Electronics

Transistor circuits for color tv: page 99
Protecting against voltage surges: page 109
Production techniques: page 116

April 18, 1966
75 cents
A McGraw-Hill Publication

Below: Experimenting with nonlinear optics: page 82
WIDE RANGE and FINE RESOLUTION
In a $190 Decade Capacitor

- 50 pF to 1.11115 µF
- Double shielding... capacitance for 2- and 3-terminal connections differs by only 1 pF
- Low-loss polystyrene dielectric in all decades
- ±1% Accuracy
- Bright, in-line readout

This decade capacitor combines precision decade steps and a high-resolution variable capacitor for continuous adjustment to better than 1 pF between steps. The four decades make possible settings from 100 pF to 1.11115 µF in 100-pF steps; nearly the entire range of commonly used capacitance is covered. The built-in 0-100 pF vernier extends the resolution still further for fine comparisons and allows precise calibration for demanding laboratory work. Small size (a mere 3½" high) and clean styling make this capacitor equally useful on a bench or in a rack. With all of its features, the Type 1412-BC is priced reasonably.

Other Decade Capacitors available from General Radio

For 0.5% Accuracy...
Type 1419-K
Decade Capacitor...$385 in U.S.A.

This three-decade unit covers the zero to 1.110-µF range in 1000-pF steps; capacitance at zero setting is 41 pF when used as a two-terminal device, and 13 pF in three-terminal connections. Silvered-mica dielectric ensures extremely low dissipation factor (less than 0.0003) and temperature coefficient (≈35 + 10 ppm/°C). The 1419-K is ideal for the demanding 2- and 3-terminal capacitance requirements.

For the Highest Accuracy and Stability in a
Decade Capacitor...
Type 1423-A
Precision Decade Capacitor...
...$750 in U.S.A.

0.05% accuracy, 0.013%-per-year stability, and a 100-pF to 1.111-µF range (in 100-pF steps). The Type 1423-A is especially valuable for precise comparison and substitution work, since its high accuracy and stability eliminate the need for repeated recalibration.

For High Values of Capacitance:
Type 1424-A Standard Decade Capacitor,
Polystyrene Dielectric
10 µF in 1-µF steps, 0.25% accuracy...
...$345 in U.S.A.

Type 1424-M Decade Capacitor,
Paper Dielectric
10 µF in 1-µF steps... 1.0% accuracy...
...$210 in U.S.A.

Type 1425-A Standard Decade Capacitor,
Polystyrene Dielectric
100 µF in 10-µF steps, 0.25% accuracy...
...$1400 in U.S.A.

Write for Complete Information
VERSATILE, VALUE-PRICED X-Y RECORDER...JUST $895!

THE MOSELEY 7035A

This is a high-performance, low-cost solid-state recorder for every-day applications not requiring high dynamic performance. Five fixed calibrated ranges 1 mv/inch to 10 v/inch. High input impedance, floating guarded input, 0.2% accuracy at full scale. Adjustable zero set.

Each axis has an independent servo system with no interaction between channels. Maintenance-free AUTOGRIP* electric paper holddown, new writing system with inexpensive disposable unit. Options available include electric pen lift, locks for zero and variable range controls, rear input, re-transmitting potentiometers.

For general-purpose applications, you can't beat the Moseley Division 7035A. Ask your Hewlett-Packard field engineer for a demonstration. Or write for complete specifications to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

HEWLETT PACKARD MOSELEY DIVISION

An extra measure of quality

*Trade Mark Pat. pend.
The new 3446A AC/DC Remote Plug-in unit lets you automate your Hewlett-Packard 3439A or 3440A Plug-in Digital Voltmeter by permitting remote programming of function (ac or dc measurements) and/or range (10, 100, 1000 v full scale). An ideal instrumentation package for automatic test stations, programmable routine measurements, measurements required at a distance from the DVM.

The DVM's themselves are compact instruments with a selection of plug-ins to provide the choice of manual, automatic and remote ranging, extra-high sensitivity, ac/dc voltage/current/resistance measurements; dc accuracy better than ±0.05% of reading ±1 digit; 4-digit readout; 30 db ac rejection at 60 Hz; capability of floating input pair up to 500 v above chassis ground. The 3440A ($1160) is systems oriented. The 3439A ($950) is a bench model. Both use the same plug-ins.

The specifications tell the performance story of the DVM's and this new plug-in. Ask your Hewlett-Packard field engineer for a demonstration of the voltmeter most useful for your application, or write for full specifications 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.

**SPECIFICATIONS, 3446A**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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<tr>
<td>Voltage range (ac and dc)</td>
<td>4-digit full-scale readings of 9.999, 99.99 and 999.9 v; 5% overrange capability, indicator,</td>
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<tr>
<td>Voltage accuracy (ac)</td>
<td>50 Hz-20 kHz, ±0.1% of reading ±2 counts.</td>
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<tr>
<td>Voltage accuracy (dc)</td>
<td>20 kHz-50 kHz, ±0.1% of full scale ±2 counts, 50 kHz-100 kHz, ±0.3% of full scale ±2 counts, from 20°C to 30°C, including ±10% line variations. Temperature coefficient = ±0.005%/°C from 0-20°C and 30-50°C.</td>
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<td>Voltage accuracy (de)</td>
<td>±0.05% of reading ±1 digit, including 10% line variation, ±15°C to +40°C (±0.1% ±1 digit 0°C to +50°C).</td>
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<td>Range selection (ac)</td>
<td>Manual, remote; auto reading &lt;2 sec; max. remote ranging time 40 msec.</td>
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<tr>
<td>Range selection (dc)</td>
<td>Manual, remote; auto reading &lt;1 sec; max. remote ranging time 40 msec.</td>
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<td>Function selection (ac or dc)</td>
<td>Front panel or remote.</td>
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<td>Input impedance</td>
<td>10 megs shunted by &lt;35 pf, all ac ranges; 10.2 megs, dc.</td>
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<tr>
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<td>$575</td>
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# Electronics Review

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# Technical Articles

### I. Design

- **Advanced technology**
  - 82 Filling in the blanks in the laser’s spectrum (cover)
  - High-power beams are generated at many new frequencies in nonlinear dielectrics
  - Fred M. Johnson, Electro-Optical Systems, Inc.

- **Reference sheet**
  - 88 Nomographs calculate values for twin-T notch filter
  - Just two graphical steps are required with these charts
  - Tom G. Purnhagen, U.S. Air Force

- **Circuit design**
  - 90 Ringing choke simplifies d-c to d-c conversion
  - Alternately storing and retrieving energy from a magnetic field boosts d-c voltage
  - J.F. Howell, General Electric Co.

- **Circuit design**
  - 94 Designer’s casebook
    - Two unijunctions form low-cost level detector
    - Exclusive OR circuit requires no voltage supply
    - Single component changes bandpass into general filter
    - Diode quad modulator suppresses carrier 65 db

### II. Application

- **Consumer electronics**
  - 99 Solid state appears in big-screen color tv
  - New design generates less heat and improves components’ reliability
  - Derek Bray, Fairchild Semiconductor Div.

- **Components**
  - 109 Voltage transients tamed by spark-gap arresters
  - A version of a radar switch protects semiconductors from power line surges
  - V. W. Vodicika, Applied Magnetics Corp.

### III. Manufacturing

- **Production**
  - 116 Production tips
    - Machine soldering gets IC’s into tighter spots
    - Fixture shaves 10 minutes from module-making time
    - Coordinate measurer puts old boards into new line
Readers Comment

‘Clash’ continues

To the Editor:

Your recent article on standards, “Clash of symbols” [Jan. 24, p. 137], contains some errors of fact and unfortunate insinuations concerning the experts who advised the IEEE symbol standards coordinating committee on insulated gate field effect transistors (IgFet).

Our IEEE committee did not, as stated in the article, “appoint three experts in FET work.” We requested advice on this subject from other IEEE and JEDEC committees concerned with the FET field.

The chairman of IEEE 28.4 originally offered the services of his subcommittees. Mr. Drusdow, a long time member of our committee, was asked to coordinate the FET project. Dr. S. R. Hofstein was a member of the IEEE 29.4.16 task group on field effect transistors and the IEEE 28.9 committee on microelectronic systems. D. M. Griswold was chairman of the JEDEC JS-8 committee on consumer product devices and a member of the JEDEC JS-9 task force on FET registration form. Such existing committees are a good source of advice in their respective fields.

The gentlemen did not represent RCA but, rather, served as a channel through which the views of others in the IEEE and in industry might reach our committee. The symbols adopted by our committee are somewhat different from the “RCA” version [Electronics, Dec. 14, 1964, p. 76]. The fact that these experts were all employed by RCA is an interesting comment on the degree of employer support and engineers' interest concerning participation in professional and industry committees attempting to solve problems in the electronics field.

While we certainly did not discuss our proposals with everyone in the electronics industry, our proposed symbols were developed from a sound technical analysis of the problem and are based on the rules and symbols of ASA Y32.2 item 73, with the addition of a new idea, the gate. Facts, not emotion...
New from Sprague!

METFILM* 'A' CAPACITORS . . . dramatically smaller in size, yet more reliable than military-grade capacitors of the past!

Just a few years ago, the only 10 µF capacitor considered dependable enough for military applications was Type CP70 (to JAN-C-25), and was a block-busting 3¾" wide x 1¼" thick x 4" high. Today, you can get a military-quality 10 µF tubular capacitor measuring only ½" in diameter x 2¼" long. And it's more reliable than any capacitor of the past!

Sprague Type 680P Metfilm 'A' Metallized Capacitors meet all environmental requirements of MIL-C-18312, yet they occupy only one-third the volume of conventional metallized film capacitors of equivalent capacitance and voltage rating. Employing a new thin organic film dielectric system, Type 680P capacitors use a dual film totalling only 0.00008" thick, as compared to conventional polyester-film capacitors with a single film measuring 0.00015".

Another distinct advantage of the Metfilm 'A' dielectric system is minimum degradation of electrical properties during life.

Hermetically sealed in corrosion-resistant metal cases, capacitor sections are effectively of non-inductive construction, resulting in capacitors with performance characteristics superior to those of comparably-sized capacitors.

Type 680P Metfilm 'A' Capacitors are available with capacitance values to 10 µF in both 50 and 100 volt ratings.


SPRAGUE COMPONENTS

CAPACITORS
TRANSISTORS
RESISTORS
INTEGRATED CIRCUITS
THIN-FILM MICROCIRCUITS
PULSE TRANSFORMERS
INTERFERENCE FILTERS
PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS

CERAMIC-BASE PRINTED NETWORKS
PACKAGED COMPONENT ASSEMBLIES
BOBBIN and TAPE WOUND MAGNETIC CORES
SILICON RECTIFIER GATE CONTROLS
FUNCTIONAL DIGITAL CIRCUITS

The Mark of Reliability

'Sprague' and '®' are registered trademarks of the Sprague Electric Co.

Circle 5 on reader service card
This 5 MHz counter/timer from Monsanto is only 3½ inches high, and weighs just 16 pounds. Yet it gives you a time base range from 1µ second to 100 seconds in decade steps, and resolution for frequency measurement of 0.01 Hz.

HOW COME? Integrated circuits. In 90% of the active circuits. That’s how Monsanto builds big performance into a small package. Plus speed, accuracy, reliability, low power consumption, low heat generation and easy maintenance. Six of the 13 printed circuit boards are interchangeable.

HOW MUCH? Just $1575. And that low selling price goes with these "high-priced" specs:
- Measures average frequency: 0—5 MHz
- Measures average periods: 0.2 µ sec. to 1 sec.
- Measures single periods: 1 µ sec to 10⁶ sec.
- Measures frequency ratios: 10⁻⁶ to 10⁶
- Measures time intervals: 1 µ sec to 10⁶ sec.
- Counts: random or uniformly spaced signals.

Want to know more? Just clip the coupon.

Monsanto, Electronics Dept. 800 North Lindbergh Blvd. • St. Louis, MO.

Details, please, on the Model 1010 5 MHz Counter/Timer
Model 1000 20 MHz Counter/Timer

Name/Title

Firm

Address

City/State/Zip

Circle 6 on reader service card
or industry bias, were the basis for our choice.

Your article would have been a more valued contribution if it had explained the technical reasons behind the construction of the FET symbols in the IEEE proposed form.

C. R. Muller
Chairman
IEEE Symbol Standards
Coordinating Committee for
Letter and Graphic Symbols

- The article made no insinuations about the competency of the three-man committee nor did it say their choice of circuit symbols was better or worse than others now also in use. It merely pointed out some facts that are unalterable.

Despite reader Muller’s protests, it is true that all three members of the committee that drew up the symbols work for the same company so the symbols do represent RCA’s rather than the industry’s thinking. For example, RCA is the only company that uses field-effect transistor symbols that have an offset gate and arrows whose only function is to distinguish between n-channel and p-channel types.

Other companies, such as the Fairchild Semiconductor division of Fairchild Camera & Instrument Corp. and Texas Instruments Incorporated, use a symbol in which the direction of current flow is shown.

We would have presented the technical reasons behind the choice of the proposed IEEE symbols, if there had been any. According to Drusdow, his group had two main goals: to make the symbols as simple as possible and to make sure they couldn’t be misinterpreted.

Drusdow points out there is no rule that a symbol must attempt to duplicate the function of a device. As a result, he adds, his committee made no attempt to indicate the direction of current flow through the transistor.

Credit, where it’s due
To the Editor:

In the article “Putting superconductors to work,” [February 7, 1965, p. 95] by Donald K. Fox, the 6-foot diameter superconducting magnet pictured was completely designed and constructed by S. R. Hawkins and associates at Lockheed’s Palo Alto Research Laboratories. However, no reference whatsoever is made in this article to S. R. Hawkins or to Lockheed.

C. F. Kooi, Sr. Member
Electronics Sciences Laboratory
Lockheed Missiles and Space Co.
Palo Alto, Calif.

- The unintended omission is corrected.

Wrong connection
To the Editor:

There appears to be an error in the schematic of the article “Adjustable current limiter for regulated power supply” [Designer’s casebook, March 7, 1966, p. 107].

The common connection of both Q4 and Q5’s collector to R1 will cause the output to sit at a value much lower than the stated 12 volts. It would appear that the collector of Q4 should be connected to the output voltage line.

Karl Hoffman
Bendix Research Labs
Southfield, Mich.

- Reader Hoffman’s sharp eyes caught a wrong connection.
How can you send him a radio message that hills and jungles can’t stop?

Granger Associates has the answer now

Intervening hills and jungles won’t stop a radio signal from G/A’s new short-range skywave antenna. Its signal travels to the ionosphere and bounces back to earth a few yards to 300 miles away, by-passing all obstacles on the surface. Other omnidirectional HF transmitting antennas are monopoles which can’t reach close-in jungle points well. The ground waves they emit are absorbed within a few miles by jungle foliage. The skywaves they launch are concentrated at low elevation angles so that they glance off the ionosphere and return to earth far away. Only Model 798 beams skywaves at high elevation angles so that they bounce back to earth nearby. It will handle all short-range HF frequencies, 2 to 20 MHz, without tuning and with a maximum VSWR of 2:1.

Send for complete technical data on Model 798, the world’s only omnidirectional short-range skywave antenna.

Leon Bess’ new job is to help man find where in the world he is. He has been named staff physicist at LFE Electronics, a division of Laboratory for Electronics, Inc., of Boston; his role will be to help develop new navigation techniques for aircraft.

In tackling the problem, Bess is taking a unique approach. Since all navigation aids introduce error, he reasons, the best practical approach may be to use several navigation aids, determine the extent of the errors of each under different circumstances and then use only the best information from each. Under the plan, an airborne navigation system would use doppler radar, inertial navigation instruments and hyperbolic signals generated by loran or omega navigation stations. A data processor in the craft would filter out the errors and, if all went well, come up with an extremely accurate position fix.

Faster than the mind. The key to the approach is the Kalman filter theory, a sort of mathematical recipe for estimating error and determining which information is the most useful. In a sense, Bess explains, the technique will work like the human mind, only a lot faster—shifting from one source of information to another, rejecting parts of some data and putting more emphasis on other data, depending on the error probabilities.

The mathematical theory was first advanced about six years ago by R. E. Kalman of the Research Institute for Advanced Study, Baltimore. Recently industry has been proposing to apply it to advanced navigational systems, and government users are now soliciting proposals.

Before joining LFE Electronics, Bess taught solid state physics at Indiana State University, where he did research on noise in semiconductors. Earlier he taught at the University of Illinois, where he had earned a doctorate in theoretical physics, and at Columbia Univer-
Highest Power Level for RF operation at C-Band: MACHLETT miniature planar triodes

For comparable size and weight in the C-Band region, and higher, the Machlett miniature planar triode provides the highest plate dissipation capability with correspondingly high duty cycle and rf power output. 1 kW grid pulse operation is currently being achieved at 6 Gc with the ML-8630. From cathode rf heater contact to anode rf surface contact, these new tubes ML-8629, ML-8630 and ML-8631 measure only .565 inches high by .7 inch diameter. These "8600 series" tubes will dissipate 100 watts, or more, with suitable cooling devices. Frequency stable for quick on-frequency performance. Phormat cathode for high voltage stability.

For complete details, write The Machlett Laboratories, Inc., Springdale (Stamford), Conn. 06879.
New from Sprague!

LOW COST DUET* 3N123
DUAL-EMITTER CHOPPER TRANSISTORS

CHECK THESE FEATURES!

- $B_{V_{BE}} > 25$ VOLTS
- $|V_{o}| < 250$ µV
- $\Delta V_{o}/R_{T} < 2.3$ µV per °C
- $f_{r} > 6$ mc

HIGH VOLTAGE! RELIABLE PLANAR CONSTRUCTION!


SPRAGUE COMPONENTS
TRANSISTORS
CAPACITORS
RESISTORS
THIN-FILM MICROCIRCUITS
INTEGRATED CIRCUITS
INTERFERENCE FILTERS
PACKAGED COMPONENT ASSEMBLIES
FUNCTIONAL DIGITAL CIRCUITS
MAGNETIC COMPONENTS
PULSE TRANSFORMERS
CERAMIC-BASE PRINTED NETWORKS
PULSE-FORMING NETWORKS

SPRAGUE®
THE MARK OF RELIABILITY

People

Warren P. Waters, who has been named manager of Hughes Aircraft Co.'s solid state research center at Newport Beach, Calif., described his new role as that of a "middle man."

"We are working with the research people, and when they find something that has an application, they come and talk to us. On the other hand, we are working with the designers and production people who come to us with the requirements," he explains.

In his new liaison role, he will be directing research in three general areas: microwave and optical, advanced solid state, and microelectronics.

Place to work. To encourage the circuit design people from other divisions of Hughes to bring in their problems and ideas, the center is setting up a special circuit design facility where they can work, he says.

This is not Waters first association with Hughes. Four years ago he left Hughes and went to work with Texas Instruments Incorporated, where he was manager of a semiconductor and development laboratory.

Waters has been in the solid state business since 1952, when he joined Hughes to work on the development of transistors. One project involved the development of npn alloys for germanium and he has retained a strong interest in germanium ever since. Most of his time at TI was spent in developing a planar germanium transistor process. It's his opinion that no real effort has been devoted to germanium. Waters says that it's because companies have neglected germanium's possibilities in their rush to get on the silicon bandwagon.

Electronics | April 18, 1966
Sorensen DCR Series now with temperature capability to 71°C.

All-Silicon Power Supplies to 20 kW.

Sorensen's wide range DCR Series has been up-dated and improved. What's new about the DCR's? They are now 100% silicon; ambient temperature capability is now to 71°C. • Four 3-phase models have been added extending power capability to 20 kW; 24 models are now available with ranges up to 300 volts. • Multiple mode programming—voltage/current/resistance. • Voltage regulation, line and load combined, is ±.075% for most models • Constant current range 0 to rated current. • DCR's meet MIL-I-26600 and MIL-I-6181 specifications and conform to proposed NEMA standards. • Front panel indicator for voltage/current crossover. These features of the improved DCR (model numbers will have an "A" suffix) are offered at no increase in price.

For DCR details, or for data on other standard/custom power supplies, voltage regulators or frequency changers, call your local Sorensen representative, or write: Sorensen, A Unit of Raytheon Company, South Norwalk, Connecticut 06856.

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<th>Voltage</th>
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Bendix announces the B-5000: (25 watts at 2.5 amps,)
10 volts and 100°C
a significant cost breakthrough in silicon power transistors.
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 highly conductive silver, 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**

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<tr>
<td>VCEO</td>
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<td>V</td>
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<tr>
<td>ICEO</td>
<td>10</td>
<td>mA</td>
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<tr>
<td>ICEBO</td>
<td>1.5</td>
<td>mA</td>
</tr>
<tr>
<td>VBE</td>
<td>1.2</td>
<td>V</td>
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<tr>
<td>hFE</td>
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<tr>
<td>VCE(s)</td>
<td>1.2</td>
<td>V</td>
</tr>
</tbody>
</table>

**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

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Bendix Semiconductor Division
HOLMDEL, NEW JERSEY
Meetings


Relay Conference, National Association of Relay Manufacturers and School of Electrical Engineering Oklahoma State University; Oklahoma State University, Stillwater, April 26-27.


International Electronics Congress, German Association of Electro-Technicians; Congress Hall on the Hanover Fairgrounds, April 30-May 8.

Symposium on Electrode Processes, Electrochemical Society; Sheraton-Cleveland Hotel, Cleveland, May 1-6.

Aerospace Instrumentation Symposium, ISA; Marriott Motor Hotel, Philadelphia, May 2-4.


Industrial Communications Conference, ICA; Queen Elizabeth Hotel, Montreal, Canada, May 2-5.


Bionics Symposium, Air Force Systems Command; Sheraton Hilton Hotel, Dayton, Ohio, May 3-5.


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


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.


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

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

Call for papers

Automatic Support Systems for Maintainability, IEEE; Colony Hotel, Clayton, Mo., Nov. 7-9. May 1 is deadline for submission of 500-word abstract on computer applications to automatic test equipment, advanced testing techniques, dynamic analysis, failure prediction methods, and multi-maintenance level compatibility to Mr. Don L. Reed, Program Chairman, P.O. Box 4124, St. Louis, Missouri 63136.

Symposium on the Physics of Failure in Electronics, Rome Air Development Center, Battelle Memorial Institute; Columbus, Ohio, Nov. 15-17. June 17 is deadline for submission of 500-word abstract on physical, chemical, and metallurgical processes that contribute to the degradation or failure in electronic materials and devices to Theodore S. Shilliday, Symposium Co-Chairman, Columbus Laboratories, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio 43201.

* Meeting preview on page 16
new disciplines in DC

take the models with magnified meter ranges

Multiple Range Meter provides increased resolution and accuracy at low output

<table>
<thead>
<tr>
<th>DC OUTPUT</th>
<th>SIZE</th>
<th>MODEL</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7.5V, 0-3A</td>
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<td>$445</td>
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<td>$350</td>
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<td>0-40V, 0-3A</td>
<td>3½&quot; x HRW</td>
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<td>0-100V, 0-3A</td>
<td>3½&quot; x HRW</td>
<td>6261A</td>
<td>$194</td>
</tr>
</tbody>
</table>

A four-position meter range switch sets the full scale voltmeter and ammeter values at either 100% or 10% of the nominal output rating (approximately). Meter and associated circuitry are foolproof — no danger of burnout for any DC output combined with any meter range.

Chart lists 25 low and medium power models from LAB, MPB, and DPR series — all have multiple range meters at no extra price — all are recently updated or added instruments featuring all-silicon circuitry. Typical specs include: Regulation, Load or Line, 0.01%; Ripple, 200 µV Constant Voltage, 500 µA Constant Current; Transient Recovery Time less than 50 microseconds. All units are designed for both bench and rack use.

Front and Rear Output Terminals • No Overshoot on Turn-On, Turn-Off, or Power Removal

Constant Voltage/Constant Current Operation with Automatic Crossover, Except Constant Voltage/Constant Current Limiting on Some Dual Range Models • Remote Programming • Remote Error Sensing

Special High Speed Programming Circuitry on Models 6200B, 6201B, 6202B, and 6203B

Auto-Series, Auto-Parallel, and Auto-Tracking Operation • Floating Output, Ground Either Side

Full Output Rating to 50°C • Convection Cooling, No Moving Parts

Options Include Overvoltage Protection "Crowbar" and 10-Turn Front Panel Output Controls

Contact your nearest Hewlett-Packard Sales Office for full specifications.
6 Reasons Why SPRAGUE is a Major Resistor Supplier

**FILMISTOR®**
PRECISION FILM RESISTORS
metal-film, molded case
Distinct limited temperature coefficients and low tolerances to meet exacting application requirements. Rugged end cap construction for long-term stability and reliability. Superior resistance to humidity and mechanical damage. Surpass MIL-R-10509E requirements. Send for Bulletin 7050B.

**ACRASIL® PRECISION/POWER WIREWOUND RESISTORS**
silicone-encapsulated
Combine the best features of both precision and power wirewound types. Resistance tolerances to ± 0.05%. Unusually tough encapsulation protects against shock, vibration, moisture, fungus. Meet MIL-R-26C requirements. Smaller than conventional wirewounds, yet greater in stability. Send for Bulletin 7450.

**BLUE JACKET® VITREOUS ENAMEL POWER WIREWOUND RESISTORS**
All-welded end cap construction with special vitreous coating for long-term dependability. Axial-lead style for conventional wiring or on printed boards. Tab terminals for higher wattage applications. Meet MIL-R-26C requirements. Send for Bulletins 74008, 74100, 7411A.

**KOOLOHM® CERAMIC-SHELL POWER WIREWOUND RESISTORS**

**STACKOHM® POWER WIREWOUND RESISTORS**

**GLASS-JACKETED POWER WIREWOUND RESISTORS**
Ferrule terminals soldered to metallized ends of glass casing for true hermetic seal. Virtually failure-proof, even in extremely corrosive industrial and salt atmosphere. Standard and non-inductive windings. External meter-multiplier types also available. Send for Bulletins 7350, 7420, 7421.

Meeting preview

Two firsts for NAECON
The National Aerospace and Electronic Conference will concentrate for the first time on interdisciplinary systems that are growing more typical in the development of aeronautical systems. The conference, to be held May 16-18 in Dayton, Ohio, is sponsored by the Institute of Electrical Engineers, the American Institute of Aeronautics and Astronautics and the Institute of Navigation, which is participating for the first time.

In the opening session on low-altitude high-speed flight, papers will be presented on environment, aircraft structures, cockpit displays, control problems and human factors. The session will attempt to relate the operation of military aircraft at low altitudes to strategies that decrease vulnerability to radar detection and antiaircraft weapons.

**Adaptive systems.** Advances in adaptive flight-control systems will be explored in a special session moderated by Prof. H. Phillip Whitaker of the Instrumentation Laboratory of the Massachusetts Institute of Technology. H. N. Tobie and E. M. Elliott of the Boeing Co. will examine criteria for adaptive control systems, such as the blend of pitch rate, pitch acceleration and normal acceleration. Donald T. Makers of the General Electric Co. will discuss an automated design procedure for flight-control systems. Hybrid simulation of self-adaptive techniques and mechanization of adaptive systems techniques by a programmable computer will be examined. A temperature-rate flight control system using thermocouples as primary sensors will be discussed by J. Stanlony-Dobrzanski of Northrop's Norair division.

Other sessions will survey trends in inertial navigation systems and the application of integrated electronics to the development of aircraft instruments.

On the last day of the convention, a special classified session will be held at Wright-Patterson Air Force Base. Base commander Maj. Gen. C. H. Terhune Jr. will deliver the keynote address.
Over 60% of all Heinemann hydraulic-magnetic circuit breakers produced each year are rather odd in one way or another.

By the usual standards, at any rate. But for us the far-out is all in a day's work. We're tooled up to manufacture the out-of-the-ordinary as a matter of routine.

The fact is, we have an extensive roster of options for you to work with when you want really tight overload protection. Current ratings in any integral or fractional value, from 0.010 to 225 amps. A choice of several time-delay characteristics or instantaneous trip. A selection of special-function internal circuits — relay-trip, shunt-trip, etc. A broad array of models, from one to six poles, from subminiature on up.

The cost of a job-matched Heinemann breaker will probably be a good bit less than you would expect. The reason is simple enough. 'Specials' are our specialty—60% every year.

If you've got a knotty protection requirement, get in touch with us. For a starter, try our Bulletin 302; it covers our entire line of breakers. We'll put a copy in the mail as soon as we hear from you. Heinemann Electric Company, 2626 Brunswick Pike, Trenton, N.J. 08602.
NEW TWISTER...

ACCURATE TIME/COUNT CONTROL

New and consistently better! At the left is the new face of our famous Microflex® reset timers and counters. High-visibility, direct reading dials enable you to make highly accurate settings, easier! The larger, 20-turn scale, for example, may be in minute divisions with the inner in seconds. Settings as short as $3/4$ second with $1/40$ second accuracy are readily obtained. Other dial selections to 120 hours are available. After the desired pre-set time period, a variety of 15 amp. contacts can be opened or closed to control motors, solenoids, valves, etc. Uniform new lettering and attractive neutral grey color make units compatible with all other Eagle Signal types and with your most advanced machine designs. For full details about these new timers and counters, use Reader Service Card, circle number 472.

TURN...TURN...TURN...

HA42A6 RESET TIMER

CLUTCH

BRAKE

And not one turn too many! The operating characteristics of radio tuning coils depend on precise winding techniques. The Man from E.A.G.L.E. did a good turn for a leading manufacturer when he suggested the system shown above. Using a Microflex counter, variations in motor speed resulting from wire tension changes are taken care of... and an accurate product is produced each time. The operator merely needs to set the high-visibility dial and press the button. The arbor turns the pre-set number of revolutions and stops automatically. In this system, the Microflex counter controls brake, clutch and motor. Complete information is in Bulletin 730. For a copy, use Reader Service Card, circle number 473.

FILL’ER UP...

HZ60A6 COUNTER

VALVE

LIMIT SWITCH

HOPPER

LINE

MOTOR

And not one ounce too many! A leading food supply manufacturer presented the Man from E.A.G.L.E. with the packaging requirement shown at the left. This manufacturer wanted to accurately fill containers. A versatile Microflex timer was the answer. It moves the containers under the hopper... filling and advancing them by the time lapse technique. The limit switch in this system activates the Microflex which controls hopper-valve and motor circuits. An accuracy of $1/4$% of full scale is consistently maintained and the manufacturer can vary the container sizes and amounts he wants them to carry. Intriguing? Write for Bulletin 110 for full data. Use Reader Service Card, circle number 474.

The Man from E.A.G.L.E. would like you to see his complete "showcase" of process control ideas. May we send you our catalog? For your convy, use the handy Reader Service Card, circle number 475, or write directly to Eagle Signal Division, E. W. Bliss Company, Federal Street, Davenport, Iowa 52803.

EAGLE SIGNAL
A DIVISION OF THE E. W. BLISS COMPANY
22AP Plug-in General Purpose Relay

...the epitome of relay craftsmanship and design. Versatile to the Nth degree on loads to 10 amps. Available in 8- and 11-pin styles for AC, DC and plate circuit requirements. Features include: forms to 3PDT plus specials on request; standard units have gold-plated contacts for longer shelf life; lower pull-in voltages (DC: 70% of nominal, AC: 75% of nominal); AC operating voltages 0.5 to 250, DC 0.2 to 130 in current ranges from .005 to 10 amp. Complete information is in our new relay bulletin. For your copy, use Reader Service Card, circle number 479.

SPECIFICATIONS
- Contacts: SPDT, DPDT, 3PDT
- Contact Rating: 5 and 10 amps.
- Pull-in: 22 milliseconds average
- Drop-out Speed: 12 milliseconds average
- Size: 11/4" x 11/2" x 1/2"
- Weight: 3 ounces

25PS Medium Power Relay

... toss your toughest medium-power-handling assignments to this workhorse. 25PS types carry loads to 20 amps, on a fast duty cycle in a breeze. UL listed. Features include: rugged 1/2" diameter silver cadmium oxide alloy contacts; lower pull-in voltages (DC: 75% of nominal, AC: 76% of nominal); AC operating voltages 4 to 250, DC 1 to 130 in current ranges from 0.2 to 10 amp. For full technical information on this and other Eagle Signal general purpose and medium power relays, use the Reader Service Card, and circle number 478.

SPECIFICATIONS
- Contacts: SPDT
- Contact Rating: 30 amp, 115/230 VAC 60 cycle resistive • 1 HP @ 115/230 VAC motor-inductive
- Pull-in: 50 milliseconds max.
- Drop-out Speed: 30 milliseconds max.
- Size: 2 1/2" x 1 3/8" x 1 1/2"
- Weight: 3 ounces

25AA Open Frame General Purpose Relay

...and boy what a relay it is! Versatile, dependable, economical. You'll find hundreds of uses for these 5 or 10 amps, UL listed high-reliability types. Standard units have gold-plated contacts which permit longer shelf life. Other significant features include: lower pull-in voltages (DC: 70% of nominal, AC: 75% of nominal); AC operating voltages 0.5 to 250, DC 0.2 to 130 in current ranges from 0.05 to 10 amp. Detailed specifications on these and other Eagle Signal general purpose relays are given in a new technical bulletin. For your copy, use Reader Service Card, circle number 477.

SPECIFICATIONS
- Contacts: SPDT, DPDT, 3PDT
- Contact Rating: 5A and 10A @ 115 VAC; 5A-1/10 HP @ 115, 1/6 HP @ 230 VAC; 10A-1/6 HP @ 115, 1/3 HP @ 230 VAC
- Pull-in: 22 milliseconds average
- Drop-out Speed: 12 milliseconds average
- Size: 1 3/4" x 1 5/8" x 1 1/2"
- Weight: 2 ounces
GET MORE
from the new hp dual-beam scope!

Only with the hp 132A do you get this combination
of performance features:

- Two completely independent beams that let you:
  display signals at different sweep speeds
  make simultaneous x-y and y-t plots

- Two 100 μv/cm vertical amplifiers offering:
  common mode rejection of 40,000:1
  constant 500 kc bandwidth 1 mv/cm to 20 v/cm - 200 kc at 100 μv/cm
  shock mounted nuvisor input stages for stable displays

- Recorder outputs from each vertical amplifier

- 3.5 kv aluminized, internal-graticule crt - for bright traces with no parallax error
LOOK AT WHAT YOU CAN DO WITH THE NEW hp 132A:

Make x-y plots with 100 µV/cm sensitivity!
To get x-y plots of low-level signals, such as transducer outputs, just plot Channel A against Channel B. No need for external preamps with the 100 µV/cm sensitivity of both channels. Phase shift between the two vertical amplifiers is less than 2° for frequencies up to 50 kc.

Observe an entire signal plus a magnified portion simultaneously!
You can simultaneously see fast and slow signal changes with a unique feature on the 132A that lets you magnify the Channel B sweep while leaving the Channel A sweep unmagnified. Thus, for example, in amplifier tests, you can apply the output to both scope inputs and simultaneously observe overall pulse response and the response to the leading edge in detail. The horizontal position control lets you observe any part of the unmagnified waveform ... and you can identify that part by an intensified area (the magnified area) on Channel A. Essentially, you have the equivalent of two time bases and a unique arrangement that takes the place of a costly sweep delay generator for most applications.

