

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CIRCLE 3 ON READER-SERVICE CARD

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## Coming Next Issue

Remember the wave of interest that swelled after news of the tunnel diode first broke? And the flood of questions that followed? Designers everywhere wanted to know: How can it be applied? How soon?

ELECTRONIC DESIGN's annual diode report, appearing in the April 26 issue, will include four practical design articles indicating how the tunnel diode can be used in amplifier, oscillator and switching circuits. In addition the latest Defense Dept. approved diodes are listed with their specification number.

Don't miss this special report with its timely, stimulating articles.



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The Greeks had a word for it, which escapes us at the moment. And we should have a better word for it, but we haven't. In this day and age, a pedestal is not a simple device to hold something up. Rather, at least in the electronics industry, it is a unique and complex portion of an antenna system.

Canoga designs, develops and manufactures rugged, reliable, light-weight, low-cost pedestals for almost any radar and telemetry, optical and infra-red use—land-based, ship-borne, on trailers, on roof-tops; for use in the arctic, in the desert or in the tropics.

## LET'S TALK ABOUT PEDESTALS



Canoga pedestals are slim, minimizing wind loading and permitting the mounting of counter-balances significantly closer, thereby greatly reducing polar moments of inertia.

Gear trains and related electronics are completely enclosed—providing protection from weather, fouling, corrosion, breakage, etc. Up to 810° of travel are available without slip-rings for non-rotational tracking and slip-ring models are available for all around tracking capability. (Canoga has developed the Tri-Ped antenna which provides complete flexibility by the addition of a third, or traverse, axis to the conventional azimuth and elevation axes.)

A single stowing lock secures both elevation and azimuth gears and disengages servos in one operation. Elevation of 200° permits "plunging" for boresight purposes.

Canoga pedestals offer compact, double planetary, interchangeable drive modules with eccentric backlash adjustment, modular interchangeable data packages, balanced elevation yoke which eliminates eccentric loading of the azimuth bearing, yielding increased high-elevation angle accuracy and minimizing the perpendicularity problem. Also, a synchro-torque transmitter hand-wheel follow-up feature eliminates unexpected pedestal accelerations when switching from the slaved to local mode of operation.

Canoga pedestals can accommodate paraboloidal dish antennas up to 28' in diameter and various helix arrays.

Standard bolt circle and bolt dimensions provide for adaptability to standard mounts or mounting can be engineered to customer specifications.

Canoga Electronics Corporation also manufactures complete radar systems, microwave ferrite devices and components, radar and telemetry antennas, radar reflectors, range instrumentation, test equipment and special electronics equipment to customer specifications. **CANOGA**

# New Printed Circuits Closing a Gap in Design

*Integrally Damped Boards, Circuitry on Anodized Aluminum,  
And Electroformed and Resistance-Fused Eyelets Offered*

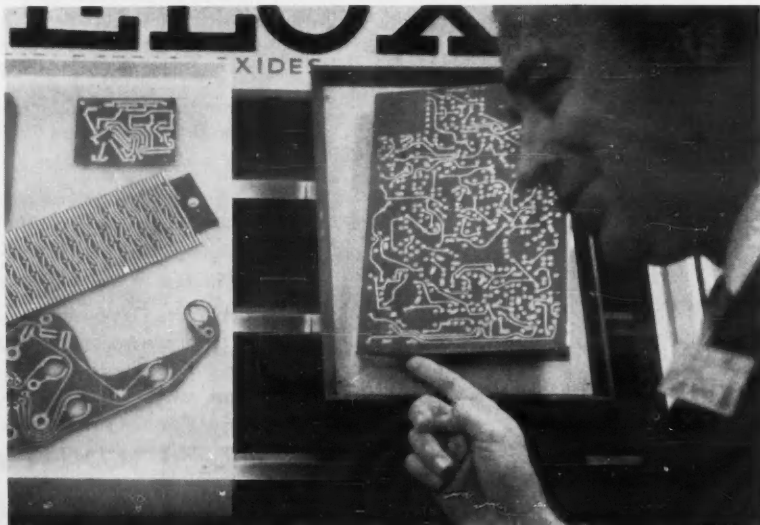
**Alan Corneretto**  
News Editor

**P**RINTED circuitry, criticized as recently as a year ago as lagging in the big push forward by the electronics industry, is posting some impressive advances for designers.

Among recent developments are integrally damped boards highly resistant to vibration; circuitry printed on anodized aluminum; eyelets, formed by an electroplating method, that offer the advantages of both eyelets and plated-through holes; resistance-fused eyelets that minimize cold-working effects, and circuits printed on flexible, heat-resistant Teflon.

## **Copper-Clad Damped Boards Designed for Airborne Use**

Integrally damped boards highly resistant to vibration and other environmental conditions have been developed by Lord Manufacturing Co., Erie, Pa. They are made by sandwiching a broad-temperature-range elastomer between a NEMA AG-11 epoxy-fiberglass laminate of 2-oz weight and then cladding one or both sides of the boards with 0.32-in. thick copper. The elastomer is 0.020 in. thick.



According to the company, vibratory energy is converted into shear strains that are dissipated in the elastomeric layer. The combination of elastomer and epoxy-fiberglass laminate is said to reduce transmissibility by roughly one-half to two-thirds that of undamped material.

The boards are intended primarily for airborne equipment. They reportedly damp effectively from  $-65$  to  $+250$  F and are at least as resistant to other environmental factors as standard epoxy-fiberglass laminates. The boards are said to maintain their dynamic and physical properties after the normal printed-circuit production processing.

Lord is selling samples of the boards to several manufacturers.

## **Metal Circuits Offer Strength And Can be Printed on Chassis**

Electralab Printed Electronics Corp., Needham Heights, Mass., has developed techniques to print circuits on metal. The circuits are dimensionally stable at high temperature and are reportedly not subject to crazing, breaking or warping. They can be made in any size, the company says.

Various alloys of aluminum are used by Electralab, which calls its new product Dielox cir-

**Circuits printed** on anodized aluminum are said to resist heat in excess of 500 F. Printed-on-zinc circuits are reported to take 700 F. Use of metal gives circuits bond strength in excess of 100 lb, and yield strength of 10,000-15,000 psi under tension and 50,000-60,000 psi under compression. Anodized surface of aluminum, on which circuit is printed, acts as insulating layer. Aluminum may be formed into chassis to provide a chassis with an integrally printed circuit.

uits. The first step is piercing or drilling, followed by anodizing to form an insulating layer. This is done in a special bath in batches. Forming, if needed, is next.

One advantage cited for Dielox circuits is that they can be applied to chassis-type aluminum, which when formed and printed becomes a chassis with an integral circuit.

After forming, the board is metallized by a spray or chemical deposition. Finally a silk-screen circuit is printed and plated, and the excess metal is removed by a brief etch.

So far the company is using only plated-through holes. Depending on the type of metal used, the circuits can be made to operate continuously up to 700 F. They are said to have a dissipation factor of 0.0009 and a dielectric constant of 6.3. Electralab reports that hand-soldered connections can be made repeatedly without damage to the circuits.

Similar printed-on-metal circuits are reported being made for internal use at Graphik Circuits Div., Cinch Manufacturing Co., City of Industry, Calif. The company uses the metal boards for high-temperature switching plates, and it reports zinc versions have been operated to temperatures of 800 F.

## **Electroformed Eyelets Give Continuity And Constant Wall Thickness**

Graphik has announced development of electroformed eyelets made by electroplating that give the advantages of continuity of conductor from surface to surface while maintaining a constant thickness of metal wall in the hole. In the technique, only the hole and the land immediately around it are plated. It permits the metal in the hole to be thicker than that in the conductors assuring reliable connections.

A copper-clad board is printed or silk-screened, then etched to remove excess copper. After drilling, it is sensitized by copper reduction and selectively masked with a plating resist that leaves holes and their lands exposed. These are then plated. The final two steps are removing





**Electroformed eyelets** combine advantages of plated-through holes with those of eyelets. Wall thickness can be made different from conductor thickness and reportedly can be maintained constant.

the resist and dissolving the sensitized film.

Dissolving the sensitized film in an oxidizing solution leaves the board with a copper-printed circuit and copper-plated holes, with a continuity of copper from conductors to holes.

Graphik reports that circuits produced this way faithfully reproduce artwork and can be made with tight tolerances. Wall thicknesses of 0.0002 to 0.0005 in., with a tolerance of 0.00005 in., can reportedly be maintained, regardless of the number of or location of holes. Holes 0.020 in. in diameter can be plated in boards 1/16 in. thick, the company says.

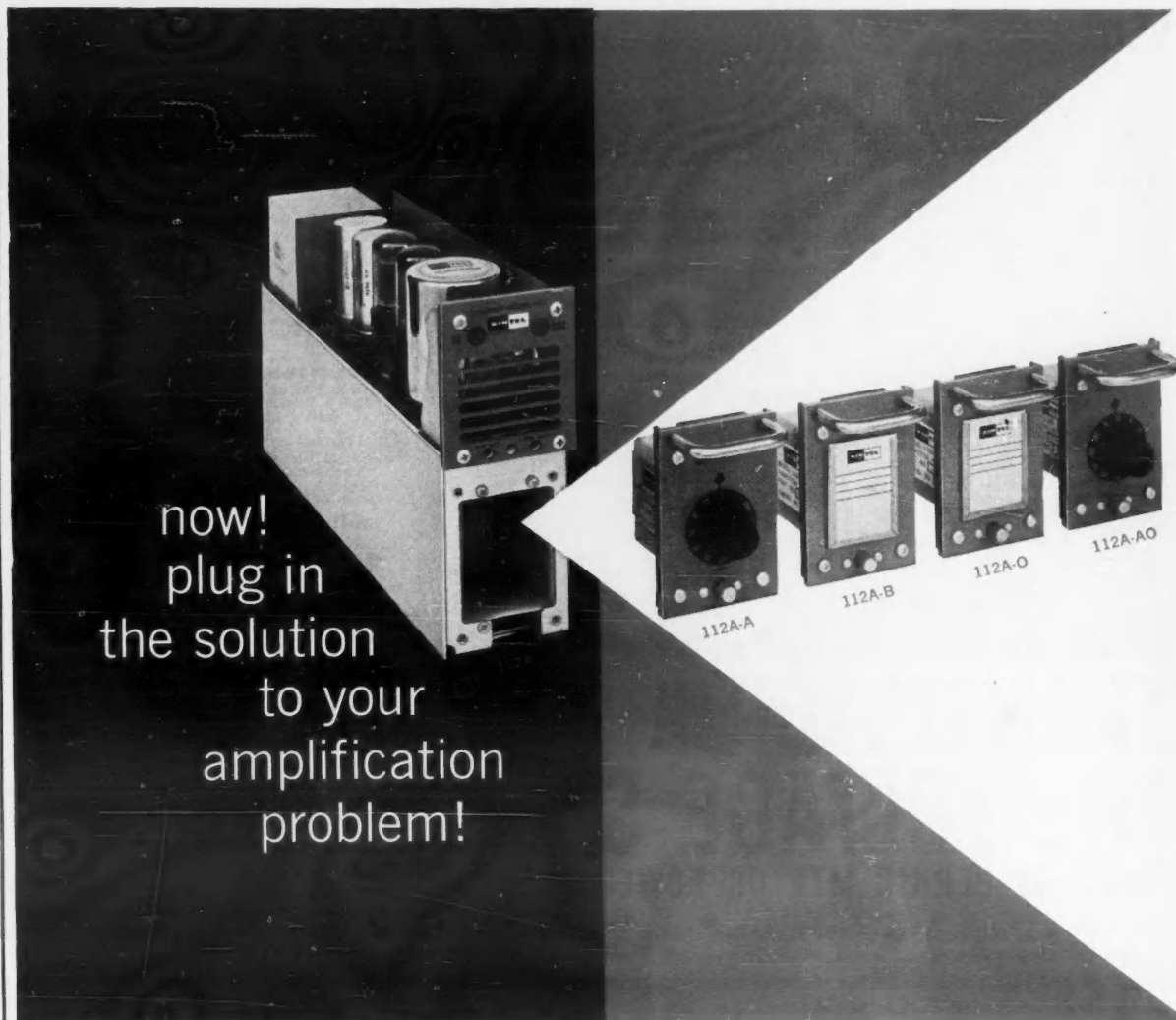
#### Circuits Printed on Teflon Called Flexible and Heat-Resistant

Garlock Electronic Products, Camden, N.J. is offering circuits printed on Teflon. These are said to operate from  $-122$  to  $+400$  F and have dielectric constants of 2.1. According to the company, they remain stable throughout a frequency range of  $10^2$  to  $10^8$  cps throughout their complete temperature span.