Plot two signals against a common third!
Plot both vertical amplifiers against a common 5 mV/cm 300 kc horizontal amplifier. Measure phase shift in two parts of your circuit at one time or compare phase shift of a test circuit with the standard. Relative phase shift between vertical and horizontal amplifiers is within 2° for frequencies to 10 kc, insuring accurate measurements.

Measure two signals vs. time — simultaneously!
Measure gain, delay time, pulse response. For comparing two signals at the same sweep time, the 132A is a regular dual-beam scope. No need for preamplifiers for displaying small signals ... both vertical amplifiers offer 100 µV/cm sensitivity and constant 500 kc bandwidth from 1 mV/cm to 20 V/cm. And bandwidth is 200 kc at the most sensitive range. Because bandwidth is constant over a wide range of sensitivities, displays remain the same as the range switch is changed. Nuvistor input amplifiers mounted in a common shock mounted heat sink assure steady displays even in the presence of vibration and shock; 40,000:1 common mode rejection, too. Thus, you get accurate displays of differential signals. Each vertical amplifier provides outputs for driving a recorder or other external equipment.

Make simultaneous x-y and time plots!
Here's an exclusive feature that lets you monitor phase shift in a circuit while simultaneously measuring another signal against time. Just use Channel B and the horizontal amplifier for the x-y plot, while displaying the signal vs. time on Channel A. Ideal for servo and audio work, it lets you do many tasks that previously required two scopes. Added to the advantages inherent in the unique 132A design is the scope's low price of just $1275. Compare 132A performance with that of any other comparable scope. You'll see how much more you get from the new Hewlett-Packard instrument. For complete data or a demonstration, call your hp field engineer, or write for complete information: Hewlett-Packard, Palo Alto, California 94305, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.
An assistant professor at State grew attached to his PDP-8.
When he tried to express it,
he was told to repress it,
for hugging might NOR an OR gate.

We don't sell the PDP-8 for its emotional value. We sell it as a small, high speed, core memory, full general purpose computer that scientists can afford.
But it gets personal.
It's a real-time, on-line computer that becomes part of the experiment. And it's a computer that a man can talk to (FORTRAN), play with, fit to a special mold, then change the mold, if need be. Scientists involved with their work sometimes develop special feelings for the machine.
There are 101 standard Digital modules available for building and interfacing special inputs and outputs. There are 35 standard plug-in options. There are 85 Digital field engineers to advise. And if the PDP-8 is not perfectly suitable, there are the LINC-EIGHT, the larger PDP-7, and the very large PDP-6 behind it.
**Editorials**

**Sounding the tocsin**

*Almost everybody* in the electronics industry agrees: business was never better. Semiconductor and component producers have backlogs piled up to ceilings; some have even stopped accepting new orders until the autumn. At communications companies, the manufacturing floors are crammed with gear earmarked for South Vietnam and production workers toil round the clock to meet schedules. Instrument companies are adding on new plant facilities to meet the rush of orders. Shortages of essential materials and components are pinching more than they have at any time since World War II.

The glow of current good business is so blinding that many people can't see some dark clouds on the horizon.

Probably the blackest is the inflationary trend that is threatening to make U.S. electronic equipment noncompetitive in price with equipment made elsewhere in the world, particularly in Europe and Japan. The labor market is suffering most. High school graduates with technician experience in semiconductor processing techniques, for example, are being offered salaries of $13,000 a year, though the rate for such an experienced technician was $9,000 just two months ago. Ph.D. candidates graduating in June with a specialization in electronics are being offered as much as $16,000 a year to start, even though they have no industrial experience.

At first glance, the situation appears to be a bonanza for engineers. Now is the time to get a new high paying job because many companies have thrown reason to the wind.

All this sounds horrifyingly familiar. People were talking like this in 1960—then came the layoffs of 1963 and 1964, driving thousands of engineers into the insurance and real estate business because there were no engineering jobs for men who had job-hopped up the salary ladder. The job with the higher salary often led to a career cul de sac.

Unhappily, the industry seems bent on repeating that disastrous circle once again.

On top of the inflationary climb, economists see two other reasons for alarm, signals that often mean trouble in the economy. One is the rate at which inventories are growing, currently far faster than the economy as a whole. Second is the high rate of capital spending. Companies are also expanding manufacturing facilities at a faster rate than the economy is growing.

In general, economic chart-watchers believe the boom will continue for about 12 more months, and then trouble can set in. Electronics companies stand a good chance of getting trapped. Concentrating on production to meet the order backlogs, many are putting nothing into the bank for the future. They've slowed new product development and almost stopped exploring and cultivating new markets.

Though the state of the industry's health has changed radically for the better since 1964, one fact has not changed at all. The greatest potential for the future in electronics lies in new fields that are not now great users of electronic equipment: industrial electronics, educational electronics and medical electronics.

In the flood of orders and fast-rising profits, companies and engineers are forgetting a well-established truism. The best time to plan for the future is when things are going well. Clearly, that is right now.

**An embarrassment**

*An engineer who attended* many of the technical sessions at the annual meeting of the Institute of Electrical and Electronics Engineers in New York last month summed up the quality of the meeting nicely. "If a foreign engineer came to IEEE and hoped to learn the state of our technology from the papers presented," he said, "he would have to conclude that the U.S. trails slightly behind Ghana."

Long rambling papers on the history of devices like the cathode-ray tube, and product pitches on old established equipment soured even those who continue to hope for improvement in technical papers. Microelectronics, probably the most talked-about industry development today, was represented in only two of IEEE's 80 sessions. And, maddening to anyone interested, both sessions took place at the same time.

Happily, this year there seems to be increased resentment at the continued mediocrity of the technical sessions. The vice president of engineering at a West Coast communications company asked, "Is it really necessary to send all those engineers to New York every year?"

The brutal recruiting and the high cost of maintaining people in New York hotels and bars have led some companies to take a second look at participating in the show at all.

If the IEEE show has in fact lost some of its appeal to the men who buy exhibit space, IEEE may well be forced to take some action to improve the technical sessions so they will no longer be an embarrassment to engineers.
The table below shows a small sample of the multispeed pickoff units produced by CPPC for such high reliability programs as Apollo, SIDS, Titan, Pace.

The data listed below are representative of the input/output parameters that we have supplied to meet customer requirements. The accuracies reflect the maximum errors allowed. Clifton units usually are well below these specified maximums.

The outline dimensions given in the table are applicable to rotor-stator combinations; although, as the photographs on this page show, our multispeed units are usually supplied in housings.

If you have a requirement for a high accuracy, high reliability multispeed component, contact CPPC Sales Engineering for additional information.


---

### CLIFTON Multispeed Gimbal Pickoff Synchos and Resolvers

<table>
<thead>
<tr>
<th>Function</th>
<th>Input</th>
<th>Primary</th>
<th>Common Input Impedance</th>
<th>Output Imp., Prim. Shorted</th>
<th>TR &amp; Phase Shift</th>
<th>Accuracy</th>
<th>Dimensions</th>
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<td>Rotor</td>
<td>85 + j190</td>
<td>100 + j20</td>
<td>20 + j15</td>
<td>.220 - 9°</td>
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<td>Rotor</td>
<td>105 + j165</td>
<td>150 + j25</td>
<td>60 + j130</td>
<td>.390 - 21°</td>
<td>10°</td>
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<td>26v 800-</td>
<td>Rotor</td>
<td>175 + j600</td>
<td>200 Max</td>
<td>100 Max</td>
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<td>26v 800-</td>
<td>Stator</td>
<td>40 + j500</td>
<td>-</td>
<td>450 + j800</td>
<td>-</td>
<td>2°</td>
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<td>Rotor</td>
<td>100 + j300</td>
<td>100 Max</td>
<td>100 Max</td>
<td>.333 - 3°</td>
<td>10°</td>
</tr>
<tr>
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<td>26v 800-</td>
<td>Rotor</td>
<td>165 + j600</td>
<td>175 + j100</td>
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<td>1.00 - 3.5°</td>
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<td>Stator</td>
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<td>-</td>
<td>230 + j200</td>
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<td>8°</td>
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<td>80 + j120</td>
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<tr>
<td>64x Resolver</td>
<td>26v 800-</td>
<td>Rotor</td>
<td>260 + j200</td>
<td>-</td>
<td>350 + j260</td>
<td>-</td>
<td>5°</td>
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</tbody>
</table>
RCA considers outside customers first in IC sales

The Radio Corp. of America, in rushing to catch up with its competitors in the production of integrated circuits, is favoring its commercial customers over its in-house customers.

Last fall, when RCA started producing linear IC's for outside customers, it cut back some production lines of digital IC's for its Spectra 70 computers; this forced RCA to turn to outside suppliers for more Spectra 70 digital circuits. Now, RCA plans to divert some of its semiconductor facilities in Somerville, N. J., to the manufacture of a series of linear IC's for use in the f-m sound channel of television receivers produced by other manufacturers. [Electronics, March 21, pp. 140-141]. The biggest customer for the IC's is the Home Instruments division of RCA.

It's rumored that RCA's Somerville management is planning to add metal-oxide-semiconductor IC's to its production line later this year.

New computers made in Japan

A pair of Japanese companies may reverse the direction of the prevailing one-way flow of computer technology from the United States to Japan.

The Nippon Electric Co., which is licensed to build Honeywell, Inc.'s H-200 series, has developed a computer that could round out the large end of Honeywell's line. NEC sees a chance that Honeywell will produce its design in the U.S.

Hitachi, Ltd., the Japanese licensee for the Radio Corp. of America's Spectra 70 computers, plans to market a model smaller than any made by RCA. RCA is investigating the possible U.S. import market for the small Hitachi computer.

Mass producing hologram plates?

A method of stamping out hologram plates like phonograph records has been developed by the Xerox Corp. Scientists John C. Urbach and Reinhard W. Meier have worked out a technique for making the plates on thermoplastic materials instead of conventional silver halide photographic plates or films.

Thermoplastic holograms do not require chemical developing and are free of grain patterns characteristic of photographic plates. They can be duplicated by a simple mechanical pressing technique.

Army to buy first equipment using a laser

After years of research and development, the Army is ready to procure its first field equipment using a laser—a portable range finder for artillery observation. A call for bids will go out about June, 1967; the order could amount to as much as $70 million.

The 31-pound range finder, the XM23E1, was developed at the Frankford Arsenal in Philadelphia. It uses a ruby Q-switched laser with a peak pulse of two megawatts with a 0.5-microsecond duration.

The Army's next piece of laser field equipment will probably be a helicopter-borne target-locating and range-finding system. It is being developed by the Bell Aerospace Corp. for use in the Bell UH-1 helicopter; the range finder will undergo tests next year.

Work also is proceeding on a laser range finder for tank fire-control systems and tactical aircraft. The military also is interested in the possibilities of using lasers for illumination in night photography and other
reconnaissance and as homing beams for missiles. This year the Defense Department is spending nearly $15 million on laser research and development.

The United States’ first astronomical satellite, plagued by a series of launching delays, was finally orbited last week only to be rendered useless by a battery problem. The $44-million Orbiting Astronomical Observatory, designed to gather data on the stars, failed before it was able to relay its first pictures of space above the earth’s atmosphere.

Although the National Aeronautics and Space Administration is receiving intermittent signals from the satellite, space officials doubt that it will perform any useful functions.

However, the mission isn’t a total loss; NASA checked out the system’s star tracker, which successfully stabilized the two-ton observatory to the degree necessary for conducting experiments in space.

Three more orbiting observatories are planned; the next will be launched late this year.

Continued Gunn-effect research may bring these solid state microwave devices out of the laboratory and into commercial use.

Researchers at Cornell University are stringing several Gunn oscillators together and using them with conventional microwave circuits. And scientists at the International Business Machines Corp. have found an easy way to produce gallium arsenide with high purity and resistivity.

In the Cornell development, under an Air Force contract, Lester Eastman, Lee MacKenzie and G. Conrad Dalman of the electrical engineering department are coupling the devices with conventional microwave circuits and using mechanical tuning of the cavity to provide a wide frequency range. Also by stringing several Gunn oscillators in parallel, in a resonant ring, power outputs are added. With several smaller pieces of GaAs, heat does not build up and burn out the devices—a problem with larger pieces of GaAs.

At IBM, J. M. Woodall and J. F. Woods of the research division, heat-treated bulk GaAs and found they could obtain material with a resistivity between 0.5 and 1,000 ohm-centimeters. For continuous-wave operation, Gunn devices generally need a resistivity between 1 and 100 ohm-cm. Previously, high-purity GaAs could be produced by epitaxial growth, or fortuitously in certain bulk samples.

Woodall and Woods heat GaAs to between 600°C and 950°C, and keep it there for from a few hours to two weeks. Mobilities of the heat-treated material average 7,500 cm²/volt-second, excellent for Gunn device operation.

A paper radar antenna that can be inflated with air and thrown away after use is being developed for the Air Force by the Westinghouse Electric Corp. The tactical antenna is sprayed with a metalized epoxy coating.

Westinghouse also is developing a three-dimensional radar antenna made of metal-coated polyfoam. It will be about two-thirds lighter than a comparable metal antenna but just as strong. The antenna has the same kind of stacked beam and planar array of conventional tactical 3-D radars.
New dual AND gate and OR expander increases logic functions, reduces count

As with any electronic device, a new integrated circuit must be evaluated both on its function and on how well it performs that function. But just as important is how well the new IC works with other units in the line. Two new units in Sylvania’s SUHL II line get excellent ratings on all three points. As individual devices, they perform significant logic functions in a minimum number of packages, in a minimum amount of time, and with minimum power consumption. With these additions to the Sylvania IC line, circuit designers can find within SUHL II the answers to any basic logic scheme they choose.

An extraordinary new dual gate now adds AND/OR logic to Sylvania’s SUHL II integrated circuit line. This development means that now designers can choose any basic logic function (NAND/NOR, AND-NOR, AND/OR) in designing systems with transistor-transistor-logic.

Each member of the new SG-280 series contains two four-input AND gates with non-inverting amplifiers. Each dual gate unit functions either as an AND element in positive logic or as an OR element in negative logic. By combining the AND function with a non-inverting amplifier, Sylvania’s SG-280 performs in a single package and on a single chip the same function that requires three separate packages in other IC lines. It can do this in less time too: 12 nsec compared with the 24 nsec time of the 3-package method.

The logic diagram for the SG-280 series (Figure 1) shows that an internal tie point (terminals M and 1) is brought out on each gate. A new series of Expander gates (SG-290) provides single wire feed-in at this terminal to perform the wired-OR function without degrading the fanout, noise immunity or wave-form integrity of the SG-280. Decrease in speed is negligible.

Why this happens can be more easily seen by first redrawing the SG-280 and SG-290 function to show the internal logic action (Figure 2). The wired-OR is performed without any (Continued)

**Figure 1 SG-280**

- **Figure 2 Performing the wired OR**

Redrawing the SG-280 and SG-290 functions, as shown, illustrates the internal logic action.

- Notice the wired OR is performed without loading the SG-280 output. Therefore fanout of SG-280 is maintained as well as wave form integrity.

**This issue in capsule**

- **Photoconductors**—simplified UV detection using a new, small-size cell.
- **Microwave diodes**—you can get the exact varactor you need, in the package that best suits your paramp design.
- **Spark gaps**—how two simple electrodes can protect equipment from destructive electromagnetic surges.
- **Integrated circuits**—now you can build an eight-stage, 50 nsec fast adder using only 12 IC packages.
- **Diodes**—news of a silicon epitaxial product line perfect for communication, computer and consumer product use.
- **Photoconductors**—how photoconductor/lamp assemblies can solve musical instrument problems.
capacitive or D-C loading on the output of the SG-280. Thus, performance characteristics are not degraded.

These new monolithic epitaxial circuits are designed for high-speed operation over the military temperature range of -55°C to 125°C or for the range of 0°C to 75°C for industrial applications.

Compatibility with other units in the SUHL II line can be seen in the Up-Down Counter shown in Figure 3. This particular circuit uses Sylvania SF-260 flip-flops, SC-280 gates, and half an SC-290 Expander gate.

**INTEGRATED CIRCUITS**

**Build an eight-stage, 50 nsec fast adder using only 12 IC packages**

Introduction by Sylvania of a new basic TTL fast adder digital subsystem, part of a family of Monolithic Digital Functional Arrays, makes possible a whole new breed of large-scale, high-performance, general-purpose digital computing systems. These systems not only offer significant speed advances over conventional computers; they will be smaller, more reliable and far less costly than equivalent systems built from standard integrated circuits.

Using only 12 of Sylvania’s new single-stage fast adder circuits, you can build an 8-stage fast adder with anticipated carry having a total add time of only 50 nanoseconds. Only 96 of the new packages are needed to make a fast anticipated carry adder of 64 bits having a 300-nanosecond total add time. An equivalent 64-bit fast adder using conventional integrated circuits would require at least 320 separate packages.

This new transistor-transistor-logic circuit array represents the first time that highly complex fast adders with anticipated carry have been integrally formed on a single monolithic silicon chip without compromising system performance characteristics. This Sylvania circuit has a noise margin of ±1.0 volt, power dissipation of 120 milliwatts, and a fan-out of 6 to 15.

The basic fast adder circuit configuration is interconnected with three standard metalizations to form either a single-stage full adder (SM-10 series), a single-stage dependent carry fast adder (SM-20 series), or a single-stage independent carry fast adder (SM-30 series). To build parallel fast adders larger than 4 bits, the independent and dependent fast adder are used in conjunction with a specifically designed carry decoder package, the SM-40, which extends the anticipated carry operation beyond four stages. Two dependent adders, SM-20 circuits, form the first and last stages of each of eight stages to provide for end-around carry operations.

Circuits in the fast adder family are available in Sylvania’s standard 14-pin dual in-line plug-in package as well as in the TO-85 flat pack.

These circuits are completely compatible with all circuits in Sylvania’s
advanced SUHL (Sylvania Universal High-level Logic) line. SUHL has a total of 120 circuits, by far the biggest TTL line in the industry. In all, these integrated circuits provide superior performance in terms of speed, fan-out, noise immunity, high logic swing, and low power consumption.

**DIODES**

**High-performance silicon diode line perfect for communication, computer & consumer product use**

The Sylvania silicon epitaxial diode (DF-22) product line is especially suited for logic circuits, high-frequency detectors, choppers, and clippers in rugged applications.

By careful in-process control, Sylvania’s DF-22 diodes are able to stand up under the most rigorous in-plant testing program given any diode product. They meet or exceed such tests as: 4500-g shock perpendicular to the whisker, 15,000-g centrifuge, 0 °C to 100 °C thermal shock, -65 °C to 150 °C temperature cycling, 300 psi internal pressure, 300-pound water bomb, +200 °C storage, and ion drift (back bias at elevated temperature).

Sylvania uses a stud body (see cross section) and rates its silicon epitaxial diode at 400 milliwatts when customer specifications require this rating. Reliability is enhanced by the solid silver sphere which Sylvania deposits on every epitaxial chip to assure for-ward current stability.

**AbsOLUTE MAXIMUM RATINGS**

- Average Rectified Current, I_{AR} 75 ma
- Peak Forward Current, I_{FWM} 225 ma
- Forward Surge Current (8.3 μsec) 500 ma
- Power Dissipation, P_{D} 250 mw
- Storage Temperature, T_{ST} -65°C to +200°C

SUHL is the fastest saturated logic available for applications down to 5 nanoseconds.

**CIRCLE NUMBER 301**

**CIRCLE NUMBER 302**
PHOTOCONDUCTORS

PL assembly is an economical, efficient new approach to musical effects

Not long ago we would have been hard put to relate music and electronics. Electronic components now play a large role in creating musical effects...so much so that these effects today take on electronic definitions. Vibrato is a frequency or phase modulation of the audio at subsonic values. Tremolo is subsonic amplitude modulation of the audio.

Before photoconductor-lamp assemblies, vibrato and tremolo effects in electrical musical instruments were created by mechanical means—shutters, vibrators, and other devices. But these techniques were too often subject to irregular variations and abrupt changes. The resulting effect is not always pleasing to either the musician or the average listener.

Now, with a new photoconductor-lamp device from Sylvania, a gradual rise and lowering of the desired effects (amplitude or frequency) can be designed into electronic organs, guitar amplifiers, and other instruments. The PL-1823P, a double-ended device having one neon lamp and two cadmium sulfide photoconductors, is the most effective approach yet to the problem, from the standpoints of both performance and economy.

Functionally, tremolo is most effectively used with fixed frequency tone generators while vibrato is used to control oscillating generators. The PL-1823P is designed especially for use in these areas.

The tremolo circuit for a single channel is shown on this page. Since the device’s neon lamp is always in the conducting state, there is no perceptible “thump” when the unit is switched in or out of service. Also, the intrinsic characteristics of cadmium sulfide provide a response envelope waveform with a gradual “attack” and “decay,” both of which are mandatory for the effect to be pleasing to the listener. The latter is the chief reason for incorporating optical devices in the music instrument field.

Since vibrato is more pleasing to the listener, this effect is used in instruments with tone generators wherever possible. If the tones are produced by phase shift or Wein bridge oscillators, the type PL-1823P may be readily used for the subsonic frequency modulation as shown.

Because of the relatively high extinguishing voltage of the neon lamp, the device is not readily available for wide-range attenuation as are tungsten lamp-photoconductor combinations. However, this device does lend itself to applications where a DPST switch function with solid-state reliability, electrically isolated input-output circuits and silent operation is desired.
Simple, economical route to surge protection for industrial and commercial equipment

Two simple electrodes can protect your electronic equipment from catastrophic failure caused by high-voltage electromagnetically induced pulses. They can, that is, if the two electrodes are part of Sylvania's new SG-1361 spark gap. In this secondary protector, two electrodes enclosed in a gas-filled, hermetically sealed glass envelope provide an economical way to protect critical electronic circuits and components used in non-military applications.

The new device offers protection against high-voltage transients by shorting the surge to ground. By design, the device is then immediately ready to quench the next disturbance. The one-inch-long SG-1361 fires at from 500 to 900 volts and handles currents of up to 25ma for 30 seconds. A minimum open line impedance of 100 megohms insures that the SG-1361 acts as an open circuit when not conducting.

Typically, the new spark gap can be applied as a protective device in industrial and commercial controls as well as in lighting systems. Also it can be used to guard relays and capacitors against sudden power line pulses. Control, computer and communications equipment (which must be protected against downtime, malfunction or even destruction when subjected to surges) offer ideal application areas for these protective devices.

The recommended protection for high-energy surges up to 110 coulombs is Sylvania’s SG-1360 spark gap. Used in both new and retrofit, this device is built to meet the most rigid military and industrial specifications. It can prevent transient overloads, such as those generated with a lightning strike, and even withstands repeated high-energy charges.

PRODUCT MANAGER’S CORNER

Would you believe 35,000,000 CRTs?

"Think back for a moment. It's 1932... the year Pearl Buck received a Pulitzer Prize for "The Good Earth"... Walt Disney created Mickey Mouse... Manchuria became Manchuko... FDR was elected... France won the Davis Cup; the Yankees beat the Cubs in the World Series.

In 1932 in Salem, Massachusetts, Sylvania was making Type 902P1 3-inch cathode ray tubes. General Radio was the customer. They built 902P1s into oscilloscopes housed in cabinets of wood.

Today, 35,000,000 cathode ray tubes later, we're still busy at Sylvania taking care of all kinds of CRT needs. To fill your needs, Sylvania has designed and produced many outstanding innovations in cathode ray technology through the years. But we're not alone. Other companies have contributed also to advances in the state of the art.

For example, aluminized picture tubes. We don't claim to have invented this technique, but we're proud to have been one of the pioneers in mass-producing aluminized picture tubes. In cooperation with glass suppliers, we also invested a lot of research and engineering to produce the newest methods of building safety factors (e.g. implosion protection) in picture tubes.

Sylvania has been especially active in the development and mass production of color television picture tubes. Color picture tube production was started at our Seneca Falls, N. Y., plant in the early fifties. The color bright 85™ picture tube with its rare-earth phosphor was undoubtedly one of the most significant advances in the state of the art in recent years. Several months ago, we introduced new 12” CRTs for battery-operated, portable black-and-white TV receivers. The neck is just .788 inches in diameter and 3¾ inches long. It has a 150ma 12.6 volt heater and a 100 volt G2. Several set makers have already designed this new 12” CRT into their 1967 lines.

In commercial and military displays, we developed a low-heater power tube that consumes 94% less power than conventional CRTs for battery-powered portable oscilloscopes. High-speed electrostatic charge printing tubes (for address label printing and computer readout), high-resolution assemblies (for photographic recording), console and rear window tubes (for computer readout or radar navigation), and fiberoptic CRTs are among the more recent developments in which Sylvania has participated.

While we were innovating in CRT technology, our engineering people intensified Sylvania’s continuing CRT reliability program. This has resulted in significant advances in furnishing tubes with the longest possible life and, equally important, optimum performance throughout tube life.

Today and tomorrow Sylvania will continue to offer the broad range of quality cathode ray tubes, all benefiting from long experience plus the very latest advances in modern technology.
Get the paramp varactor you need, in the package you want

When it came to designing paramps, for too long the engineer had to design around standard varactor packages. The diode of his choice actually offered him little or no choice in physical dimensions. But today, because of Sylvania’s custom packaging capability, the chances are that his precise varactor need can now be met.

Now you can get the exact electrical device characteristics you need, in the package you desire, from Sylvania. Pick the varactor, be it silicon or gallium arsenide, from the biggest line in the industry and we’ll put it in almost any standard or special package. What’s your special parametric amplifier diode requirement? Broadband or low noise? Aerospace or cryogenic use? Whatever the requirement, no longer is your choice of device or package limited.

For paramps where a low noise figure is the prime consideration, our varactor series D-5046 offers unusually high cutoff frequencies of up to 200 GHz, in combination with a minimum beta of 3.0 at -3V. For broadband operation, the D-5146 or D-5371 series is the answer, with minimum beta of 8.0 along with a cutoff frequency as high as 125 GHz min. at -3V. Varactors with beta ratings as high as 12 are available (with Fo -3V rating of 100 GHz or less). Exceptionally high-gain-bandwidth products can be achieved with both these series. Because they do not require external cooling, these silicon units make possible systems of small overall size.

Gallium arsenide varactors take over in the higher frequency ranges, generally above X-band, and are used for very low noise applications. Sylvania’s GaAs devices excel at both cryogenic and room temperature operation. When cooled with liquid nitrogen, noise temperatures of about 75°K in the 6 to 8 GHz range can be attained. With liquid helium, 35-50°K temperatures are possible.

Sylvania’s D-5337 GaAs varactor improves performance at operating temperatures as low as 10°K. This is due in part to the use of molybdenum heat sinks. The moly’s excellent thermal conductivity actually improves at low temperatures, thereby maintaining the low junction temperature necessary for improved noise performance. Its thermal expansion coefficient matches that of the semiconductor material, insuring reliable operation under severe environmental conditions.

Sylvania’s work in paramp varactors is based on a solid foundation of long and continuing work with microwave diodes. In addition to the units described above, Sylvania produces two series of general-purpose silicon epitaxial varactors, four series of step recovery diodes, a series of gallium arsenide varactors for harmonic multiplier applications, PIN switching diodes and silicon diffused epitaxial switching diodes.

CIRCLE NUMBER 305

### SILICON PARAMP VARACTORS

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<tr>
<th>Type Number</th>
<th>Package Outline</th>
<th>Fc -3V (min. GHz)</th>
<th>Cq (typ. pfd.)</th>
<th>( \beta ) (min.)</th>
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### GaAs PARAMP VARACTORS

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<th>Cq (typ. pfd.)</th>
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### 10°K DIODES

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<th>Type Number</th>
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<th>Cq (typ. pfd.)</th>
<th>( \beta ) (min.)</th>
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<td>023</td>
<td>200</td>
<td>0.3-0.8</td>
<td>3</td>
</tr>
</tbody>
</table>
Detecting and measuring the presence (or absence) of ultraviolet radiation has been simplified by a new sensitive photoconductive device from Sylvania. Requiring only simple low-voltage circuitry, the Type SRP-3614A combines the properties of small size, long life and analog response characteristics to obtain substantial cost savings and high reliability.

Simplified circuit requirements result from high power ratings and high dark/light resistance ratios. A power handling capability of up to 300 mw enables the device to translate UV to immediately usable signal levels, operating a sensitive relay directly if required. Dark-to-light resistance ratios of up to 400 further simplify circuit design.

The device retains the proven high reliability of Sylvania's hermetically sealed cadmium-sulfide photoconductors, and includes an integral filter to optimize the response to spectral energy in the ultraviolet region. The Type SRP-3614A can be used to pick out the UV in ambient exposures containing both infrared and ultraviolet radiation.

Electrical characteristics are enhanced by physical advantages of small size (T-4 envelope, 0.670" diameter by 1½" long) and rugged construction, offering significant advantages in such application areas as UV detection and control, UV regulation, intrusion alarm systems, fire detection and control, and medical electronic systems.

The low operating voltage, the simplified associated circuitry, and the inherently long life and reliability of expertly manufactured semiconductors make this new unit ideal for your critical applications.
Product specifying made easy with one-stop shopping

In the past year, increasingly more specifiers of electronic products have found they can maximize time by consulting the supplier with the broadest capabilities. It's the same basic principle as one-stop shopping, providing the source has behind it all the essential inputs—product line diversity, depth within each of those lines, a progressive R&D policy, an experienced sales engineering team, and a vigorous sales policy.

Any specifier, especially one who is concerned with diverse needs, will find these advantages in Sylvania's Electronic Components Group. It's been a year since Sylvania's diverse electronic component facilities were combined into an integrated team of specialists in semiconductors, tubes, microwave devices, readout systems and special components.

Sylvania sales engineers therefore are in the best position to advise you on which product to use, be it solid-state or vacuum.

In all, this change made strictly in the best interests of our customers is proving to be increasingly successful. If you haven't dealt with Sylvania ECG in recent months, we'd suggest you take advantage of this new team. Here are the sales office locations and phone numbers to call:

SALES SERVICE

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Soft-spoken coaxial programming for your low-level circuits

The very low crosstalk and VSWR values of this Coaxial Programming System are easy on low-level circuits. It's perfect for programming HF communications, telemetry equipment, analog computers and similar low-voltage switching applications. And it lets you change up to 2024 coaxial circuits in seconds!

Pre-program a panel with the coaxial patchcords and slip it into the frame for convenient, quick-change programming. The exclusive camming action of AMP's Coaxial Patchcord System provides a unique wiping action that pre-cleans each coaxial contact. Excellent shielding between inner and outer conductor and between adjacent cells reduces losses and interference to the minimum. When necessary, patchcords may be removed and inserted after the patchboard is in place, permitting program changes without any interruption to other circuits.

Worried about installation? That's easy too—permanent wiring of the rear board is accomplished with one crimp on each coaxial contact for rapid, reliable connection to the equipment. The patchboards and rear panels are made of diallyl phthalate (or proven equivalent) and are retained by rigid aluminum frames; the operating mechanism is of stainless steel; result—rugged, compact design. Some other features of this out-of-the-ordinary Coaxial Programming System:

- Redundant contacts on both center and outer conductor
- Standard sizes—506, 1012, 2024, 3036—plus hybrid systems
- Unique contact cleaning action
- Adjacent circuit crosstalk—60db at 100 Mc
- Individual coaxial contacts
- Exclusive AMP gold over nickel plating
- Maximum VSWR of 1.2 at 100 Mc

If you need a reliable coaxial programming system for your critical low-level equipment, go no further—this is the only one available. But investigate first. Write today for all the facts about AMP's full line of programming systems.

Electronics | April 18, 1966
Suddenly, there's a simpler, faster approach to system design—

with Philco's new monolithic "interface" circuits!

Up to now, your standard operating procedure as a system designer has been to pick your microcircuit logic family, design the logic system, then sit your own designers down to improvise all the necessary interface circuits, from input to logic, from logic to output. And possibly from one logic type to another. This obviously takes time and costs money. Why hasn't somebody done something about this? At Philco Microelectronics, we've done something. We are in production on four exceedingly useful interface circuits. With these silicon planar monolithic devices you can take inputs from relays, toggle switches, discrete component logic systems, DTL systems up to 28 volts, all to Standard RTL logic systems. And outputs from RTL systems to drive an 80 ma lamp, a 40 ma relay, or a 75 Ω line. These four circuits are, clearly, only the first of a line of interface circuits from Philco (and other producers are likely sooner or later to follow our lead). But the point is, the four microcircuits listed below are here today. Specified. Available. Off the shelf. And ready to help you shorten system reaction time and cut your design cost.

3-Input Driver Switches
PL 9606 and PL 9607. For high-current outputs from RTL. Output driver for filament lamps (80 ma). Relay driver (40 ma). Coaxial cable driver (75 Ω). High fan-out DTL driver. These two circuits differ only in the output resistor networks.

Triple Level Shifter Circuit
PL 9611. Three conveniently packaged independent interfaces. For relay contacts, toggle switches to RTL logic. High noise immunity—rejecting up to 700 millivolts at 125°C.

Pulse Threshold Circuit
PL 9610. Specifically designed for inputs from any DTL or discrete component system up to 28 v to RTL, DTL or other logic families. High noise immunity. Pulse level restoration. Why not take this opportunity to re-think your system design problems? We'll be glad to furnish more detailed information about Philco monolithic interface circuits. Write or phone us (213-855-4681), or contact your Philco distributor for prices, specifications and delivery.
Space electronics

Beating the blackout

Since the earliest Mercury flights, space engineers have wrestled unsuccessfully with the problem of the communications blackout that occurs during the launch and reentry of a space vehicle. For years, engineers have probed a method of piercing the hot sheath of ions that envelopes the craft while, at the same time, they have downgraded the importance of the blackout. "We consider it a luxury to be able to keep in constant touch with a bird—not a necessity," says one high official of the National Aeronautics and Space Administration. Luxury or not, the intensive study appears to have paid off, and a solution—employing millimeter waves—may be at hand.

The first flight test of a millimeter telemetry system is only weeks away; this spring engineers at the Marshall Space Flight Center in Huntsville, Ala., will aim a six-foot diameter parabolic antenna at an airplane and try to track it automatically and pick up 35-gigahertz (gigacycles per second) signals transmitted by it. If the test is successful, the next step will be to try to pass the millimeter signals through the flaming trail of a booster. And if that's successful, the telemetry system may be designed into the Saturn V—the booster that will lift the Apollo on its trip to the moon.

Channel space. If the use of the millimeter band of frequencies is approved, it will be a milestone for NASA. So far, the highest frequencies officially planned by the space agency are S band—1,550 to 5,200 megahertz. Although S band provides more channel space, the signals can't penetrate the sheath of ions that builds up like a wall around the nose of the incoming spacecraft and the nozzle of a rocket at lift-off. The sheath acts like a reflector to all frequencies below the 35-Ghz level because of an interaction between the ions making up the sheath and the radio signals. When a signal below 35 Ghz strikes the sheath, the wave imparts some of its energy to the ions and the ions eventually absorb the entire signal; in the millimeter region, however, this transfer of energy doesn't occur, and the signals can pass easily through the sheath.

In the current round of tests, NASA turned to Radiation, Inc., of Melbourne, Fla., for a 35-Ghz receiving system. The antenna automatically tracks at 35° per second—exceeding the space agency's design requirements of 25° per second. Radiation's antenna probably will be used only to pick up telemetered data from the Saturn during the first 200 seconds after lift-off—a distance of from 60 to 75 miles.

Says Thomas G. Barnes, project manager of the radio-frequency branch of the aeronautics laboratory at Marshall: "Currently we're planning to use a klystron to transmit the data, but eventually we'll turn to solid state components because a klystron just can't stand the rough treatment it'll encounter on a booster."

Power push. The klystron will have an output of only 1.5 watts. If the telemetry tests are successful, Barnes says, NASA probably will push intensive research for a solid state transmitter with up to 20 watts of power. "Clearly, that's beyond the state of the art," he concedes, "but several companies are confident it can be done."

A solid state 35-Ghz transmitter with that much power "will give us the capability of a communications link between a spacecraft in earth orbit and a ground station," Barnes adds.

But he notes: "This is still speculation—we haven't even made a firm
decision to go to millimeter frequencies yet."

Millimeter waves will provide other assets besides solving the blackout problem. They will make available a vastly wider spectrum for communications. For example, there will be room on the millimeter band for television and other telemetry data—far more than is available on S band. Also, millimeter waves offer the possibility of secret communications without complex electronic scramblers. The reason is that the beamwidth can be kept very narrow (Radiation's antenna has a beamwidth of only 0.33°), so messages beamed from a spacecraft can only be picked up by a ground station in the transmitter's line of sight. Such an advantage obviously is of interest to the military and much work on millimeter waves is secret.

**Some problems.** The turn to millimeter waves has created problems. There are relatively few commercially available high-power components that can transmit at 35 Ghz. However, NASA engineers believe this problem can be overcome with more research. A second problem is attenuation of the millimeter signal by moisture in the atmosphere, but Barnes brushes this aside, saying: "With the power levels we're talking about, only a severe rainstorm will blot out the signals."

The millimeter waves are being tested to eliminate blackout during both lift-off and reentry but each has its own peculiarities. In lift-off, the blackout varies in intensity and is greatest during the crucial intervals when one stage of the booster separates from another. Blackout time is longer during reentry; signals are blocked out as long as half an hour as the craft plunges into the atmosphere.

**Always on target.** Accurate tracking is, of course, an important part of the millimeter system. The Radiation antenna achieves it with a technique involving simultaneous lobing of the received signal, commonly called monopulse. In such a system, sum-and-difference radiation patterns are used to derive a signal that is proportional to the position of the target off the axis of the antenna. This signal is then used to steer the antenna. Tracking errors of less than 0.05° for tracking speeds of less than 5° per second are claimed by Radiation.

Company engineers also have included provisions for manual steering. A closed-circuit television camera is attached to the side of the antenna and provides the operator with a view of the soaring spacecraft. If the automatic tracking system fails, the antenna switches to a manual mode and the operator is able to steer the dish with a joy stick, keeping tabs on the spacecraft through the tv system.

**Computers**

**Plug-in teacher**

First-graders at the Brentwood public school in East Palo Alto, Calif., will be getting an unusual teacher this fall: a computer that not only knows all the answers but can handle the most sensitive child with kid gloves and the smart aleck with a stern hand. Although many teaching computers are being tested, this is the first to play a regular part in a school curriculum.

The computer is a prototype developed by the International Business Machines Corp. and is called the IBM 1500. It is based on the central processing unit of the IBM 1130, the smallest IBM computer using solid state hybrid microcircuits. Patrick Suppes, a professor at the Institute for Mathematical Studies at Stanford University, developed the computer's program and its curriculum.

**Two-way program.** The computer will control as many as 16 teaching consoles, each with two remote stations for pupils. Each station provides four different modes for pupil-computer communication: a cathode-ray tube on which the computer writes information and questions; a teletype-writer; a screen on which the computer can flash any of 1,000 slides; and a headset for recorded commands. In addition, each pupil will have a light pen with which he can write on the crt. The light pen can be used, for example, to indicate the correct answer to a multiple-choice question. Data on student performance is collected in a disk storage unit and can be printed out.
for analysis by the teacher.

The computer can be programed to deal with a variety of responses in a lesson. Should a pupil answer a question correctly, he proceeds with the lesson. If he answers incorrectly, a recorded gentle voice informs him of his error and suggests another approach. The computer thus patiently guides the pupil to the correct answer and, theoretically, to a better understanding of the subject matter. If the pupil is having difficulty, the system also can inform the teacher of the need for personal attention.

**Programed psychology.** The computer also can be programed to handle a cantankerous pupil. If the pupil attempts to answer questions in a smart-alecky manner, the computer admonishes him with a curt reply.

Stanford University will start trying out the IBM 1500 at the Brentwood school in September. Pupils will work with the machine and their regular teacher for at least an hour each day. Other computer makers will start marketing similar teaching machines soon.

A production model of the IBM 1500 will cost from $6,000 to $12,000 a month to rent and $250,000 to $450,000 to buy. Educators, however, do not see the cost as prohibitive to computerizing classrooms. Richard L. Bright, director of research at the United States Office of Education, says that "classrooms around the country will probably be completely computerized" within the next 10 to 15 years [Electronics, April 4, p. 8].

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**Solid state**

**A LID with legs**

Three years ago Alloys Unlimited, Inc., introduced a tiny ceramic U-shaped channel, the CM67, for use in mounting active-device chips to substrates of hearing aids. Hearing aid manufacturers mounted the active-device chip onto the channel. The channel, rather than the chip, was then mounted to the substrate. This provides a number of advantages: automatic assembly is much faster and easier, damage to the chips, because of handling, is reduced and degradation of other circuit components by the heat needed to bond the chips to the substrate is eliminated. These advantages appealed to builders of hybrid integrated circuits; and CM67's and similar devices have since found wide use in hybrid-IC equipment [Electronics, Feb. 21, pp. 110-114].

Now an improved channel, called a leadless inverted device (LID), has been developed by Alloys Unlimited. Each side of the channel has a slot through its center, making it a four-legged device. The active-device chip is placed inside the channel and covered with an epoxy coat. The channel can be flipped over and attached by its legs to the substrate.

The LID's advantages:
- LID's can be tested like discrete transistors because, within the epoxy layer, wire leads connect the emitter, base and collector to the various channel legs.
- All of the LID's can be placed on the substrate simultaneously, shortening production time. Even when mass production equipment is used, it's customary to place chips down one at a time.
- LID's can save space on the substrate. The area under the LID's can be used for connection paths. Even the LID's themselves can be used for crossovers when needed.
- LID's can eliminate the need for wire bonding by the user. If chips are used, precision handling equipment must be employed to attach the chip to the substrate and the wire leads to the chip. Only simple tools or jigs are needed to position LID's.
- The danger of damage to the passive-component network by high bonding temperature is eliminated.
- LID's can be color-coded or marked for easy identification during testing or assembly.
- Attaching LID's to the substrate is easily accomplished. A temperature of about 200°C melts the tinned bonding pads, soldering
the channel legs into place.

The LID's cost 3.2 cents each in quantities of 10 million or more and come in two widths, 40 mils (the CM182) and 60 mils (the CM-177); both are 75 mils long and 30 mils high.

Alloys Unlimited's first customer for LID's is the Amperex Electric Corp., which is offering two families of transistors in LID's; one series is intended for switching applications, the other for general-purpose amplifier service. Amperex also plans to bring out a line of dual diodes in LID's shortly.

Amperex uses thermocompression bonding to attach the leads from the legs to the chip and conventional silicon-gold eutectic bonding to attach the chip to the ceramic channel. The bases of the legs and the area of the channel to which the chip is attached have a layer of moly-manganese, which is gold plated. Amperex puts the same chips it uses for its conventional low-power transistor line into the LID's. Typical chip sizes are 12 by 15 mils; however, Amperex says chip sizes up to 30 by 30 mils can go into the LID's.

Alloys Unlimited also has a LID for integrated circuits, the CM181, which can be supplied with as many as 14 legs. Two additional LID's are still on the drawing board: one will eliminate all wire bonding and will accommodate a flip chip; the other is hermetically sealed.

Communications

On the beam

The very factor that makes a laser beam such a secure and versatile means of communication—the concentration of energy in a pencil-thin beam—is one of the biggest headaches in actually achieving such communication. Locking onto a laser beam and tracking it has proved to be a far more difficult task than overcoming atmospheric attenuation.

Most laser communications systems are forced to use a comparatively wide beam to solve the tracking problem. The laser experiment in the Gemini 7 flight, for example, employed a beam that diverged at 10 minutes of arc. But this method dissipates the power of the laser, and aggravates the attenuation problem. For the last couple of years, a group at the Space and Information Systems division of North American Aviation, Inc., has been experimenting with a system that can acquire and track a beam that diverges only 30 seconds of arc. The work has been company-funded, but has progressed to a stage where the Navy recently gave the concern a one-month, $10,000 contract to run tests on voice transmission up to five miles.

The system has two lasers and two photomultiplier tube receivers, for two-way transmission. The beams and the photomultipliers move in a dual raster scan until they acquire and lock on to each other.

Transmission powers are one milliwatt for voice and video, and a tenth of a milliwatt for voice only. The experimental system sits atop a two-story building at the division's Anaheim, Calif., headquarters and is aimed at a trailer 3,500 feet away.

On track. After tracking 3,500 feet, the laser beam has expanded to about eight inches in diameter and can be tracked by telescope and aimed roughly to an area half-a-degree square. In a long-distance system—in space, for example—the rough alignment would be made from guidance data or by any conventional navigational method.

The half-degree area that is scanned after rough alignment is divided into 64 imaginary squares, in an eight-by-eight array. Station A, which is the remote station, holds at square one while station B scans all 64 in sequence. Then, station A moves to square two and station B goes through the process again. Obviously they will hit each other once each complete scan—but it is only when the angle between them is zero that the scanning process stops and tracking begins.

As a further refinement, one station is equipped to make a super-fine scan. It divides the correct square into 64 smaller squares and then moves square-by-square through the small areas, looking for the best one. The mean time to acquisition is 30 to 40 seconds.

A rule of thumb derived from tracking equations is that for a beam to successfully track its target, it must be pointed with an accuracy an order of magnitude greater than the beam's width. Thus, this system must have an accuracy of three seconds of arc. "We're doing better than that," says Robert Parkinson, the head of the company's Communications Systems division. "How much better I can't say, because it's more accurate than we can measure at the present distance."

Good results. The long-distance Navy tests also will provide more information on attenuation. The present setup gives good voice and video transmission even though the beams are passed about a foot above the roof of the building so that air turbulence generated by the heat of the building will affect the beam.

"But it could be that we have had no attenuation problem because we haven't tested the system enough," Parkinson says. "For instance, we have never used it in rain or heavy fog."

The Navy will take care of that.

Manufacturing

Braided memories

Centuries ago pre-Columbian tribes in Peru braided colored ropes of hemp, called quipu, to record the phases of the moon and celestial events. Soon, electronics engineers may do about the same thing to store information in a computer that will guide a spacecraft.

Engineers at the Instrumentation Laboratory of the Massachusetts Institute of Technology are developing a technique for producing a random-access memory they hope will eventually contain as many as
George had a problem—the bridge rectifiers in a 30 KC static inverter power supply were running much too hot. This perplexed him since the bridge output current of 1 Amp was within the rating of these rectifiers, 1N3189s. Although crowded for space, George decided to try larger stud mounted 1N1124As. No help! They also ran hot and in addition reduced output voltage and operating efficiency.

What George needed was a fast recovery rectifier to eliminate the severe reverse recovery losses at this frequency. Such losses cause conventional diodes to overheat and drop their output voltage. The solution... UNITRODE UTR22s which have recovery times of 100 nanoseconds in the standard 1 Amp to 30 volt test circuit. In contrast the 1N3189 has a typical recovery time of 2 microseconds; a stud mounted 1N1124A is even slower.

In addition, George picked up some other bonuses—much smaller size, lighter weight, higher thermal efficiency and increased reliability because of the unique Unitrode monolithic construction.

P.S. Note the Unitrode 50 watt surge zeners (the same small size as the UTR 22) used to protect the expensive power transistors from burnout due to voltage spikes.
three million bits per cubic foot. And that includes the electronics, the sensing equipment and the chassis—everything except the power supply.

**Won't forget.** Work on the memory has been funded by the National Aeronautics and Space Administration, but its applications needn't be limited to space use. Braided memories are fixed memories; as such, they can't be reprogrammed or erased. Hence, an electrical malfunction or a human error can't harm the memory; once data is fed in, it's stored permanently. A memory with such an asset would be valuable in industrial process control, too.

The read-only digital memory is made by using a loom to braid information into a wire harness. The harness is then placed on an array of ferrite transformer cores.

"The loom process makes braid manufacture fast and economical," says Ramon L. Alonso, leader of the MIT group. "It promises to be cheaper, less complex and provide higher density than any wired-in memory now realizable."

**Tedious job.** Alonso also heads the core rope group at the lab that designed the computer for the Apollo's guidance and navigation system. The wired-in memory for Apollo isn't braided but consists of ropes of wire on which cores are strung. Stringing cores is tedious, even if done by machine.

The MIT braided memory consists of an array of U-shaped linear transformer cores interwoven by a number of word lines that either thread or bypass each transformer so that when a particular word is pulsed, energy is transferred to sense windings. After the wires that forms the lines are woven by a loom and bundled into a harness with temporary separators, the harness is placed over the core array. Caps are then added to close the flux path of the cores.

The number of memory bits is the number of wires times the number of cores. This makes for very high density storage plus high speed. Sometime in the future, says Alonso, the technique will permit manufacture of a million bits in an eight-hour day.

Alonso says a working model has only 256 transformer cores for a memory capacity of 16,384 words of 16 bits each, totaling about a quarter-million bits. It has a cycle time of two microseconds and its power consumption is less than 3.5 watts. A half-million bit model also has been made.

Alonso adds that the electronic circuitry costs less than conventional memories.

**Wire weaver.** W. Bard Turner of
How to find the carbon composition resistor that does the most for you...when all U.S. brands are good

Before we show you how to do it, let's clear up some of the confusion surrounding this question of resistor reliability.

You have been exposed to some 4-color full-page advertising citing “10 billion field proven resistors” and “not even one catastrophic failure.”

When you get right down to cases—unless U.S. made composition resistors are badly abused, failures are virtually nil. As a rule, malfunctions are the result of failures of other circuit elements. Long life and reliable performance are sure fire results when operating conditions are reasonable.

It's true that composition resistors are susceptible to ambient influences. But if you plan your design to accommodate the modest and completely defined resistance changes that might occur, you'll be more than compensated by the resistors' workhorse performance. (Not to mention their rock-bottom price.)

Which brings us back to our original problem—how to find the best composition resistor among the many equally reliable U.S. brands.

Solution? Come to Speer.

Before you accuse us of shameless subjectivity, consider the following points. (1) We produce billions of completely reliable carbon composition resistors for hundreds of satisfied repeat customers. (2) We have a high-volume production schedule, which permits us to offer realistic pricing without sacrificing product quality.

And (3) we offer quite a bit more in the way of technical support and service.

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All we know for sure is that they'll be there—in the Speer Electronics Booth (524).

If you missed these new precision resistor networks and packaged assemblies at the IEEE Show, here's another chance to see them in action. You'll find, for example, that they can be calibrated to tolerances better than .02%, with characteristics of very low temperature coefficient of resistance and compatible stability.

What's more, they can be designed to meet any network application. They offer broad environmental capabilities, at the lowest possible cost, with the shortest delivery schedule—

You know, those clever little devils might just end up stealing the Show after all.

Postscript: if you can't make it to the Dallas Auditorium, use the coupon. We'll send you more information about our Jeffers Electronics Division's new networks.
the MIT lab originally suggested that a loom be used for manufacturing the memory, and two 64-wire looms were built to test mechanical selection techniques. Turner is now completing a 256-wire loom that will simultaneously handle 1,024 wires—four bundles of 256 wires each. The loom uses a jacquard lift mechanism, nearly identical to the jacquard used by textile plants for more than 100 years [see story below for other wiring techniques using a jacquard].

In a standard jacquard, the weaving pattern is controlled by rods positioned by a punched card. However, MIT needs a fairly elaborate procedure to provide a proper separation of zeros and ones in the long braids. The instrument division has developed a tape-controlled equivalent of the punched card for selection of one and zero wires.

Initially, the rods on the loom are set in the vertical position. The tape control sends signals, allowing one rod, for example, to fall; the selection mechanism is solenoid-controlled. An electronic monitoring system compares the tape with signals generated each time a wire is selected and a rod drops. The rod actuates a switch that sends a signal to the monitoring circuit.

In addition, to protect against memory errors, the group is investigating the possibility of building the memory with redundancy and alternate paths.

All wires are terminated in a work area next to the loom, and the separators are inserted there.

**Woven wiring**

Stan Rask is an electronics engineer doubling as a textile salesman. Until recently, he hasn’t had much luck selling his wares to his peers.

Rask isn’t selling woven-wire computer memories, which have been catching on in commercial computers, or braids for core memories [see preceding article]. The textiles he has been toting around for two years are a form of wiring matrix for component interconnection, similar in design principle to welded wiring matrices [Electronics, Oct. 9, 1959, p. 62], but made by weaving wire and glass-fiber yarn on jacquard looms.

Doors in the electronics industry are starting to open now for Rask because systems manufacturers are searching for more efficient ways of interconnecting integrated circuits. Among the companies considering IC interconnection with woven matrices, Rask says, are the Hughes Aircraft Co. and Lockheed Aircraft Corp.

The matrices aren’t cheap. Rask’s employer, the Southern Weaving Co., is charging $1 an inch for matrices with wires spaced 20 to the inch (50-mil spacing, the same as IC flatpack leads). But $50 worth may do the job of a $500 multi-layer printed-circuit board, contends Odes Tatum, another salesman for the company.

The price prevents competition with conventional printed circuits in routine applications. A radio set was built with the cloth and discrete components, but it is only used now to show that the wiring works at radio frequencies. However, the Western Electric Co. is reportedly evaluating woven wiring for relay interconnection and the Chrysler Corp. is considering it for harness wiring in autos. The Eleco Corp. is developing connectors for the woven wiring.

**Chip and wire.** IC assemblies like the one shown are made by soldering or welding the flatpack leads to the horizontal, or fill, wires. The warp wires run under the glass yarn except when they cross over the fill wires at locations called nodes. The nodes, dip soldered after the cloth is woven, form the herringbone pattern in the photo. Another way of making assemblies is to solder the IC’s to long strips, which are rolled up like bandages.

The nodal patterns are varied in the weaving process. The looms are usually used to make patterned tapes, such as the labels in men’s suits. Patterns are changed by making changes in the hole patterns of punched cards that control the location of warp and fill patterns of punched cards that control the location of warp and fill crossover points—a form of design automation invented a century before electronic data processing.

This design flexibility is one reason that Erwin Pease, a senior engineer with Lockheed, likes the process. Another reason, he says, is that solid wiring can be used for easy soldering to component
**Four reasons for using heat-shrinkable tubing of Kynar!**

1. It's two to three times tougher than any other shrinkable plastic tubing.
2. It's thermally stable... operates at 150°C, flexible at -65°C.
3. It shrinks 50% at 175°C.
4. It's UL approved for 600 volt rating at 150°C.

And how can you use it? Here are just five of the many ways.

**For corrosion protection**—Resists chemicals and weathering at battery terminals.

**For strain relief**—Transfers flex stress away from joint; protects conductors.

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**For identification**—Eliminates the need for stocking colored or printed wire.

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If you are using or considering heat shrinkable tubing, investigate all the advantages of specifying Kynar. It's available in a range of diameters from Raychem Corporation as Thermofit™ Kynar. For information, write Plastics Department, Pennsalt Chemicals Corporation, 3 Penn Center, Philadelphia, Pa. 19102.

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apply several drops of oil to the drive-motor shaft-ends each year (or every fifty-million lines). Brush out any accumulated dust or lint. Clean the air filter periodically.

That's the extent of maintenance for a Franklin Model 1000. . . the only digital printer that offers a printing rate of 40 lines per second (or less) at low, low, OEM prices.

REQUEST BULLETIN 2301

medical electronics

IR thermometer

Taking the temperatures of patients in a ward is at best a time-consuming chore. At its worst, particularly when infants are involved, it can even result in fatal injuries. Now all this may be changed—thanks to an infrared fever thermometer that gives an instant reading of a patient's temperature without touching him.

The instrument is a battery-powered radiometer the size of a flashlight and uses a thermistor bolometer infrared detector as its sensing element. The instrument was developed by Stephen Boba, manager of the infrared techniques and systems group of the Raytheon Corp.

Say “Ahhhh” To use the infrared thermometer, the operator stands three to seven feet from the patient and aims the instrument at the patient through a lens. The patient's open mouth, nasal cavity or eye is used as a target; each is a sufficient source of radiant energy for an accurate reading. The instrument's lens is pierced to accommodate a light-spot projector that operates in the visible spectrum so the operator can see where the infrared detector is focused. A reading is available immediately and a beam splitter built into the aiming sight superimposes an
image of the scale on the target. Thus it is possible for the operators to see both the patient and the reading.

With such a thermometer, a nurse can take the temperatures of all the babies in a hospital nursery in the same time normally required to take the temperature of one baby—and without disturbing any of them.

Flip a switch. The thermometer is calibrated between 96° and 106° F. It has a sensitivity of 0.2° F and an accuracy of ±0.1° F. A switch on its side turns on the power, and a knob under the switch recalibrates the instrument. Recalibration is necessary after one hour of use and can be done by aiming the thermometer at a person whose temperature is normal or with a special calibration device with a standard infrared source.

A vibrating reed chopper converts the infrared signal to an a-c electrical current for processing.

Raytheon says it is considering sale of the manufacturing rights for the thermometer but will not produce it commercially itself. Raytheon estimates the price in production quantities at less than $300 each.

Electronics notes

- **Weather laser.** Scientists at Stanford Research Institute's Electromagnetic Techniques Laboratory have designed a two-headed laser system that produces four colors: red-infrared and green-ultraviolet. By comparing the reflections of the laser pulses that are aimed into clouds, for example, the scientists hope to gather meteorological information since different color laser beams are attenuated and reflected to different degrees by clouds.

- **Portable microwave link.** The International Telephone and Telegraph Corp.'s ITT Federal Labs has developed a portable microwave terminal that weighs about 55 pounds and fits into two packages, each no bigger than an attaché case. The terminal can multiplex 12 channels for voice communications.
The capabilities of microwave technology
Solving today's scientific and industrial problems frequently requires the application of new disciplines. How two of these problems are being solved—by microwave technology—is described here.

**The problem:** Build an ultra-reliable magnetron and modulator package for an airborne radar system that "sees" weather 180 miles ahead.

The advanced system is the Bendix Corporation's RDR-1E airborne weather radar, now widely used on commercial jet aircraft.

For this Bendix system, Raytheon's Microwave & Power Tube Division combined several capabilities. It built a magnetron tube and a pulse modulator package designed to work extremely well together to provide Bendix with an ultra-reliable system.

The magnetron is a Type 2J55, a super-high frequency oscillator capable of delivering 70 kw of peak power. The modulator package is a complete module containing pulse transformer, pulse forming network and charging choke. All are combined into one compact package that is dynamically tested with the tube to ensure matching the characteristics of the magnetron. Because of this compatibility, the magnetron's life is extended and the system's efficiency improved.

By utilizing the single Raytheon magnetron-modulator source, Bendix gained reductions in system size, more reliable operation, and significant engineering savings.

**The problem:** Build a laser system to pierce—on a mass production basis—diamond dies used in drawing small diameter copper wire.

The laser system for Western Electric's Buffalo plant had to be capable of one pulse per second operation—with extremely high repeatability—while piercing holes in diamonds.

To meet Western Electric's requirements, Raytheon's Laser Advanced Development Center developed the LE-1 laser system. This system combines an efficient water cooling method and optical pumping scheme by which, once set, variations in output energy are virtually negligible. Controllability is essential in piercing holes having extremely small diameters. With a modified LE-1 system, hole diameters as small as 0.0025 inch through 1/8"-thick diamonds are feasible.

The LE-1 is capable of producing more than 10 joules of energy per pulse at the rate of one pulse per second. Pulse width is variable from 1 to 10 milliseconds.

Building lasers for production line use indicates the ability of Raytheon laser technology to meet the needs of today's industrial requirements.

For additional examples of our capabilities in solving scientific and industrial problems, write to Raytheon Company, Microwave & Power Tube Division, Dept. A, Willow Street, Waltham, Mass. 02154.
Ultra-fast switching with hp associates 2900 Hot Carrier Diode is now more economical than ever. New production techniques and experience have reduced the cost of these popular devices, and the savings is passed on to you.

The performance characteristics and pricing listed in the chart make the hpa 2900 ideally suited for use in TV tuners, commercial communications limiters, detectors and mixers, and multiplexing in signal processing.

Contact your Hewlett-Packard field engineer for complete data.

**TYPICAL SPECIFICATIONS, hpa 2900**

<table>
<thead>
<tr>
<th>Forward Current $I_{F}$</th>
<th>Breakdown Voltage $B_{V}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ma min. $@ V_F = 1.0$ v</td>
<td>10 v $@ I_n = 10 \mu A$</td>
</tr>
<tr>
<td>1.0 ma min. $@ V_F = 0.4$ v</td>
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</table>

<table>
<thead>
<tr>
<th>Leakage Current $I_n$</th>
<th>Lifetime $\tau$</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 na $@ V_n = -5.0$ v</td>
<td>100 ps</td>
<td>1 to 99, $3.00$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 to 999, $2.25$</td>
</tr>
</tbody>
</table>

Data subject to change without notice. Prices f.o.b. factory.
New Epoxy Packages make Amelco FET's more economical than ever before!

KEY SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>2N4302</th>
<th>2N4303</th>
<th>2N4304</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{DS}$ (max. mA)</td>
<td>5.0</td>
<td>10</td>
<td>15</td>
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<tr>
<td>$g_{m}$ (min. μmhos)</td>
<td>1000</td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>$V_{p}$ (max. volts)</td>
<td>4.0</td>
<td>6.0</td>
<td>10</td>
</tr>
<tr>
<td>$C_{DG}$ (max. pf)</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
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<td>1.0</td>
</tr>
<tr>
<td>Price ea. (1000 qty.)</td>
<td>$1.45</td>
<td>$1.75</td>
<td>$1.15</td>
</tr>
</tbody>
</table>

Amelco Semiconductor, world's largest manufacturer of N Channel Field Effect Transistors, has just reduced prices drastically by offering several types in moisture resistant, high quality epoxy packages. These epoxy FET's will do virtually everything the Amelco metal can line does except fly classified missions. Don't let that bother you, though — Amelco Epoxy FET's will meet all requirements of MIL-S-19500.

So, if the cost of converting your circuits to the advantages of Field Effect Transistors has been a problem, forget it. Once again, Amelco has found the answer!
new

Allen-Bradley line of
subminiature low pass filters provide...

HIGHER PACKAGING DENSITIES AND
EFFECTIVE FILTERING TO 10 GHz

This new line of FO type subminiature low pass filters is designed to provide maximum reduction of RFI in a minimum of space—attenuation is greater than 50 DB over the frequency range from 100 MHz to 10 GHz.

The exclusive Allen-Bradley design allows unusually close spacing. The filters can be introduced into connectors with no reduction in the number of terminals, still providing the possibility of individual replacement of filters if desired.

With these filters mounted through a ground plane in the connector, there's complete shielding to prevent the possibility of rf coupling between input and output.

A-B engineers will be pleased to cooperate with you in the application of these new subminiature filters. For more details, please write: Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee, Wisconsin 53204.


ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS
“Allen-Bradley hot molded resistors have always proved absolutely reliable and superior to any others . . . foreign or domestic”

H. H. Scott, Inc.
Maynard, Mass.

* "Based on our use of more than 30,000,000 Allen-Bradley hot molded resistors over the past 18 years, under a continuous re-evaluation program for all component parts."

The known reputation of Scott hi-fi equipment is based on their unquestioned engineering excellence and their rigid quality standards. And Allen-Bradley hot molded resistors have played an important role in this achievement.

The consistently high quality of Allen-Bradley resistors—year after year, and million after million—is the result of an exclusive hot molding process developed and used only by Allen-Bradley. It produces such uniformity that the long term performance of Allen-Bradley resistors can be accurately predicted . . . and catastrophic failures never occur.


**HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, plus values above and below standard limits. Shown actual size.**

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS
CERAMAG® FERRITE PARTS ARE CONSISTENT

Stackpole offers over 30 grades of Ceramag® material. More are being developed continually. Such up-to-the-minute technology permits you to specify Ceramag® on every new application. Discover the unique advantages of the versatile Ceramag® ferrites: complete moldability to virtually any shape, and the important savings over steel alloys for low frequency applications. When high permeability is an important factor, Ceramag® is the answer.

Hundreds of Ceramag® parts are already tooled as toroids, cup cores, insert cores, transformer cores, deflection yokes and rectangular solids. Special tooling is also available.

Stackpole is a name long associated with quality components in the electronic field. Only the closest attention to every production detail can result in the kind of product uniformity available with Ceramag® ferrites. As one of our customers put it, "Your ferrite cores are more consistent from order to order than any of your competitors."

If you are about to select a ferromagnetic material for a new application, or if you are dissatisfied with the performance and service of your present ferrite supplier, why not investigate Stackpole's Ceramag®? To discover how you can save and still insure superior performance, write for our Bulletin 1-A, Stackpole Carbon Company, Electronic Components Division, St. Marys, Pennsylvania 15857. Phone: 814-781-8521 — TWX: 510-693-4511.

*Circle 52 on reader service card*

Circle 53 on reader service card
Miniaturization of RF communications equipment has opened a broad new range of space- and weight-saving opportunities for systems designers. Consider these examples:

**AN/ART-47 and AN/ARR-71** — an airborne transmitter/receiver combination covering 3500 UHF channels with AM or FSK duplex capability. Transmitter output is 1 kW. Transmitter and receiver, embodying latest solid-state techniques, fit into 2.65 cubic feet.

**AN/GRC-112** — 1-kilowatt data link radio, all solid-state except power amplifier stages, selectable AM or FM, in a tactical configuration occupying only 9.5 cubic feet for duplex operation.

**AN/SRC-27** — a shipboard transceiver now being evaluated by the U. S. Navy, this ECI development requires only 5 cubic feet. Yet it delivers 100 watts of AM UHF power and permits communication on 3500 channels, 20 of them preset.

**AN/GRC-134** — in the Marine Tactical Data System, this transceiver offers 50 watts of UHF AM power and covers 3500 channels from a 2.6 cubic foot package. You can probably use ECI's outstanding solid-state design capability on your next communication system. Use the coupon at left for full details.
You can cash in on more than two years of production experience with miniaturized solid-state multiplex already accumulated by Electronic Communications, Inc. Reliable ECI multiplex is field proved through service with the Post Attack Command and Control System (ACC-1 and ACC-3), and with Marine Corps and U.S.A.F. troposscatter communication terminals (AN/GCC-5 and AN/GCC-6). This means that you can design your system around multiplex gear that's ready to go without costly, time-consuming engineering and development. ECI multiplex is available in building-block units of 3, 4, 12 and 24 channels. The equipment is fully qualified to military specifications. Whether you're working on airborne, shipboard or air transportable multiplex systems you can enjoy a free design head start. For full details, use the coupon above.
Learn how Saturn experience has proved reliability of ECI space instrumentation

ECI's microelectronic flight control computer now under development for advanced space programs.

ECI's capabilities in the field of space instrumentation have been clearly demonstrated by the Company's success in assigned responsibilities for Saturn. ECI flight control computers flew aboard the last six Saturn I vehicles and have performed well within mission requirements. Improved triple-redundant versions are part of the Saturn IB and Saturn V programs. ECI now has under development a microminiaturized flight control computer for follow-on space programs.

In telemetry, ECI has produced solid-state transmitters from VHF to L and S band for the U.S. Air Force, U.S. Navy and NASA's Saturn program.

ECI meets NASA's MSFC 200-4 specification for fabrication and assembly facilities.

ECI missile system experience includes the design, development and manufacture of special solid-state receiver equipment for the Minuteman program.

To learn how ECI's successful space instrumentation background can be applied to your system, use the coupon above.
Evaluate ECI experience in solving interface problems

If your present system problem includes complex interfaces involving RF equipment, multiplexing, telemetry and switching systems, find out how ECI's broad systems integration experience can help you.

To date, Electronic Communications, Inc., has successfully performed on major system integration contracts for three generations of the Strategic Air Command's Airborne Command Posts and ground terminals; for airborne command programs for the Pacific and European Commands; and for Marine Tactical Data System. These and other system integration assignments have built an experience backlog which reaches into air-to-air, air-to-ground, ship-to-ship and ship-to-ground command and control communications.

If you would like to find out how experience in systems engineering and systems management can help you — it's easy — just ask ECI.

CAREERS ARE BUILT WITH ECI

ECI has unusually attractive career opportunities for qualified professionals in the fields of RF engineering, space instrumentation, thin-film circuit design and systems integration. For more information, fill the coupon at right.

An equal opportunity employer.

ELECTRONIC COMMUNICATIONS, INC.
P.O. BOX 12248, ST. PETERSBURG, FLORIDA

I'm interested in
ECI's career opportunities in

☐ space instrumentation  ☐ RF engineering
☐ systems integration   ☐ thin-film circuits

Name ____________________________
Title ____________________________
Company _________________________
Address __________________________
City ______________________________
State _______________ Zip __________

Circle 57 on reader service card
CONSIDER COLORADO... transportation gateway... East or West. North or South. Interstate, Intra-State.

Air, rail, truck or bus, consider Colorado, the distribution center for a 13 state area. The state is served by 7 Class I railroads, on 3,671 miles of track within our borders. It's served by 75 transcontinental truck lines, five of which are headquartered in the state. Four of the five are among the largest in the nation. Also, Colorado boasts the second busiest general aviation and the 12th busiest commercial airport in the nation, with 8 commercial airlines making 269 scheduled flights per day. Throughout the state there are a total of 36 public use and 80 civic airports to keep all Colorado in commuting distance of the nation.

If transportation is a consideration in your business, consider industrial Colorado for your expansion or relocation. Complete information is available from Dwight E. Neill, Director, Division of Commerce and Development, 15 State Services Building, Denver, Colorado.
Six ratings from 1 to 3 amps...

1.0 amps, VT1
1.2 amps, VT1N
1.75 amps, VT2
2.0 amps, VT2N
2.6 amps, VT3
3.0 amps, VT3N

CUT COSTS by SPECIFYING CLOSER to YOUR NEEDS

with OHMITRAN v.r.® Low Power, Variable Transformers

You don't have to be satisfied any longer with a few meager ratings in low power variable transformers. Make your selection from 1.0, 1.2, 1.75, 2.0, 2.6, and 3.0-amp Ohmitran v.r.® ratings. No other manufacturer offers this extensive selection, or the exclusive series VT1 and VT3 units.

By specifying closer to actual needs, you normally can cut component cost and make your equipment more competitive.

Ohmitran units offer some unique engineering features, too:

Adjustable shaft (extends from either end) for mounting convenience or for operating auxiliary controls.
Multi-purpose terminals for soldering, quick connectors or screws.
Replaceable brushes with rapid, snap-in design and husky heat sink.
Same silhouette and mounting arrangement for all six ratings allowing standardization of panel treatment.
Model variations include fixed and portable enclosures, ganged assemblies, and motor-driven assemblies.