In the printed-on-Teflon circuits, the conductor material is electrolytic copper. The circuits are permanently bonded under pressure and are said to be almost completely resistant to short circuits or broken connections caused by vibration.

Resistance fusing by application of high currents is a technique being used by Melpar, Inc., Falls Church, Va., to anneal eyelets and remove some of the deleterious effects of cold-working them into final shape. The annealing also enables the eyelets to expand and contract with changes in temperature that affect the boards.

Another advantage cited for resistance fusing is that it melts solder that may be plated or placed on the eyelet, so that it flows around and under the eyelet, for a better connection. ■ ■



### Special Plug-In Units Make KIN TEL's Wideband DC Amplifier the Basic Component in a Variety of Data Acquisition Systems. Why Not in Yours?

**With a 112A-A Plug-in**, the amplifier provides accurate drift-free signals at any of ten fixed gains from  $-20$  to  $-1000$  with a stability of  $\pm 0.1\%$  and an accuracy within  $\pm 0.5\%$ . A Micro-Gain control sets individual fixed gains within  $\pm 0.01\%$ , and a 2:1 vernier control adjusts gains between fixed steps. Outputs are available up to  $\pm 45$  volts or  $\pm 40$  ma at an impedance less than 1 ohm, linear within 0.01% at DC and within 0.1% to 2 kc. Drift is less than  $2 \mu v$  for 400 hours, and noise is less than  $5 \mu v$  from DC to 750 cps, less than  $12 \mu v$  to 50 kc. Bandwidth is within  $\pm 0.5\%$  to 2 kc,  $\pm 3\%$  to 10 kc,  $\pm 3$  db to beyond 40 kc.

**With a 112A-B Plug-in**, the amplifier gain is fixed at  $+1$  with an accuracy, stability, and linearity within  $\pm 0.001\%$  at DC,  $\pm 0.1\%$  to 2 kc. Input impedance is 10,000 megohms  $+100 \mu f$  at DC, 1,000 megohms  $+100 \mu f$  at 2 kc. Bandwidth extends to 100 kc. Output capabilities are the same as with the 112A-A plug-in.

**With a 112A-O Plug-in**, the user may install resistances for any fixed gain or for  $+1$  operation as described above. Resistive and reactive components may be installed for use as a summing amplifier, an integrator, or for other specialized operational application.

**With a 112A-AO Plug-in**, ten fixed gains are available with all the features described for the 112A-A unit, and in addition,

an operational position is provided on the panel control for use with an external feedback network in specialized summer, integrator, or computer functions.

**With any plug-in**, the 112A may be used in a single-amplifier cabinet on a bench or in either a one- or six-amplifier module to fit a standard 19-inch rack. Write today for detailed technical literature or demonstration. Representatives in all major cities.

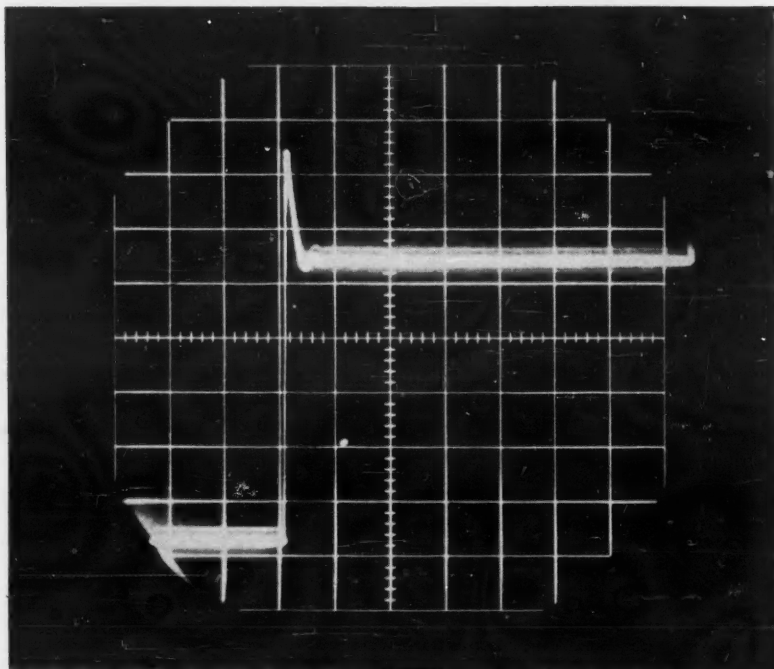
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112A amplifier alone .....	\$530.00
112A-A Ten-gain Plug-in .....	95.00
112A-B Plus-one Plug-in .....	85.00
112A-O Empty Plug-in .....	45.00
112A-AO Ten-gain/Operational .....	105.00
195 single-amplifier cabinet .....	125.00
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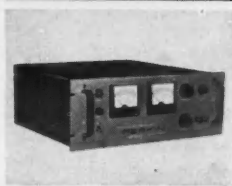
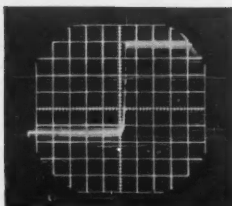
CIRCLE 5 ON READER-SERVICE CARD



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MTR636-15	6-36	15	±25MV	±50MV	±25MV	±.75V	105-125V	5MV
MTR636-30	6-36	30	±25MV	±75MV	±25MV	±.85V	105-125V	5MV
MTR28-5	24-32	5	±0.1%	±0.1%	±0.1%	±.3V	105-125V	5MV
MTR28-10	24-32	10	±0.1%	±0.1%	±0.1%	±.4V	105-125V	2MV
MTR28-30	24-32	30	±0.1%	±0.1%	±0.1%	±.5V	105-125V	5MV

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## NEWS

### IR Device Built to Detect Any Vegetation on Mars

*High-Resolution Space Analyzer  
Will Scan 2-to-4-Micron Region*

**A**N infrared spectrophotometer, suitable for space missions, has been designed to detect absorption bands characteristic of certain hydrocarbons found in vegetation.

The instrument is being evaluated by Jet Propulsion Laboratory for use in a Mariner vehicle shot to Mars, tentatively scheduled for 1964. Perkin-Elmer Corp., Stamford, Conn., built the prototype instrument.

Spectral resolution of better than 330 Å over the 2-to-4 micron band is provided with a 1-mm slit and an oscillating grating. Detection is accomplished with a lead selenide cell, radiation-cooled to -78 C. An umbrella cuts off the sunlight on one side of this detector and leaves the other side exposed to deep space temperatures. Chopping is accomplished with a darkened flag on a resonant reed, vibrating at 300 cps.

To confirm the presence of certain types of vegetation on a planetary surface, an IR spectrophotometer must determine the precise wavelengths of peak absorption (a 0.02-micron shift could be sufficient to invalidate a particular life process theory), and both the width and amplitude of the absorption band.

#### Reed Vibrates at 300 cps To Chop Incoming Radiation

In operation, incoming radiation is focused by a telescope on a slit in a focal plane field stop. The resonant-reed chopper, driven at 300 cps by electromagnetic coupling to a pole piece energized by a transistor feedback oscillator, is directly in front of the entrance slit.

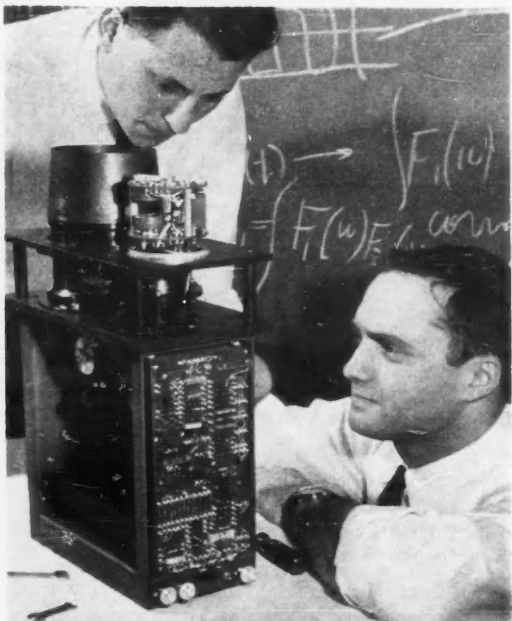
A mirror directs the chopped radiation onto the nutating grating, which first scans up and then down in wavelength. A grating angle signal, accurate to 1 part in 100, is resolver-generated for wavelength calibration of the spectral data. From the grating, the radiation is bounced off a mirror and focused on an exit slit. It passes through the slit and is imaged on the photoconductive detector.

The spectral information, riding on the 300-cycle carrier provided by the reed chopper, is transistor-amplified in a channel that permits an information bandwidth of ±60 cps. This is sufficient bandwidth to pass 180 sample points every 3 sec.

An automatic gain-control loop, keyed by an end-of-scan signal, detects the carrier envelope

CIRCLE 6 ON READER-SERVICE CARD

CIRCLE 7 ON READER-SERVICE CARD



**Infrared spectrophotometer**, designed to find out if there is any vegetation on Mars, is checked by Harold Sachs, left, project manager at Perkin-Elmer Corp., and John J. Russo, electronic engineer. The instrument is sensitive to absorption bands characteristic of hydrocarbons in vegetation.

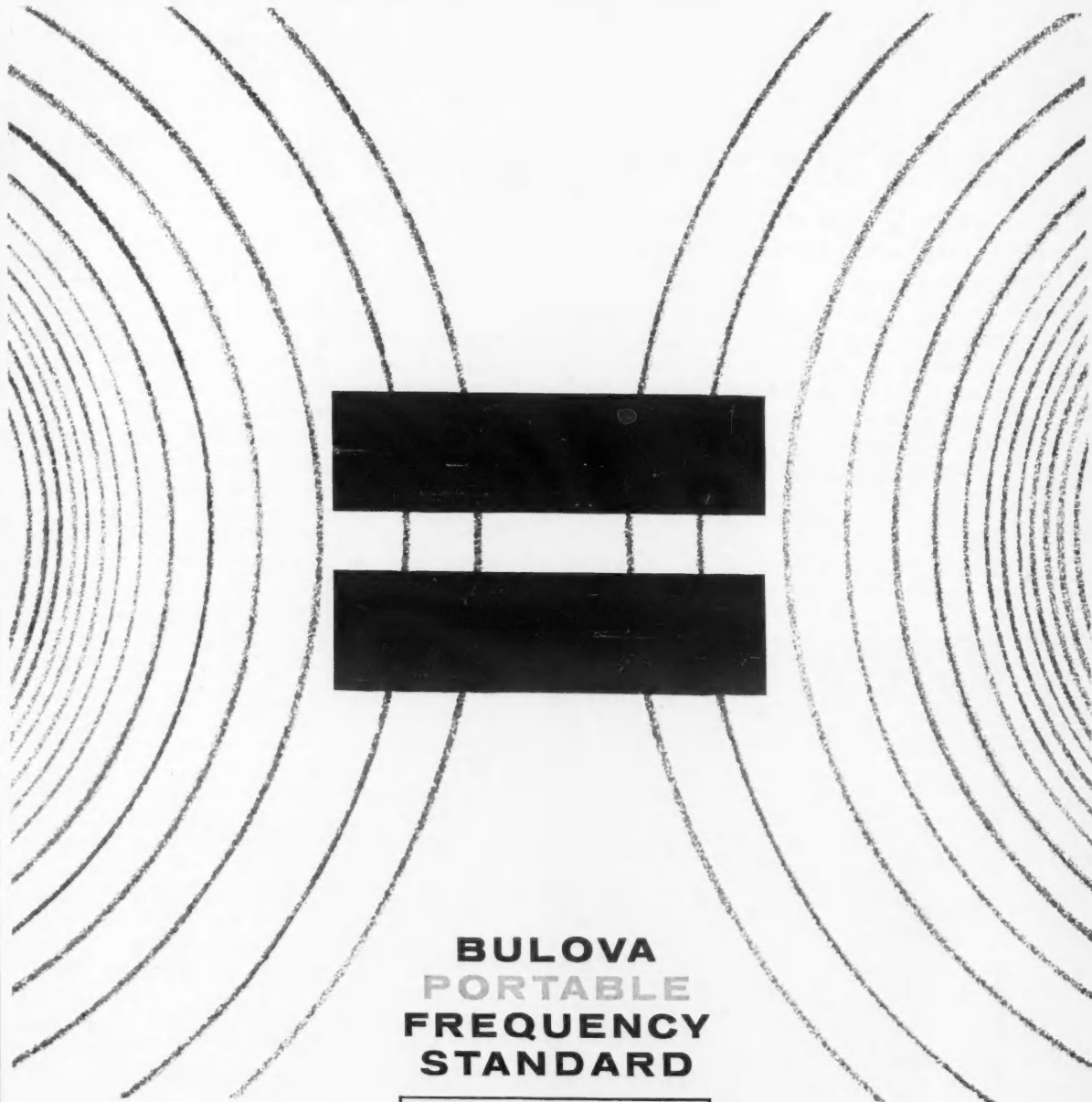
peak over each cycle and adjusts gain of the next cycle accordingly. Self-calibration is provided by a 300-cps burst of known amplitude introduced during each scanning cycle.