The Industry's Fastest Growing Line of Variable Transformers... 1 to 25 Amps, Hundreds of Stock and Made-To-Order Models. Write for Catalog 500.
McDonnell needed a battery for the Phantom II that pilots could count on!

Mallory made it.

What can we do for you?

McDonnell needed a battery. A battery that could be relied on when the Phantom II's regular power system failed. A battery that would keep a warning system working in emergencies. A battery able to stand up to the extremes of temperature, vibration and pressure that a supersonic aircraft encounters. McDonnell brought its specifications to Mallory. Mallory made the battery—a mercury battery completely sealed in epoxy resin to withstand these conditions. A battery pilots can depend on!

TWO TYPES OF PATIENT BATTERIES
How long can a battery stand before it's used and still maintain useful capacity? Indefinitely! Some Mallory batteries have their electrolyte stored away from the anode and cathode. They can sit forever until they are needed—then the twist of a screw and they're ready to work.

And normal Mallory Mercury and Mallory Alkaline batteries are distinguished for long shelf life in many applications—emergency transmitters and alarms, cameras and remotely controlled instruments. Mallory Mercury batteries lose only a few percent of capacity per year at normal temperatures (21°C)—some have been stored for 12 years and still have retained useful capacity. Mallory Alkaline batteries are completely reliable even after two or more years of storage.

ALL SIZES, ALL CAPACITIES
Mallory is currently producing over 100 batteries of all sizes and capacities. And if we're not actually producing the battery you need, we'll be happy to work with you in designing a new one.


It's good business to do business with Mallory.
A communications-satellite ground station just completed at Caddo Gap, Arkansas will enable Hughes scientists to begin long-range experiments in space communications completely independent of commercial requirements. Built and operated with company funds, the $2-million station includes an 85-foot dish antenna capable of maintaining contact with satellites over both the Atlantic and Pacific Oceans.

First F-111B to test the Navy's new Phoenix missile landed at the 9,000-foot Hughes runway at Culver City, Calif. in early April for installation of the system. The latest in a long line of advanced airborne weapons systems, the Phoenix was brought in below the minimum size and weight prescribed by the Navy. The Phoenix mission: maintain air superiority over distant objects (beachhead landings) as well as Navy fleets in anti-air warfare.

The attenuated radio signals received from space can now be boosted by a high-power (8-10 kw) traveling-wave tube recently developed by Hughes for ground-station amplifiers. It's the first commercially available tube that can replace klystrons and that can cover the entire communications band. It carries a 2,000-hour warranty, too.

A laser rangefinder, designed for low-flying fighters, has been successfully tested at Eglin AFB. It solves a problem that has long plagued microwave radar systems: their returns get lost in ground clutter at the small grazing angles encountered in low-altitude penetration. The recent USAF tests indicate that the new laser system will definitely improve weapon-delivery accuracy.

Our new Missile Systems Division will combine all Hughes missile activities in one plant at Canoga Park, Calif. The Canoga Park force, planned for more than a thousand, is growing daily. Current programs include the Phoenix missile for the F-111B, the TOW anti-tank missile, and the AIM-4D, GAR-11, HM-55, HM-58, and other members of the Falcon missile family.

100% increase in engineering staff. Latest count at Hughes shows that one employee out of four is either a scientist or an engineer (just six years ago it was only one in eight). And the need continues to increase. So if you're interested in the advanced programs at Hughes (and the good life in Southern California), just write: Mr. D. A. Bowdoin, Hughes Aircraft Co., Culver City, Calif. An equal opportunity employer.

The GIs have a new combat radio that won't be easy to jam: a transistorized, single-sideband, two-way radio with 10,000 individual voice channels. Dubbed Manpack, it's the size of an attache case and weighs only 29 pounds. Manpack bounces its high-frequency signals off the ionosphere, which gives them far greater range than the line-of-sight signals of previous combat radios. Units communicated easily at over 500 miles in recent jungle-terrain tests. Another advantage: Manpack operates as efficiently on flashlight batteries as it does on wet cells. Hughes is producing Manpack for the U.S. Army.

Creating a new world with electronics

HUGHES
HUGHES AIRCRAFT COMPANY

Circle 61 on reader service card
Who designed and constructed the world's highest power RF feed-through bushing?

Lapp Insulator Company

Lapp? Yes, Lapp Insulator of LeRoy, N. Y. Matter of fact Lapp has been designing and producing Feed-Through Bushings for 42 years. They get bigger, and more intricate, all the time. Demanding, unusual specifications don't bother us. Why? Because when it comes to radio frequency insulating components we've got plenty of "know-how"... and ingenuity... and ability to produce the finished product.

Getting back to that "world's highest power" bushing, we designed and made three of these for Continental Electronics Manufacturing Company. They are a vital part of the U. S. Navy VLF transmitter at Northwest Cape, Australia. Each one is rated for 2545 amperes continuous duty at 140 kv RMS at 15.5 kc and is both internally and externally graded to assure uniform voltage distribution. These bushings are approximately 16 feet tall and weigh about 7000 pounds each.

Two other Feed-Through Bushings we've made are shown here. But there have been hundreds of others. Write or call us with any radio frequency insulating problem. Radio Specialties Division, Lapp Insulator Co., Inc., Dept. E, LeRoy, N.Y., 14482.

Lapp

Electronics | April 18, 1966
New ULTRONIX breakthrough!

NEW ULTRONIX POWER RESISTORS WITH SOLID ALUMINUM CORES GIVE MAXIMUM HEAT DISSIPATION

5W Power Resistor
Aluminum Oxide Core
8 BTU-Ft/Ft²Hr·°F (at 275°C)

5W Power Resistor
Beryllium Oxide Core
64 BTU-Ft/Ft²Hr·°F (at 215°C)

Ultronix 5W Power Resistor
Solid Aluminum Core
13 BTU-Ft/Ft²Hr·°F (at 275°C)

RESISTORS SHOWN ACTUAL SIZE

Development of a new dielectric in the Ultronix materials laboratory allows power resistor winding on a solid aluminum core—and brings you the advantages of maximum heat dissipation and design capabilities not possible before! The new Ultronix dielectric material is a high temperature, high emissivity insulation which withstands continuous operation at 350°C and intermittent temperatures in excess of 500°C. This Ultronix dielectric material also withstands high voltage tests between leads and core without flashover—under high temperature and high altitude conditions.

Pick the resulting Ultronix power wire-wound resistor advantages you need:

- **Miniaturization.** An Ultronix power resistor with solid aluminum core requires 1/5 the volume of a beryllia core resistor, and 1/18 the volume of an alumina core resistor—at the same power ratings.

- **Increased Reliability.** With the same physical size at identical power, an Ultronix power resistor with solid aluminum core will have longer life and higher stability than a BeO core resistor, because the Ultronix resistor will operate at half the temperature rise.

- **Increased Power.** When operating at the same temperature, an Ultronix power resistor will dissipate twice as much power as a BeO core resistor of the same size.

For complete electrical specifications, power ratings, heat dissipation pattern and listings of advantages of new Ultronix power wire-wound resistors, request Data Sheet R366—Ultronix, Inc., 461 North 22nd, Grand Junction, Colo. 81502, phone (303) 242-0810.
New TWT delivers 1 KW from 5.5 to 12.5 GHZ... and ITT can deliver the tube.

The new ITT Type F-2085 is a grid-pulsed, helix-type traveling wave tube. It features PPM focusing with temperature-compensated, low-cost ferrite magnets and compact metal-ceramic construction for conformance to MIL-E-5400 requirements. The tube is designed for optimum gain flatness from 7.0 to 11.0 GHZ, but useful gain from 5.5 to 12.5 GHZ can be realized at a minimum power output of one kilowatt. Rated duty is .01 with conduction cooling, or .02 with forced air cooling.

Field tests of the F-2085 have demonstrated outstanding saturation and overdrive characteristics in long-pulse or pulse-burst modes of operation. For additional details and performance data on the F-2085, or on any other tube in our complete line of special-purpose electron tubes, write: Dept. EL4, ITT Electron Tube Division, International Telephone and Telegraph Corporation, Easton, Penn.
These cycle controlled tools give a precise, consistent crimp every time for terminals, lugs, splice fittings, RF fittings, connectors and special devices. They're light and have high-leverage action allowing low-closing hand pressure. Less operator fatigue means higher production . . . lower cost per crimp.

In-line die action and ratchet control provide the most uniform crimping. Tools are corrosion resistant. Available in standard and miniature models.


CH Tools Crimp Co-axial and Shielded Fittings and Connectors—Dies are interchangeable and positive bottoming. These tools will crimp BNC, TNC, and N series connectors, and many other fittings requiring hex crimps. Miniature models also available.

CD Tools for Special Custom Applications are furnished with blank dies or special dies as required. Write today for complete information on these high performance crimping tools.
A new era for current-mode switching... with Motorola's 1800 MHz 2N3960 NPN Silicon Annular* Transistor

A new magnitude of switching speed for non-saturated, digital systems applications is here — ready for your immediate prototype designs... with typical $f_t$ performance of 1800 MHz!

Previously, frequency response has been limited to a range of about 1200 MHz before encountering a self-limiting trade-off with breakdown voltage. Now, Motorola's newly developed "narrow-base profile" process technique makes possible a micro-thin base thickness (on the order of 0.1 micron) and a new high level of frequency response ($f_t$).

And, because the 2N3960 uses Motorola's patented annular device structure, this frequency response is offered to you at no sacrifice in breakdown voltages. You've come to expect this with all annular built devices.

As a result, both 2N3960 and its sister device, 2N3959, are able to satisfy, as never before, the three key requirements for highest speed in current-mode designs — high $f_t$, low capacitances, and low base-spreading resistance.

Guaranteed minimum $f_t$ values are 1300 MHz for 2N3959 and 1600 MHz for 2N3960 at 10 mA. Both are also specified at 5 and 30 mA collector currents.

**TYPICAL SWITCHING TIMES**

<table>
<thead>
<tr>
<th>Collector Current (mA)</th>
<th>0.5</th>
<th>1.0</th>
<th>2.0</th>
<th>5.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (ns)</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Fall Time (ns)</td>
<td>1.5</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Turn-On Delay (ns)</td>
<td>0.5</td>
<td>1.0</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Turn-Off Delay (ns)</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
<td>16.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

**LIMIT CURVES AVAILABLE IN DESIGNERS' DATA SHEET**

You'll find a full complement of limit curves on each device in a special Motorola Designers' Data Sheet. Thus, you can readily explore their use in your circuits using "worst case" design techniques. Both devices are in stock in TO-18 packages. TO GET STARTED, send for your copy of the Data Sheet. Simply write Technical Information Center, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.
New FEL digitally programmable Microwave Synthesizer!

Tuning time is less than 50 u.s. Frequency accuracy .001%. Spurious rejection more than 60 db. Adaptable to the control of many existing sweep generators. Ideal for automatic test equipment or frequency agile systems.

plus new YIGS, wavemeters, synchronizers, and filters from 1 to 40 Gc!

NEW YIG FILTERS
Octave or waveguide bands to 40 gc. 2 or 4 sphere structures; low insertion loss. Wide bandwidths available.

NEW TUNABLE BANDPASS FILTERS
Octave or waveguide tuning ranges from 1 to 40 gc. Single knob tuning; 2, 3 or 4 sections. Typical 3 db bandwidth 20 MC.

NEW WAVEMETERS
Octave and waveguide tuning ranges. Direct reading. Absolute accuracy ±0.05%. Also direct reading meter accuracies to 0.001%.

NEW SYNCHRONIZERS
Klystron & BWO phase lock units for each frequency range, plus a model 136A which handles 1-40 gc complete. Crystal oven option available for improved stability.

NEW DIGITAL DATA ACCUMULATOR
For use in analysis of output of receivers, etc. Detects and indicates absolute amplitude, performs digital integration of video signals, or serves as autocorrelator. Can be adapted to measure pulse repetition frequency, pulse width, etc. For data handling functions, the sample and hold circuit is capable of less than 60 nanoseconds aperture time and can hold information to 0.01% accuracy in excess of 100 microseconds.

EXCEPTIONAL EMPLOYMENT OPPORTUNITIES FOR MICROWAVE, INSTRUMENTATION AND DIGITAL ENGINEERS in one of the fastest growing young companies in the field.

Mail coupon for complete details.

FREQUENCY ENGINEERING LABORATORIES
A Division of Harvard Industries, Inc.
P. O. Box 527
Farmingdale, N. J. 07727
Aree Code 201) 938-9221
or dial CD 7-7040 toll-free from N. Y.

[Circle 67 on reader service card]
1. MORE POWER in MIL SPEC SIZE

<table>
<thead>
<tr>
<th>DALE TYPE</th>
<th>MIL-R-26C TYPE</th>
<th>MIL-R-23379 TYPE</th>
<th>POWER RATING (WATTS)</th>
<th>RESISTANCE RANGE (OHMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-1</td>
<td>—</td>
<td>—</td>
<td>1.0</td>
<td>10 to 950, 1 to 3.4K</td>
</tr>
<tr>
<td>G-3</td>
<td>RW-70</td>
<td>RWP-18</td>
<td>2.25</td>
<td>1 to 2.7K, .1 to 10.4K</td>
</tr>
<tr>
<td>G-5C</td>
<td>RW-69</td>
<td>RWP-20</td>
<td>5</td>
<td>1 to 8.6K, .1 to 32.3K</td>
</tr>
<tr>
<td>G-15</td>
<td>RW-68</td>
<td>RWP-23</td>
<td>15</td>
<td>.5 to 73.4K, .1 to 273K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DALE TYPE</th>
<th>MIL-R-18546C TYPE</th>
<th>POWER RATING (WATTS)</th>
<th>RESISTANCE RANGE (OHMS)</th>
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</thead>
<tbody>
<tr>
<td>HG-5</td>
<td>None</td>
<td>15</td>
<td>1 to 6.5K, 1 to 24.5K</td>
</tr>
<tr>
<td>HG-10</td>
<td>RE-65</td>
<td>20</td>
<td>1 to 12.7K, .1 to 47.1K</td>
</tr>
<tr>
<td>HG-25</td>
<td>RE-70</td>
<td>35</td>
<td>.5 to 25.7K, .1 to 95.2K</td>
</tr>
<tr>
<td>HG-50</td>
<td>RE-75</td>
<td>50</td>
<td>.5 to 73.4K, .1 to 273K</td>
</tr>
</tbody>
</table>

Major Environmental Specifications: LOAD LIFE: 1% Max. ΔR in 1000 hours at full power. OVERLOAD: .5% Max. ΔR at 3, 5, or 10 times momentary overload per applicable Mil. Spec. OPERATING TEMPERATURE: -55°C to +275°C

G Series models are typical: 10 resistors in complete line.

2. THE SAME POWER in LESS SPACE

- 1 Watt Silicone Coated Resistor
  Conventional MIL-R-26C and MIL-R-23379
  DALE G-1

- 15 Watt Mil. Rated Housed Power Resistor
  Conventional MIL-R-18546C Size
  DALE HG-5

3. EXCEPTIONAL STABILITY at CONVENTIONAL RATINGS

Two RW-69, MIL-R-26C resistors (Dale G-5C and conventional silicone-coated wirewound) operated at Mil power levels.

Two RE-65, MIL-R-18546C resistors (Dale HG-10 and conventional housed power wirewound, RH-10) operated at Mil power levels.

4. IMPROVED THERMAL EFFICIENCY

The chart at right shows the outstanding heat dissipation advantages which the beryllium oxide cores used in Dale G and HG resistors have over conventional core materials. To complement this advantage, Dale uses a special high temperature silicone coating on the G Series and a new extruded aluminum housing for the HG Series.

FOR COMPLETE INFORMATION
WRITE FOR CATALOG A

DALE ELECTRONICS, INC.
1300 28th Avenue, Columbus, Nebraska

Circle 68 on reader service card
Despite resolute White House and Pentagon silence, the widespread assumption in Washington is that military spending for Vietnam will continue to rise and production to fill military orders will continue to run at a high-priority pace.

It's generally accepted that President Johnson will have to ask for another hefty supplemental appropriation to finance the war. He recently received an extra $13 billion for fiscal 1966. The outstanding questions are how much will he ask and when will he ask for it. Guesses run all the way from a few billion dollars to $10 billion or more, with the request coming right after the November elections.

The fiscal 1967 defense budget, drawn up last December, assumed that the war would not continue beyond mid-1967, that equipment consumption rates would not climb faster than last year's predictions and, apparently, that the manpower commitment would remain below 300,000. Defense Secretary Robert S. McNamara held his planners to these assumptions to insure against overbuying of the type that left the Defense Department with huge surpluses after the Korean War.

The Navy and Air Force are proceeding toward the design of the next generation of tactical aircraft—replacements in the early 1970's for McDonnell Aircraft Corp.'s supersonic F-4 and Ling-Temco-Vought, Inc.'s supersonic A-7, just going into production. Both services want a plane with combined air-to-air combat and ground-support capability. Though they are proceeding independently, before Defense Department approval is granted to a development program, chances are they will have to mold their ideas and come up with a common plane. McNamara's commonality concept is still in effect despite the flap over General Dynamics Corp.'s F-111.

The Air Force Systems Command has awarded a contract for preliminary design studies to North American Aviation, Inc., the Boeing Co. and Lockheed Aircraft Corp., and hopes to enter final design competition by January. The avionics will probably incorporate an advanced version of the F-111's Mark 2, now in the contract-definition stage with the Hughes Aircraft Co., North American's Autonetics division and Sperry Rand Corp.'s subsidiary, the Sperry Gyroscope Co., competing for the development contract.

The Navy is drawing up for submission to the Pentagon a technical development plan culled from studies conducted by Boeing and the Douglas Aircraft Corp. The Navy's variable-sweep winged plane will probably incorporate a refined version of the integrated light attack avionics system being developed for the A-7 by Sperry Gyroscope.

The resignation of E. William Henry as chairman of the Federal Communications Commission could have a serious impact on three areas of the electronics industry: community antenna television (CATV), nationwide pay-tv and the forthcoming investigation of the American Telephone & Telegraph Co.

Henry, a commission member since October, 1962, is credited with steering through the agency the new rules covering the operation of CATV; he is known to fully support the probe of the rate structure
The Federal Trade Commission has given television tube manufacturers a six-month delay, to Jan. 1, on its size-measurement rules; producers now include outside areas in their measurements.

The FTC also has exempted from the ruling tv sets manufactured before July, 1966, because most manufacturers already have printed tube-size specifications for this year. The ruling will cut the advertised size of most black-and-white tubes by one inch and the size of most color tubes by two inches.

The Senate is considering federal regulations of portions of the electronics industry in an effort to stem the growth of industrial espionage. An inquiry into the extent of industrial spying, with special emphasis on the use of electronic equipment to gain access to industrial secrets, will be opened next month by Sen. Edward V. Long's (D., Mo.) subcommittee on Administrative Practice and Procedure. The subcommittee is part of the powerful Senate Judiciary Committee.

Long's investigations already have led to tightening of restrictions on bugging within the Federal Bureau of Investigation and other government investigating agencies.

Long says his subcommittee is exploring a range of possible federal controls, from regulating the manufacturer of the devices to prohibitions on their sale.

This session of Congress probably won't act on legislation to loosen the government's legal hold on inventions developed during work under federal contract. Unless some concession is made to mollify those who favor tighter rules governing the ownership of such patents, Sen. Russell Long (D., La.) says he plans to filibuster against the Senate patents bill. Even if he fails to block the bill in the Senate, Long has sufficient support in the House to stalemate action this year.

Except for certain agencies—for example, the Atomic Energy Commission and the Federal Aviation Agency—federal administrators exercise wide latitude in assigning rights to inventions developed during government projects; the FAA and the AEC operate under separate laws that set patent-ownership standards.

The current round of congressional bargaining is over a bill introduced by John McClellan (D., Ark.) chairman of the Senate Patents subcommittee, which would turn over to contractors an estimated 75% of all patents arising out of federal contracts; this would represent a more liberal policy, favoring industry. The subcommittee is part of the Judiciary Committee.

Two Senators who support Long on the five-man subcommittee have said they'd back the bill provided it were amended to say that, in general, decisions on patent ownership will be made after inventions are developed, not during preliminary negotiations.

The McClellan bill, which President Johnson supports, is patterned after the current government policy on patents.
Why specify Mallory wet slug tantalum capacitors?

One reason:
\( \square \) lowest weight and smallest size per microfarad-volt

Check these characteristics:

<table>
<thead>
<tr>
<th>Wet Slug Mallory MTP</th>
<th>Solid Mallory TAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mfd-volts/in³</td>
<td>178,000</td>
</tr>
<tr>
<td>Wt: grams/mfd-volt</td>
<td>0.00067</td>
</tr>
</tbody>
</table>

Specify Mallory wet slug tantalum capacitors wherever you need lowest DC leakage, and proven freedom from catastrophic failure. Note: they don’t need voltage derating. We’ll help you by recommending the best type for your application.

And we’ll recommend without bias, because we make a complete line of wet slug, solid and foil types. Write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

Electronics | April 18, 1966

Circle 71 on reader service card
Dick Whittington, ace space scientist, was baffled by an over-modulated data signal while testing the 7-litre rockets of his supersport moon machine. The signal looked like a stock-market cycle: \( \begin{array}{c|c|c|c|c|c|c} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ \end{array} \) Naturally, our resourceful hero thought of A.G.C. But he knew that wouldn't work.

Suddenly, he had an inspiration! With the speed of light, he contacted Sangamo Electric Company via his two-way 17-jewel wrist TV. From Springfield, Illinois, came the comforting voice of Philo Faraday, a crack Sangamo engineer, saying, "Why, that's easy as \( \pi \). What you need is our Type AR-2L two-level automatic solid state Attenuator/Restorer with integrated circuits."

"It attenuates your data signal so that it looks like \( \begin{array}{c|c|c|c|c} 1 & 1 & 1 & 1 & 1 \\ \end{array} \) as stored on magnetic tape, and like \( \begin{array}{c|c|c|c|c|c|c} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ \end{array} \) when reconstituted by the restorer."

"Eureka!" Dick exclaimed. "And you say it's inexpensive, too?" Excitedly, Mr. Faraday replied, "Right! And the Type AR-2L substantially broadens the effective dynamic range of your recorder, and allows for transients without sacrificing low-level data... no need for costly channel sharing, either."

"Zounds, I must have one posthaste!" allowed Dick. "Now my peaks won't look so peaked, and Sangamo's two-level automatic Attenuator/Restorer will put my missing data back on the band."

THE MORAL: No need to lose expensive data. If you don't have a wrist TV, write, wire, or phone for complete description to

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When we design special components for our systems—we're designing efficiency. That's a HODAD* our engineer is holding, it's just one of the many special subsystems in the Ci-5000 Analog-Hybrid Computer shown above. What's so special about it? It's the first all solid state device to replace servo-set potentiometers in a hybrid computer system! Why does it increase the efficiency? Because one hundred HODAD's can be set-up in less than one second! Before the HODAD, it took over one second to set-up each potentiometer. All subsystems in the Ci-5000 are designed to keep set-up time to a minimum and operating time to a maximum—find out more about the "efficient" Ci-5000, see your COMCOR representative or contact COMCOR direct. Telephone (714) 772-4510. TWX 714-776-2060.

*Hybrid Operated Digital Attenuator Device

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A SUBSIDIARY OF ASTRODATA, INC.
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The RFL Model 1605A Calibration-Transfer Standard has just about everything—a potentiometer, galvanometer, volt-box, shunt-box, standard cell and thermal transfer element—in one compact cabinet (27" x 16" x 11"). There's no slaving over "patchwork" transfer standards... no fussing and fooling with interconnecting wires and separate components.

And the 1605A brings precise measurement and calibration to instruments that can't be brought to a central standards lab. Because it's all-in-one, it gives fast measurement of AC and DC emf to 1500 V and current to 15 A over frequencies from 20 Hz to 50 kHz (to 30 mHz with adapters). Long term accuracy, traceable to NBS, is .05%... $3,750.

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Designers and Manufacturers of Electronic Equipment since 1922.

Circle 75 on reader service card
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3 Triplett’s famous self-shielded Bar-Ring magnet, with one-piece die-cast frame, all DC and DC suspension type instruments.  

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GO

20 Hz to 1 GHz

Kay 1500 Sweep & Marker Generator

TYPICAL PLUG-INS

<table>
<thead>
<tr>
<th>Model</th>
<th>Center Freq.</th>
<th>Sweep Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-141</td>
<td>20 Hz-200 kHz</td>
<td>20 Hz-20 kHz</td>
</tr>
<tr>
<td>P-142</td>
<td>35 Hz-600 kHz</td>
<td>20 Hz-20 kHz</td>
</tr>
<tr>
<td>P-130</td>
<td>100 Hz-2 MHz</td>
<td>200 Hz-2 MHz</td>
</tr>
<tr>
<td>P-152</td>
<td>10 KHz-20 MHz</td>
<td>10 KHz-20 MHz</td>
</tr>
<tr>
<td>P-855</td>
<td>2-32 MHz</td>
<td>5 Hz-800 kHz</td>
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<tr>
<td>P-856</td>
<td>10-120 MHz</td>
<td>10 Hz-1 MHz</td>
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<td>10 KHz-30 MHz</td>
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<tr>
<td>P-867</td>
<td>220-470 MHz</td>
<td>20 KHz-30 MHz</td>
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<tr>
<td>PL-123</td>
<td>100-1000 MHz</td>
<td>5 KHz-Octave</td>
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<table>
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<tr>
<th>Model</th>
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<tbody>
<tr>
<td>PM-763</td>
<td>6 Pulse &amp; Ext.</td>
</tr>
<tr>
<td>PM-762</td>
<td>6 Pulse &amp; Ext.</td>
</tr>
<tr>
<td>PM-932</td>
<td>30 Pulse</td>
</tr>
<tr>
<td>PM-861</td>
<td>6 Harmonic and CW Osc.</td>
</tr>
</tbody>
</table>

VOLTAGE CONTROLLED OSCILLATORS

- MARKERS
  - Pulse
  - RF Turn-off
  - Harmonic
  - CW Birdie

- SWEEP
  - 0.2 to 60 cps
  - Log and Linear
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Great editorial is something he takes to work
One Good Single-Turn Calls for Another... Now Bourns Offers You Eight!

Whenever it's a question of single-turn precision potentiometers, you get more and better answers from Bourns. Here's the all-star lineup:

<table>
<thead>
<tr>
<th>BUSHING MOUNT</th>
<th>SERVO MOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 3530, 3/4&quot;</td>
<td>Model 3580, 3/4&quot;</td>
</tr>
<tr>
<td>Model 3430, 1 1/4&quot;</td>
<td>Model 3480, 1 1/4&quot;</td>
</tr>
<tr>
<td>Model 3410, 2&quot;</td>
<td>Model 3460, 2&quot;</td>
</tr>
<tr>
<td>Model 3440, 3&quot;</td>
<td>Model 3490, 3&quot;</td>
</tr>
</tbody>
</table>

In this complete single-turn line, the quality matches the quantity. Exclusive SILVERWELD® multi-wire termination eliminates the chief cause of potentiometer failure. Construction insures humidity performance that meets the cycling requirements of MIL-R-12934. One hundred per cent inspection and the double-check follow-through of the Bourns Reliability Assurance Program are your final quality guarantees. Whatever you need in single-turns, you'll find the answer at Bourns — the complete source! Write for technical data on our entire line of bushing and servo models, KNOBPOT® potentiometers, and turns-counting dials.

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Why buy a new Esterline Angus Servo Recorder instead of brand A, B, C or D?

for 12 good reasons*

<table>
<thead>
<tr>
<th>X's indicate standard features at no extra cost</th>
<th>Esterline Angus</th>
<th>Brands (names available on request)</th>
</tr>
</thead>
<tbody>
<tr>
<td>List price, $975 or lower</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td>Solid state amplifier</td>
<td>X</td>
<td>B</td>
</tr>
<tr>
<td>50,000 ohm off balance input impedance or better</td>
<td>X</td>
<td>C</td>
</tr>
<tr>
<td>Response as fast as $\frac{1}{2}$ second even at a 1 MV range</td>
<td>X</td>
<td>D</td>
</tr>
<tr>
<td>Accuracy $\pm \frac{1}{4}%$ span or $\pm 3\frac{1}{2}$ microvolts</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dead band 0.1% of span or less</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Stray rejection: longitudinal 60 cycle AC, 1,000 times span or 120 volts</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Permanently sealed slidewire requires no cleaning</td>
<td>X</td>
<td></td>
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<tr>
<td>5 chart speeds</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chart tear off</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Tilt writing platen</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pen lifter</td>
<td></td>
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</tbody>
</table>

*Discover additional reasons for buying Esterline Angus Single and Two-channel Wide Chart (10") Servo Recorders. Write for Series "E" Catalog.

Esterline Angus Instrument Company, Inc.
Box 24000 E • Indianapolis, Indiana 46224

Excellence in instrumentation for over 60 years
Laser research is turning to Raman and Brillouin effects as a way of controlling the frequency of a laser so that any desired wavelength for a particular application can be obtained. For example, our cover shows a green laser beam in an underwater communication experiment. Water is relatively transparent to green laser light.

A well-known principle, little used outside auto ignition systems, is the basis of a converter-regulator circuit that can provide efficient and reliable conversion of d-c voltages from one level to another. The technique takes advantage of the stored energy in a magnetic field.

Up to now semiconductor components haven’t been able to cope with the design requirements imposed by large-screen color television receivers. Now, using newly available high-voltage video drive transistors and some sophisticated circuitry, one company has designed and demonstrated a 23-inch receiver that is almost completely solid state.

Expensive solid state equipment literally can be destroyed in a flash—by transients occurring on a-c power lines. Gas-filled surge arresters—simple devices that resemble radar transmit-receive switches—provide fast, reliable protection.
Nonlinear dielectrics permit high-power beams to be generated at many new frequencies. These should open new applications in medicine, chemistry, physics and communications.

By Fred M. Johnson


In the constant search for ways to put lasers to work, a major obstacle has been the difficulty of obtaining powerful beams at several frequencies from the same laser. One of the most promising approaches to a solution is the interposition of a dielectric material in which an intense optical field produces nonlinear effects.

When the material and the original beam intensity are chosen carefully, they permit powerful new beams to be generated in almost any portion of the spectrum from the near ultraviolet to the far infrared. It may also be possible to control pulsewidths and repetition rates, and to modulate the beam externally.

The resulting nonlinear effects could be valuable in many fields:

- In biology, providing high-power beams at specific frequencies, to induce mutations and other genetic changes.\(^1\)
- In medicine, where laser-radiation therapy may be a powerful weapon against certain diseases.\(^2,3\)
- In chemistry, where intense radiation at wavelengths corresponding to those of molecules in an excited state may lead to new reactions and perhaps new compounds.
- In underwater communications, because high-intensity coherent green light, produced by doubling the frequency from a neodymium laser, is the color that is best transmitted through water and also the color to which the eye and other detectors are most sensitive.
- In engineering, in applying nonlinear optics to parametric amplifiers, oscillators and IR detectors.
- In atmospheric studies, high-power beams at Raman-shifted frequencies are best for producing differential light absorption and backscattering from aerosols.\(^4\) This technique permits the remote determination of air density, pressure, temperature, wind velocity and concentration of oxygen, carbon dioxide and water.

When intense laser light passes through a material, electric fields associated with the light produce changes in the material’s refractive index. These nonlinear and complex changes, in turn, can produce new frequencies at high intensities.

If the change in refractive index is described as an induced electric dipole, and written as a power series in terms of the electric field (E), successive components, particularly the quadratic term, of the series may be comparable in magnitude to the linear component. This is similar to radio technology, where the square law (E\(^2\)) is used to obtain modulation, demodulation and mixing.

Materials that behave nonlinearly in the presence of an intense optical field can provide almost any optical frequency with powers as high as a megawatt. One nonlinear medium, lithium metaniobate, has been tuned continuously through the infrared.\(^5\) Ruby and neodymium-doped glass lasers, Q-switched to provide multimegawatts of power, often provide the fundamental wavelengths of 6,943 angstroms (red) and 10,600 angstroms (infrared), respectively.

With an appropriate medium, two light beams
Parametric laser amplifier can be operated as an oscillator if the ends of the crystal to the right of the laser are coated with a reflective dielectric. Such oscillators are tunable and can provide high-power coherent frequencies.

may be mixed; sum and difference frequencies may be obtained, and the frequencies may be doubled, tripled or quadrupled. With a nonlinear medium and Raman-active material—which shifts wavelengths towards either infrared or ultraviolet—the number of frequency combinations can be increased even further.

Controlled scattering

Two important nonlinear effects are the Raman effect and the Brillouin effect. Raman-shifted frequencies have been studied for the applications mentioned previously.

For more than a quarter of a century, scientists have observed Raman lines—new frequencies generated in a dielectric by an intense incoherent light source. With the laser, under suitable conditions, coherent light can generate a new set of coherent frequencies, each shifted by an exact multiple of the fundamental frequency of the dielectric material.

Coherent Raman frequencies are generated when the input power exceeds a certain threshold, which varies depending on the material. However, dielectric breakdown caused by focusing the laser light with a lens to concentrate the electric field can cause damage. If the field intensity becomes too high, it can cause deterioration of the Raman-active material, the lens and even eventually of the laser rod. Some materials, which can be made to produce Raman frequencies, can also accommodate even higher powers, enough to produce the Brillouin effect. This scattering produces intense ultrasonic energy in which acoustic waves interact with light.

High power of Raman-shifted frequencies is built up when a laser is Q-switched. The new frequencies are emitted predominately in the same direction as the original beam. Coherent Raman frequencies can be emitted by many organic liquids—benzene, nitrobenzene, chlorobenzene, carbon tetrachloride and carbon disulfide—and by some gases and solids. The Brillouin effect, on the other hand, produces its largest frequency shift in an optical beam that travels backwards, toward the original beam’s source.

Both mechanisms cause high-intensity laser light to interact with phonons. In the Brillouin effect, the interaction results in a net transfer of energy; in the Raman effect, no energy is transferred among the phonons.

For the Raman effect, the phonons are present
in the crystal lattice of the nonlinear medium; they consist of dipoles whose charges move apart and together as the molecules vibrate. Although charges are displaced within the dipole, there is no net transfer of energy between adjacent dipoles.

For the Brillouin effect, energy is transferred between successive molecules as the acoustic phonons move in a wavelike manner.

In a medium where both effects can be achieved, the first to appear is the one that occurs at the lower threshold—usually the Raman effect in nonlinear materials. For some materials, however, notably water and quartz, the Brillouin threshold is lower.

At Electro-Optical Systems, Inc., a combination of Raman and other nonlinear phenomena has been observed with the experimental setup that is shown below. With potassium dihydrogen phosphate (KDP) as a dielectric, the frequency of 1.06-micron radiation from a Q-switched neodymium-doped laser has been doubled, and a pulse power of 10 megawatts produced at a new wavelength, 5,289 angstroms. This second harmonic then generates many new, coherent Raman frequencies in various organic liquids. When helium and methane were mixed under high pressure, combination lines were observed; coherent radiation in the near infrared was detected by parametric up-conversion. The table on page 86 lists some of these frequencies.

The intense hypersonic acoustic waves generated with the Brillouin effect—30 to 60 gigahertz at up to one kilowatt of pulse power—have been found valuable in materials probing. These power densities are at or near the limit that can be withstood by nonlinear materials; at higher power densities, materials either degrade severely or disintegrate completely. For example, $10^9$ megawatts per square centimeter is required to stimulate Brillouin scattering in quartz, but this density produces defects in the crystal at the focus of the laser beam. Higher power densities probably would shatter the quartz crystal.

Applications for Raman-shifted frequencies have already been mentioned for biology, medicine, chemistry, communications and physics. Applications for the Brillouin effect are expected in underwater communications, because of the ease with which acoustic waves can be transmitted through water. In medicine, hypersonic waves may help to detect tumors in the same way in which they map the ocean bottom; lower frequencies already have been used to detect tumors.

For medical experiments, ruby and neodymium lasers have been the most common. Only recently have researchers begun to realize that other frequencies of high-intensity light are available. The

![Diagram of nonlinear elements](https://example.com/diagram.png)

**To generate the fourth harmonic**, unfocused output from a Q-switched neodymium laser is passed through a crystal of potassium dihydrogen phosphate (KDP) at left to convert 1.06-micron radiation to 5,300 angstroms. A prism separates the two frequencies; the 5,300-angstrom line is reflected and focused onto the second KDP crystal. This crystal changed the 5,300-angstrom radiation to 2,650 angstroms, or four times its original frequency.

**Nonlinear elements used for multiple-frequency generation** are aligned in experimental arrangement. Some of the elements can be interchanged to provide higher power at specific frequencies; for example, the Raman cell can be placed behind the KDP crystal instead of in front of it. In that case, a new set of frequencies could be Raman-shifted, using the doubled frequency as the pump.
rubylaser even has been used as an amplifier of Brillouin-shifted light.\textsuperscript{10}

Green light from a laser has been used to destroy pigmented cellular tissues on the retinas of 12-day-old embryos of chicks. Radiation as low as one megawatt per square centimeter was enough to destroy the cells; this result is explained by the fact that the retina is most sensitive to the green portion of the spectrum. Also observed was a slowing of the rhythmic muscular contraction in cardiac muscle cells of a five-day-old embryo following exposure to 5,300 Å radiation. The lethal effects on tissue cultures of an intense 2,650 Å line in the ultraviolet are now being studied.

These experiments have been conducted by Donald E. Rounds of the Pasadena Foundation for Medical Research, and the author.

A mathematical model

The interaction of a laser beam with a nonlinear medium can be represented by Maxwell's equations for electromagnetic radiation. Nonlinearity is introduced into the equations as an inhomogeneous current. This model permits the mathematical representation of some properties of nonlinearity, including dispersion, resonance and symmetry.\textsuperscript{11}

The dominant effect of the laser’s high-intensity field on the dielectric medium is an induced electri-
Intensities of new Raman frequencies

<table>
<thead>
<tr>
<th>Compound</th>
<th>With ruby laser (6943 Å)</th>
<th>With second harmonic of Nd&lt;sup&gt;3+&lt;/sup&gt;-doped laser (5289 Å)</th>
<th>Raman shifts excited by 5289 Å second harmonic of Nd&lt;sup&gt;3+&lt;/sup&gt;-doped laser (cm&lt;sup&gt;-1&lt;/sup&gt;)</th>
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</thead>
<tbody>
<tr>
<td>Cyclohexane</td>
<td>medium</td>
<td>very strong</td>
<td>2843 ± 10</td>
</tr>
<tr>
<td>Methyl cyclohexane</td>
<td>medium</td>
<td>very strong</td>
<td>2920 ± 10</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>(none)</td>
<td>very strong</td>
<td>2855 ± 10</td>
</tr>
<tr>
<td>Carbon disulfide</td>
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<td>very strong</td>
<td>2935 ± 10</td>
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<tr>
<td>Acetonitrile</td>
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<td>very strong</td>
<td>2850 ± 10</td>
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<td>Acrylonitrile</td>
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<td>2920 ± 10</td>
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<tr>
<td>Benzene</td>
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<td>weak</td>
<td>655 ± 20</td>
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<td>Pyridine</td>
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<td>very strong</td>
<td>2945 ± 20</td>
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<td>Tert-butyl bromide</td>
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<td>medium</td>
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</tr>
<tr>
<td>Cyclopentene</td>
<td>(none)</td>
<td>weak</td>
<td>2214 ± 10</td>
</tr>
</tbody>
</table>

The induced dipole moment; a displacement occurs between the positive and negative charge. As the beam passes through the medium, the induced electric dipole oscillates either at the same frequency or at a harmonic frequency of the driving electric field—assuming that the medium is lossless and non-magnetic. The frequency of oscillation depends on the direction in which fields are applied, and on the crystal symmetry of the dielectric medium. Doubling and mixing can be observed only in asymmetrical crystals such as KDP and lithium niobate (LiNbO<sub>3</sub>).

From the induced dipole moment arise second and third harmonics as well as direct-current polarization and mixing. For generating second harmonics, the applied electric field must be in the KDP crystal’s XY plane with equal components of the field applied in the X and Y directions. P. A. Franken and J. F. Ward have demonstrated generation of second harmonics, but the power was low. Later, higher powers and efficiencies were obtained by taking into account a factor

---

**For detecting coherent Raman frequencies,**

the spectrometer separates wavelengths and records those from about 0.25 micron to 1 micron directly on photographic film. Wavelengths greater than 1 micron and less than 3 microns are recorded directly on photographic film after parametric up-conversion.
 called the coherence length. The coherence-length effect arises because most media are dispersive to some extent, and their refractive indexes vary as functions of their wavelengths. Thus, a second harmonic travels at a speed different from that of its primary driving field; the coherence length is the distance at which the second harmonic is 180° out of phase with the driving field. Beyond this length, destructive interference occurs and no additional advantage is gained from the use of larger crystals.

However, in a birefringent crystal, if the direction of the incident light is chosen so that the refractive index of the ordinary ray at the incident frequency is equal to the refractive index of the extraordinary ray at the second harmonic, both rays travel at the same speed. The locus of points for the two rays around the crystal’s optical axis is a cone. However, since the input electric field is in a specific direction, the paths of the rays reduce to one particular direction. Conversion efficiencies as high as 20% have been attained with this technique. At Electro-Optical Systems, an output power of 10 megawatts at 5,300 Å has been obtained with an input of 50 megawatts at 10,600 Å.

**Parametric amplifier**

Parametric amplification of light at various frequencies requires three basic elements: a pump-driving field, a signal wave and an idler wave. It is not necessary to supply all three externally, however, because if the signal and pump are present the idler is generated automatically. Furthermore, if gain occurs for the signal frequency it will also occur for the idler frequency. Two conditions must be satisfied: conservation of photon energy and of momentum.

At the bottom of page 84, a Raman cell generating a single frequency is shown. In the diagram on page 85, the signal is introduced externally by a gas laser. In both cases, observations are made both at the signal and at the automatically generated idler frequency. The pump frequency is provided by doubling the frequency of the output from the Q-switched laser with a KDP crystal. Both of these approaches to parametric amplification are being followed at Electro-Optical Systems.

An optical parametric amplifier has recently been built by C.C. Wang and C.W. Racette at the Philco Corp.15

For a five-centimeter KDP crystal, a gain of 25% is expected, with a pump power of five megawatts. If a KDP crystal is to be used as an oscillator, the ends of a second KDP crystal are made reflective; this crystal is shown at the right of the laser in the photograph, at the top of page 83, of a typical parametric amplifier.

Infrared frequencies have been recently detected by parametric up-conversion—mixing the infrared frequency with the output of a pulsed ruby laser. Infrared was detected as far as 2.2 microns in the visible region—about 5,000 Å.

**Double vibration**

More than 30 Raman-active liquids have been studied at Electro-Optical Systems. One such substance, benzonitrile, can be made to oscillate in two modes, one at $3 \times 10^{10}$ cycles per second, the other at $6.657 \times 10^{14}$ cycles. Coherent Raman frequencies are produced as a result of these two fundamental vibrations; addition to multiples of these frequencies, sums and differences have been observed. The experimental arrangement is shown in the diagram on page 86.

So far, only a few compounds have exhibited this double vibration mode, although there also have been other experiments with mixtures of liquids and of gases. Only a few of these mixtures exhibit coherent Raman phenomena, and even fewer exhibit sum and difference effects. Their importance lies not only in extending the coherent frequency ranges, but also in clarifying the fundamental mechanisms of Raman phenomena.

Quadrupling of 1.06-micron radiation was achieved at Electro-Optical Systems by successively doubling two crystals of KDP. Tripling of the radiation from a 1.06-micron neodymium-doped glass laser in KDP also was achieved recently. The table at top left summarizes the data on frequency quadrupling. These frequencies are expected to be very useful in biological research.

**References**

6. F.M. Johnson and J.A. Durando (to be published).
Nomographs calculate values for twin-T notch filter

In two quick steps, an engineer can easily determine the values of components needed for a twin-T filter that has a symmetrical responsive curve.

By Tom G. Purnhagen

Air Force Cambridge Research Laboratories
L.G. Hanscom Field, Bedford, Mass.

A nomograph greatly simplifies the design of twin-T notch filters that have symmetrical response curves. Such filters are frequently used to reject a specific frequency, or may be included in a negative feedback loop of a selective amplifier as a tuning element. Although other combinations of components may be used, the one shown in the schematic at the right has the greatest possible selectivity.

With this general configuration, any filter exhibits infinite attenuation at notch frequency \( f_0 \), which is specified by the values of \( R_1 \) and \( C_1 \). If the aim is only to reject \( f_0 \), then the choice of one of these values is arbitrary. In most cases, however, it is also desirable to design the filter with a symmetrical response curve, so the d-c gain is equal to that at high frequencies. These conditions are accomplished when

\[
R_1 = \left( \frac{1}{2} R_g R_L \right)^{1/2} \tag{1}
\]

The notch frequency is determined by

\[
f_0 = \frac{1}{4\pi C_1 R_1} \tag{2}
\]

The author

Tom G. Purnhagen is a captain in the United States Air Force and is presently assigned to the Air Force Cambridge Research Laboratories as an electronics engineer. Previously, he served as communications officer at various Air Defense Command radar stations in the U.S. and Canada.

Two nomographs based on equations 1 and 2 are shown. The usual design problem requires the solution for values of \( R_1 \) and \( C_1 \) when \( f_0 \), \( R_g \) and \( R_L \) are known. However, the charts can be used to determine any of the equation parameters if two are specified. Chart 2 can be used alone—with \( R_1 \) or \( C_1 \) arbitrarily selected—if symmetrical response is not essential.

Design example

A filter is required to have infinite attenuation at a frequency of 500 cycles per second and it is to be inserted between a source impedance of 2,000 ohms and a load resistance of 100,000 ohms. The steps in using the nomograph to solve this problem are indicated by the dotted lines. The resulting values for the circuit elements are \( R_1 = 10,000 \) ohms from chart 1 and \( C_1 = 0.01 \mu \text{f} \) from chart 2.
Nomographs for designing symmetrical twin-T filters

Chart 1

SOURCE IMPEDANCE $R_s$ (OHMS)

SHUNT RESISTANCE $R_s$ (OHMS)

LOAD RESISTANCE $R_L$ (OHMS)

Chart 2

SHUNT RESISTANCE $R_s$ (OHMS)

SERIES CAPACITANCE $C_t$ (MICROFARADS)

NOTCH FREQUENCY $f_0$ (CYCLES PER SECOND)
Ringing choke simplifies d-c to d-c conversion

Seldom-used method of boosting d-c voltage, by alternately storing and retrieving energy from a magnetic field, has important advantages over conventional techniques

By J.F. Howell
General Electric Co., Milwaukee, Wis.

Conversion of direct current from one voltage level to another usually requires at least two transistors and a special transformer. But for low-power and pulse-discharge types of applications, there is a simpler, more efficient and more reliable technique. It takes advantage of the stored energy in a magnetic field to change the voltage level. The principles of ringing choke conversion have been previously reported in technical literature, but surprisingly, application to date has been rather limited.

Basic principles

If energy is stored in the magnetic field of an inductance, and if the field is allowed to collapse, the voltage across the inductance will assume a level necessary to dissipate the stored energy. This well-known principle, used in auto ignition systems and the basis of energy conversion in the ringing choke converter-regulator, is illustrated in the circuit shown at the right. When switch S₁ is closed, current flows, and energy builds up in inductance L, according to the formula E = ½ Lf². After the energy in the inductance has reached some arbitrary level and S₁ is opened, energy in the magnetic field will be transferred to capacitor C through diode D. Repeated opening and closing of the switch gradually increases the voltage accumulating across the capacitor to many times the amplitude of the input voltage. Therefore, energy is converted from one potential level to another by storing it within and retrieving it from a magnetic field. Furthermore, regulation is achieved by controlling the number and rate of switch operations.

It is important to remember that when the switch is closed, energy is transferred only to the magnetic field, not to the capacitor. Additionally, when the stored energy of the switch is being transferred to the capacitor, the voltage across the inductance is dependent on the potential already existing on the capacitor; it is not dependent on the magnitude of the voltage V₁, the initial source of stored energy in the magnetic field.

D-c to d-c conversion

A simplified schematic diagram of a d-c to d-c converter, in which these principles are applied, is on page 91. Transistor Q₁, in a blocking oscil-
Basic schematic of a d-c to d-c converter. Transistor Q₁ serves as a fast-acting switch connected to blocking oscillator circuit. R₃ controls regulation.

Converter-regulator circuit includes variable impedance Q₂ for controlling frequency of oscillation and a zener diode for automatic regulation.

In the converter diagram above, right, the frequency of oscillation can be varied by adjusting resistance R₃. If this circuit is modified by an arrangement that senses the output voltage V₂ and controls the value of R₃, then automatic voltage regulation results.

Such a modification is shown in the circuit directly below. Transistor Q₂ acts as a variable

The voltage Vₓ is dependent on the resistance of the load, R₅. The voltage automatically results in constant power dissipation in the load.

D-c to d-c converter-regulator

Ringing choke d-c to d-c converter-regulator uses a blocking oscillator to chop the input signal. Extra winding on inductance provides an isolated 2,400-volt d-c output. The Darlington pair, Q₁, Q₂, provides high input impedance. Q₃ is regulating transistor, and Q₄ is the blocking oscillator transistor.
impedance controlling the frequency of oscillation. A zener diode, serves as a reference element for automatic regulation of the frequency of oscillation; it maintains voltage $V_2$ constant, despite variations of input voltage $V_1$ or load resistance $R_L$.

The frequency of oscillation, which controls the rate of energy transfer, is variable from zero to several thousand cycles per second. Transistor $Q_1$ is always either off or saturated. Therefore, the heat dissipated in the transistor is a minimum. The maximum voltage across $Q_1$, equal to $(V_1 + V_2)$—occurs when the transistor is off. If the output is taken off by an additional winding on the inductance, then the maximum voltage across $Q_1$ is the input voltage $V_1$ plus the output voltage as reflected to the primary by the inductance turns ratio. For a voltage step-up application, the maximum voltage across $Q_1$ is therefore $V_1 + V_2 \left(\frac{N_1}{N_2}\right)$. Another advantage: regulation is achieved by frequency control, rather than by using a series voltage dropping element, so conversion efficiency is high.

The ringing choke is relatively easy to construct from a laminated, silicon-iron split core. The high effective frequency, resulting from the relatively short transistor on-time (approximately 50 microseconds), means only a few turns are required. An air gap in the core of several mils must be provided to obtain low residual core magnetization between pulses. When input voltage $V_1$ is applied to the circuit shown on page 91, the output voltage $V_2$ responds linearly with time. Thus, its regulating action is faster than the more conventional converters, which respond exponentially.

If the output is short-circuited, peak current through $Q_2$ is not affected because the load is disconnected during transistor conduction. This is an important feature for pulse-discharge type applications. Shorting the output does not increase the primary current as would happen in a transformer type converter. Therefore, the components are not damaged, and the only effect of the short is an increase in the frequency of oscillation from regulator action. This frequency of oscillation is limited by the $R_3C_2$ time constant.

**Typical circuits**

Typical ringing choke converter-regulators like that shown above and on page 91 are designed to convert an input ranging from 24 to 32 volts d-c to relatively high regulated potentials. The circuit on page 91 utilizes a blocking oscillator for pulse generation, and provides two outputs, $+365$ volts and an isolated $2,400$ volts. The isolated winding used to couple $V_3$ has a common volts/turn relationship with the other windings; therefore the load impedance across $V_3$ is also regulated.

The circuit above utilizes a unijunction transistor for pulse generation. The oscillator circuit consists of UJT $Q_3$ and transistor $Q_4$.

Both converters operate with an energy storage pulse of fixed duration—50 to 100 microseconds—and regulate by varying the pulse repetition rate.

Another version of the ringing choke power supply maintains the frequency of the input current pulses constant, while the pulse duration is varied to provide regulation of the output voltage. Both methods work equally well.

With high-quality components, regulation of these supplies is approximately 0.02%, for combined input and temperature variations. With low-cost commercial components, the regulation will be about 0.2%, adequate for many applications.

The techniques described afford significant advantages in low average power applications and particularly in pulse discharge systems where the output supply is frequently shorted.
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Kodak
Designer's casebook

Two unijunctions form low-cost level detector

By John G. Peddie
H. Dell Foster Co., San Antonio, Tex.

The low-cost level detector shown at the right provides constant-width pulses at a fixed repetition rate while the input signal exceeds a specific level.

In the application for which the circuit was required, the main design problems were:

A maximum of 100 microamperes could be drawn from the signal source.

The reference level was negative with respect to ground and the supply voltage was positive with respect to ground.

A three-stage circuit was developed to provide the necessary level detection pulse. An emitter follower input stage Q1 draws only 35 µa, well under the maximum specified. The threshold of the circuit is set by R5, which forms a voltage divider with R1. The second stage, Q2, is a unijunction transistor (UJT) whose triggering level is set by potentiometer R2. When Q2 fires, a series resistance is formed, consisting of R4, R50, and R3. Capacitor C1 now begins to charge. When the peak point of Q3, another UJT, is reached, it fires and provides a discharge path for C1.

As long as the input voltage is above the threshold of the circuit, Q2 will stay on—forming a relaxation oscillator out of C1, R5, Q3, and R5. An emitter follower could replace Q2, but the threshold would not be as predictable and also would be more affected by temperature.

If temperature stability is not critical, type 2N2160 unijunction transistors may be used, reducing the cost still further. To improve temperature stability, R5 can be reduced to 27 ohms, at the sacrifice of lower output pulse amplitude.

Exclusive OR circuit requires no voltage supply

By T.P. Sylvan
General Electric Co., Schenectady, N. Y.

A simplified exclusive OR circuit, useful in industrial controls, reduces the number of components required in conventional circuits of this type, and requires no voltage supply for the transistors.

An exclusive OR circuit yields a logical 1, if only one of the logic inputs is present. The logic output is 0 if none of the logic inputs is present, or, if more than one of the logic inputs are present.

This is expressed in the truth table shown at the right for the logical expression, \( F = AB' + A' B \).

Usually, high speed is not required and standard transistor-resistor (TRL) NOR logic is used. With TRL, an equivalent expression is derived using double negation and by applying De Morgan's theorem:

\[
F = AB' + A'B \\
= [(AB')' (A'B)']' \\
= [(A' + B) (A + B')]' \\
= (A' + B) + (A + B')' \\
= [(A' + B)' + (A + B')]' \\
\]

An exclusive OR circuit using TRL and based on this final expression is shown in the upper diagram.
Definitions of logic symbols and theorems

- $A + B$ stands for “A or B”.
- $AB$ stands for “A and B” (sometimes shown as $A\cdot B$).
- $A'$ stands for logic negation “not A” (sometimes shown as $\neg A$).
- $A''$ stands for double negation.
- $(A + B)'$ stands for “not A or B” (nor functions).
- De Morgan's theorem states that $(A + B)' = A'B'$ or $(AB)' = A' + B'$.

**Truth table for exclusive OR**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<td>$A$</td>
<td>$B$</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
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<tr>
<td>1</td>
<td>0</td>
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<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Conventional transistor-resistor NOR circuit to perform logic function $F = [(A' + B')' + (A + B')]'$.**

**Simplified, faster exclusive OR circuit** which has fewer components and operates without voltage supply, achieves output $F = AB' + A'B$.

The circuit can easily be extended to three or more inputs, requiring one transistor and one diode for each additional input.

**Reference**


---

**Single component changes bandpass into general filter**

By Richard Kurzrok, Communications Systems Laboratory, Radio Corp. of America, New York

The general filter network at the right offers both sharp pass and reject behavior at adjacent frequencies. The characteristic is achieved simply by bridging the network with $C_0$ and retuning with the variable capacitor $C$. 

Bandpass filter is converted to general filter by bridging network with $C_0$ and retuning with the variable capacitor $C$. 

Electronics | April 18, 1966 | 95
ing a conventional bandpass network with a single capacitor. The circuit is useful in systems requiring asymmetrical frequency selectivity characteristics.

The general filter is formed by bridging the filter with capacitor $C_{oo}$. Equation 1 expresses the normalized rejection frequency, $X_p$, with respect to the center frequency, $f_o$, as obtained from nodal analysis of the circuit

$$X_p = \frac{C_{oi}^2 Q_t}{C_t C_{oo}} = \frac{f - f_o}{f_{3db}}$$  \hspace{1cm} (1)

From this the value of $C_{oo}$ is

$$C_{oo} = \frac{C_{oi}^2 Q_t}{C_t X_p}$$  \hspace{1cm} (2)

where

$$Q_t = \frac{f_o}{f_{3db}}$$  \hspace{1cm} (3)

The basic bandpass filter in the diagram is designed for a 20-Mhz center frequency, $f_o$, and exhibits a large loaded $Q$ with low insertion loss. It incorporates a commercial air-core inductor wound on %" stock, chosen to resonate with $C_t$, the total circuit capacitance, which is equal to $C_{oi} + C = 121$ picofarads.

Using equation 1 with center frequency $f_o = 20$ Mhz and bandwidth $f_{3db} = 1$ Mhz, $Q_t = 20$.

The normalized frequency is found to be $-1.7$ with the peak signal rejection frequency, $f$, equal to 19.15 Mhz. Negative polarity indicates that the frequency of peak rejection is below the center frequency.

The Response curves of bandpass and general filter.

### Characteristics of general filter

<table>
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<tr>
<th>Characteristics</th>
<th>Bandpass</th>
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<tbody>
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<td>Center frequency</td>
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<td>19.15 Mhz</td>
</tr>
<tr>
<td>Peak insertion loss</td>
<td>0.9 db</td>
<td>34 db</td>
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</table>

With all values on the right side of equation 2 known or derived, $C_{oo}$ is calculated and found to equal 47 pf. After bridging the original bandpass network with this value of capacitance, the peak rejection frequency measures 19.15 Mhz. The curves above show the response of the original bandpass and the general filter network. To evaluate the quality of band-reject behavior the theoretical insertion loss, $I.L.$, at the frequency of peak rejection, 19.15 Mhz, is derived from a nodal analysis of the general filter circuit:

$$I.L. = 10 \log \left(1 + X_p^2\right) + 20 \log \frac{C_{oi} Q_{ul}}{C_{oo} C_t}$$  \hspace{1cm} (4)

With a normalized frequency, $X_p = -1.7$ and the given values of $C_{oi}$, $C_{oo}$, $C_t$ and $Q_{ul}$, $I.L.$ is calculated to be 32.3 db, very close to the measured value of 34.7 db.

The generalized filter can be used as a selection filter for mixers or frequency converters.
Diode quad modulator suppresses carrier 65 db

By W.H. Ellis
Page Communications Engineers, Inc., Washington

A balanced modulator/demodulator has been developed for an experimental high-capacity communication system. It operates at a carrier frequency of 250 megahertz (megacycles per second), with a modulation rate of 110 megabits per second. The circuit at the right suppresses the carrier voltage to 65 decibels below that of the desired sidebands and suppresses the modulation signal at the output to 39 db below the modulator’s input level. The input modulation level is 3 volts and the carrier level is 0.3 volt. At the modulated terminals, the sideband voltages are within 1 db of each other. Insertion loss in the circuit is 6 db.

Hewlett Packard’s diode quad, made up of matched hot carrier diodes is the nonlinear element. The manufacturer guarantees greater than 50 db balance for the quad at 70 Mhz. Even at 250 Mhz, the quad was very well balanced. This eliminates bias networks to equalize the diode’s operating characteristics.

In general high carrier and modulation suppression is difficult to achieve because extremely accurate amplitude and phase balance in both the carrier and modulation inputs are necessary. For example, to get rejection of 60 db, assuming no phase shift, the amplitudes must be within 0.01% of each other. Assuming identical amplitudes, the phase balance must be better than 0.006°.

Carrier balance is obtained by adjusting the length of the variable line for proper phasing and the attenuator for proper amplitude balance. Because adjustment of the attenuator changes the phasing, attenuator and line adjustment is an iterative process.

The modulation section poses a more difficult problem because it is a broadband circuit. As a result, it is not possible to make fine phase adjustments with tuned elements. Nor is it possible to use delay-line phasing because a delay in the arrival of the balanced components from the transformer is not permissible.

Phase balance in the modulation circuit is achieved by using wideband transformers that are designed to be as well balanced as possible. The modulation transformer has a frequency response from 100 kilohertz to over 100 Mhz. A degree of amplitude balance is obtained by adjusting the center tap on the high frequency potentiometer, R2. Using a Ruthroff balanced-to-unbalanced transformer to drive the modulation transformer increases the modulation rejection.

Carrier suppression is measured with the experimental arrangement shown in the block diagram above. The Stoddart type NM-30 field intensity meter is first tuned to the carrier frequency. Next the attenuator and the coaxial line are adjusted for the minimum carrier level and the reading on the output meter of the field intensity meter is recorded. After the receiver is returned to the sideband frequency, the output meter level is again recorded. The difference in the readings is the carrier suppression with respect to the sidebands.

Modulation suppression is measured in the same way except in this case the suppressed modulation signal is compared to the input modulation signal.

Insertion loss is measured by tuning the receiver to one sideband and recording its level. Next, the input signal is connected directly to the receiver and its level recorded. The difference in reading (corrected 6 db) is the insertion loss. A 6-db correction is necessary because each sideband voltage is theoretically one-half the carrier amplitude.

Sideband levels are measured simply by tuning to each sideband and recording the output level. Work is continuing on improving modulation balance and frequency response, and reducing insertion losses.
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*without batteries

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Solid state makes debut in big-screen color tv

With all functions transistorized except deflection and rectifier circuits, performance approaches quality of tube set

By Derek Bray

The new 90° shadow-mask tube makes possible a more compact color television set. But a smaller cabinet packed with the same number of tubes means increased heat—and degrading of component reliability—a problem which a solid state receiver could overcome.

To demonstrate that an almost completely transistorized large-screen color receiver was well within the state of the art, Fairchild Semiconductor has built a 23-inch receiver that is almost completely solid state. In general, the performance of the semiconductor circuits in the set approaches that of the original vacuum-tube circuits.

A circuit in which tubes are retained is the high-voltage rectifier, which at the moment presents an economic rather than technical barrier to the use of solid state devices. In several large-screen, black and white receivers, the high-voltage rectifier remains the only circuit not transistorized. Tubes also perform this function in the otherwise all solid state Chromatron small-screen color receiver, which Fairchild demonstrated last year.

In the large-screen shadow-mask receiver built by Fairchild Semiconductor, three other circuits are not transistorized. One is the horizontal-scan output stage, which must handle more than 4,000 peak volt-amperes. The best solid-state devices available have ratings of less than 3,000 va. The vertical-scan output circuit is not transistorized, though it could be by matching the yoke impedance to that of the circuit and by providing a separate low-voltage power supply. A single high-voltage power supply for both horizontal and vertical scanning is preferable.

A conventional vhf tube tuner was used, since a suitable transistor tuner was not available.

With these exceptions the receiver is transistorized, including the high-voltage video-drive circuits, built with newly available 300-volt transistors.

The receiver, which represents only one of many design alternatives, is outlined in the block diagram on the next page. For simplicity, picture-tube details, convergence coils, controls, power supplies and high-voltage circuits are omitted.

Video i-f amplifier

The video intermediate-frequency amplifier schematic, page 100, center, is a three-stage amplifier with forward automatic gain control (age) on the first stage $Q_1$. The first two stages are coupled by a low-$Q$ circuit tuned to 43.75 megahertz (megacycles per second). The low $Q$ ensures minimum variation in the over-all i-f response with forward automatic gain control of the first stage. The bifilar-wound T-trap at the input is tuned to the adjacent channel sound frequency and provides at least 60-db of rejection at 47.25 Mhz. The second stage $Q_2$ has fixed gain, and is followed by a two-pole coupling network. The two poles, one at 42.5 Mhz with a $Q$ of 40 and the other at 45.75 Mhz with a $Q$ of 26, help shape the desired response curve. High $Q$'s can be used, since neither the second nor third i-f stages have age, and no pole-shifting occurs. Both $Q_1$ and $Q_2$ are low-capacitance transistors, eliminating the need for neutralization while maintaining adequate gain stability margins.

The author

Derek Bray is a professional engineer who has written many papers on the use of semiconductors in radio and television. He heads Fairchild Semiconductor's consumer-applications circuit design group.
Hybrid receiver block diagram illustrates all but picture-tube details, convergence coils, controls, power supplies and high-voltage circuits. Each block represents at least one circuit.

Video i-f amplifier is a three-stage amplifier with forward automatic gain control on the first stage. Third-stage transistor Q3 was especially designed for this application.

Sound i-f amplifier has three stages: wideband amplification, limiting and output. A Foster-Seeley discriminator gives the most linear possible output.

The third i-f output stage, Q3, uses a new transistor designed specifically for the application. The output transformer and detector circuits feature sound traps at 41.25 MHz before detection and 4.5 MHz after detection. Trapping before detection prevents a 900 khz beat between the color subcarrier and the sound carrier. The output is biased at 18 volts and 15 ma to obtain linearity in the output video.

The over-all i-f response, in which the positions
of the dominant frequencies are reversed in relation to the transmitted tv spectrum, is shown below. The response of the chroma bandpass rolls off gradually to produce a 60-db rejection of the cochannel sound carrier. A flat chroma-bandpass response out to 41.65 Mhz with a sharp cutoff at the soundcarrier frequency tends to produce undesirable chroma phase shifts. To compensate for the high-frequency rolloff of the video i-f amplifier, the chroma amplifier has a response which is peaked at the higher frequencies.

Over-all voltage gain is 75 db and power gain is 50 db. Maximum undistorted video output is approximately 6 volts peak to peak and the maximum age range is 60 db.

Sound i-f amplifier

The 4.5-Mhz output of the sound detector is amplified in the three-stage sound i-f amplifier, page 100, bottom. Its first stage, Q1, is wideband with a single-tuned 4.5-Mhz filter at the input. Limiting action is provided in the second stage, Q5, by the shunt diode across the tuned circuit and by saturation of output stage Q6. A Foster-Seeley discriminator circuit yields the maximum output linearity. Output audio of 1 volt peak to peak is obtained with a limiting sensitivity of 0.5 millivolt at the input. The amplifier transistors are low-capacitance Fairchild SE 5025's.

Audio amplifier

The audio amplifier on page 103, top, operates class A with a capability of two watts of sine wave power. Class-A rather than class-B operation was chosen to reduce the average supply current variations and thus reduce the decoupling problems normally encountered with class-B high-power stages. Over-all d-c stability is achieved with feedback from the emitter of Q6 to the base of the input common-emitter stage Q7. Emitter-follower Q8 provides the base current for the output stage. Over-all a-c feedback from the collector of Q8 to the emitter of Q7 controls the voltage gain. The turns ratio of the output transformer must reflect a load impedance of 100 ohms at the collector of Q9. Over-all sensitivity of the amplifier is 140 millivolts for the required full two-watt output. This high power level is required for large-screen receivers.

Luminance amplifier

The input stage Q10 of the luminance amplifier, page 102, top, is an emitter-follower that presents a low capacitance, high-impedance load to the i-f video detector. The 3-volt input video signal is d-c coupled throughout the amplifier, so that d-c gain is the same as high-frequency gain, and black level in the output is held constant.

Emitter-follower Q11 is used as the output driver stage. This provides a low impedance source required for the output stage and simultaneously presents a high-impedance load to the delay line. In this way, the Miller capacitance effect—the increase of collector-base capacitance with voltage gain—is minimized and the delay line can be terminated in an accurately matched impedance to avoid reflections.

Brightness is controlled by shifting the base-bias voltage of Q12. Contrast is controlled by varying the a-c emitter impedance, thus varying the gain of the output stage. Conventional inductive peaking is used to couple the collector of Q12 to the picture-tube cathodes.

The transistors used in this amplifier are: the general-purpose, low-capacitance epoxy SE5025 and 2N3638 and a high-voltage, n-p-n, video power transistor TO300 in the output stage. The TO300 was developed by Fairchild primarily for this application. Some typical parameters are given in the table above.

Automatic gain control

The automatic-gain-control circuit, page 102, bottom, is gated by a pulse from a winding on the horizontal flyback transformer. The pulse is applied to the collector of Q13. The additional diode and resistor at the collector of Q13 invert the video signal to drive the noise inverter stage for the sync separator.

Automatic-gain-control voltage is generated at the base of Q14 across the base coupling capacitor. It is a function of the average current supplied by Q13. The bias on Q14's emitter and the bias voltage of the video i-f amplifier's detector circuit maintain the video output amplitude at about 3 volts. To set maximum gain on the video i-f amplifier when there is no signal input, a 100-kilohms potentiometer is provided.

The age applied to the i-f amplifier is a positive voltage taken directly from the emitter of Q14. For the tuner however, the i-f age voltage must be negative with respect to ground. An additional stage, Q16, inverts the age for the tuner.

To maintain a high signal-to-noise ratio for weak signals, the tuner age is delayed with respect to the i-f age. The delay is determined by the setting of the 10-kilohm potentiometer in Q15's emitter. The rolloff is compensated for in the chroma amplifier.

Operating parameters for Fairchild's TO300

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CE}$</td>
<td>&gt; 300 volts</td>
</tr>
<tr>
<td>$I_{B}$</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>$f_l$</td>
<td>= 50 Mhz typ.</td>
</tr>
<tr>
<td>$C_{be}$</td>
<td>= 10 pF typ ($I_s = 0$, $V_{ce} = 50$ volts)</td>
</tr>
<tr>
<td>$Q_{be}$</td>
<td>= 6°C/watt</td>
</tr>
</tbody>
</table>

I-f amplifier response rolls off at higher frequencies in the chroma bandpass to reject the sound carrier. The rolloff is compensated for in the chroma amplifier.
Luminance amplifier with a bandwidth of 2 Mhz provides a 200-volt peak-to-peak output. Parameters for the output transistor, developed primarily for this application, are listed in the table on page 101.

control is set so that the catching diode at the collector of Q₁₅ stops conducting when the i-f age voltage produces a 20-db gain reduction in the i-f amplifier, thus allowing the negative age voltage for the tuner to be generated.

Sync separator

A 1-volt inverted video signal from the first stage of the luminance video amplifier drives Q₁₇, the sync separator. The sync separator conducts only during the period of the synchronizing pulses. It produces a 50-volt, negative-going pulse at the output as shown in the schematic page 103, center.