Signals from the main amplifier channel are applied to a 300-cps demodulator, which is synchronized with the vibrating reed drive circuit. The demodulated output is in the form of a 0-to-60-cps wave. This signal is filtered, to eliminate ripple, and applied to an analog sampler circuit, which performs amplitude sampling. The samples then are transferred to boxcar holding networks.

An analog-to-digital converter shifts these analog levels to six-bit binary words, permitting 20 gray scale levels plus parity check. Scan angle signals for wavelength synchronization are also processed, and then all data are stored for transmission.

The information rate for transmission will be time-expanded some 100 to 200:1, because of the expected 60-million-mile distance from Mars to earth. The instrument will scan perpendicular to the direction of motion across the Mars disk, generating about 300 geographical picture elements. At an expected 9,500 miles altitude, the surface projection will cover an area about 40 by 400 miles on the Martian surface.

The Perkin-Elmer spectrophotometer weighs less than 20 lb, measures 18 x 10 x 6 in., and dissipates less than 6 w power. ■ ■



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can assist you in pulling more accurate on-the-spot checks, write Department 1672, Bulova Electronics, Woodside 77, New York.

CIRCLE 8 ON READER-SERVICE CARD

## Solid State Emerging From Infancy With Impressive Gains

*Growth Apparent at IRE Show and Convention in Semiconductors, Integrated Circuits, Novel Transducers and EL Display Devices*

**I**MPORTANT steps forward in solid-state electronics appeared to be the dominant theme of the recent 1961 IRE International Convention and Show in New York. Another aspect of the show, however, was the wide range of product advances in every segment of the expanding electronics industry.

Rapid progress in the face of keen competition was apparent in equipment and component displays on all four crowded floors of New York's Coliseum.

Significant developments at the year's biggest



Piezoelectric and electroluminescent effects are combined to produce this flat display panel for moving images. Inventor Stephen Yando, scientist with General Telephone and Electronic Laboratories, described at an IRE Session how timing of pulses from each edge of the lead zirconate-titanate panel controls spot location. Background noise is rather high in the panel shown because a nonlinear resistance layer was not included for cutting out nonreinforced signals.

electronic convention included the following:

- **Heavy emphasis on human engineering in instrument lines.** This included appearance (color, panel layout, knobs and dials) as well as convenience (direct and digital readout, mobility, and easy maintenance).

- **Important semiconductor progress.** Laminar diodes and transistors were introduced at the show by Pacific Semiconductors, Inc., Culver City, Calif. A fast switching germanium transistor, designated ECDC (Electrochemical Diffused Collector), was introduced by Sprague Electric Co., North Adams, Mass. It is said to withstand higher currents than conventional types. A new semiconductor field-effect tetrode offering very high input impedance was shown for the first time by Crystalonics, Inc., Cambridge, Mass. (*ED*, March 29, p 66). Epitaxial transistors also drew high interest as several varieties were shown. Radio Corp. of America, Somerville, N.J., announced its entry into the field, and Fairchild Semiconductor Corp., Mountain View, Calif., introduced a planar epitaxial. Many other companies revealed plans to enter the field soon.

- **Logic circuits in transistor cans** (*ED*, March 29, p 4). These logic nets in TO-5 and TO-18 cans were shown by Raytheon Corp., Boston, Fairchild and General Instrument Corp., Newark, N.J.

- **New devices.** A gallium arsenide transducer that converts electrical energy to ultrasonic at microwave frequencies was described by a Bell Telephone Laboratories scientist. A light-actuated silicon switch capable of handling surge currents of 5 amp for 8 msec was introduced by Solid State Products, Inc. A ferrite piezomagnetic stress transducer was reported by C. E. Land of Sandia Corp.

A flat-panel electroluminescent display device, operated by the electrical fields set up by acoustical waves in a ceramic plate, was described by a General Telephone and Electronics Corp. researcher. The waves are set up by voltage pulses applied to electrodes at the edges of the ceramic piece, which is coated with electroluminescent material.

Attendance at the IRE Show slid to 66,432 from last year's 69,760. Many exhibitors com-

mented, however, that they believed the attendance was comprised of more engineers this year.

The carnival-like exhibits, reminiscent of years past, appeared definitely on the downgrade at this year's show. There were few "hawkers" in outlandish costumes, and the general tenor of the displays was low-pitched rather than hard-sell.

### Many New Semiconductor Approaches Give Higher Speed, Other Advantages

Advances in semiconductor technology made the biggest news at the show.

Five companies announced the immediate production availability of epitaxial transistors; other exhibitors revealed plans to produce them soon.

Motorola, Inc., Phoenix, Ariz.; Texas Instruments, Inc., Dallas; Sylvania Electric Products Inc., Woburn, Mass.; Fairchild Semiconductor and RCA all reported immediate availability of epitaxials and displayed specifications for the units.

Most were mesa types, but Fairchild was offering a planar epitaxial transistor which, it asserts, is useful both for high-speed switching and driving cores. Described as the first unit that combines both epitaxial and planar techniques, the 2N914 transistor is said to perform better than mesa devices at low current, because of the planar construction, and has better high-current characteristics than nonepitaxials.

In volume production, the 2N914 is priced at \$23 in less-than-hundred lots. Fairchild plans are to convert the company's other planar transistors to epitaxial devices.

Because the combination of planar and epitaxial techniques appears to offer usable current gain over a broader current range than either process affords alone, other manufacturers said they were planning to adopt the planar-epitaxial process. Five of them—General Transistor Corp., CBS Electronics, Solid State Products, Sperry Semiconductor Div. and General Electric Co.—indicated they are now developing planar epitaxials. GE reported it is working with both silicon and germanium versions, while Sperry said it is close to marketing a silicon planar epitaxial designed for switching.

RCA entered the epitaxial market with its

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Improved characteristics of epitaxial transistors, like those displayed here at the Motorola Semiconductor Products booth, drew the interest of many designers visiting the New York IRE Show.

2N934, a high-current, high-beta, pnp germanium mesa transistor for core driving. It has low saturation at high currents and resembles the company's 2N1300 medium speed dot mesa.

The company also plans to announce two other germanium mesa epitaxial transistors. It reported it was delaying the announcement pending standardization of new numbers for several epitaxial types.

Rheem Semiconductor Corp., Mountain View, Calif., is sampling a mesa type designed for high-current core-driving applications. The company said that as soon as the results of its sampling program can be analyzed, it will probably market an epitaxial transistor. It has already set up pre-production manufacturing facilities, Rheem said.

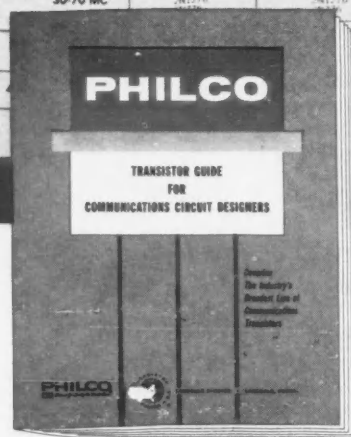
Other companies at the show reported epitaxial programs in various stages of development. Raytheon Co., Waltham, Mass., is planning to introduce a germanium unit around June, and possibly a silicon device later. Transatron Electronic Corp., Wakefield, Mass., said it will soon market the first of what will be a family of epitaxial units. Delco Div. of General Motors Corp., Kokomo, Ind., stated that for some time it has been researching high power silicon epitaxials. Silicon Transistor Corp., Carle Place, N.Y., asserted it has an R & D program under way in silicon epitaxial devices. CBS Electronics, Danvers, Mass., reported it plans to offer a silicon epitaxial device this summer. Hoffman Semiconductor Div., Los Angeles, is conducting research into epitaxial crystal growing, it said.

National Semiconductor Corp., Danbury, Conn., reported that it plans to introduce silicon epitaxials for ultra-high-speed switching—in the 20-nsec-total-time range—and for core driving, in a few months. Clevite Corp., Waltham, Mass., said it is near production of a fast-switching mesa epitaxial. Shockley Transistor, a Clevite affiliate, reported that it, too, is conducting R&D

CIRCLE 9 ON READER-SERVICE CARD ►

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2-10 MC	2N1747 2N1748 2N1749 2N1750 2N1751 2N1752 2N1753 2N1754	2N1747 2N1748 2N1749 2N1750 2N1751 2N1752 2N1753 2N1754	2N1746 2N1747 2N1748 2N1749 2N1750 2N1751 2N1752 2N1753	2N1746 2N1747 2N1748 2N1749 2N1750 2N1751 2N1752 2N1753	2N1586 2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593	2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593 2N1594	2N1267 2N1268 2N1269 2N1270 2N1271 2N1272 2N1273 2N1274 2N1275 2N1276
10-30 MC	2N1745 2N1746 2N1747 2N1748 2N1749 2N1750 2N1751 2N1752	2N1745 2N1746 2N1747 2N1748 2N1749 2N1750 2N1751 2N1752	2N1744 2N1745 2N1746 2N1747 2N1748 2N1749 2N1750 2N1751	2N1744 2N1745 2N1746 2N1747 2N1748 2N1749 2N1750 2N1751	2N1586 2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593	2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593 2N1594	2N1167 2N1168 2N1169 2N1170 2N1171 2N1172 2N1173 2N1174 2N1175 2N1176
30-70 MC	2N1742 2N1743 2N1744 2N1745 2N1746 2N1747 2N1748 2N1749	2N1742 2N1743 2N1744 2N1745 2N1746 2N1747 2N1748 2N1749	2N1741 2N1742 2N1743 2N1744 2N1745 2N1746 2N1747 2N1748	2N1741 2N1742 2N1743 2N1744 2N1745 2N1746 2N1747 2N1748	2N1586 2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593	2N1587 2N1588 2N1589 2N1590 2N1591 2N1592 2N1593 2N1594	2N1167 2N1168 2N1169 2N1170 2N1171 2N1172 2N1173 2N1174 2N1175 2N1176



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CIRCLE 10 ON READER-SERVICE CARD

## NEWS

in silicon epitaxials.

Laminar transistors announced at the Show by Pacific Semiconductors are made by a triple diffusion process, and are said to be very similar to epitaxial transistors. But if PSI's epitaxial processing is developed to the point where it proves more economical than the triple-diffusion process, the company may switch to epitaxial processing, according to a spokesman.

### Sprague High Power Transistor Avoids Use of Epitaxial Layer

Taking a different route from the new makers of epitaxial transistors, Sprague Electric Co. announced a germanium transistor, designed without an epitaxial layer. According to the company, it will handle five to six times the power of present germanium transistors.

The new XT100 electrochemical diffused-collector transistor was reported to combine power dissipation of 400 mw with a gain-bandwidth product of 300 mc. Beta linearity was said to be good between 0.5 and 500 ma. Designed for high-current, high-speed core driver and computer memory applications, the XT100 was priced at \$22.50 in quantities of 1-99, \$15.00 for 100 or more.

Varactor diodes with cut-off frequencies of 150 Gc were available from Raytheon, Sylvania Electric Products and Micro State Electronics Corp. The Raytheon unit was a gallium-arsenide type that is expected to find application as a pre-amplifier in radar systems, where it would provide low-noise microwave amplification.

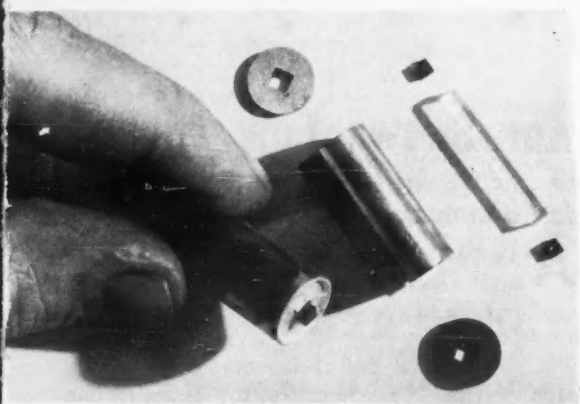
Sylvania offered two versions of its variable-reactance diode: a microminiature type with 150 Gc cut-off, and a double-ended unit with 100 Gc cut-off in a ceramic package for high Q applications. Both are silicon units made by epitaxial techniques.

Micro State's varactors are packaged in a pill-box configuration 0.120 in. diam and 0.050 high. They are gallium-arsenide mesas designed for use in parametric amplifiers, microwave switches and harmonic generators.

### Ultrasonic Microwave Transducer Reported in Technical Session

A new gallium arsenide transducer which converts electrical energy into ultrasonic energy at microwave frequencies was described during a technical session by Donald L. White of Bell Telephone Laboratories.

According to Mr. White, the transducer should open up many avenues for ultra-speed computer and microwave designers. Two immediate appli-



**Ultrasonic delay line** using two gallium arsenide transducers. The small blocks of piezoelectric semiconductor, coated with thin metal films, are bonded to each end of an inch-long quartz crystal which acts as the delay medium. Ultrasonic waves are formed and detected in the high-resistance depletion layers in the semiconductor next to the quartz. The device was reported by Bell Telephone Laboratories.

cations will be in microwave delay lines and as a scientific tool for study of materials.

The device is based on the fact that gallium arsenide semiconductor material, unlike germanium and silicon, is also piezoelectric. The novel feature, Mr. White said, is that the electromechanically active portion of the transducer is the high-resistance depletion layer of the p-n junction formed at a rectifying metal-to-semiconductor contact.

The electrical inputs are the voltage variations across this diode. Outputs are the coherent mechanical waves coming from the depletion layer region of the gallium arsenide.

A new flat-panel display device for moving images described by Stephen Yando of General Telephone and Electronic Corp. Laboratories, Bayside, N.Y., uses both piezoelectric and photoelectric effects.

An electroluminescent phosphor coating is applied to a ceramic plate which has electrodes at the sides. When voltage pulses are applied to the electrodes, electric fields are set up in the ceramic because of piezoelectric effects. These fields cause the phosphor coating to luminesce. Spot positions are controlled by timing of the pulses from each edge of the plate, and the spot intensity is modulated by an electric field applied to a transparent conductive coating over the electroluminescent layer.

Lead zirconate-titanate was used by Mr. Yando for his experiment. A nonlinear resistance layer is included in the panel to cut off spurious effects of noninteracting signals. Trace brightness of about 0.1 ft-L and spot size of about 80 mils have been achieved. ■ ■

# 3 new additions to the

## SPRAGUE MADT\* transistor line!

High-speed switching transistors in TO-18 cases are now being mass-produced by Sprague. These hermetically-sealed germanium Micro-Alloy Diffused-base Transistors are made by a controlled-etch process to insure extreme uniformity. Maximum frequency capabilities have been improved by graded-base construction. Automated manufacturing techniques have brought about increased production efficiency, permitting favorable reductions in prices. This is why Sprague MADT Transistors can offer you greater performance per dollar than other high-speed devices in low-current switching circuits.

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#### TYPE 2N768

- Micro-energy switch—designed for low current, low voltage, high speed applications
- 10 mc pulse rates, collector currents as low as 1 ma, collector supply voltages as low as 1 volt
- No reduction in switching speed, as with ordinary low current, low voltage devices. Permits higher density packaging
- Typical DC beta of 40 @  $V_{CE} = -0.20$  v,  $I_C = -2$  ma

#### TYPE 2N769

- World's fastest switch—will operate reliably at speeds in excess of 100 mc
- Gain bandwidth product ( $f_T$ ) typically 900 mc
- Low capacitance, low saturation voltage, high beta—ideal for low-level, high-frequency logic circuits
- Extremely low hole storage factor ( $K'_s$ ) typically 18 nsec

#### TYPE 2N779

- Manufactured with tighter parameter control than any other transistor in the industry
- Designed to meet rigid specifications of 16 electrical characteristics—ideal for NOR logic and other supercritical applications
- Low saturation voltage—typically 0.12 volts
- Higher in performance, lower in price than mesa transistors with lesser specifications

#### Other Sprague Micro-Alloy Diffused-Base Transistors

TYPE	APPLICATION
2N499	Amplifier, to 100 mc
2N501	Ultra High Speed Switch (Storage Temperature, 85 C)
2N501A	Ultra High Speed Switch (Storage Temperature, 100 C)
2N504	High Gain IF Amplifier
2N588	Oscillator, Amplifier, to 50 mc

For complete engineering information on the types in which you are interested, write Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts.

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## EECO CIRCUIT APPLICATIONS UNLIMITED

### Pulse Width Detection

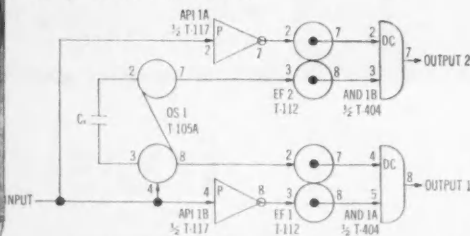
Pulse width detection circuits are normally required to perform only one of two functions: They produce an output signal when the input pulse (1) is wider than specified, or else (2) is narrower than specified. The EECO pulse width detection circuit described here performs both of these functions.

#### EECO T-SERIES MODULES

The circuit employs the following five T-Series germanium plug-in circuit modules:

- 1 only T-105A One-Shot Multivibrator (OS 1)
- 1 only T-117 Dual Pulse Inverter (API 1A and API 1B)
- 2 each T-112 Dual PNP Emitter Followers (EF 1 and EF 2)
- 1 only T-404 DC Logic (AND 1A and AND 1B).

The specified pulse width is established by the output pulse duration of the one shot OS 1. This is primarily determined by an external capacitor connected between pins 2 and 3 of OS 1.



**CIRCUIT DESCRIPTION** Input pulses are applied to both halves of pulse inverter API 1, and also to one shot OS 1. Capacitor  $C_x$  is selected so that the output pulse duration of OS 1 is longer than that of narrow input pulses to be detected, but shorter than that of wide input pulses to be detected. This selection is based on the following relation between capacity and duration:

$$C_x = 50(t-2)$$

where  $C_x$  is capacitance in  $\mu\text{f}$  and  $t$  is duration in microseconds. (The minimum pulse duration is 2 microseconds with no external capacitance; the maximum pulse duration is 1 second with  $C_x = 50 \mu\text{f}$ .)

**DETECTING WIDE PULSES:** The positive-going excursion of an input pulse triggers OS 1, but does not affect API 1B. As OS 1 is triggered, the output at pin 8 of OS 1 decreases to -11 volts. This voltage is coupled through EF 1 to inhibit AND 1A at pin 4 for the duration of the one-shot pulse. When the input pulse ends, the negative-going excursion triggers API 1B, which, in turn, couples an output through EF 1 to pin 5 of AND 1A.

If the input pulse is narrower than the established critical pulse width, AND 1 is still inhibited when a pulse is presented by API 1B. If, however, the input pulse is wider than the established critical pulse width, the output at pin 8 of OS 1 will have returned to -3 volts by the time a pulse is presented by API 1B, and AND 1A will be enabled. In this latter case, the pulse from API 1B causes an output from the circuit.

**DETECTING NARROW PULSES:** Input pulses trigger one-shot OS 1 as described above. In this case, the "0" (pin 7) output of OS 1 is coupled through EF 2 to enable AND 1B at pin 3 for the duration of the one-shot pulse. When the input pulse ends, the negative-going excursion triggers API 1A, which, in turn, couples an output through EF 2 to pin 2 of AND 1B.

If the input pulse is narrower than the established critical pulse width, AND 1B is still enabled when a pulse is presented by API 1A, and the circuit generates an output pulse. If, however, the input pulse is wider than the established critical pulse width, the output at pin 7 of OS 1 will have returned to -11 volts by the time a pulse is presented by API 1A and AND 1B will be inhibited, preventing any outputs.

This is typical of the many practical applications of EECO T-Series Germanium plug-in circuit modules. We stand ready to furnish circuit modules and application data to meet the needs of your specific problems. Write or wire today.

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## NEWS

### New Maser Resonator Shows Low Losses

Confocal Structure Described at Quantum Conference  
Said to Have Minimum Mode Volume and Diffraction Loss

**A** PROMISING new type of multimode resonator, reported to show minimum mode volume and diffraction losses, has been operated in a ruby maser.

G. D. Boyd of Bell Telephone Laboratories, Murray Hill, N.J., describes the resonator as formed by two spherical reflectors separated by their common radius of curvature and sharing a common focus.

Diffraction losses of the confocal resonator, he reports, are orders of magnitude less than those for the commonly used Fabry-Perot interferometer resonator, in which flat mirrors face each other in precisely parallel alignment. The optical alignment of the new resonator is said to be not critical.

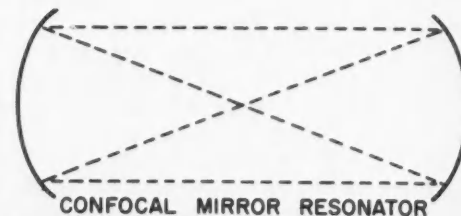
Other advantages cited for the confocal resonator were:

- It is relatively free from vibratory effects.
- It does not appear to require as highly accurate surfaces over large areas as parallel-plate devices do.
- It combines all unsymmetrical modes at a single frequency.

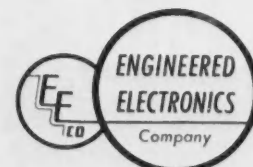
Mr. Boyd told an audience at the recent Second Quantum Electronics Conference at Berkeley, Calif., that because of the smaller mode volume, the confocal resonator required less fluorescent material for a cavity of given Q than plane-parallel resonators. This, he said, indicates that the pump power required may be less.

Bell Laboratories believes that the confocal resonator will be widely used in masers ranging from the millimeter through the optical range.

**Confocal resonator, top, is formed by two spherical reflectors separated by their common radius of curvature. The mirrors share a common focus, through which they re-image radiation. Mode volume and diffraction losses are said to be lower than for conventional plane-parallel Fabry-Perot interferometer resonators, bottom, which lose radiation that is reflected from plates at an angle. Bell Laboratories researchers believe confocal resonators will find wide use in millimeter through optical-wavelength masers.**



ELECTRONIC DESIGN • April 12, 1961





At the three-day meeting, some 700 listeners—more than were expected to be present—heard about 65 invited papers, 12 of which were given by researchers of Bell Telephone Laboratories. Although reports of work in optical masers dominated the conference, significant papers from other areas of quantum electronics were presented.

#### Researchers Disagree On Nature of Resonant Modes

Two approaches to determining resonant modes in gaseous maser interferometers were reported at the meeting. They indicate different results.

A. G. Fox and Tingye Li of Bell Laboratories are using an iterative computer technique to analyze the low-loss modes in interferometer cavities. At American Optical Co., Southbridge, Mass., Elias Snitzer is studying mode patterns by a shortcut method using glass fibers.

An extension of this approach indicates that the modes of an interferometer cavity appear to be some linear superposition of the plane-wave modes in the glass fiber waveguides, as their indices of diffraction go toward zero. The fibers used have diameters of 0.1 to 25 microns and core indexes of refraction ranging from 1.49 to 1.75.