Since a noise pulse in the video might cause Q₁₇ to conduct, creating a false synchronization pulse, sync-noise cancellation is provided: the inverted video signal—less sync pulses—from the age circuit is added to the 1-volt video signal at the base of Q₁₇. Q₁₆ allows the noise pulse to pass, but not the normal luminance signal. The noise threshold is established by the voltage divider in the emitter circuit of the noise inverter stage Q₁₆.

Chroma amplifier

The chroma amplifier must have a response that compensates for the high-frequency rolloff in the video i-f amplifier's response. The chroma amplifier page 104, top, fulfills this requirement. It includes an automatic color control, to ensure that the correct color amplitude is always maintained, and a color-killer control which cuts off the chroma amplifier during monochrome operation.

The desired response is obtained with two single-tuned circuits—a series resonant input circuit, tuned to 4.1 Mhz, with a Q of 40; and a parallel resonant circuit at the collector of Q₁₃, tuned to 3.1 Mhz, with a Q of 10.

Automatic color control (acc) is achieved by voltage gain reduction on the first stage. The input to the amplifier can vary over a range of 20-db and only a 3-db variation in the chroma output voltage will be observed. The control signals for

Automatic-gain-control circuit supplies bias voltage to the video i-f amplifier's detector circuit to maintain the video output amplitude at about 3 volts.
Three-stage audio amplifier, includes class-A output, producing two watts of sine-wave power.

Sync separator eliminates any noise in the horizontal sync pulses and separates the pulses from the video information.

Burst amplifier and 3.58-MHz oscillator are driven by output of first stage of the chroma amplifier. Amplifier burst locks oscillator frequency to subcarrier frequency required by color demodulators, and provides reference burst to acc circuit.
Chroma amplifier has a response slope opposite to the i-f response. Automatic color control maintains optimum color amplitude and color killer cuts off amplifier during monochrome operation.

Automatic-color-control and color-killer circuits use the amplified burst as a reference to determine the amount of bias on the first stage of the chroma amplifier. If burst amplitude falls below a certain level, the color-killer voltage cuts off the chroma amplifier.

B-Y demodulator shown is the same as the R-Y and G-Y demodulators except for slight differences which provide the necessary separation between the three demodulation angles.
acc and for the color killer are generated in another circuit, described later.

Amplifier stage \(Q_{19}\) is a wideband amplifier with an output of 10 volts peak-to-peak. For color reception, the external color-killer voltage, biases \(Q_{19}\) to operate as a linear amplifier. With black and white transmission, the base-emitter junction of \(Q_{19}\) is reverse biased, cutting it off. Color amplitude is controlled by the 500-ohm potentiometer in the base circuit of \(Q_{19}\).

### Burst amplifier and 3.58-Mhz oscillator

The compensated chroma signal obtained at the output of \(Q_{18}\) also furnishes the burst signal reference for the 3.58-Mhz crystal oscillator, and for the acc and color-killer voltages. The schematic for the burst amplifier and locked oscillator is shown at the bottom of page 103.

The burst amplifier \(Q_{20}\) biased by the burst gating pulse from a winding on the horizontal output transformer, conducts only during the horizontal flyback period. The primary of the transformer in the collector circuit of \(Q_{20}\) is parallel resonant at 3.58 Mhz. The primary is loosely coupled to the secondary which, in series with the crystal, is resonant at 3.58 Mhz. The 10-volt peak-to-peak burst signal at the collector of \(Q_{20}\) generates the d-c control voltage in both the acc and the killer circuits.

The 3.58-Mhz crystal in its series resonant mode provides a common-base configuration for oscillator \(Q_{21}\). Positive feedback for the oscillator is produced by the capacitive divider between collector and emitter. Because of large gain variations found in most transistors, it is necessary to stabilize the oscillator output amplitude with a local age loop. The loop consists of a common-emitter stage \(Q_{25}\), which acts as a detector-amplifier and controls the bias of the oscillator.

The oscillator operates on the injection-lock principle. The tuned circuit in series with the crystal acts as a positive or negative variable reactance, depending on the phase relationship between the injected burst and the oscillator output. The phase stability is satisfactory—a 20° phase shift occurs for a 100-hertz change in burst frequency. The stability is determined, to a large extent, by the \(Q\) of the crystal.

The output of the oscillator is coupled to buffer stage \(Q_{23}\), which adds gain and prevents loading of the oscillator while providing the variable phase shift required for hue control. The output transformer is tuned by a variable capacitance consisting of a 150-pF series capacitor, a section of coaxial cable and the hue control potentiometer. The effect of the variable capacitance is to shift the phase of the color subcarrier, changing the display’s hue.

The inductance of the transformer primary is tuned so that the hue control provides approximately ±50° of phase shift about the resonant 3.58-Mhz burst frequency. From the output transformer, three 3.58-Mhz subcarrier signals are available—one for each color demodulator. At this point, the subcarriers for the R-Y and B-Y demodulators are in phase with each other and 180° out of phase with the G-Y subcarrier.

### Acc and color killer

Since the color burst is the only part of the color signal with a constant amplitude, it is used as an amplitude reference for the entire chroma signal. In this circuit, page 104, center, the amplitude of the color burst is measured, and the automatic-color-control signal is generated. This signal controls the output level of the chroma amplifier.

The burst from the amplifier is peak-detected by the shunt diode and filtered to obtain the desired bias voltage for \(Q_{26}\). During color operation, \(Q_{26}\) remains cut off and \(Q_{24}\) acts as a d-c amplifier to provide the reverse ace voltage for the first chroma amplifier stage. When the burst amplitude falls below a fixed threshold—determined by the divider chain on the base of \(Q_{25}-Q_{24}\) cuts off and \(Q_{25}\) turns on, cutting off the second chroma amplifier stage.

### Color demodulators

The three color demodulators are identical to the B-Y demodulator, page 104, bottom, except that each has a different demodulation phase angle. The chroma buffer stage \(Q_{28}\), shown here, is common to the other demodulators. High-voltage output transistor \(Q_{27}\) conducts for only 180° of a complete cycle with its conduction angle centered along the B-Y demodulation axis. In this way, the average collector current of \(Q_{27}\) will represent the desired B-Y signal. Any 3.58-Mhz component is filtered out by the 3.58-Mhz parallel-resonant trap in series with the picture tube grid.

To obtain the half-cycle demodulation, the 3.58-Mhz output from the tint control flows either into the base of \(Q_{26}\), or into the FDM 1000 diode on alternate half cycles. Some forward bias is applied to the diode to reduce the crossover voltage needed to switch from diode conduction to transistor conduction. \(Q_{26}\) therefore conducts with a 50% duty cycle and causes \(Q_{27}\) to conduct similarly.

The conduction current in \(Q_{27}\) is determined by the amplitude of the chroma signal from the emitter-follower stage \(Q_{28}\). The stage is biased so that the output collector voltage is 150 volts with no chroma signal. The 5K potentiometer provides amplitude control of the color difference output signal.

### References

New Raytheon Datastrobe* subsystem offers you reliable readouts at very low cost

The Datastrobe subsystem employs a new concept of data display that offers you precisely registered, reliable readouts and simple, flexible installations—at very low cost.

To produce high-clarity displays of precise registration, the Datastrobe subsystem utilizes (1) a single rotating, self-synchronized drum operating in conjunction with a single time-shared, high-speed strobe lamp, (2) time-shared, all solid-state circuits, and (3) an optical projection system to produce multi-digit, in-line, single-plane displays.

Reduced number of components increases reliability. The time-sharing feature reduces the number of components. Self-contained Datastrobe subsystem wires directly to logic without buffers or drivers. There are no signal amplifiers, mechanical switches or relays. One 6-digit Datastrobe subsystem can replace as many as 66 incandescent bulbs or 6 electromechanical readouts! No complementary input or 8-line to 4-line converter is required.

Self-decoding eliminates wrong readouts. A self-decoding feature incorporated into the Datastrobe subsystem uses direct logic comparison to eliminate erroneous or ambiguous readouts. The conventional white-on-black displays are bright, steady, and provide high contrast and easy recognition.

Wide range of design options. Datastrobe subsystem display screens can be integral or separate. Standard models are available with up to 12 digits; floating decimal point is optional. Models with more digits and combinations of alphanumeric characters or symbols are available. Additional readout locations are accommodated with simplified wiring. Codes other than BCD, such as 2-out-of-5 code, are available as options.

For a Datastrobe demonstration, contact your Raytheon regional sales office.
Datavue® Numerical Indicator Tubes in side-view configurations. These side-view in-line visual readout tubes display singly numerals 0 through 9 or pre-selected symbols such as + and - signs. Gas-filled cold-cathode tubes, they employ the principle of the neon-glow lamp. And their life expectancies range upward of 200,000 hours in dynamic operation.

The ¾" high characters are easily read from a distance of thirty feet. They’re also easily read in high ambient light—where other displays tend to wash out. Erroneous readouts due to segment failure do not occur because the characters are fully formed.

Side-view Datavue tubes cost less because their engineering design provides manufacturing economies. They’re also economical to install because the bezel and filter assembly can be eliminated, and their mating 11-pin sockets are less expensive than for end-view types.

Datavue® End-View Tubes. Raytheon end-view Datavue tubes have essentially the same characteristics as side-view types. They fit into standard-size receptacles and conform to EIA ratings. Models include round (CK8421) and rectangular (CK8422). Both models are designed for ultra-long life, with an expectancy of 200,000 hours or more in dynamic operation.

Recording Storage Tubes. Raytheon recording storage tubes are electronic input/output cathode ray storage devices. Applications include radar scan-conversion, slow-down video, signal processing, signal enhancement, time delay, and stop motion. Types include single gun and dual gun—standard and miniature sizes. Shown above are miniature single-gun (CK1516) and dual-gun (CK1519) storage tubes, which provide high resolution and erase capability of 1.2 seconds.

Recording storage tubes feature fast writing, long storage, fast erase and immediate readout capabilities. Information can be written and stored by sequential techniques or by random writing. Complete, partial, or selective erasure is possible. Many other types of recording storage tubes are available, covering a wide range of requirements and applications.

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SymbolRay® CRT Tube. The new Raytheon CK1414 Symbolray tube provides alphanumeric inputs for computer readout devices. The tube’s 2” target can be scanned electronically to select symbols, characters, and punctuation marks in sequence to form the readout on a display tube. This type has applications with data processing equipment as an economical method for generating characters for hard copy print-out or for cathode ray display. Design with 64 and 100 characters are available.

Send the Reader Service Card for Literature Kit containing these data sheets and catalogs—
Datastrobe Data Sheet 501
Datavue Numerical Indicator 502
Tube Catalog 503
Cathode Ray Tubes Data Sheets 504
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Or call your nearest Raytheon regional sales office, or write to Raytheon Company, Components Division, 141 Spring Street, Lexington, Mass. 02173.

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Components

Voltage transients tamed by spark-gap arresters

Semiconductor equipment operating on a-c lines is susceptible to damage from voltage surges. The arrester, a version of the radar transmit-receive switch, can prevent damage to components.

By V.W. Vodicka
Applied Magnetics Corp., Santa Barbara, Calif.

A gas-filled surge arrester—a spark gap enclosed in a tube—provides protection against voltage transients, a particular hazard to solid state equipment operating on a-c power lines.

The most familiar types of transients show themselves in those annoying clicks in a high-fidelity phonograph or on the line in a phone conversation. They are abnormally high pulses of short duration on power lines, cables or wiring.

The unpleasant phone click is a minor problem; more serious are errors in data transmission or destruction of expensive solid state equipment produced by undesired voltage pulses. A transient as short as a few microseconds can wreck a power transistor or rectifier.

What causes transients?

A positively charged thundercloud can induce in a long telephone line a negative charge which could become as high as tens of thousands of volts. De-energizing a transformer primary may produce voltage transients eight to ten times the normal peak reverse voltage across silicon rectifiers. Transient amplitudes as high as 50 kilovolts have been measured on a standard 120-volt a-c power line, and as high as 2,000 volts on a 28-volt d-c bus on an aircraft. Wherever cable or wiring may be susceptible to transients, some form of protection must be used.

The gas-filled surge arrester, really a voltage sensitive switch, is a spark gap enclosed in a gas-filled tube. Gaseous gaps have generally been limited to radar applications as transmit-receive switches. Their reliability, long life and fast action make them especially suitable for protection of solid state equipment.

The gas-filled gap of today is a precision device that consists, generally, of two electrodes spaced by a glass or ceramic insulator to which the electrodes are fused to provide a hermetic seal. A gap spacing of 10 or more mils will result in a 200-volt firing level. Spacing is precisely determined for a given combination of selected gas mixtures, pressures and voltage thresholds. In most cases, the gas pressures are below atmospheric pressure and for low voltage gaps generally in the region of 100 to 200 millimeters of mercury. The electrodes may be of several types of metals; specific applications may require single or composition metals from low melting-point materials up to tungsten. In some applications, the metal is coated with low potential material, such as alkalines, halides or cesium, to improve the characteristics of the gap.

An essential component in a gas-filled gap is radioactive material, For small gap spacings, gaseous radioisotopes such as krypton-85 with predominantly beta particle emission and with radiation levels much less than those found in luminous watch dials have been used. These relatively large particles, having a short path, produce, upon collision, constant ionization between the electrodes. This stabilizes the gap and insures a precise, repetitive and fast triggering response.

The author

Vladimir Weber Vodicka earned his Ph.D. in Prague and came to the U.S. in 1958. Since 1964, he has been technical director of the advanced research and development department of Applied Magnetics.
Depending upon gas pressure, type of gas, electrode spacing, electrode material and shape and inclusion of isotopes, the discharge in gaseous gaps will start with the application of a voltage higher than the breakdown threshold. The arc begins with barely measurable currents of a few picoamperes. Then, within the first few nanoseconds, several streamers appear with current flow at several microamperes. Some of the streamers cross the gap, and others form avalanche regions. During the avalanche period, current will increase to several milliamperes and the relatively high gas pressure will support further formation and spread of avalanche regions forming a conductive path within 10 to 50 nanoseconds. By now the current has reached several amperes, the gases have been highly ionized, the temperatures of the gas has increased considerably and the injection of vaporized metal particles from the electrodes begins. The metal vapors increase the conductivity of the region between the electrodes with explosive velocity and, providing that the current is not limited or the energy of the source dissipated, a fully conducting arc will form within 100 to 200 nanoseconds. The current then reaches several hundred amperes and within one or two microseconds many kiloamperes will be conducted through the gap. Since an arc has negative resistance or negative impedance characteristics, it has a tendency to conduct all the current which the source can supply. Although some limiting will occur in any gap, it is interesting to note that two electrodes formed from 16-gauge tungsten wire will reach a limiting point around 30 kiloamperes for a few microseconds before the ends are vaporized. After a time increased gap spacing interrupts the arc.

In certain cases, it is desirable to provide current limiting or external interruption to prevent a destruction of the gap or its conductors.

After ignition, the voltage appearing across the gap drops to a low value of between 10 and 40 volts. Like a fluorescent lamp, the gas continues to conduct after ignition, so long as the source voltage is higher than the arc-extinguishing voltage. It might be assumed that a neon tube could be used as a simple gas-filled protective device, but the low gas pressure, spacing and size of electrodes would limit its usefulness. Most small-size neon tubes are damaged by currents of a few amperes if their duration exceeds several milliseconds.

**Carbon-block gaps**

For many years the carbon-block spark gap has protected telephone lines, equipment and personnel. It performs reasonably well, provided that sufficient time is devoted to maintain and replace it. Although the cost of a carbon block is low, several factors make its use rather costly. A side effect is excessive noise produced after several firings. Carbon dust coats the holder, resulting in a noisy resistive path across the line.

Instances of wire and cable outages, caused by carbon blocks, have been widespread. The Bell Telephone Co. of Canada conducted a series of tests on carbon blocks under very similar conditions. The average outage on a carrier system protected by carbon blocks was 3.520 hours as opposed to no outages on a system protected by gas-filled gaps.3

The present-day heavy loading of each circuit—voice or data—carries with it a high price for each minute of outage. The increased use of semi-conductors makes transients a critical and expensive problem.

A well-maintained carbon block with a 3-mil (the smallest safe spacing) gap has a nominal firing voltage of about 600 volts, fluctuating during its lifetime from 400 to more than 1,000 volts. A transient with a steep waveform may produce a voltage five times or more in excess of the nominal firing voltage.

When testing a carbon block under ideal conditions, it has a reasonably quick and stable response, but the situation quickly changes when it is tested under typical operating conditions. In practice, the carbon block usually encounters a source with a highly variable impedance. The firing becomes erratic because of suddenly applied and reflected loads and ionization of the carbon. A considerable time will elapse before the gap stabilizes and develops a steady arc. Even then, the resulting arc voltage, because of the relatively high impedance of the gap, remains high—in the vicinity of 200 volts. This may not be detrimental to equipment using vacuum tubes, but it is catastrophic for transistorized equipment. The damage may occur not only in the section near the arc, but also, due to ground and current loops, in other sections of the system, including the power supplies.

The curves shown to the left compare the carbon block and the gas-filled gap units with respect to ionization time as a function of the voltage across the gap. They show that the voltage in excess of the firing voltage (overshoot), for the same pulse, is

![Comparison of the carbon block arrester with the gas-filled gap arrester shows resistance across the gas-filled gap decreases faster and to a lower level than resistance across the carbon block.](image)

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more than double for the carbon block.

The carbon block needs three to five times more time to reach a steady ionization level. The final voltage across the carbon gap is approximately 200 v as against 40 v across the gas-filled gap. To improve the overshoot characteristics of the carbon block, a reduction of the spacing from 3 mils to 1 or 2 mils is possible. However, reliability would be seriously reduced after the first firing.

**Gas-filled gaps**

In the gas-filled gap, reliability is improved by having a large gap spacing to avoid possible short circuits during maximum discharge. A gas-filled gap, operating at approximately 230 v, will have a spacing of 10 mils or more; a gap operating at the voltage of a standard 3-mil carbon gap will have spacing of 30 mils or more. The carbon block exhibits considerable variation in its firing voltage, plus or minus 100%, due mainly to previous firings, air pressure and humidity. The gas-filled gap maintains its firing level to within plus or minus 15% during its lifetime.

What is the lifetime of a gas-filled gap? When used within specified limits, and depending upon variables of the average transients, the gas-filled gap should survive more than 10,000 transients. One test was conducted in which the gap discharged a capacitor at a rate of 1 pulse per second. The gap remained in useful condition after more than 500,000 pulses. Destruction tests have shown gas-filled gaps to have excellent overload capability. The damage criteria was established at a point at which the firing level deviated more than 30% from the original firing voltage. In some cases, this point was obtained by simultaneously exceeding the current limit by 4 to 5 times and the duration by 40 to 50 times. The gap will usually withstand 4 to 5 high-energy pulses.

Some representative gas-filled isotope-prompted gaps, shown at the right, have their current/time parameters adjusted for the shapes of the transients expected in specific applications.

**Manufacturers**

The button type Siemens gap is about ¾ inch in diameter and ratings are available in voltage gradients from 230 to 800 v. This miniature gap has the capability of conducting 5 kiloamperes for 10 to 20 microseconds. It can replace standard carbon blocks on telephone lines. As a protective device for power supplies, connected across a 120-volt a-c power line, a current-limiting resistor, reactor, fuse or an automatic reset breaker should be provided in addition to the gap. To determine the proper gap, the expected level and frequency of transients can be established by a transient detector-recorder. A typical recorder is shown on the following page. In some cases, miniature gaps can be used in applications covering frequency ranges up to 500 megahertz (megacycles per second).

A primary gap (SG 1360) made by Sylvania Electric Products, Inc., a subsidiary of the General
Gas-filled surge arrester, top left, simply protects against peaks of transients. A more sophisticated application, top right, uses a gas-filled gap in conjunction with a circuit breaker to extinguish the arc across the gap in the event the voltage doesn’t drop below the sustaining voltage. Complete protection against very high voltages, bottom, can be obtained by using a gap to protect zener diodes and silicon-controlled rectifiers which suppress the lower voltage transients.

Telephone & Electronics Corp., is designed to protect against transients of very high energy levels, such as lightning might cause.

It can be used on telephone, power and antenna feeder lines and coaxial cables. Breakdown voltages range from 300 to 1,100 volts, and it can be used up to 30 Mhz. It will discharge 50 kilovolts at 12.5 kilojoules or 50 kilojoules if the current does not exceed 2,000 amperes. The mechanical design permits use in applications where high pressures and acceleration may be encountered.

Signalite Inc. spark gaps are available in a two-electrode structure with a wide variety of voltage breakdown ratings and a rated discharge capability up to several hundred joules. In the three-electrode structure, one electrode acts as a trigger. Triggered gaps usually have a ceramic body as a spacer-insulator. They cover a voltage range from 1,000 to 50,000 volts and can handle energies from 4 to 8,000 joules.

Multigap surge arresters made by the Electrons Co., a subsidiary of the General Signal Corp., are designed to protect telephone pairs and telephone repeaters as well as power circuits and antenna feeders. The voltage breakdown ranges from 300 to 500 volts. Of particular interest is the relatively high current capability in the 2-second to 10-minute range (20 to 50 amperes for 2 seconds and 7 amperes for 10 minutes). The gaps are rated at 300 joules. The single gaps have voltage ranges of 150 volts to 750 volts with a 300-joule rating and frequency range to 30 Mhz.

Triggered gaps made by Edgerton, Germeshausen and Grier, Inc., are designed to operate at high voltages—1 to 25 kilovolts. For most applications, a short delay time is characteristic of these gaps—(20 nanoseconds and up) while energy ratings up to 4,000 joules are available.

Amperex Electronic Corp. gaps have been used extensively in lower voltage applications. Breakdown voltages of 80 volts d-c are available and extend to 750-volt d-c level. The energy levels are rated conservatively at 10 joules with lifetimes exceeding 50,000 discharges. The 750-volt type permits a 500-joule discharge. The very low voltage breakdown is suitable for protecting transistorized equipment, without a secondary protector such as a zener diode or a silicon controlled rectifier.

Raytheon-Elsi S.P.A. of Palermo, Italy, has several types of gaps and multigaps designed to protect telephone lines and equipment. Breakdown voltages start at 150 volts rms; four active electrodes plus one ground electrode are available per unit. A 5-second, 120-ampere rating is available in the SCA 120 A types. High-voltage types with breakdown levels up to 17.5 kv are available.

Many applications

At present, several hundred million carbon gaps are used to protect the communication equipment in telephone exchanges, repeaters, in homes of phone users, and on telephone poles.

Growing gaps

The market for gaps, at present, is estimated at nearly $1 million a year. With the coming of solid state telephone switching centers and fail-safe gaps, it is possible to anticipate a need for 7 to
Detector-recorder is used for determining the transient level and frequency of occurrence. The data is needed in selecting the proper gap.

10 million units a year. The replacement market (one-fourth of the existing installations each year) will represent more than 25 million units annually by 1970.

Savings to operating companies and other users of gaseous gaps are difficult to express in dollars, but a rough estimate based on replacement costs, outage time and cost of damaged equipment is about $4 to $5 saved for each dollar invested.

The cost of gaps ranges from about 60 cents to several hundred dollars for special high-power units capable of absorbing several direct lightning hits without damage.

The simplest application uses the gas-filled gap to cut down the peaks of transients occurring on a-c or d-c power lines and supplies. The gap is placed across the power-input terminals, preferably in series with a fuse or a wire-wound resistor of 1 to 10 ohms, as shown in the drawing on the facing page. The gas-filled gap can reduce also the transients occurring on telephone lines, open wires or cables.

Gas-filled gaps can also be used to protect thyatrons and modulator components; also pulse transformers, meter circuits and high-powered klystrons. They can be used in relaxation oscillators to act as pulse generators or to raise spark plug firing voltages in leaky ignition systems.

Gas-filled gaps will usually keep on conducting when connected across an a-c or d-c power line or supply unless the power is interrupted by a breaker, or fuse or unless the power-supply voltage drops to less than the minimum specified sustaining voltage for the gap. In such a case, automatic reset breakers, vacuum switches or high voltage reed relays may be used with the gaps to interrupt the circuit, as indicated on the facing page.

Where the breakdown voltage of a gas-filled gap is too high to fully protect the equipment, a second or third stage can be added to reduce transients to acceptable levels. Silicon controlled rectifiers, zener diodes, selenium suppressors, voltage-dependent resistors and positive-temperature resistors are generally used in such applications, as shown on page 112.

Several gas-filled gaps can be used in high-frequency applications. In antenna input or output, where static discharges and over-illumination is encountered, the small-sized gaps followed by a second stage provide excellent protection. On transmit-receive switches, transmitting antennas, or antennas which may be exposed to direct lightning strikes, a high-power gas-filled gap affords great protection. The high-power gap is sometimes followed by a stage using a gap with a much lower breakdown voltage.

Work on gaps capable of operating in picoseconds is proceeding at Stanford University, and currents of several thousand amperes at kilovolt levels have been repetitively switched in a fraction of a nanosecond. This brings about a possibility of a solid state high power radar. Other work is taking place on multigap devices using metal deposition techniques which the devices may protect 12 or more circuits. Pairs of diodes or resistors may be deposited in the same case. The application is intended for solid-state telephone switchboards and other low-voltage applications. A similar device where the deposited layer has a controlled ablation rate during a transient period will not only protect, but will act as a fuse, if the duration of the transient is in excess of the device rating.

Other devices, operating at voltages as low as 40 volts, use a metalized paper approach, similar to self-restoring metalized paper capacitors, to reduce breakdown levels and produce a fail-safe gap. Experimental units are filled with argon/nitrogen gas mixtures. In the case of a gas leak, the firing level increases by 20 to 50%.

References

Bibliography
Lambda offers the
BROADEST LINE
of all silicon modular
power supplies

Up to 150 volts / Up to 90 amps
7 power packages
Prices starting at $69.00

Features and Data

Convection cooled—no heat sinking or forced air required

Wide input voltage and frequency range—105-132 VAC, (200-250 VAC, optional at no extra charge) 45-440 cps

Regulation (line) 0.05% plus 4MV (load) 0.03% plus 3MV: Ripple and Noise—1 MV rms, 3MV p to p

Overvoltage protection available for all models up to 70 VDC

High Performance Option—All models available with these specifications for $25.00 extra: Line regulation—.01% + 1MV; Load regulation—.02% + 2MV: Ripple and Noise—½MV rms; 1½MV p to p: Temp. Coef.—.01%°C

RACK ADAPTERS
LRA-3—5¾” height by 2¼” depth. Mounts up to 4 A, B or C package sizes; 2 D or 2 E package sizes; or 2 A, B or C and 1 D or 1 E package sizes. Price $35.00

LRA-4—3½” height by 14” depth. (For use with chassis slides) Mounts up to 4 A package sizes; 3 B or C package sizes; or 2 A and 1 B or C package sizes. Price $55.00

LRA-6—5½” height by 14” depth. (For use with chassis slides) Mounts up to 4 A, B or C package sizes; 2 D or 2 E package sizes; or 2 A, B or C and 1 D or 1 E package sizes. Price $60.00

LRA-5—3½” height by 2½” depth. Mounts up to 4 A package sizes; 3 B or C package sizes; or 2 A and 1 B or C package sizes. Price $35.00

Send for complete information on LM series and accessories.
The table contains information about LM series products, including specifications and pricing. Here is a summary of the key points:

### LAMBDA LM Series

#### Ordering Information

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<th>Model</th>
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#### Accessory Metered Panels

- **Package A**: 3½" x 3½" x 6¼"
- **Package B**: 3½" x 4½" x 6½"
- **Package C**: 3⅞" x 4⅜" x 9¾"
- **Package D**: 4⅝" x 7½" x 9½"

The table also includes ordering information for accessory metered panels and specifies the model ranges and current ratings. For a complete list of specifications and pricing, refer to the full document.
Wavesoldering has become precise enough to produce integrated-circuit assemblies for high-reliability aerospace equipment. This means that automated soldering machines can do in about 10 minutes work that took several hours by hand.

The assembly at right, containing more than 50 IC’s in TO-5 packages, is typical of those wavesoldered at the Military Electronics division of Motorola, Inc. Hand soldering of the IC assembly by an operator certified by the National Aeronautics and Space Administration would take some five hours. The density of the soldered joints is twice that of a conventional machine-soldered assembly. In the past, it has been customary to space TO-5 leads to 0.1 inch before machine soldering to prevent solder bridging between joints.

The Motorola facility served as a proving ground for several wavesoldering techniques now specified by NASA. Put in operation with the technical assistance of the Space Flight Center at Huntsville, Ala., the facility is the first such known to meet agency specifications. Electrovert, Inc., which built the basic machine, also worked with NASA.

Techniques similar to those used for several years in commercial production are employed in the facility. The boards are automatically cleaned, fluxed, preheated, soldered by an oil-coated fountain of solder, and cleaned again. The added precision...
 Fixture shaves 10 minutes from module-making time

By John Bellissimo,
Communications and Data Processing Operation,
Raytheon Co., North Dighton, Mass.

Assembling sandwich modules is fussy work because of their small size—an inch or so square and a half-inch deep—and because 28 or 30 axial-lead components have to be packed within that small volume. A component-positioning fixture allows modules to be made in 10 minutes less time than required by the most effective previous method. It avoids manipulating the circuit boards.

The new fixture, fastened to a standard assembly and continuously distilled through a gravity system.

The oil is peanut oil. Unlike petroleum oils, peanut oil does not form a film and therefore does not inhibit wetting of the copper by the solder. The oil has three functions: breaking the surface tension of the solder, thus restricting icicling (formation of solder tails on the joints) and bridging (solder path connecting adjacent joints); inhibiting dross formation; and helping the flux clean the soldering surfaces.

Since prolonged heating of the oil would carbonize it and would cause it to contaminate the boards, the oil is not reused. The oil is preheated in a supply line, which runs through the solder pot. But this line is drained when the machine is shut down. The thickness of the oil on the solder wave is controlled by micrometer-type metering system on the oil pump.

The height and slope of the solder wave is adjusted for each type of assembly by making a trial run with a piece of tempered glass. The operator can determine the right height by looking through the glass. This method, originated by NASA, has been made more precise by honing the glass to simulate the surface roughness of the board material. The glass is dry-honed with 3½-mil glass beads. A large dial added to the height-adjustment mechanism facilitates a return to a setting after the height has been changed.

To make sure each board passes over the wave at the proper height, the board carriers were machined to a tolerance of a few mils. The curved piece at the front of the carrier causes it to ski over the flanges on either side of the solder wave and the fluxing and cleaning waves.
mount with a rotating arm, is at the right. The boards, held between lips in the crosspieces, are spaced at about three or four times the finished height of the module and with the corresponding holes in the boards lined up.

The bottom leads of the components are precut. The assembler rotates the fixture with one hand until the bottom of the top board is visible. He picks up a component with the other hand, bends the end of the upper lead, angles the component between the boards as shown, inserts the hooked end of the lead into the upper hole, rotates the fixture until he can see the top of the bottom board, and drops the bottom lead into the proper hole in the bottom board.

The assembler is guided by a visual aid which calls for putting the first component into the rear, right corner of the module, filling the right-hand row of holes from back to front, and then following the same procedure row by row from right to left. This prevents mistakes in placement and always leaves ample room for manipulating the parts.

After all components are placed, the top crosspiece of the fixture is pushed down to the preset height (usually 0.442 inch) and spacers are inserted between the boards. Or, a plug-in base is attached to the boards. A few of the leads are tack-soldered to the boards to hold the sandwich firmly together. The leads are then trimmed and soldered.

**Coordinate measurer puts old boards into new line**

A coordinate-measuring setup is helping the National Cash Register Co. feed automatic component-insertion machines with printed circuit boards that weren't made for automatic insertion.

In the future NCR's Electronics division in Hawthorne, Calif., will be using boards with an easily programmed hole pattern spaced on a grid of 0.100 ±0.005 inch. However, NCR wanted first to use up large stocks of boards previously made or ordered for manual assembly. These boards varied in hole locations because of differences in the processing done by vendors. Nearly 50 programs—one for each stock of boards—were needed. Each would require precise measurement of hole locations. Done manually, that would take one or two days for each kind of board.

Measuring can be done in approximately one-tenth the time with the coordinate-measuring setup, which will also be used to check the new boards. The setup consists of a Co-Check machine, made by Assembly Engineers, Inc., plus an optical comparator and a lamp that backlights the boards.

The machine's table moves freely in the X and Y directions and registers the amount of movement on dial indicators. When a board is mounted on the table, hole coordinates are found by centering a probe in each hole. The comparator is used to find the locations of board features other than holes.
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of NPN Silicon Planar
Power Transistors
featuring
TO-66 Package
2 Amps $I_c$ max
16 watts at
100°C!

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- **2N4136** matched pair 2N2430 (NPN) and 2N2431 (PNP) for power up to 2.5 watts; TO-1 cases in dual heat-sink clip.
- **2N4107** matched pair 2N4105 (NPN) and 2N4106 (PNP) for power up to 7 watts; TO-1 cases in extruded aluminum heat-sink.
- **2N4079** matched pair 2N4077 (NPN) and 2N4078 (PNP) for power up to 12 watts; TO-3 cases.

For data and for details of the Amperex “whole ball of wax” sales and applications program (transistors, circuits, prototypes, lab reports, etc.), write Amperex Electronic Corporation, Semiconductor and Receiving Tube Division, Dept. 371, Slattersville, Rhode Island 02876.
From Eimac comes a new family of water-cooled triodes designed especially for induction and dielectric industrial heating service. The tubes feature a new cast silicon-bronze cooler design with constant cross-section spiral water channels. This design insures uniform anode cooling with minimum water flow and back pressure. For example, the 3CW20,000H3 requires only 4 GPM water flow at 3.5 psi for 20 kW plate dissipation. The new tubes feature filament connecting leads—no sockets are required—and have grid flanges for low inductance connection to the grid. This new industrial family is rated at full power to 90 Mc, with reduced ratings to 140 Mc. All include anode tabs for ease of mounting into industrial machinery plus rugged, high-dissipation grids for industrial oscillator service. Write Power Grid Product Manager for additional technical information, or contact your nearest Eimac distributor.

### CHARACTERISTICS

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New products. 
New markets. 
New acquisition. 
New look.

Diversification... worldwide facilities... increasing emphasis on commercial and industrial markets... this and more is reflected in our new corporate symbol. Over the years, the well known Bourns potentiometer and transducer lines have been augmented by relays, time-delay devices, microcomponents, medical electronic equipment and—through acquisition of more than 80 per cent of Chicago Aerial Industries, Inc.—a wide range of photographic products and services. Geographically, Bourns has expanded to include operations in Canada, Great Britain, Switzerland, the Netherlands, Puerto Rico and Japan. Behind this growth is success... and behind the success, ideas. Our new trademark sums it up: there's dynamic expansion in the world of Bourns.

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Holography has come a long way since Dennis Gabor of the Imperial College of Science and Technology in London used nearly coherent light to record phase and intensity data about an object on a photographic film or plate—a hologram—and then reconstructed the object’s image in space. In the last few years holography has become a discipline with a research budget of $10 million to $20 million, spread over about 100 laboratories.

Although there are no commercial applications yet, possibilities range from three-dimensional color television to pattern recognition. Research has already produced several breakthroughs:

- The use of ordinary white light, rather than coherent light, to reconstruct holographic images.
- Multicolor holograms.
- Hologram movies, made from multiple exposures stored on the same photographic plate.
- Excellent quality holographic images of complex objects constructed with ordinary, incoherent light.
- Holographic contour maps.
- A holographic vibration analysis technique.
- 180° and 360° holograms.
- Synthetic, computer-generated

Image of cookie jar is produced by hologram made with three different colors from two lasers. Full color reconstruction is made with laser light.
holograms, for which no physical object is required.

Interest in holography revived with the development of the laser. Research is being done, for the most part by private industry, but an estimated one-fourth of the research funds come from government agencies such as the National Science Foundation.

I. In the beginning

Gabor has been known for many years for his contributions to the fields of information theory, television and microscopy. But it is holography that is expected to win him his greatest fame.

It was in 1947, when Gabor started trying to improve the resolution of the electron microscope by overcoming the spherical aberration of the lenses, that he made the first hologram. He reasoned that if resolution of about one angstrom could be obtained, he would be able to see the individual atoms of almost any material. Unable to interest British and American companies in interference microscopy, Gabor gave up the project in 1951.

Gabor called the plate containing the phase and amplitude information describing an object a hologram, from the Greek “holos”, to indicate that the whole picture was represented by such a wavefront recording. The phase and amplitude information was stored on the plate as a diffraction pattern formed by two interfering coherent light waves — one scattered by the object, the other transmitted by a transparent background. Coherent light was also used to reilluminate the plate and reconstruct the wavefronts of the object so that its image appears in space. With great effort, Gabor managed to make several good-quality holograms of two-dimensional scenes before he gave up the project. Very little was done with the idea for the next 10 years.

Much of the current effort is concentrated at the University of Michigan, in Ann Arbor. There, research has been concentrated for over a decade on coherent optical data processing.

“The work we were doing was sufficiently related to holography so that it was natural to study it. We had the necessary equipment and the related experience,” recalls Emmett N. Leith, head of the optics group of the Radar and Optics Laboratory.

It was at Michigan that David Falconer, a graduate student of electrical engineering, gave the new field its accepted name — holography — from Gabor’s term, hologram. It was at the University in 1962 that Leith, who is also associate professor of electrical engineering, and Juris Upatnieks, a research engineer, first used two separate beams, one to illuminate a continuous-tone object, and the other to provide the interfering reference beam at an oblique angle. Using a single beam, Gabor had only been able to reproduce transparent objects, such as microfilms of text. The first holograms produced with a laser as the source of coherent light were made by Leith and Upatnieks using two-beam interferometry. Two-beam interferometry eliminated most of the out-of-focus (twin or conjugate) image previously present in all holograms, and provided images of excellent quality. This technique is now used to make most holograms.

Scene lighted. Leith and Upatnieks were responsible for another big stride in holography — the use of diffused light to illuminate the entire scene, rather than just a small portion of it. For the first time, holographic images could be observed without eyepieces or other lenses. An observer simply looked through the hologram plate as if it were a window to see the virtual image suspended in back of the plate and the real image in front of it.

Not only are resolution improved and flaws eliminated when a diffuser such as ground glass is placed between the point light source and the object, but, according to Gabor: “Diffused holograms are almost perfect examples of ideal coding; the information from every object point is almost evenly distributed over the whole photographic plate — a development of great importance to communication theory.” The new technique helped Leith and Upatnieks to make the first three-dimensional laser holograms by reflecting diffused light from a solid object, rather than having to transmit a small amount of light through a two-dimensional transparency. The University of Michigan has applied for a patent on their work with diffused light.

II. Magnification with holography

Added to the list of credits of Leith and his colleagues is a demonstration of magnification with holography — a hologram reconstruction of a fly’s wing magnified about 60 times. They also have made what promises to become a classic analysis of requirements for holographic television. Most recently, they have conceived various methods for recording several separate scenes on a single hologram; each scene is observed individually, without a trace of the other. These researchers also have been credited with white-light reconstruction of holograms and with the first hologram movie recorded on a single plate.

In fact, the most dramatic recent development was the use of white light to reconstruct holograms. Leith and Upatnieks, who reported on it in March at the Optical Society
Two-dimensional scene made with red and blue wavelengths from two lasers, and reconstructed with white light. How other colors are produced is not yet understood.

of America meeting in Washington, D.C., used ordinary white light to reconstruct images from holograms made with coherent light. Bringing the reference beam in from the back of the plate, they created standing waves perpendicular to the face of the plate. Layers formed in the emulsion, parallel to the plate, allow only light of the same wavelength with which the hologram was made to reconstruct the image. The photograph on page 140 shows a model of a molecule from which a hologram was made with red laser light. The 3-D image was reconstructed with white light, and is green because of the shrinkage of the emulsion that occurs during developing. Originally the separation between fringes in the emulsion corresponded to a half-wavelength in the red portion of the spectrum. After the emulsion shrinks, the distance corresponds to a half-wavelength of the green. The emulsion filters out all wavelengths except the green.

Charles Schwartz of Battelle Memorial Institute in Columbus, Ohio, has also used white lights in reading out holograms. Schwartz also used a reference beam incident on the back of the plate to produce a three-dimensional image of a fly and a two-dimensional picture of parallel bars.

A Soviet 'first'. The idea of white-light reconstruction was worked out both theoretically and experimentally even earlier by the Russian Y. N. Denisyuk in 1962. Denisyuk theorized that information stored in a thick emulsion could be read out in multicolor by "light with a complex spectrum" — white light. The basis for Denisyuk's work was provided in 1894 by the French researcher Gabriel Lippmann, who described a process for producing color photographs (not holograms), using high-resolution black and white film, illuminated with white light. The principle of reconstructing interference fringes stored in an emulsion is the same, however.

Leith also reported at the Optical Society meeting on work that his group had done on multicolor holograms by illuminating a cookie jar, shown in the photograph on page 139, with three different wavelengths provided by two lasers, and reconstructing the three-dimensional image from the resulting hologram with laser light. Extraneous images occur to the left and right of the cookie jar because each of the laser wavelengths reconstructs a separate image. The unwanted images can be almost completely eliminated by bringing the illuminating beams in from different angles or relying on a thick emulsion to separate the wavelengths within the hologram plate itself. This was the first time that multicolor holograms constructed with three separate colors had been reported. However, L.H. Lin, K.S. Pennington, G.W. Stroke and A.E. Labeyrie have made multicolor holographic images by illuminating an object with two wavelengths from two lasers, and reconstructing the image with ordinary white light [Electronics, Mar. 21, p. 42]. An image of more than two colors was produced (upper photograph on this page) by a mechanism not yet completely understood.

III. Movies by storage

Leith reported still a third innovation — hologram movies. They were made by storing several superimposed interference patterns in a thick-emulsion hologram. The position of the hologram was changed for each exposure. Readout was accomplished by rotating the hologram through successive angles in laser light. As the hologram rotates, a three-dimensional image of a bird dipping its beak is observed behind the plate, in space. Another way of achieving the effect of motion was devised in August, 1965, by Matt Lehmann and Wright Huntley of
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Stanford University in California. They made a series of still holograms and read them out in succession. The method required a separate hologram for each position of the object.

Other members of the radar and optics laboratory at the University of Michigan, Adam Kozma and Norman Massey, have been working with incoherent holograms. Such holograms can be made with ordinary white light but the resulting image is very poor when a complex, continuous-tone object is used. The superposition of many randomly spaced intensity patterns on a photographic plate produces a large amount of noise that masks the spatial intensity modulations within the film, which are necessary to reconstruct an image. Kozma and Massey have eliminated the noise, using optical signal correlation techniques developed for radar.

With a vibrating mirror, the researchers time-modulated the information-carrying component of light in one path of an interferometer. Then they compared an externally introduced sinusoid with the signal produced by the vibrating mirror. A point-by-point time correlation between the two signals is made over the hologram plane; that is, the signals are multiplied. Noise, occurring as a signal that is out of phase with the reference signal, averages to zero and thus does not appear on the hologram. Now, incoherent light can be used to obtain images of a quality comparable to those made with coherent light. The left-hand portion of the photograph on page 141 is typical of an image made with incoherent light; noise makes it almost unintelligible. The right-hand portion of the photograph is an image made after the noise had been eliminated. In some applications, it might be easier to use optical signal processing methods rather than to use a laser as the light source.

Percy Hildebrand and Kenneth Haines of Michigan have used multiple frequencies to construct contour maps of three-dimensional objects with holograms. They used a single frequency to read it out. An image on a background of reference patterns is obtained. The image has superimposed contours of constant depth. A holographic contour map consists of a series of distorted concentric circles that join points of equal height. The spacing between rings indicates how much a given portion of a curved object departs from planarity. The more widely spaced the rings, the more planar is the area being observed. These holograms can be used, for example, to view objects with very slight variations in dimensions such as precision-machined tools. If the hologram were to be made in the usual way—with a single frequency—the focal depth of the three-dimensional image would not display slight, relative gradations in size with precision.

IV. Deformation in materials

Karl Stetson of the G.C.A. Corp., Burlington, Mass., formerly a researcher at the University of Michigan, suggested that the diffraction of light as recorded on a hologram might be a practical method of detecting small periodic deformations in materials. If an object is vibrating or being strained, its motion, however small, will disturb its reconstructed interference patterns. The
amount of disturbance depends on the object's amplitude of vibration, and can be determined by observing the degree of degradation of the reconstructed image.

Work on synthetic holograms has been carried out by Adoph Lohmann and Dieter Paris of International Business Machines Corp.'s San Jose Research Laboratory. Instead of making a hologram of an actual object, Lohmann feeds a mathematical description of an object to a computer. The computer guides an automatic plotter that draws a picture of the object on paper, from equations. The image is recorded on film from which a hologram is made. No physical object is required for the production of the hologram. The technique is expected to have application to pattern recognition.

More views. A 180° hologram has been made by E.P. Supertzi and A.K. Rigler of the Westinghouse Electric Corp., in Pittsburgh, and a 360° hologram by Runchi Hioki and Takeomi Suzuki at the University of Tokyo. These techniques allow more views of an image than can be seen with ordinary rectangular holograms.

Supertzi and Rigler exposed a strip of high-resolution aerial reconnaissance film, 3 feet long and 5 inches wide, with laser light reflected from a pair of figurines. The reference beam was supplied by a spherical mirror placed in the path of the laser light. Read-out of the scene provides a view of the figurines, in 3-D, from various angles as the observer looks through different portions of the curved film.

Hioki and Suzuki made a shallow cylinder of film and placed an object in its center, as shown at the bottom of page 140. A laser illuminates both the mirror, A, to provide the reference beam, and the object, B, above it. The central portion of the mirror is transparent, and light passing through it also falls on the object as additional illumination. Interference patterns representing all the wavefronts of the object form on the cylindrical film, C. The hologram is reilluminated to reconstruct an image, which is formed at exactly the same place that the original object occupied. All sides of the image are completely visible and can be viewed by looking through various portions of the film.

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Military electronics

Tactical satellite program gets moving

Before long, industry will be asked for proposals for the military communications system that is urgently needed for tactical operations

By Warren Kornberg
Washington News Bureau

The Pentagon seems ready to get down to the business of building a tactical communications satellite system. The first big step will come this summer when the Air Force asks industry for proposals for a satellite tailored to the tactical needs of all the services.

For systems engineers, the tactical satellite means a reversal of the strategy developed for the Initial Defense Communication Satellite system, whose first flight of the 22 satellites in the program will be launched soon. The pioneering satellite system depends on sophisticated ground terminals and a relatively simple and light satellite. Tactical satellites, on the other hand, require small, inexpensive, lightweight and highly mobile terminals. For example, the Army wants a terminal that will be small enough to be transported by jeep or even on the back of a soldier.

But there's one big problem—small antennas require a powerful satellite beam because the power received by an antenna diminishes proportionately with its surface area. The solution is to build a satellite with equipment that will give it enough muscle for its communication job. The Pentagon is convinced that the progress being made in satellite and booster technology makes its estimate of 1968 as the target date for a working satellite a realistic goal.

Design of ground stations is further complicated by the varying requirements of the three services.

Portable 20-foot satellite antenna being developed by Radiation, Inc., will add flexibility to Army communications, but the service wants even smaller dishes for field commanders.
The Army wants foldable antennas; the Navy needs a simple structure that fits into the existing electronic pattern of a ship's superstructure; and the Air Force requires a flush array that won't ruin the aerodynamic characteristics of its aircraft.

Most of the development is still in the offing for tactical systems but the Advanced Defense Communications Satellite system—the planned follow-on to the Initial Satellite—scheduled for the end of this decade will have some tactical capability. The first eight of the 22 satellites in the Initial Satellite program will be launched soon. They will operate as a worldwide system for high-priority military communications.

I. Satellite requirements

Although most of the requirements for the tactical satellite are classified, Department of Defense planners have indicated that they want a synchronous orbit, with station-keeping capability. Moreover, they would like to have radiated power of the satellite in the kilowatt range.

The power problem is being attacked from a number of angles: by raising the frequency, by increasing the satellite’s transmitting power, and by improving the efficiency of the receiving system.

Because of the vast range of ultrahigh-frequency equipment already in use in the services, planners prefer to think in terms of that band. However, it is currently unavailable, under international agreement, for satellite communications. If no accommodation can be made, other frequency ranges will have to be explored.

A narrow-beam capability is desired to increase effective radiated power. A satellite beacon will have to be incorporated to insure minimal tracking requirements at the station end. The satellite will also have to provide virtually instant access to hundreds of users simultaneously.

For the tactical system, as in the Initial Defense Communications Satellite program, the Army will be responsible for developing ground terminals; the Air Force will manage satellite development and all airborne equipment; and the Navy will concentrate on shipboard terminal design and development.

II. Wanted: small dishes

The Army wants a system which will provide reliable communications for its patrols. This means foldable, portable antennas ranging from two-foot to six-foot dishes. Simplicity is a requirement for the equipment since the soldier in the field must operate and service it.

At present the Army has no small, portable antennas. Officials have expressed some interest in a collapsible six-foot antenna developed on speculation by the Westinghouse Electric Co., but so far no commitments have been made.

The Army does have transportable systems. A 20-foot dish is now under development by Radiation Inc.; it can be carried by a three-quarter-ton truck. The Hughes Aircraft Co. is furnishing the AN/MSC-46, a 40-foot dish that will be used in the Initial Defense Communications Satellite program.

Any new system will have to be compatible with the standard tactical Army VRC-12 family of radios that are being used in Vietnam and for which the Army has high praise. The sets will require some interface equipment on the satellite for frequency converting to the satellite’s communications band.

An Army spokesman says, “Field radios might provide receiving capability, but transmitting capability directly to a satellite may be five to 10 years off.”

III. Shipboard systems

The Navy can’t predict the design of tactical terminals, but it knows what it wants—smaller, simpler structures that do not add to the electronic clutter on ship superstructures. It must have terminals that are stabilized so they can look up from a moving, pitching platform; that have a narrow antenna beam, and whose computerized tracking equipment has minimum bulk.

The possibility of adapting existing transmitting and receiving equipment exists, but the Navy hasn’t determined if it can be done economically. Several uhf sets have been considered, but if they are to operate satisfactorily they’ll have to be converted from amplitude-modulation to frequency modulation or digital transmission. Pre-amplifiers with greater sensitivity...
would also have to be devised.

The Navy uses both the high-frequency and the ultrahigh-frequency ranges for communications. With uhf limited to line of sight and the h-f ranges subject to propagation anomalies and spectrum crowding—a special problem for ships—over-the-horizon uhf through a satellite looks particularly attractive.

The Navy has two six-foot dishes, the AN/SSC-2 built by Hughes, on two ships. These will soon be superseded by the AN/SSC-3, especially designed for shipboard use with the military communication satellite program.

IV. For the Air Force

The Air Force is looking for flush arrays that won’t interfere with the airflow over an airplane’s skin. A major problem will be guarding against multipath interference from the surface of the sea or earth, “Simple ground antennas and simple extra antennas on the airplane” is what the specifications ask for so far. The consideration of satellite needs comes at a time when the Air Force is facing replacement of existing airborne communications equipment.

The AN/ARC-34 radio systems in most military aircraft are less adequate than those used in commercial planes. Research and development is being intensified to correct this deficiency.

“We couldn’t justify junking a system just to meet satellite requirements,” says one officer. “But any new system will probably have to include—or be supplemented by—satellite capability.”

Unless some arrangement can be made to permit use of the new uhf equipment in satellite communications, a separate satellite system will have to be bought, according to an Air Force spokesman.

The leading candidates for replacement of the ARC-34’s are the ARC-109’s developed for advanced aircraft, and the ARC-54’s preferred by the Navy. Both have a better predicted mean-time-between-failures than the 34’s, and the Air Force believes the 109’s are twice as good as the 54’s in time between failure. Both the 109 and 54 are built by the Collins Radio Corp. Each gives double the 1,735 channels of the ARC 34’s.

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- Power factor insensitive
- Current overload protection
- No phase shift
- All solid state
- Optional 400 cycle operation
- Efficiency—up 10% more in rated tests

#### PRODUCT COMPARISON CHART

<table>
<thead>
<tr>
<th>R-3200/60</th>
<th>Typical 60 va Ferroresonant Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$20.00 *</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>±1%</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>±1%</td>
</tr>
<tr>
<td>Frequency</td>
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<tr>
<td>Power Factor</td>
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<tr>
<td>Phase Shift</td>
<td>No</td>
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<tr>
<td>Response</td>
<td>50 µ-sec</td>
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<tr>
<td>Weight</td>
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</tr>
<tr>
<td>Size</td>
<td>3 x 3½ x 4 in.</td>
</tr>
<tr>
<td>Units to be mounted</td>
<td>1</td>
</tr>
</tbody>
</table>

*F.O.B. Santa Ana. Subject to change.
**Dimensions do not include separate capacitor.

The new Wanlass R-3200 Series voltage regulators are designed specifically for a wide variety of electronic instruments and equipment. Compare cost, performance, economy of operation with other competitively priced units (see table). Wanlass R-3200 voltage regulators are the ideal choice for all original equipment applications now using constant voltage ferroresonant transformers. Write today for complete technical data. Wanlass Electric Co., 2189 S. Grand Ave., Santa Ana, Calif. 92705. (714) 546-8990.

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Unretouched photo shows output waveform R-3200 has significant line noise suppression, superimposed over input. Regulation is achieved by “peak clipping.”

R-3200 has significant line noise suppression. Note 25 volt input change (upper) and 50 µ-second response in output (lower).
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Space electronics

Where the action is

At Houston, a little known but highly influential division of the Manned Spacecraft Center plays a key role in the Apollo program

By Ron Lovell
Houston News Bureau

With little fanfare, a peripatetic group of engineers headquartered in Houston at NASA's Manned Spacecraft Center is playing a major role in the Apollo program to put a man on the moon before the end of the decade. They work for the center's Instrumentation and Electronics System division (IESD), originally set up to provide technical support for operational manned spacecraft systems.

But often, when the National Aeronautics and Space Administration needs instruments in a hurry, the division supplies them. For example, when the first manned Apollo flight lofts off from Cape Kennedy late this year or early next year its command module will carry aboard a number of instruments that the lead contractor saw for the first time as a package that the division had developed itself.

In its role of technical adviser, and—in time of need—supplier of spacecraft communications and telemetry systems to the spacecraft center, the division deals directly with about 50 electronics companies. Its activities affect scores more.

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Ralph Sawyer says his group doesn’t do much ‘why is the grass green’ work.

The division has supplied communications and telemetry systems for both the Gemini and Apollo programs. The systems often represent a hefty investment, sometimes as much as $300,000 to $800,000 each. On a once-only airborne test, for instance, the division provided a system consisting of three transmitters, three telemetry packages, a commutator, a camera system, and 80 to 100 transducers. There simply wasn’t time, IESD says, to go through the normal procurement procedure.

**Apollo backpack.** The evolution of the communications and telemetry equipment built into the Apollo astronaut’s flight suits is a good example of IESD’s work. Early in the Gemini program, the division developed a communications “belt pack,” then delivered a printed-circuit board backpack for voice communications and physiological telemetry. This was followed up with a smaller backpack which used welded circuit techniques.

By the time the major subcontractor for the spacesuit, Hamilton-Standard, a division of the United Aircraft Corp., was ready to pick its communications and telemetry subcontractor, the Instrumentation and Electronics System Division had, in Sawyer’s words, “a heavy hand in the specs.” A development contract was eventually let to ITT Kellogg, a division of the International Telephone and Telegraph Corp.

Thus the division both furnished equipment and provided technical advice for the spacesuit system.

It will even, in some cases, perform experimental work that is related to specific hardware needs. One area currently under study is what Sawyer calls “the problem of spacecraft data management.”

“The quantity of information required of long-distance manned flights cannot be met within the weight, power, and volume restrictions unless new techniques are developed to use narrower transmission bandwidths,” he says. He believes that pretransmission analysis of data, eliminating redundant or unnecessary information, would better utilize the permissible bandwidth.

One group in the division is now
III. In the laboratory

NASA employees or not, staff members have an opportunity to work in an ideal engineering environment. Major facilities include:

- An instrumentation and electronic facility for evaluating instruments, determining causes of failure with radioactive materials, testing circuits, evaluating flight data records, developing television systems, and developing and calibrating heat flux sensors to deter-

II. Organization men

The division does more, however, than perform research for future programs or take orders for flight instrumentation. (Contracts for $10.1 million were awarded in fiscal 1966.) To carry out the diversified responsibilities of the division, Sawyer has special assistants on his staff for long-term development and procurement, personnel and security, and the budget. Two other special assistants supervise activity on this level—one for general instrumentation, the other for electronic systems.

The more technical members of the staff are organized into four branch offices: flight data systems, electromagnetic systems, general instrumentation, and standards and quality control assurance.

Because the development of flight instrumentation for Apollo has a finite goal, the number of engineers and technicians on the staff is deliberately restricted by NASA. Rather than add new men to the payroll permanently for special programs, the division uses contractor personnel; it currently has 253 men from the Lockheed Space and Systems Co., a division of Lockheed Aircraft Corp., and 71 from the Philco Corp. As a result, the division's current liaison man at North American's Space and Information Systems division is an employee of Lockheed. Such anomalies are not at all rare when IESD breadboards a system and sends it to a contractor for installation on a test spacecraft.

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mine heat shield performance. This facility also has a microcircuit lab for work on techniques and devices to miniaturize spacecraft electronic systems and for evaluation of industrial production techniques.

- An environmental qualification facility to simulate the temperature, altitude, vibration, and humidity extremes found in space.
- A standards and calibration facility where some 20,000 Manned Spacecraft Center measuring instruments, including those of outside contractors, are checked, on a continuous basis, at the rate of 90 to 120 a day.
- An anechoic chamber to test Apollo communications in radiation environment similar to those of deep space.
- A 46-acre antenna range with independently mounted 6-foot and 12-foot dish antennas that transmit between 10 megahertz (megacycles per second) and 12.4 gigahertz. Range lengths of 1,000, 2,000 and 2,500 feet are used.
- An optical frequency range for both communications and radar systems. Tests on these are carried out in a cylindrical vacuum tube 262 feet long and 13 feet in diameter.

All of this adds up to an elaborate but strictly practical lab. Most of the work is directly concerned with Apollo; “there’s not much ‘why is the grass green’ type of work,” says Sawyer dryly.

The future is now. It’s almost impossible to predict the direction the activities of the Instrumentation and Electronics Systems division will take. When asked what they’ll be working on next, the engineers at IESD reply, “It all depends.”

In a real sense they are right. The success of Apollo depends on the practical approach to manned space flight that is characteristic of the division. Its job is not to develop the most advanced system, but to help Apollo fly on time. Any equipment that goes to Cape Kennedy is two years old, at least, because of the freeze on design. IESD’s job is to translate the design restrictions into hardware that will work when the first astronaut steps onto the lunar surface. To do that, its wandering engineers will follow any path as long as it ends on the moon.
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NEW functions extend state-of-the-art capabilities of versatile HLTTL series

new high-speed "D" type flip-flop
- Transistor's TFF3512 and TFF3514 raceless, dual-rank, high-speed "D"-type flip-flops represent a new addition to what is already the broadest line of flip-flops in a single logic family.
- The new high-speed unit complements, typically, on a 50-megacycle input signal. The unusually high operating speeds, which are particularly insensitive to heavy loading, have been achieved by dual steering of the second rank flip-flop.

new non-inverting gates
- A new generation of non-inverting "AND" and "OR" gates has been added to Transistor's broad HLTTL family. Developed for use in systems where simplification and higher speeds are important factors, the new gates exhibit the high capacitive drive capability, high noise margin, and high speed characteristic of the HLTTL design.

new 16-bit memory cell
- A new 16-bit, bit-oriented, non-destructive readout, integrated circuit memory cell utilizing HLTTL technology is now available from Transistor for "scratch pad" memory applications.
- The new memory cells, designated TMC3162 and TMC3164, consist of 16 two-transistor flip-flops arranged in a 4 X 4 matrix which provides the information storage. Two write amplifiers and two sense amplifiers are also built into the element. Extremely high speed operation is achieved through a unique circuit design. The unit exhibits delay times of less than 20 nanoseconds between addressing and writing or sensing. Both data and data complement are available at the sensing terminals, which can be paralleled with those of similar units to form larger arrays.
- The memory cell operates from a nominal supply voltage of 5 volts with addressing, writing and sensing voltage levels compatible with HLTTL logic circuitry. Typical high noise margins are in excess of 1.0 volt.

Functions in the series include:
TNG6222 and 6224 - Dual 4 input "AND" gate with transient control
TNG6522 and 6524 - Expandable 16 input "AND" gate
TNG6262 and 6264 - Expandable dual 3 input "AND" gate with transient control
TNG6522 and 6524 - Expandable single 4 input driver gate with transient control
TNG7252 and 7254 - Expandable dual 2 + 2 input "OR" gates
TNG7712 - 4 + 3 input expander gate
TNG7812 - 4 + 4 + 3 input expander gate
TNG7912 - Dual 2 + 3 input expander gates

Extremely sharp voltage transfer characteristics are provided by the series, resulting in noise margins typically in excess of 1.3 volts. Fast charge removal from the output transistor provides the ultimate in reduction of supply current during switching. Double inversion is utilized to provide the non-inverted feature with no sacrifice in propagation delay. Typical propagation delay times are 12 nanoseconds with 15 pf load and fanout of 1. Some of the circuits offer the possibility of controlling output transients through the use of an external capacitor. This is particularly useful in applications where length of interconnections would result in excessive noise coupling.

PACKAGING - All of the new HLTTL units shown here are available in a 14-lead flat package (designated by the suffix "F" added to the type number), or a 14-lead dual in-line package (suffix "P" added to type number).

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Center Frequency — Variable, calibrated from 0 to 500 kc
Markers — At 10 and 100 kc intervals, ±0.02% acc.
Resolution — IF bandwidth variable 100 cps to 4 kc
Sweep Rate — 1-60 cps, free-running or synchronized

Amplitude Scales — Lin, 40 db log (usable 60 db), 0.5 db EXP
Distortion — Harmonic and IM at least 60 db down
Sensitivity — 200 μv to 100 v full scale deflection
Accuracy — 0.5 db any 200 kc segment 200 cps-525 kc
Attenuators — 0 to 120 db, step and smooth
Smoothing Filter — 0 to 0.25 sec time constant, low pass

Dynamic analysis shows SB-15a versatility: (1) FM (shows dynamic deviation), (2) AM, (3) SSB with sine wave modulation.

Harmonic analysis of 20 μsec 11,000 pps video pulse waveform on SB-15a 200 kc sweep width, linear amplitude scale.

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<table>
<thead>
<tr>
<th>Logic</th>
<th>Propagation Delay (Typical)</th>
<th>Fan-Out</th>
<th>D-c Noise Margin (Guaranteed)</th>
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<td>Series 54 TTL</td>
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<tr>
<td>930-series DTL</td>
<td>25 nsec</td>
<td>8</td>
<td>350 mV</td>
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</tbody>
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That's one of the many roles played by our Corporate Director of Reliability. He's responsible for the reliability of all IRC products. He double-checks basic designs. Keeps an eagle eye on production. Never goes easy on inspection and testing.

He's not above stopping a shipment at the door if it doesn't meet IRC's standards. Even if it does meet the customer's specifications.

This IRC attitude toward total reliability has practical advantages for you. Now you can choose from several optimum economical levels of reliability in resistors, potentiometers and semiconductors. And IRC is the first to publish prices for standard metal films at three reliability levels.

At IRC, reliability is a management responsibility... not just a specification gesture. For top management attention, address your questions on reliability to our Director of Reliability.

IRC, Inc., Philadelphia, Pa. 19108
Cathode-ray tube displays fast transients

Fiber-optics faceplate captures more light for film recording of nanosecond information; concentrated beam writes faster

A fiber-optics cathode-ray tube for film recording of high-frequency transient waveforms as short as 200 nanoseconds is available from Du Mont Electron Tubes, a division of Fairchild Camera & Instrument Corporation.

Because the tube gathers 30 to 40 times more light than an f/1 camera lens and uses a concentrated beam, it has a tracing speed 50 times faster than the standard CRT.

The KC2427P, developed originally for the Air Force's Defense Atomic Support Agency as part of a nuclear detection system, is a 3-inch CRT using electrostatic focus and deflection.

The best previous system for film recording of images from standard CRT's uses camera lenses and captures flashes only as short as 10 microseconds because much of the light energy is lost when the images pass through the lens. In the fiber-optic tube, the loss in light energy is radically reduced because bundles of 10-micron-diameter glass fibers form the faceplate. The light travels directly from the phosphor coating, through the glass-fiber bundles and onto the film, which is pressed up against the faceplate.

The equivalent lens speed of the fiber-optic display approaches the speed of the phosphor—a value of f/0.05.

Repetitive waveform frequencies of up to one gigahertz (gigacycle per second) can be displayed and recorded because the capacitance of the deflection plates has been reduced and the beam deflection sensitivity has been increased. The reactance of the plate capacitance has disastrous effects on standard CRT's at high frequencies—it effectively shortens the input signal. In the KC2427P, the deflection plates have been chopped up, lengthened and repositioned—reducing the capacitance. The plates are close to the beam, therefore the sensitivity factor, the number of millivolts needed to move the beam a distance of one trace width (2 mils), is only 15.

The speed of the trace is 10^12 trace widths per second. To get an image at such high speed, a concentrated beam is used to stimulate the phosphor.

For recording, Du Mont recommends Kodak's 2475 35-mm unperforated film with an ASA rating of 1,600. The faceplate, optically finished to within one mil of absolute flatness, provides a smooth film transport surface.

The tube is available with either P11 or P16 phosphors.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>1.0Hz</td>
</tr>
<tr>
<td>Trace width</td>
<td>2.mils</td>
</tr>
<tr>
<td>Writing speed</td>
<td>10^12 trace widths/sec</td>
</tr>
<tr>
<td>Acceleration voltage</td>
<td>10 kilovolts</td>
</tr>
<tr>
<td>Useful scan across</td>
<td>1.6 in.</td>
</tr>
<tr>
<td>deflection plates, d1, d2</td>
<td></td>
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<tr>
<td>Sensibility factor</td>
<td>1.2 in.</td>
</tr>
<tr>
<td>across deflection</td>
<td>15 mV/trace width</td>
</tr>
<tr>
<td>plates, d3, d4</td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td>6-8 weeks</td>
</tr>
<tr>
<td>Price</td>
<td>On request</td>
</tr>
</tbody>
</table>

Du Mont Electron Tubes, 750 Bloomfield Ave., Clifton, N.J. 07015

Circle 349 on reader service card

Small servo repeater features versatility

The 771E is a compact 400-cps servo repeater, which follows a 1 and 36 speed synchro bus. It is completely self-contained, and includes servo amplifier, power supply, damping and switching networks, precision gearing, feedback synchros and servo motor. An output shaft at 36 speed is provided, and all connections are made through a miniature connector.

Size is 6¾ x 2½ x 4 in. (depth). The repeater is designed for synchro stators rated at 90 v/line. Power required is 117 v, 400 cps. Static accuracy and top speed at the 36-speed output shaft are 0.2° and 100 rpm respectively.

With the versatile 771E, an engineer can quickly and simply assemble a two-speed synchro frequency converter, an analog multiplier, an indicator or digitizer, just by coupling the appropriate data element or dial to the output shaft provided.

Price is approximately $1,100.

Industrial Control Co., Central Ave. at Pinelawn, Farmingdale, L.I., N.Y., 11735. [350]
New Components and Hardware

Wirewound pot with infinite resolution

The first wirewound trimmer potentiometer allowing infinite resolution has been introduced by CTS of Canada Ltd.

The rectilinear trimmer, called IRW, combines the inherent stability of wirewounds with the infinite setting resolution previously available only in film potentiometers.

CTS uses an exclusive winding construction in the trimmer. In other wirewound potentiometers the contactor usually rides across the windings. This bridging effect precludes the possibility of infinite resolution. CTS, however, has wound the resistance wire around the mandrel in a spiral groove (see above). As the adjustment screw turns the mandrel, the contactor rides along the spiral winding. Each turn of the screw controls a relatively small resistance range. On a 2,000-ohm potentiometer, for example, 60 turns are needed to cover the full range from essentially zero to 2,000 ohms.

The IRW is designed for applications where preset ratio settings (contact to end terminals) of extreme accuracy and stability are required. These include precision voltage dividers in sensing circuits for regulating low-voltage power supplies and as the ratio arm of a wheatstone bridge.

Other applications include precise gain control of chopper stabilized d-c amplifiers and feedback stabilized a-c amplifiers.

CTS of Canada Ltd., Streetsville, Ontario, Canada. [351]

Repeat cycle timers designed for industry

A line of low cost, industrial type, repeat cycle timers is said to offer capabilities hitherto found only in more costly timers. Series designations are L42401 and L42402.

Twenty-three models are offered, providing a selection of 170 different over-all cycle times from 6 seconds minimum to 25 hours maximum. Up to 23 possible combinations of spdt switches are available for 15 or 25 amp loads at 115 v a-c, 60 hz. The switches are snap-in types for easy replacement or maintenance and have a mechanical life rating of over 1 million operations.

These timers are synchronous motor driven, and models can be furnished for operation on 6, 12, 24,
Mylar capacitors in flat construction

Flattened Mylar dipped capacitors (type MDEF) offer higher component densities in printed circuits because of their construction. These capacitors exhibit high insulation resistance, low dissipation factor, low capacitance change, and excellent moisture and life characteristics.

The body consists of a phenolic coating that is vacuum impregnated with epoxy. This not only improves the moisture resistance of the capacitor but also increases its ability to withstand a rugged lead pull test.

The capacitors are available in voltage ratings of 50, 75, 200 and 400 v d-c for operation up to 125°C. The Electro Motive Mfg. Co., Inc., Willimantic, Conn., 06226. [353]

Flexible circuitry reduces costs

A new application of Flexmax printed circuitry has been developed. This circuit, consisting of two layers of laminated flexible circuits, solves the problem of interconnecting 21 trimmer potentiometer components 21 trimmer potentiometer components. One-way frictions in the gear trains and split cams provide for very easy timing adjustment in the field. The A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. [352]

Why pay custom prices for conductive plastic pots?

Our off-the-shelf ECONOPOT™, the industry's only standard conductive plastic precision potentiometers, provide multimillion-cycle rotational life and infinite resolution for as little as $11.55!