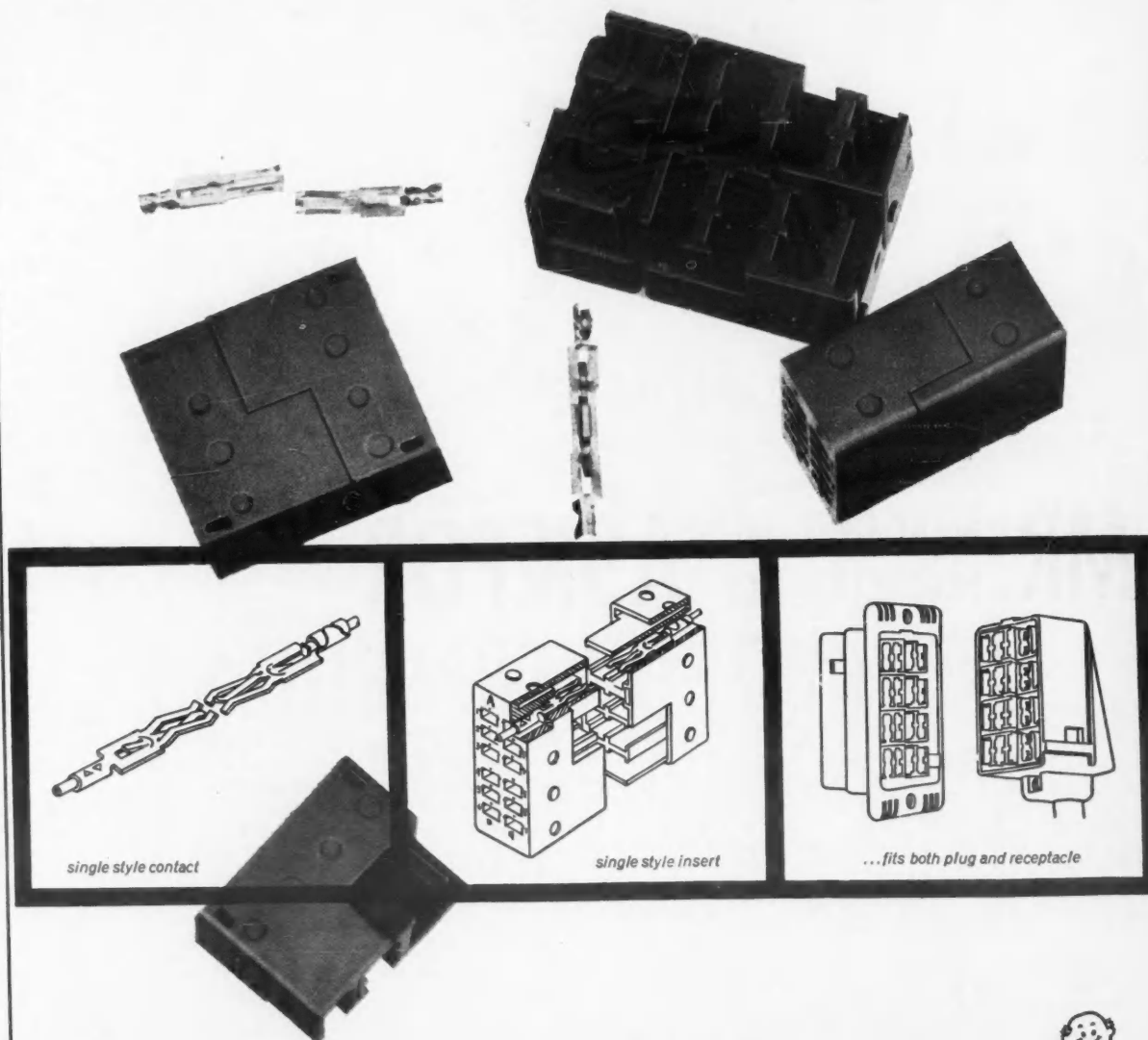
At Bell Laboratories a digital computer is programmed to compute the electromagnetic field across the interferometer mirror. This computation was done for separate modes having various field distributions over the aperture. The frequency of the first unsymmetrical mode, which is in good agreement with that observed in gaseous masers, falls at 1.3 mc.

The preliminary results at American Optical indicate that there should be a large number of individual peaks or resonance modes in the region below 1.3 mc.

#### Linewidth of Gaseous Maser Is Narrower Than Thought

Recent work on the gaseous maser developed at Bell Laboratories was reported in three papers. Researchers there are evaluating the type of light being produced, refining measurements, measuring gains and making duplicate units for use in other parts of the company. They report that the gaseous maser still appears to be permanently limited to low-power outputs but that its beam would be entirely adequate for communication purposes. Modulation and detection problems rather than low output were cited as limiting factors for such use immediately.

D. R. Herriott of Bell Laboratories reported



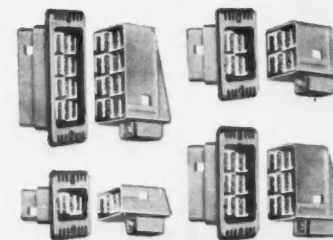
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# CANNON PLUGS



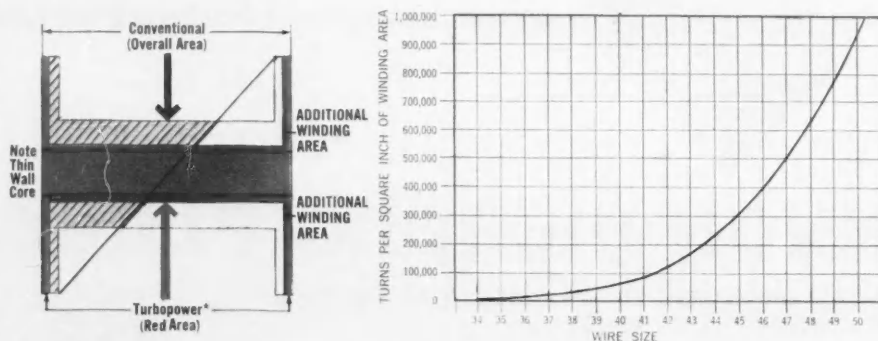
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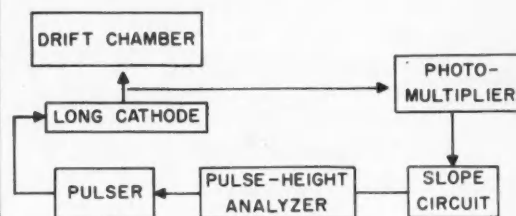
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## NEWS



**Measurement system** examines radiated decay to determine lifetimes of atomic states of gases for use in gaseous masers. The impact of electrons from the long cathode excite atoms in the gas tube. Photons are emitted through a monochromator (not shown) to a photomultiplier, which converts them to an electrical signal. The delay of this exciting signal after the exciting pulse indicates the lifetime of the state.

that spectral line width with the helium and neon mixture used is much narrower than previously thought. Linewidths now appears to be a few kc, rather than 10 kc.

### Electrical Modulating System Held Promising for Light

In a discussion of various methods of modulating light at microwave frequencies, P. S. Pershan, of Harvard University indicated that he preferred electrical modulating schemes to mechanical or magnetic methods. Electrical modulation, he said, would use the electro-optic effect of the modulating medium. In the microwave region, solids appear to have larger electro-optic effects and lower losses than liquids, which require very high power for even the lowest microwave frequencies, Mr. Pershan reported.

The most promising solid appears to be potassium dihydrogen phosphate, he said. The electro-optic effect in crystals of this material is large enough to overcome the effects of dielectric losses that create heat.

The disadvantages of mechanical modulation were said to be the difficulty of obtaining uniform modes of short-wavelength acoustical waves for interaction with the light beam. Magnetic modulation was said to be possible with either paramagnetic crystals or crystals with cooperative magnetization, such as ferromagnetic or ferrimagnetic crystals. Paramagnetic modulation must be accomplished at cryogenic temperatures, but modulation with cooperatively magnetized materials could probably be accomplished at room temperature, the speaker said.

Mr. Pershan reported that a traveling-wave-tube modulation system using a  $\text{KH}_2\text{PO}_4$  crystal was in development.

Among the papers that did not deal with optical masers, that of Benjamin Lax of the Lincoln Laboratory, Lexington, Mass., attracted much attention. Dr. Lax reported that a semiconductor

cyclotron resonance maser appeared quite feasible. Such a unit would supply a tunable monochromatic source in the submillimeter and far-infrared region of the spectrum, he said.

The proposed system involves optical pumping by an electric dipole interband transition between selective magnetic levels of a valence band to those in the conduction band to create a population inversion.

The stimulated emission would be achieved between two adjacent levels in the valence band corresponding to a cyclotron resonance transition. An optical ruby maser or its equivalent should be the ideal source for the optical pump, Dr. Lax said, because 100 w of peak energy should be adequate for providing sufficient electrons in the desired magnetic level to overcome the losses in the interferometer.

Daniel Kleppner of Harvard University, reported on highly stable signals achieved with an atomic hydrogen maser. He anticipated that experiments would soon show ultimate stabilities as small as one part in  $10^{14}$ . He said the interaction of beam atoms and wall atoms was the limiting factor in achieving the highest possible stability.

Photodetection and photomixing of optical maser outputs were discussed by A. T. Forrester of Electro-Optical Systems, Inc., Pasadena, Calif. His theory that such mixing or beating is possible has been vindicated by the appearance of extremely narrow optical maser beams and their use in experiments in mixing. He said that the vast increases in optical power per unit bandwidth per unit source area per unit solid angle were making virtually the entire radio-frequency receiver technology available for optical purposes in spectroscopy and communications.

At Bell Laboratories difference frequencies of 300 mc are said to have been achieved by mixing optical maser outputs. The low response of a multiplier tube is limiting achievement of higher beat frequencies, Bell reports.

#### Cerenkov Effect May Give Sub-Mm Power; 0.6 w at 8 mm Already Produced

Cerenkov radiation was described as a promising source of power in the sub-millimeter wave region by P. D. Coleman, University of Illinois, who reported that 0.6 w had been produced at 8 mm by using an S-Band Rebatron. Cerenkov radiation is produced by charged particles passing through a transparent medium with a velocity exceeding their velocity in the medium. The medium used was a Teflon cone. Dr. Coleman said a K-band Rebatron would produce more power at narrower wavelengths, with wavelengths of less than 0.3 mm easily achieved. Use of a plasma or ferrite medium was said to promise higher powers than Teflon. ■ ■

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2N781  
2N782

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#### • SYLVANIA 2N781 ... world's fastest PNP germanium switch!

CONDITIONS	MAX.
$V_{BE(ON)} = 0.5 \text{ V}; I_{B(ON)} = -1 \text{ mA}$	$t_d + t_f, 60 \text{ nsec}$
$V_{CC} = -3.5 \text{ V}; R_C = 300 \text{ Ohms}$	$t_r, 20 \text{ nsec}$
$I_{B(OFF)} = 0.25 \text{ mA}$	$t_f, 50 \text{ nsec}$

#### ... features unusually low $V_{CE}$ (sat)

CONDITIONS	MAX.
$I_C = -10 \text{ mA}, I_B = -1 \text{ mA}$	-0.16 V
$I_C = -100 \text{ mA}, I_B = -10 \text{ mA}$	-0.25 V

**SYLVANIA 2N781**—a remarkable advance in epitaxial mesa techniques—is a superior switching device featuring speeds previously unattainable with a germanium transistor. Too, it provides exceptionally low saturation voltage at all current levels.

**SYLVANIA 2N782**, electrically similar to the 2N781, is specifically designed for service where high speed switching, low saturation voltage and economy are prime design requirements.

**SYLVANIA 2N781, 2N782**, utilize the TO-18 package with the collector internally tied to the case. Both are products of highly automated Sylvania manufacturing techniques and possess exceedingly uniform electrical characteristics.

#### ABSOLUTE MAX. RATINGS (AT 25°C)

	2N781	2N782	UNIT
Collector to Base Voltage	-15	-12	V
Collector to Emitter Voltage	-15	-12	V
Emitter to Base Voltage	-2.5	-1.0	V
Collector Current	100	100	mA
Power Dissipation (free air)	150	150	mW
Power Dissipation (case at 25°C)	300	300	mW
Storage Temperature	-65 to +100	-65 to +100	°C
Junction Temperature	+100	+100	°C

#### ELECTRICAL CHARACTERISTICS (AT 25°C)

Symbol	Conditions	2N781		2N782		UNIT
		Min.	Max.	Min.	Max.	
$V_{CE(O)}$	$I_C = -100 \mu\text{A}, I_B = 0$	-15	—	-12	—	V
$V_{BE(O)}$	$I_B = -100 \mu\text{A}, I_C = 0$	-2.5	—	-1.0	—	V
$V_{CE(SAT)}$	$I_C = -100 \mu\text{A}, V_{BE} = 0$	-15	—	-12	—	V
$t_{90}$	$I_C = -10 \text{ mA}$ $V_{CE} = -0.22 \text{ V}$	25	—	—	—	nsec
$t_{95}$	$I_C = -10 \text{ mA}$ $V_{CE} = -0.25 \text{ V}$	—	—	20	—	nsec
$V_{BE}$	$I_C = -10 \text{ mA}, I_B = 0.4 \text{ mA}$	-0.34	-0.44	-0.34	-0.50	V
$I_{CBO}$	$V_{CB} = -5 \text{ V}, I_B = 0$	—	-3.0	—	-3.0	$\mu\text{A}$
$V_{CE(SAT)}$	$I_C = -10 \text{ mA}, I_B = -1 \text{ mA}$ $I_C = -100 \text{ mA}, I_B = -10 \text{ mA}$	—	-0.16	—	-0.20	V
$t_d + t_r$	$V_{BE(ON)} = 0.5 \text{ V}, I_{B(ON)} = -1 \text{ mA}$	—	-0.25	—	-0.45	V
$t_r$	$V_{CC} = -3.5 \text{ V}, R_C = 300 \text{ ohms}$	—	60	—	75	nsec
$t_f$	$I_{B(OFF)} = 0.25 \text{ mA}$	—	20	—	35	nsec
$t_t$		—	50	—	75	nsec

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## NEWS

**Designer's dream** is the glittering row upon row of competitive products brought together for the year's annual IRE Show at New York's Coliseum. Foot-weary shoppers who made it all the way through four

floors of exhibits found many new encapsulating materials, printed-circuit boards, solid-state devices, improved instruments, and more useful products. (See show wrap-up story, p 8).

# IRE Show, 1961: A Panorama of Glittering Products . . . Speeches . . . People



**Communication at optical frequencies** is altogether practical, says Bell Telephone Laboratories' G. C. Dacey at a session on "Broadening Device Horizons." He reported that modulation of light over a bandwidth of only 0.001 per cent of the carrier would give a communications channel of several gigacycles, enough to carry all the north-south communications in the United States. He noted, however, that optimum modulation schemes are still not available. He added that research in the area is looking promising. Laser is in foreground.



**Circuit** is printed on an integrally damped board made by sandwiching a broad-temperature-range elastomer between two sheets of laminate, one or both of which may be copper clad. Such damped boards are extremely resistant to vibration, says Lord Manufacturing Co., Erie, Pa., manufacturer of the damped boards. They are intended for airborne applications.



**Monkeying around** as they are registered for the IRE Show by Show Manager Will Copp are Murph and Jerry, two medical research assistants who drew crowds to the International Rectifier Corp. booth. Heartbeat signals from the chimps were displayed on oscilloscope monitors as they played inside a huge plastic bubble.



**Matched microwave** components, integrated into a complete system unit, were introduced at the show by Raytheon Co., Boston, Mass. This unit is a 6-megawatt S-band chain.



**Round and round** went this little train at the Westinghouse Corp. exhibit, powered by a 40-w thermoelectric generator.

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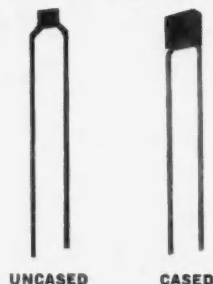
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  .3 x .3 x .1 through 10,000 mmf
- Also available uncased for complete assembly encapsulation.



.....Rugged pre-molded flame-resistant outer case assures standard wall thickness, guaranteeing environmental immunity and absolute product uniformity. Square modular shape affords highest capacity per usable volume.

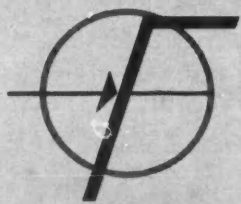
.....Epoxy potting solidly anchors, hermetically seals capacitor within case; increases mechanical strength and eliminates humidity leaks around leads.

.....Resilient, moisture-proof plastic sheathing protects unit during assembly and absorbs thermal shock at extremes of temperature cycling.

.....Uniformly exact dielectric margins around electrodes eliminate short circuiting and breakdown across edges under surge voltages through 400% of rating. Single standard 0.2" lead dimension for all values simplifies circuit design.

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These double-diffused silicon transistors have low saturation resistance and a reserve of speed, power handling and current range that permit the widest latitude in circuit design. Silicon's temperature characteristics are an added bonus.

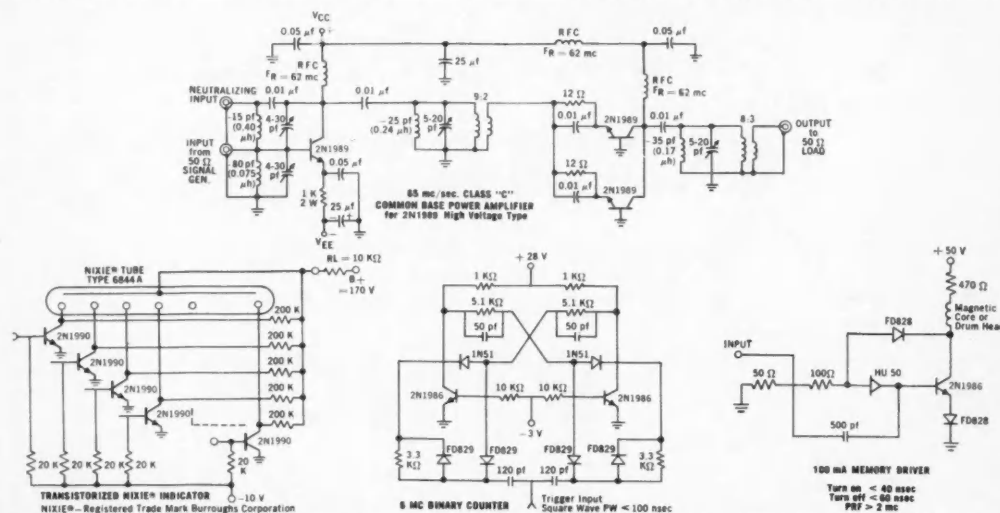
## AT COMPETITIVE PRICES

Prices are now comparable or lower than silicon transistor types of more limited performance. They are also competitive with germanium.

## WITH ASSURED AVAILABILITY

All are available nationwide through regular Fairchild distributors. The Fairchild name and the 2N numbers are double protection for circuit designs you base on these specifications.

## TYPICAL CIRCUIT APPLICATIONS



## ELECTRICAL CHARACTERISTICS (25° C except as noted)

TYPES	DESCRIPTION	JEDEC OUTLINE	f <sub>T</sub> TYPICAL	P <sub>C</sub> @25°C CASE TEMP.	h <sub>FE</sub> MIN. MAX.	V <sub>CE</sub> R	V <sub>CE</sub> O	V <sub>BE</sub> (Sat) MAX.	V <sub>CE</sub> (Sat) MAX.	I <sub>CEO</sub> @25°C MAX.
2N1985 2N1984 2N1983	Small signal types for AC and DC amplifiers	T0-5	50 mc	2 watts	15* 45* 35* 100* 70* 210*	40	50	—	—	5 μA
2N1987 2N1986	Switching types	T0-5	50 mc	2 watts	20 80 60 240	40	50	0.9	0.6	5 μA
2N1989 2N1988	High voltage types particularly suited to video amplifiers and RF oscillators	T0-5	50 mc	2 watts	20 60 35 120	60	100	1.0	2.0	5 μA
2N1991	PNP complement to the small signal and switching types	T0-5	50 mc	2 watts	15 60	25	30	-1.5	-1.5	5 μA
2N1990	Neon tube and Nixie® driver type	T0-5	—	2 watts	20 —	60	100	1.0	0.5	—

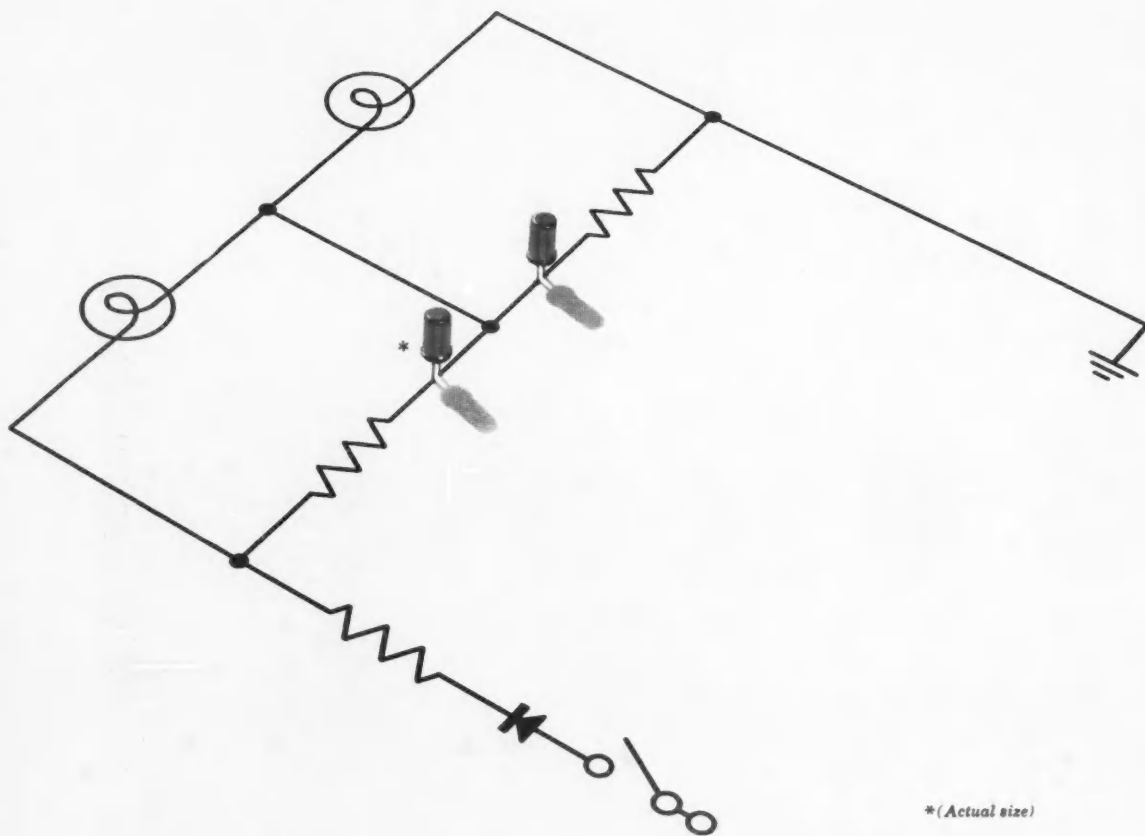
Nixie Registered Burroughs Corporation.

\* For the small signal types, this specification is h<sub>FE</sub> at 1 h<sub>CE</sub> instead of h<sub>FE</sub> at DC.

Write for full specifications



545 WHISMAN ROAD, MOUNTAIN VIEW, CALIF.-YORKSHIRE 8-8161-TWX: MN VW CAL 853  
A wholly owned subsidiary of Fairchild Camera and Instrument Corporation



\*SHOCKLEY 4-LAYER DIODES used in Roto-Tellite two-lamp reliability alarm circuit designed by Master Specialties Company, Los Angeles, California.

\*(Actual size)

## ALARM CIRCUIT RELIABILITY

When alarm circuits are required by critical military and industrial applications, two lamps are often connected in parallel for maximum reliability. The circuit shown above, now in production by Master Specialties Company, Los Angeles, uses the Shockley 4-layer diode to provide a shunt path around the defective lamp when one lamp fails.

The 4-layer diode, the semiconductor equivalent of a single directional relay, is ideal for alarm circuits where space, weight and positive operation are important. This simple, inexpensive and

dependable device performs a function which formerly required four or five components in alarm and annunciator circuits. It is suitable for circuits of every type—a basic alarm with one lamp or two—flashing or continuous master light indication—high or low power alarm signal.

For application notes on alarm circuits...or on pulse modulators, flip-flops, ring counters, dc to ac inverters, pulse generators...or just plain solid state switching—call or write your local Shockley representative or write Dept. 11-2.

**Shockley** TRANSISTOR

UNIT OF CLEVITE TRANSISTOR

STANFORD INDUSTRIAL PARK, PALO ALTO, CALIF.

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CLEVITE  
CORPORATION

## NEWS

### New Approach to Diode Construction: 19 Layers

*Units Have Low Capacitance And High Forward Current*

**L**OW-capacitance, high-forward-current diodes are being built in 19 layers to combine many desirable characteristics in one component.

The manufacturer, Pacific Semiconductors, Inc., of Culver City, Calif., reports the new laminar diodes show 200 ma per pf at 1 v, compared with the conventional 20 to 30 ma per pf. Henry Frazier, the company's R&D program director, says:

"It's not hard to make diodes with high current, or fast diodes, or diodes with high reverse breakdown voltage, high Q, low stored charge, or what have you. But it is hard to make a diode that optimizes all these characteristics. And that's what we're doing now."

#### Layer Structure Adaptable To Different Diode Types

The laminar structure permits the manufacture of 18 or 20 different diode types, Mr. Frazier says. By varying the parameters of layers within the diode, the company can switch from one type to another. Diodes can be made so the forward-current characteristics—with respect to forward voltage—make the diode look like a germanium gold-bonded type, and with reverse characteristics that make it look like silicon.

Classically germanium gold-bonded diodes have about 20 ma forward current at 0.6 v. The reverse characteristics of silicon, which the diodes also have, are measured in nanoamperes, while germaniums are in microamperes.

The multiple-layer structure includes the following steps:

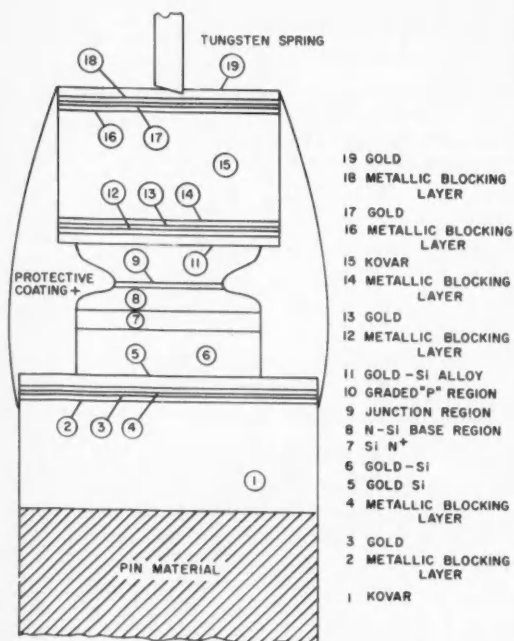
A mils-thick layer of Kovar is welded to the crystal pin. An opposite layer, or tab, is later attached. In plating processes, the Kovar tabs are coated with layers of different metals, each designed to serve a specific purpose. Then the prepared electrodes are gold-bonded to the silicon.

Next a metallic layer, several millionths of an inch thick, serves as a block for the diffusion of Kovar constituents up toward the silicon.

A third layer, gold, separates the two metallic blocking layers to cut down porosity. The second blocking layer prevents diffusion of silicon downward to the Kovar.

The fifth layer is a stratum of gold several ten





**Nineteen-layer diode** structure developed by Pacific Semiconductors combines many advantages.

thousandths of an inch thick. This is used as the base material during mounting for the formation of a gold-silicon eutectic layer, which is fluid at the mounting temperature.

"This layer, then," Mr. Frazier explains, "is the layer of bonding material in the final unit, composed of silicon and gold in the eutectic composition."

Silicon single-crystal material, a couple of mils thick and of almost uniformly heavily doped n-type silicon, serves as the back contact layer for the diode. Beyond this layer is a sharply graded layer or n-type silicon, which grades n-type doping from a heavily doped material of a level of from  $10^{16}$  to  $10^{17}$  atoms per cc. This layer is less than a mil thick. The next layer, also less than a mil thick, is of uniformly doped material at a level of about five times  $10^{16}$  n-type silicon. This level establishes the capacitance and breakdown value of the final unit. An infinitesimally thin layer of material, depleted of carriers, follows and represents the p-n junction.

The next layer, Mr. Frazier explains, is a graded distribution of p-type silicon, graded from the junction up to the top surface of the mils-thick layer, where the concentration of p-type dopant is on the order of  $10^{20}$ .

Now the system on the bottom is repeated on the top. The final top layer is a mils-thick layer of gold.

"We use this gold layer to give us good rugged contact from the diode to the tungsten spring whisker," Mr. Frazier notes. ■ ■

# NEW...

## Regatron Programmable CONSTANT-CURRENT POWER SUPPLIES

Extremely low ripple... 0.1% load regulation\*... wide operating range... the well-known Regatron features are incorporated in these new constant-current power supplies. Transient response time is less than a millisecond. A modulation input is a standard feature. A vernier permits continuous zero-to-maximum coverage throughout each of 16 current ranges.

These c-c supplies are programmable too. Current output can be controlled by means of a remote resistor at any convenient location. Shunt the programming terminals with the resistor and the Regatron delivers a precise value of constant-current to your load. Voltage compliance, or load voltage capability, rises above the minimum values cited in the brief table below, with decreasing current settings.



### BRIEF SPECIFICATIONS

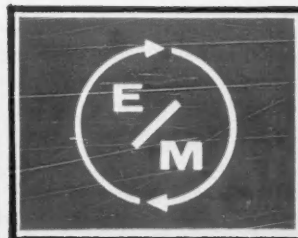
105-125 V, 50-60 CPS LINE  
(Prices are F.O.B. Eatontown, New Jersey)

MODEL	OUTPUT	VOLTAGE COMPLIANCE (MINIMUM)	DIMENSIONS			PRICE
			H	W	D	
C612A	1 uA to 100 ma	100 V	3½	19	9¼	\$289
C624A	2.2 uA to 220 ma	100 V	3½	19	9¼	\$364
C621A	5 uA to 500 ma	100 V	5¼	19	15	\$479
C620A	5 uA to 500 ma	50 V	5¼	19	15	\$449

\* Load regulation is 0.1% for all models except 0.2% on 1 and 2.2 uA ranges of Models C612A and C624A.

You'll find the programming feature, voltage compliance, and other performance data fully detailed in four-page Specification Sheet 3072A. Ask your local E/M representative or write...

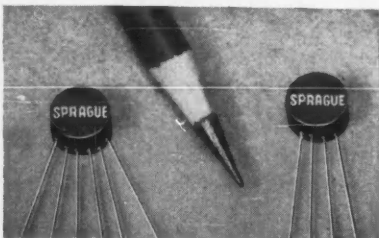
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**ELECTRONIC  
MEASUREMENTS  
COMPANY, INCORPORATED**  
EATONTOWN · NEW JERSEY

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## New Nanosecond\* Pulse Transformers for Ultra-miniature, Ultra-high Speed Applications



Digital circuit designers will find the new Sprague Type 43Z Nanosecond Pulse Transformers of considerable interest. These tiny transformers have been carefully designed for the all-important parameter of minimum rise time at high repetition rates up to 10 mc.

The new Type 43Z series is comprised of a broad line of 72 pulse transformers in 10 popular turns ratios. They are Sprague's latest addition to the most complete listing of pulse transformers offered by any manufacturer for use in digital computers and other low-level electronic circuitry.

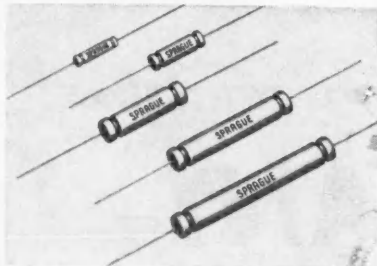
Type 43Z Pulse Transformers are designed so that the product of leakage inductance and distributed capacitance is at a minimum. They are particularly well suited for transformer coupling in transistor circuits since transformers and transistors are very compatible low impedance devices. Nanosecond transformers are equally suitable for transmission line mode of operation, in twisted-pair transmission line coupling, and in regenerative circuits.

The epoxy-encapsulated "pancake" package is excellent for both etched wire board or conventional chassis mounting. To simplify etched-board design, these ultra-miniature pulse transformers are available with leads terminating at the side or the bottom of each unit.

For complete technical information on Type 43Z Nanosecond Pulse Transformers, write for Engineering Data Sheet 40235 to Technical Literature Section, Sprague Electric Co., 347 Marshall St., North Adams, Mass. \*millimicrosecond

CIRCLE 20 ON READER-SERVICE CARD

## Foil-type Tantalum Capacitors Now Available in Ratings to 250 V



Sprague Electric Company has announced another major capacitor improvement. Higher voltage ratings, sorely-needed by circuit designers of military and industrial electronic equipment, are now available in Sprague's family of Tantalex® Foil-type Tantalum Capacitors.

Plain-foil 125 C types, previously limited to 150 volts, may now be obtained in 200 volt ratings. Plain-foil capacitors designed for 85 C operation, with a previous maximum of 150 volts, are now available in 250 volt ratings. Type numbers and pertinent characteristics are shown in the following table.

Capacitor Type	Polarity	Anode	D-C Voltage Range
<b>85 C Max. Operating Temperature</b>			
110D (MIL CL34, CL35)	polar	plain foil	3 to 250
111D	non-polar	plain foil	6 to 250
112D (MIL CL24, CL25)	polar	etched foil	15 to 150
113D	non-polar	etched foil	15 to 150
<b>125 C Max. Operating Temperature</b>			
120D	polar	plain foil	10 to 200
121D	non-polar	plain foil	10 to 200
122D	polar	etched foil	10 to 100
123D	non-polar	etched foil	10 to 100

Manufactured to meet or exceed the performance requirements of Specification MIL-C-3965B, this series of Tantalex Capacitors sets new standards of reliability for all types of military and industrial applications.

Tantalex Capacitors are available promptly in production quantities. For off-the-shelf delivery at factory prices on pilot quantities to 499 pieces, Sprague industrial distributors stock the more popular items in Types 110D, 111D, 112D, 113D, 120D, and 121D, as well as MIL Types CL24, CL25, CL34, and CL35.

For complete engineering data on the types in which you are interested, write Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Mass.

CIRCLE 21 ON READER-SERVICE CARD

# WASHINGTON REPORT



J. J. Christie

## PRIVATE MICROWAVE SYSTEMS VS AT&T

It's now a certainty that the Federal Communications Commission will conduct an investigation and hearing on American Telegraph and Telephone's new Telpak rate package, which manufacturers of private microwave systems view as an unfair attempt to ward off competition. This was signified by the commission's decision to open hearings this week on another recently instituted AT&T tariff known as WATS (Wide Area Telephone Service), which offers unlimited use of a telephone within specified zones at a flat monthly rate.

Telpak, against which Motorola and Western Union have filed petitions, is a special rate package covering transmissions of telephone, teletyping, data, closed-circuit TV and facsimile. Thus far only four intrastate Telpak tariffs have been approved. They cover New York, South Dakota, Mississippi and Michigan.

*Objections to Telpak* are based on contentions that the rates represent "a gross understatement of the telephone company's costs." Thus it is held, Telpak could have the effect of subsidizing a service in direct competition with private systems. Also, the petitioners say, AT&T policies with respect to interconnections, sharing and control and maintenance are discriminatory.

Microwave equipment manufacturers concede that Telpak's cost advantage, on the basis of initial rates, lies only in narrow-channel-width operation. They acknowledge that private systems clearly would be competitive where 24-channel service is required and that savings over Telpak would multiply sharply with progressively wider channel operation. Their concern is that Telpak may nullify this ultimate advantage by inhibiting demand for private systems.

Some of AT&T's critics are also warning that retarded growth of private microwave communications might result in withdrawal or curtailment of the hard-won frequency allocations for the business radio service.

## A CHANGING MILITARY MARKET

The Kennedy Administration's reappraisal of defense policy, as reflected in its revisions of the Eisenhower fiscal 1962 defense budget, calls for expediting R&D and procurement on a number of programs while slowing down or phasing out others. It also provides guidelines to areas of R&D destined for higher priority.

Significance of the revised budget for firms heavily engaged in military electronics lies more in these shifts of emphasis than in the over-all increase in spending authority requested by the Administration.

Increases in funding cutbacks and cancellations are predicated on two underlying objectives in the Kennedy defense policy: (a) expediting development and procurement of weapons systems that offer the best hope of effective retaliation following an initial nuclear strike and (b) improving capabilities for waging limited nonnuclear warfare.

**Polaris and Minuteman**, with their advantages of mobility and concealment, provide the quickest means of building effective retaliatory capacity in the view of the defense planners. Thus plans call for expediting both procurement and further development work on both missiles.

By accelerating development work on the advanced A-3, 2,500-mile range Polaris missile it is hoped that an earlier phasing out of the A-2 version will realize savings of about \$100 million.

Additional funding is sought to permit earlier than scheduled incorporation of Minuteman design changes to improve reliability, guidance accuracy, range and re-entry. Provision is made for devising additional production capacity for Minuteman to reduce lead-time in the event that a sharp procurement step up becomes necessary. According to Defense Dept. officials the additional standby production capacity will require little in the way of duplicating facilities, more in the way of breaking bottlenecks.

Increased allotments of both Polaris and Minuteman missiles for practice firings are sought as a means of acquiring more data for determining improved reliability requirements.

Another missile given top priority on the basis of its high degree of invulnerability to surprise attack is the Skybolt. New obligational authority of \$50 million, double the present funding, is requested to accelerate development of this air-to-ground, 1,000-mile range missile, designed for B-52 delivery.

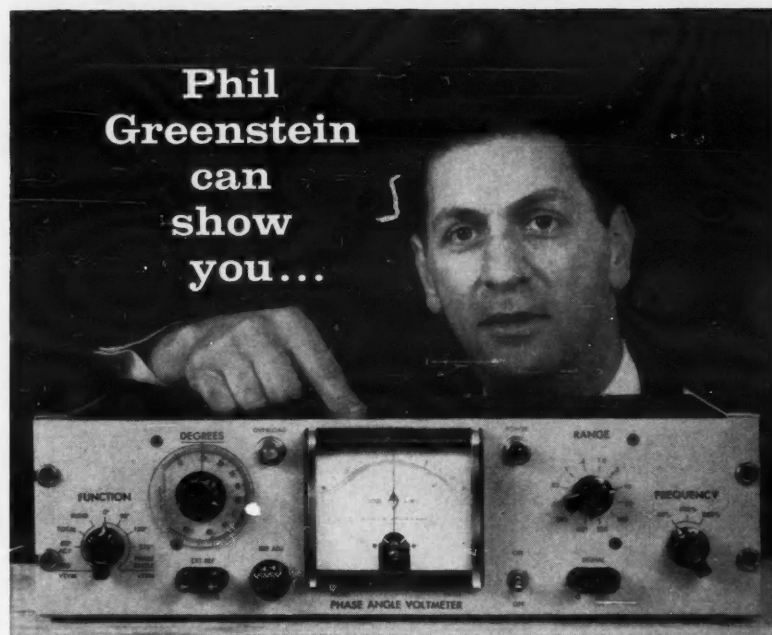
**Command and control facilities** on the strategic level are due for major emphasis to meet requirements for fast yet selective response to either deliberate or miscalculated enemy action. Defense Dept. officials have indicated need for development of a variety of command post facilities, both underground and mobile land, sea and air types. Along with requirements for more advanced communications systems will be demand for simplified data processing, analysis and display equipment.

The Administration requested substantial increases in obligational authority to increase the funding of development programs designed to bolster detection and early warning capabilities. Thus, for example, an increase of \$60 million is sought for the Midas early warning satellite development program and a total of \$226 million in funds to accelerate such space programs as Dynasoar, Advent, Defender and Discoverer.

**Phasing-out of Older and Unpromising Weapons** will result in canceling production of 18 Titan II missiles—two squadrons—for a saving of \$100 million in fiscal 1962 and ultimate savings of \$270 million. Procurement of the subsonic air-breathing long-range Snark missile will be halted.

Whereas the Eisenhower budget withheld further funding for development of the Navy's Missileer fleet defense aircraft but provided for continued work on the Eagle missile designed for use with the plane, the revised budget terminates both programs for a \$57 million saving.

The Administration's surprise decision to cut back the B-70 development program, eliminating a market of relatively high electronics potential, will result in an ultimate saving of \$1.4 billion. Plans call for developing only four instead of 12 prototypes and these to be limited to airframe, engine and bomb-nav system.



## how North Atlantic's Phase Angle Voltmeters solve tough ac measurement problems ... in the lab or in the field.

Designed for critical tasks in circuit development, production and testing, North Atlantic's Phase Angle Voltmeters provide direct reading of phase angle, nulls, total, quadrature and in-phase voltages—with proven dependability even under field conditions. Your North Atlantic engineering representative can quickly demonstrate how they simplify ac measurement jobs from missile checkout to alignment of analog computers—from phasing servo motors to zeroing precision synchros and transducers.

Shown below are condensed specifications for single-frequency Model VM-202. Other models include high sensitivity, three-frequency and broadband types.

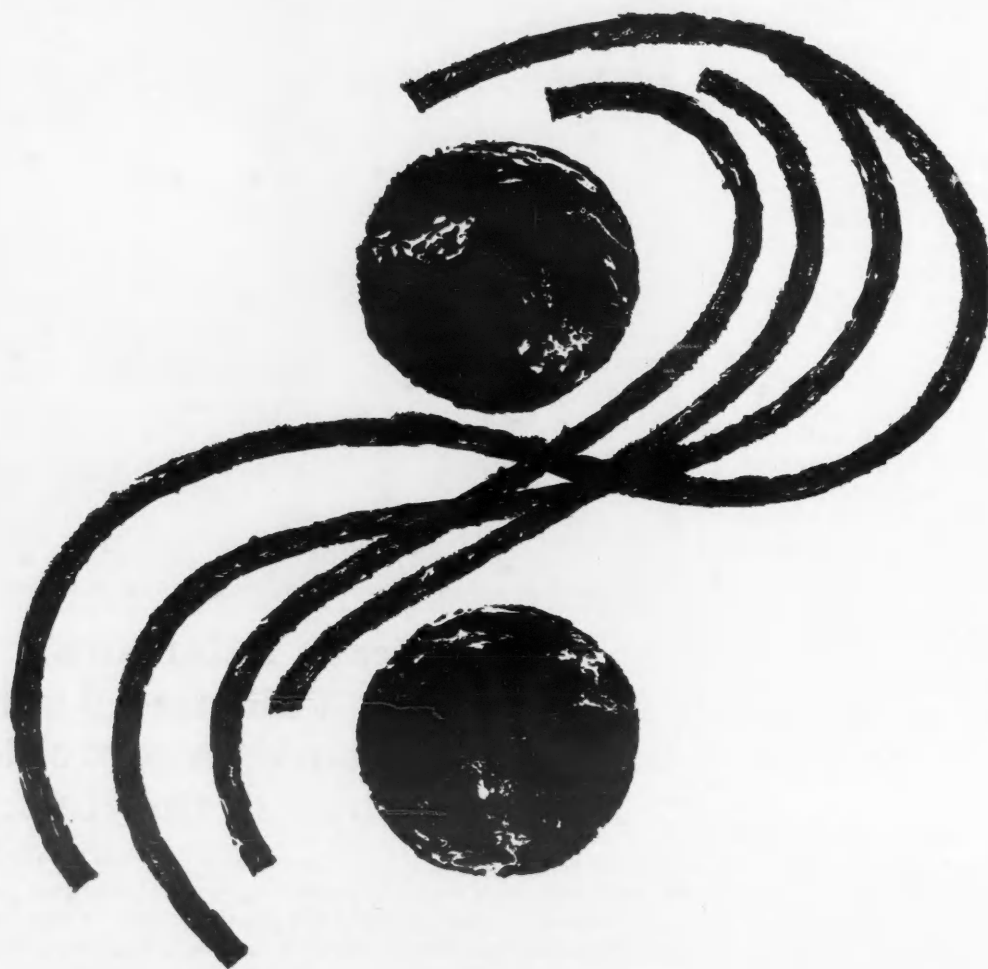
Voltage Range.....	1 mv to 300 v f.s., 12 ranges
Voltage Accuracy.....	±2% f.s.
Phase Accuracy.....	dial: ±1°; meter: ±3% of F.S. degrees
Signal Frequency.....	1 Freq., 30 cps—10 kc
Input Impedance.....	10 megohms
Reference Input.....	100 K, 0.25 v min.
Meter scale.....	3-0-3, 10-0-10 linear
Phase Angle Dial.....	4 scales, 90° (elec.) apart
Nulling Sensitivity.....	2 microvolts (phase sensitive)
Harmonic Rejection.....	55db (with filters)
Dimensions.....	5¼" h. x 19" w. x 7¾" d.

The North Atlantic man in your area has full data on standard and special models for laboratory, production and ground support. Call today for his name, or request Bulletin VM-202.



**NORTH ATLANTIC industries, inc.**  
TERMINAL DRIVE, PLAINVIEW, L. I., NEW YORK • OVERbrook 1-8600

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**Said Johann Kepler:** "The planets move in elliptical orbits about the sun, and the square of their periods of revolution are proportional to the cube of their mean distances from the sun."

With interplanetary voyages fast becoming a reality, complete information regarding the velocity requirements for travel between planets is of vital importance. With these data available, it is possible to analyze propulsion requirements, plan ultimate system configurations, and conduct feasibility studies for any particular mission.

Lockheed Missiles and Space Division scientists have actually evolved a rapid-calculation method, utilizing a high-speed computer. This has produced literally thousands of orbits, velocity requirements, and elapsed time, for design studies of trips to and from both Mars and Venus—every tenth day from now until January, 1970.

More simple to analyze are many factors which make Lockheed Missiles and Space Division a wonderful place to live and work. Located in Sunnyvale and Palo Alto, California, on the beautiful San Francisco Peninsula, Lockheed is Systems Manager for such programs as the DISCOVERER and MIDAS satellites and the POLARIS FBM. These, together with research and development projects in all disciplines, make possible a wide diversity of positions for creative engineers and scientists in their chosen fields.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-14B, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

## **Lockheed** / MISSILES AND SPACE DIVISION

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

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## NEWS

### TV System Permits Long-Distance X-Ray

A television system reported capable of transmitting X-ray pictures over long distances has been tested successfully for use in the medical and industrial fields.

Developed by Tokyo Shibaura Electric Co., Ltd., of Japan, the system includes an X-ray camera and transmitter. With it a physician can give direct X-ray examinations, even though a patient is several miles away.

In industry direct consultations with a manufacturer are possible in the event of equipment failure at a factory.

The company plans to develop color transmission for the system.

### Mobile Telephone Unit Permits Simultaneous 2-Way Conversing

A mobile dial telephone that allows simultaneous two-way conversation has been developed by General Electric Co., Lynchburg, Va.

Previous push-to-talk mobile telephones automatically cut off transmission from one end, so that a listener could not interrupt the speaker.

Battery drain is as low as 2.9 amp on standby and 5.6 amp when transmitting, GE says. The unit offers five-channel operation with push-button selection in case some channels are already busy. The phone automatically reverts to its assigned channel on completion of a call.

A car equipped with the GE telephone will be able to place and receive calls to and from any part of the country.

### WESCON Sets May 12 Deadline For Industrial Design Competition

The deadline for the Third Annual Industrial Design Award Competition of the 1961 Western Electronic Show and Convention is May 12.

Carl J. Clement Jr., of Hewlett-Packard Co., chairman of the competition, has urged potential competition to submit photographs of components, instruments, systems and other electronic products of original industrial design.

Submissions on entry forms must be the products of WESCON exhibitors, members of the Western Electronic Manufacturers Assoc. or companies exhibiting in booths of authorized representatives.

WESCON will be held Aug. 22-25 in San Francisco's Cow Palace.

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ELECTRONIC DESIGN • April 12, 1961

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TELEMETRY FIRST  
**A LOW LEVEL  
SUBCARRIER  
OSCILLATOR**  
THAT IS COMPLETELY  
INTERCHANGEABLE  
**WITH...**

ACTUAL SIZE