Nearly every other industry has been able to standardize and take advantage of mass production. Why not the precision potentiometer industry?

Why not? This question marked the genesis of our ECONOPOT™ concept. We surveyed thousands of precision pot requirements, found definite common denominators, and designed 18 precision conductive plastic models that meet these common needs. The inherent efficiencies of standardization and automation enable us to offer these 18 models from stock at a small fraction of the prices usually paid for precision pots of this quality.

**HERE’S ALL THE INFORMATION YOU NEED TO ORDER ECONOPOT™**

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>MOUNT LINEARITY RESISTANCE</th>
<th>INTR. PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>78ESA102</td>
<td>Servo 1%</td>
<td>1K $13.60</td>
</tr>
<tr>
<td>78ESA103</td>
<td>Servo 1%</td>
<td>5K $13.60</td>
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<tr>
<td>78ESE102</td>
<td>Servo 0.5%</td>
<td>1K $16.45</td>
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<tr>
<td>78ESE103</td>
<td>Servo 0.5%</td>
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<tr>
<td>78ESC102</td>
<td>Servo 0.25%</td>
<td>1K $19.55</td>
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<tr>
<td>78ESC103</td>
<td>Servo 0.25%</td>
<td>5K $19.55</td>
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<tr>
<td>78EBA102</td>
<td>Bushing 1%</td>
<td>1K $11.55</td>
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<td>78EBA103</td>
<td>Bushing 1%</td>
<td>5K $11.55</td>
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<tr>
<td>78EBB102</td>
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<tr>
<td>78EBC102</td>
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<tr>
<td>78EBC103</td>
<td>Bushing 0.25%</td>
<td>5K $17.50</td>
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Prices subject to change without notice

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<tr>
<th>PARAMETER</th>
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<tbody>
<tr>
<td>Electrical angle</td>
<td>340° ±5°</td>
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<tr>
<td>Noise</td>
<td>100 ohms maximum</td>
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<tr>
<td>Rotational life</td>
<td>&gt; 10,000,000 shaft revolutions</td>
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<tr>
<td>Resolution</td>
<td>infinite</td>
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<tr>
<td>Power Rating</td>
<td>1.25 watts at 70°C, derated to 0 at 125°C</td>
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<tr>
<td>Temperature Coefficient of resistance</td>
<td>±200 ppm/°C nominal</td>
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<tr>
<td>Resistance Tolerance</td>
<td>±10%</td>
</tr>
<tr>
<td>Starting Torque</td>
<td>&lt;0.5 oz-in</td>
</tr>
</tbody>
</table>

For as little as $11.55, you can evaluate an ECONOPOT! For fast service, airmail the coupon. For same-day service, call us collect.

**FREE ON REQUEST** 4-page technical catalog plus 25-page comprehensive report of reliability evaluation tests conducted on ECONOPOTs. Report includes results of tests for mechanical strength and high speed rotational life, and resistance to shock, vibration, humidity, soldering, and temperature shock.

**ECONOPOT TEST REPORT**

**NEW ENGLAND INSTRUMENT COMPANY**

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If your purchasing procedures permit, NEI will honor this signed coupon as a purchase order.

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- Send free copy of 29-page ECONOPOT Catalog and Environmental Test Report
- Send technical literature on all NEI products & capabilities

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**COMPANY:**

**ADDRESS:**

**CITY:**

**STATE:**

**ZIP:**

**SIGNATURE:**
HERE IT IS! The FAIRCON multiturn potentiometer with all the features of precision 10 turns yet at a price that fits the industrial OEM budget. Check these features: Standard linearity ±0.2%—resistance values from 500 to 125,000 ohms—high humidity, vibration, shock and acceleration resistance—2 watts power dissipation at 40°C—plus excellent resolution, long life, low noise…and complies with applicable environmental requirements of MIL-R-12934C…all for an amazingly low price. Write for our new FAIRCON short form catalog. And for immediate delivery from stock…Call ARCO.

New Components

A Flexmax circuit has the key feature of reducing several layers of flexible printed circuits to a single multilayer piece. This is made possible because Flexmax design permits unscrambling of conductor routings and thus allows for freedom of pin address.

Connections are made of homogeneous copper with no interface of solder connections. All connections are completely encapsulated in FEP Teflon and protected by high temperature—240°C—Kapton film on the external surfaces. The Flexmax interconnection technique is well suited for making complex interconnections on both electrical components and complete electronic units.

Sandars Associates, Inc., 95 Canal St., Nashua, N.H. [354]

Component-mounting shielded containers

A series of shielded black-box containers is designed for mounting electronic test components. The units provide shielded protective packages for custom-designed voltage dividers, passive or active networks, attenuators, isolation networks, or other circuitry needed for specific electronic tests.

Boxes are die-cast aluminum, finished in blue paint to Federal Standard 595. Cover is 0.040 aluminum, clear anodized per MIL-A-8625A. It is secured to the box by four self-tapping screws to insure...
HERE'S HOW...
THE ELECTRONIC INDUSTRY IS USING THESE TWO FAMOUS ULANO FILMS IN
ULTRAMINIATURE MASK TECHNOLOGY AND COMPLEX PRINTED CIRCUITRY

Ulano

RUBYLITH™ • AMBERLITH™

HAND CUT MASKING FILMS FOR THE GRAPHIC ARTS

ULANO RUBYLITH . . . a revolutionary knife cut red film is laminated to a stable transparent plastic backing sheet. The red film is “light safe” so that when contacted to a sensitized emulsion and exposed to a suitable light source, light passes through the cut-out portions only . . . not through the red film. The polyester backing is absolutely stable . . . insures perfect register. Special effects such as crayon tones, paste ups, benday sheets, and opaquing are easily combined with versatile ULANO RUBYLITH.

ULANO AMBERLITH . . . a companion to Rubylith serves as a color separation medium used as the master on camera copy board to secure negatives or positives. A wide variety of Ulano films—in rolls and sheets—is readily available.

RUBYLITH® • AMBERLITH®
HAND CUT MASKING FILMS FOR THE GRAPHIC ARTS

NEW ZELTEX AMPLIFIER WITH FETS!

More FET amplifier news from Zeltex—true economy with the industry’s most outstanding performance! Featuring exceptionally high differential and common mode input impedance with low current, this new Zeltex amplifier utilizes silicon transistors throughout for utmost reliability. Where performance, cost and size are important, the Model 132 offers the industry’s best from the industry’s leader!

Check these key specifications:
- Input Current: 100 picoamp
- Voltage Gain: 100,000
- Voltage Drift: 20 µvolt/°C
- Input Impedance: 10,000 meg
- Slew Rate: 10 v/µsec

Model 132 Differential Operational Amplifier with Field Effect Transistors...

Also available in a 0.4 in. high enclosure, this remarkable new Zeltex FET Amplifier is available virtually from stock. For complete information, write or phone today.

ZELTEX, INC.
1000 Chalmar Road, Concord, California
Phone: (415) 686-6660
The broadest spectrum of Amplifiers and Computer Elements

Circle 169 on reader service card
Low Noise VCXOs (Voltage Controlled Crystal Oscillators) for an Important Reduction in Phase Jitter

Another FIRST from DAMON . . . Low Noise VCXOs with extremely low phase-jitter (—120 db or 0.001 cps deviation at 1 kc.) This excellent short term stability is typified in the VCXO output spectrum illustrated, above.

Damon Low Noise VCXOs may now be inserted into systems as simple components with no auxiliary compensating circuitry. Only a source of power and a control signal are required.

Applications include: Doppler Radar (CW, CW-FM, FM and Pulse Doppler); Phase Locked Receivers and Transmitters; Doppler Simulation and Compensation; Frequency Synthesizers and other applications requiring electronic frequency control with crystal stability and extremely low phase jitter.

Write for Data on Low Noise VCXOs

DAMON ENGINEERING, INC.
240 HIGHLAND AVENUE, NEEDHAM HEIGHTS 94, MASS.
(617) 449-0800

New Components

100% effective r-f shielding.

The series consists of 12 individual models in two sizes. Twelve different connector combinations are offered to fit an exceptionally wide range of existing test equipment. Solder turret terminals provide noise-free connections for components. Operating range is —55° to +150°C.

Pomona Electronics Co., Inc., 1500 E. Ninth St, Pomona, Calif., 91769. [355]

Mercury-wetted reed switches

Two series of hermetically sealed mercury-wetted reed switches have no contact bounce and very low contact resistance. Series MV and MH are both momentary action. They have identical electrical and environmental characteristics but differ dimensionally. Series MV, for vertical mounting, is 1.350 in. long by 0.625 in. wide. Series MH, for horizontal mounting, is 1.225 in. long by 1.225 in. wide. Both have contact ratings of 3 amps and are capable of 10 million operations under full load.

The no-bounce characteristic of the switches is assured by the use of permanent magnetic lines of force to actuate the mercury contacts. This produces strong contact holding pressure completely independent of push-button actuating pressure. Initial contact resistance is 50 milliohms maximum and will not increase during the life of the switch.

Double-sealed in epoxy and glass, both switches are ideal for dry circuits in explosive or corrosive atmospheres. Housings are of black anodized aluminum with the
housing on series MH keyed for proper horizontal panel positioning. Standard button-actuating pressures are 17 grams or 8 oz with others available to customer specifications. Switch forms presently available are single-pole single-throw normally open, and spst normally closed.

George Risk Industries, Inc., P.O. Box 907, Columbus, Neb., 68601. [356]

Reverse stand-offs for dense packaging

Subminiature reverse stand-off terminals are designed for use in panels where dense packaging is required. The parts are designated type No. RST-SM-14.

With a major diameter of 0.150 in., this Press-Fit terminal can fit on 0.170-in. centers in a 0.050-in.-thick panel. To conserve additional space, the solder-plated brass lug is 0.100 in. long. Over-all length of the new unit is 0.210 in. For simple installation, insertion tool No. B6-X3, which is also available from the manufacturer, is used for mounting.

Press-Fit terminals are fashioned of 100% pure virgin Teflon and are available in any of the standard EIA colors for coding.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y., 10544. [357]

P-c board heat sink for TO-5 transistors

Series 150 is a lightweight heat sink, which takes up a small board area and has good performance characteristics with TO-5 cases. The case temperature rise is 36°C at 1 w with bright aluminum natural finish or 30°C rise at 1 w with black anodize finish. The area required for mounting is only 0.375 square in. Material used is 1100

One of the important reasons for specifying Voltrol Stabilizers is the advantage of being able to select from a complete line of uniformly high performance designs. If one application calls for 30 VA and another has a load of 5000 VA; or, if the installation nominal supply voltage is 230, or 460 volts, you can be supplied from one source—Acme Electric. This is a plus buying reason well worth considering.

ENCLOSED TYPE
Sizes from 30 VA thru 1000 VA can be supplied with heavy gauge steel enclosures. Conduit knockouts on four sides of terminal enclosure. Also available with cord and plug adapter set, for use with equipment not permanently installed.

3 KVA and 5 KVA units with mutli-voltage inputs and 240 or 480 volt outputs
Voltrol Stabilizers are available in many voltage variations.

*Voltron is a trademark of Acme Electric.
America's principal defense contractors, computer builders, instrumentation manufacturers and electronic systems developers use more Metal Removal Company solid carbide circuit board drills and routers than all other makes combined.

For more information, may we send you our Catalogs D63 and E65 ... and name of nearest distributor?

**New Components**

aluminum alloy.

Two No. 4 by ¼ in. long sheetmetal screws are used to solidly clamp the TO-5 case in the heat sink. Three eyelets extruded from the mounting base provide keying to the circuit board. A sheet metal screw in the center eyelet anchors the heat sink to the p-c board and the two outer eyelets are set for permanent positioning.

Price is less than 3 cents each in volume quantities without black anodizing. Series 150 heat sinks are provided without screws.

Wakefield Engineering Inc., 139 Foundry St., Wakefield, Mass. 01881. [358]

**Versatile connectors in three assemblies**

A versatile concept in connector design, called the A-MP series G connector, provides almost unlimited signal, power or coaxial circuit combinations in a single basic connector style. The series G connector allows packaging of circuit connectors in any required combination, eliminating the need for a separate connector for each type of circuit.

The series G line is currently available in three different assemblies incorporating one, two or three connector modules. Each module can accommodate 4, 8, 11, 14 or 23 circuits.

Each connector assembly consists of three parts: the shell, module insert and retainer back plate. The cast aluminum shells have polarizing grooves in the receptacle and matching tongues in the plug and are available with or without floating bushings. The shell and
When you think small... think Deutsch.
Mass circuitry subminiatures for hard-to-find connector space.
All shapes and sizes... cylindrical, square, rectangular.
All coupling types... bayonet-lock, threaded, push-pull.
All applications... hermetics, environmentals, non-environmentals.
When in a tight spot... squeeze in your local Deutschman.

NOW - DEUTSCH SUBMINIATURES ARE AVAILABLE WITH EITHER STANDARD OR REAR RELEASE INSERTABLE/REMOVABLE CONTACTS.
ULTRA SENSITIVE NANOVOLT AMPLIFIER

Never has a dc amplifier provided more versatile performance with as precise amplification for signals as low as 100 nanovolts. The completely transistorized Model 120 is specifically engineered for low-level, low frequency transducer outputs typifying geophysical, seismographic, bolometer, cryogenic, cellular, Hall-effect, and related applications. Gains from 200 to 1 million, selected by front panel switch. Operated directly from ac power line or by battery, thus eliminating 60-cycle hum interference and providing floating amplification. Built-in battery charger and front-panel monitor. Just 14 pounds light.

SPECIFICATIONS

Gain Steps . . 200 to 1 million in 1, 2, 5, etc. sequence
Input Resistance . . . . Greater than 1 megohm
Bandwidth . . . From dc to greater than 100 cps
Gain Accuracy . . . . ± 1% at dc
Gain Stability . . ± 0.01%/day, ± 0.1%/6 months
Linearity . . . . . . . . . . ± 0.02%
Noise . . . . . <0.05μv pk to pk referred to input
Drift . . . . . <0.05μv/hour referred to input
Output . . . . . . . ± 5 volts at 5 ma
Size . . 6 ¾”w by 8 ¾”h by 10 ½”d portable cabinet
Power . 115VAC or self-contained rechargeable batteries

New Components

10-turn precision pot is ¾ inch long

Model 7266, measuring ¾ in. long, is said to be the industry's shortest ½-in. diameter, 10-turn precision potentiometer. It has a wirewound resistance element and standard resistances from 10 ohms to 125,000 ohms. Standard resistance tolerance is ±3%, with ±0.2% independent linearity. The bushing mount potentiometer has a power rating of 1.6 w at 40°C, derating to 0 at 85°C.

Construction features include molded plastic housing, gold-plated terminals and ¼-in. diameter stainless steel shaft. The pot is available in ganged units as well as single sections.

Helipot division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. [360]

Multilayer capacitors resist delamination

A line of ceramic multilayer capacitor chips has a high uniformity of dielectric and electrode layers and exceptional delamination resistance. Called Multi-cap capacitor

---
chips, they are made with high-quality AlSiMag dielectric materials, including a new NPO composition that gives 50% greater capacitance, according to the manufacturer. A special manufacturing process is said to insure a strong lamination of materials, virtually eliminating any delamination problem.

Multi-cap capacitors are available in sizes ranging from 0.152 x 0.052 x 0.065 in. to 0.375 x 0.155 x 0.065 in., with capacitance values from 330 pF to 0.5 µF, at working voltages of 25 to 50, 100 to 200 d-c.

Prices are based on quantity, value, tolerance and voltage required. An 0.01, 50-v unit is listed at less than 30 cents. Delivery in limited quantities is possible in approximately one week, and samples are available on request in various sizes, values and voltage combinations.

Titation division, American Lava Corp., Chattanooga, Tenn., 37405. [361]

Moisture-proof
Teflon terminal

A terminal has been developed that serves two purposes—as a conventional panel feed-through or as a moisture-proof terminal for component housings.

The Teflon body is held under tension by a spring push-nut, which gives it maximum mechanical stability. Product advantages are low initial cost; fast, low-cost assembly; and mechanical reliability—plus the thermal and electrical values of Teflon.

All tests indicate that the terminal does not leak and can be used on applications to meet MIL-T-27A specifications. A sample kit that includes literature and product samples is available.

Lundey Associates, Inc., 694 Main St., Waltham, Mass., 02154. [362]
New Semiconductors

Fast adder formed on single chip

Integrated circuit digital subsystems on individual silicon chips have been introduced by Sylvania Electric Products, Inc., a subsidiary of the General Telephone & Electronics Corp. The units, called monolithic digital functional arrays, provide high reliability, low power consumption and reduced systems assembly costs, according to Alvin B. Phillips, Sylvania's general manager of integrated circuits.

One of these subsystems is a complete transistor-transistor logic (TTL) fast adder. The fast adder circuits are formed on individual 48 by 61 millimeter silicon chips. The basic adder configuration may be interconnected by three standard metal patterns to form a single-stage, independent-carry fast adder, called the SM 30 series; a single-stage, dependent fast adder, SM 20 series or a single-stage full adder, SM 10 series.

Most advanced high speed computers use parallel, anticipated-carry, fast-adder systems in which the addition of binary digits and the addition of carries between digits is performed simultaneously. To build parallel anticipated-carry fast adders larger than four bits, independent and dependent fast adders are used in conjunction with a specially designed carry decoder package, series SM 40. The SM 20 dependent carry adders form the first and last stages of an adder system to provide for end-around carry operation. Where speed is not critical, computer systems can use ripple carry adders made from SM 10 series full adders. In ripple carry adders, a separate carry operation is performed following the addition of each binary digits.

A 64-bit anticipated carry adder that will perform 3 million 64-bit additions in less than a second can be made from only 96 Sylvania packages. Mounted on printed circuit boards, the entire system will fit into a 3-inch cube. A similar system using conventional integrated circuits would require approximately 320 individual packages, occupy approximately six times the space, and take twice as long to perform the same function, according to Phillips.

The fast adder circuits are avail-

<table>
<thead>
<tr>
<th>Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Propagation delay</td>
<td>35 nanoseconds for 8 stages to final sum (anticipated carry)</td>
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<tr>
<td>Noise margin</td>
<td>±1.0 volt</td>
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<tr>
<td>Power consumption</td>
<td>120 mw per stage</td>
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<tr>
<td>Fanout</td>
<td>6 to 15</td>
</tr>
</tbody>
</table>

Electronics | April 18, 1966
24 STANDARD MODELS...

RHG OCTAVE AMPLIFIERS

FEATUREING
- Noise figures to 2.5 db
- Solid State Reliability
- Low input and output VSWR
- RFI and Weatherproof housing
- Octave coverage to 1000 MHz
- With or without power supply

FOR EXAMPLE

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency</th>
<th>Gain</th>
<th>Noise Figure</th>
<th>Input and Output Impedance</th>
<th>Input and Output VSWR</th>
<th>Price</th>
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<td>B505</td>
<td>200-400 MHz</td>
<td>20 db (min.)</td>
<td>&lt; 4 db over band</td>
<td>50 ohms</td>
<td>2:1 typical over band</td>
<td>$495</td>
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</tbody>
</table>

Utilizing RHG's broad background in low noise pre-amplification, an additional 43 CUSTOM DESIGNS have been produced. The solution to your problem may be on file in our library now.

For specials, test our ONE-DAY-QUOTE Service. For standards, see complete listing in EEM Section 3400.

What happens when you insulate with HYGRADE SLEEVING?

No cracking, no corrosion, no wicking, no dielectric breakdown... nothing! It just sits there... preventing trouble the way it's supposed to. In fact, you can forget it! Isn't that what you want in insulating sleeving? Just tell us where you plan to use it, under what conditions. We'll recommend the right material. You can take our word for it... because we've been insulation specialists for 44 years.

HYGRADE INSULATING SLEEVINGS

Markel HYGRADE Slevings are constructed of carefully braided fiberglass yarn, impregnated and coated with specially formulated varnishes, vinyls, resins, or silicone rubber compounds. A wide range of types, grades and sizes meet virtually every conceivable requirement for dielectric and mechanical strength under all kinds of operating conditions... at continuous temperatures from $-70^\circ F$ to $1200^\circ F$. We'll be glad to send you specifications and Sample File on the entire HYGRADE Slevings line. Just write. No charge or obligation.

L. FRANK MARKEL & SONS
Norristown, Pa. 215-272-8960

INSULATING TUBINGS & SLEEVINGS • HIGH TEMPERATURE WIRE & CABLE
New Semiconductors

able in Sylvania's standard 14-pin dual in-line, plug-in package and the TO-85 flatpack. They are designed for operation in the temperature range —55° to +125°C.


Optical isolator in epoxy package

An optoelectronic coupling device permits economical high-voltage electrical isolation up to 5,000 volts. The TIXL101 optical isolator combines a planar silicon light sensor (LS600) with a gallium arsenide light source (TIXLO1) in a single opaque epoxy package.

The new device is designed to provide electrical isolation where circuit feedback problems exist. As a replacement for electromechanical relays, it offers significant advantages in switching speed, reliability, mechanical ruggedness, and compactness.

Though capable of handling very high voltages, the TIXL101 is sensitive to small signal changes. Therefore, it is particularly suitable for application in high-voltage low-current telecommunications relay lines.

Switching speed greatly exceeds that of the fastest relays, permitting the transmission of more information with fewer devices. Capable of flat response beyond 10 kHz (kilocycles per second), the device has a typical reverse switching time of 1.5 μsec and a forward switching time of 15 μsec.

Input current rating is 50 ma. Output is 250 μa minimum, a highly usable signal level sufficient to drive simple amplifier circuits.

Incorporation of two hermetically sealed components in a solid, one-piece epoxy package results in a physically rugged component suitable for heavy-duty industrial applications where they are subjected to high vibration, shock, and other environmental extremes, according to the manufacturer. Contact chatter or bounce, often encountered where relays are subjected to high vibration, is completely eliminated. The device provides stable performance over a broad temperature range from —55° to +125°C.

The TIXL101 is encased in an electrically isolated cylindrical package measuring only 0.22 by 0.35 in.

Price of the unit is $34 in quantities of 100 to 999.
Texas Instrument Incorporated, 13500 North Central Expressway, Dallas, Tex. [366]

22-ampere scr’s in TO-48 package

A 22-amp series of silicon controlled rectifiers is available with peak reverse voltage ratings from...
Delco Radio’s new 400V silicon power transistors will change your thinking about high voltage circuitry. You can reduce current, operate directly from rectified line voltage, and use fewer components. Our standard TO-3 package stays cool (junction to heat sink 1.0°C per watt). And price is low—less than 3c a volt even in sample quantities—for wide ranging applications. Vertical and horizontal wide-screen TV outputs, high voltage, high efficiency regulators and converters. Your Delco Radio Semiconductor distributor keeps them on ice. Call him today for data sheets, prices and delivery.

### Ratings

<table>
<thead>
<tr>
<th></th>
<th>DTS 413</th>
<th>DTS 423</th>
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<td>Vce (Sat)</td>
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<td><strong>Frequency</strong></td>
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<td>5 MC (Typ)</td>
</tr>
</tbody>
</table>

### Field Sales Offices

- **Union, New Jersey**
  - Box 1014, Chestnut Station
  - (201) 637-3770
- **Syracuse, New York**
  - 1094 James Street
  - (315) 472-2668
- **Detroit, Michigan**
  - 57 Harper Avenue
  - (313) 873-6560
- **Chicago, Illinois**
  - 5151 N. Harlem Avenue
  - (312) 775-5411
- **Santa Monica, Calif.**
  - 776 Santa Monica Blvd.
  - (213) 567-8870
- **General Sales Office**
  - 700 E. Firmin, Kokomo, Ind.
  - (317) 457-8451—Ext. 500

*Office includes field lab and resident engineer for application assistance.
New Semiconductors

25 to 700 v (800 v nonrepetitive transient rated). The series has a maximum current rating of 22.3 amps average (35 amps rms) at up to 70°C case temperature and a junction temperature capability of 150°C. The maximum operating temperature of 150°C permits significant current ratings in higher ambient temperatures than with conventional 125°C maximum devices of identical physical size.

Applications for the new series range a broad spectrum from battery chargers and temperature controllers, to motor speed controls and process control instrumentation. The series is in the TO-48 package. Availability is two to four weeks. Price is $10.80 to $51 in lots of 1 to 99, and $6.90 to $35 in 100 to 999 lots.

International Rectifier Corp., 233 Kansas St., El Segundo, Calif., 90245. [367]

Field effect devices offered in 11 models

Eleven advanced-design, field effect devices have been introduced. Seven transistors and four quads in the enhancement mode with insulated gates offer the many advantages of FET performance at half the price of generally available FET's, according to the manufacturer.

The RN1020, RN3020, and RN3020R have applications as high-frequency amplifiers where high input impedance and high gain are specified. The RN1030, RN1030A, and RN3030R are efficient in digital logic and chopper applications featuring zero offset, high input impedance and low “on” resistance.

The RM5008 is a monolithic device incorporating four p-channel enhancement mode integrated FET's on a single silicon chip. The 14-lead, flatpack quad has applications in switching, chopping, logic gating and amplifying.

The RM8007 is similar except that it employs dual common source pairs and hence is a 12-lead unit. The RM5008D and RM8007D have diode protected gates.

All these devices are rated for 125°C and 6-v gate reverse bias. They are currently in production and immediately available. Prices in the 1 to 99 quantities range from $3.95 for the RN3030 to $35 for the RM5008D.

Raytheon Co., Components division, Lexington, Mass., 02173. [369]
Is this your design department?

Bill can't find a small enough pushbutton.

Ed wants an extra-tiny indicator light.

Joe's checking four sources for a toggle.

George wants a snap-in switchlite.

You fellows ought to know Control Switch!

Rip out the bingo card in this book now and tick off numbers for any or all of the Control Switch catalogs listed below.

If you get all seven catalogs, you'll have the most complete file you can get from any single source!

Control Switch makes more types of switches and switchlites than anybody. So our catalogs offer the best chance of finding what you want . . . first try!

In addition, some manufacturers don't make any of the switches and lights we make.

So these catalogs save chasing all over for switches.

Finally, Control Switch makes quality switches. For applications like data processing equipment, space age projects, and instrumentation systems. So our catalogs save horsing around with switches that can't deliver. Send that bingo card now!

Here are the Control Switch catalogs. Check numbers on the Reader Service Card corresponding to those on the left below for the catalogs you want.

#480 Basic Precision Switch Catalog 110
#481 Toggle Switch Catalog 180
#482 Indicator Light Catalog 120
#483 Hermetically-Sealed Switch Catalog 130
#484 Switchlite Bulletins 54, 55, 63
#485 Switchlite Catalog 220
#486 Pushbutton Switch Catalog 190
#487 RFI-Shielded Component Bulletin 62
This 20-joule High-Q CAPACITOR has inductance of ONLY 1 NANOHENRY

- Q is 250 at 5 mc
- 0.1 microfarad
- 20 kilovolts

The Model ESC 247B coaxial disc capacitor is one of a series whose inductance is essentially that of the terminal. Its coaxial construction results in maximum self-inductance of only one nanohenry for any capacitance from 250 pf to 0.5 ufd.

Capacitors in this configuration can be furnished in 50kv rating or, at lower voltage, to 500 joules. They can also be constructed to operate at high repetition rates.

The through-hole in the center of the terminal permits efficient installation of circuit components, such as the TOBE Model SBG-6 low-inductance spark-gap switch.

Ask for Bulletin EB365-20; it gives detailed information about the physical structure and electrical characteristics of coaxial disc capacitors.

And write or call us whenever you have a special or unusual requirement for capacitors.

TOBE DEUTSCHMANN LABORATORIES
CANTON, MASSACHUSETTS 02021
Telephone (617) 828-3366

New Instruments

Low-cost dynamic IC tester

An integrated circuit tester, developed by Monitor Systems, Inc., a subsidiary of Epsco, Inc., provides the small user of integrated circuits with an inexpensive instrument for dynamically testing a variety of IC's. Other IC testers either perform only static tests or are large, complex systems that are too costly for modest users of IC's.

Monitor's model 851 is a self-contained unit that has selectable pulse rates and levels, adjustable power supplies and selectable circuit loads. The unit can test diode-transistor (DTL), resistor-transistor (RTL), emitter-coupled (ECL) and transistor-transistor (TTL) logic modules and linear circuits such as operational amplifiers. Separate plug-ins program the tester for the appropriate electrical tests for each type of IC. A typical IC module can be thoroughly checked in less than 15 seconds.

All that is necessary to test a circuit is to select the appropriate program plug-in and then set the proper bias voltages, pulse rate and load. The device is then inserted into the appropriate receptacle. As an added safety measure, no power is applied to the circuit until the test button is pressed. The d-c outputs are monitored on a front-panel meter and the dynamic responses observed on an oscilloscope.

The test instrument accommodates all of the commonly used integrated circuit packages including flatpacks, TO-5 cans, and dual inline packages. An optional vacuum probe facilitates rapid, foolproof lifting and positioning of flatpacks for testing. The vacuum is automatically turned on when the probe is removed from its receptacle and can be interrupted with a switch on the probe to release the IC. The vacuum is turned off automatically when the probe is returned to the receptacle.

Monitor provides two separate bias supplies for circuits under test. Each has a range of 0 to 15 volts d-c, adjustable by front-panel controls. Both supplies are floating with respect to ground and output voltages of either polarity can be selected.

Test pulses are generated by a clock circuit with a selectable fre-
1,200 MHz is covered in two bands, with the lower from 0.5 MHz to 300 MHz and the upper from 275 MHz to 1,200 MHz. Sweep width on the low band is continuously variable from 50 kHz to 300 MHz; while on the high band it can be varied from 50 kHz to 40% of center frequency.

The VS-80 is also provided with a c-w output mode. The unit has provisions for accepting up to eight single frequency or harmonic plug-in markers.

R-f output for the low band is 0.5 v, ±0.25 db; for the high band, 0.5 v, ±0.50 db. Impedance is 50 ohms. Weight is 18 lbs. Price is $1,495; delivery, two to three weeks.

Texscan Corp., 51 South Koweba Lane, Indianapolis, Ind. [373]

Phase meter covers
20 hz to 10 Mhz

Type 422A is a video and r-f phase meter that offers the following features: 1) direct reading in degrees without amplitude or frequency adjustment; 2) amplitude fluctuation from 0.3 to 20 volts without affecting the accuracy of phase reading; 3) capability of plotting phase characteristic curve or direct reading in degrees over five decades, 20 hz to 10 Mhz; 4) equal accuracy for symmetrical waveforms of any shape; and 5) provision for self-calibration, self-adjustment identification of lead and lag.

The instrument can be used for plotting envelope delay curve up to several hundred megahertz with a sweep oscillator and type 712 group delay curve tracer. It is also suitable to use for measuring phase shift between antennas with amplitude modulated signal. No error will be introduced for signals with modulation under 70%. The signal amplitude can be varied from 0.3

---

Why Hyvac puts a high voltage relay in a vacuum—

one word... RELIABILITY!

VACUUM RELAY RELIABILITY means short contact travel, low contact mass, contacts free of oxides and pitting and minimum contact bounce. These long-life reliability features are made possible only because of operation in a high vacuum dielectric. Vacuum technology has made high reliability, long life high voltage switching practical, with considerable savings in space and weight. Developed for high voltage, high peak current applications, Hyvac relays are well suited and widely used in radar, communications, pulse forming networks, ECM, sonar, medical electronics, antenna switching and antenna couplers, microwave systems and switching in explosive atmospheres. Hyvac's broad line and "Quick Reaction Time" is geared to your most critical delivery schedule. We have the high vacuum experience, design and production capability to provide special modifications of our standard off-the-shelf designs in unbelievably short order. Hyvac, a company small enough to be responsive, large enough to be responsible. Check the brief specifications of our "H" series:

<table>
<thead>
<tr>
<th>HYVAC TYPE</th>
<th>H-8</th>
<th>H-9</th>
<th>H-11</th>
<th>H-12</th>
<th>H-14</th>
<th>H-16</th>
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<td>SPDT</td>
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<td>Operating time, max (ms)</td>
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<td>20</td>
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<tr>
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<td>$105</td>
<td>$110</td>
<td>Factory quote</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Carry only

For complete technical information, contact your nearest sales engineering representative, or write directly to us.

HYVAC
HIGH VACUUM ELECTRONICS INC. • 538 MISSION STREET
SOUTH PASADENA, CALIFORNIA • PHONE: (213) 682-2149 • TWX 213-449-2552

Circle 185 on reader service card
RMC Type C DISCAPS meet or exceed all specifications of the EIA standard RS-198 and RS-165-A. Rated at 1000 working volts, Type C DISCAPS provide a higher safety factor than paper or mica capacitors.

Constant production and quality control checks assure that all specifications and temperature characteristics are met.

Throughout the years leading manufacturers have relied on RMC for quality of product and maintenance of delivery schedules. Write on your company letterhead for additional information on DISCAPS.

**TEMPERATURE COMPENSATING TYPE C**

**SPECIFICATIONS**

- **CAPACITANCE:** Within tolerance ±3% or ±5% or ±10% or ±20%
- **CAPACITANCE TOLERANCES:** ±3%, ±5%, ±10%, ±20%
- **WORKING VOLTAGE:** 1000 VDC
- **QUALITY FACTOR:** Greater than 1000 for 30 pf and above. Below 30 pf = Q = 400 + 20 k cap (pf)
- **INSULATION RESISTANCE:** Greater than 7500 Megohms @ 500 VDC
- **TEMPERATURE COEFFICIENT:** As noted on capacitance chart
- **FLASH TEST:** 2000 VDC for 1 second
- **LIFE TEST:** Per EIA RS-165-A Class I
- **BODY INSULATION:** Durez phenolic — vacuum wax impregnated
- **LEAD STYLES AVAILABLE:** Long lead — #22 AWG tinned copper (2.250 for .890" diameter)—and all types for printed wire circuits.

**New Instruments**

A push-button controlled oscilloscope is entirely free of d-c drift. Every major function is programable by external circuit closures. Settings for any desired series of waveform observations may be pre-selected, Displays are presented in rapid order, and repeated exactly. With drift eliminated and correct settings assured, testing is fast and errors are reduced.

Model 155A oscilloscope is a 5 mv/cm, 25-Mhz instrument with illuminated push-button controls. D-c drift is eliminated by continual feedback corrections. Sensitivity and sweep are push-button-selected on the front panel, the setting indicated by illumination of the button pressed. D-c offset (trace position) is also indicated on an illuminated scale. A companion to the scope, the model 1550A programer has 18 buttons, each of which will, at one touch, select an entire set-up on the scope. The present combination will include not only sensitivity, sweep, and offset (vertical position), but also input coupling (a-c or d-c), trigger source, and trigger slope. Programs are determined by the position of plug-in diodes in the programer's circuit boards. Programers may be cascaded, extending the number of available programs without limit.

With its programer, the model 155A scope is especially useful in test applications where repetitive measurements must be made quickly and unerringly in the same way. Production test procedures...
may be simplified and testing time reduced, errors and training time minimized. Electronic components, circuit assemblies, and finished products all may be tested more quickly. The automated test stand, for the first time, now may include automated scope presentations. Any of the common programing devices may readily be applied—paper tape, cards, magnetic tape, etc.

Push-button convenience is also valuable to the laboratory user. Positive vertical calibration is retained, even with an off-screen d-c reference, by the no-drift feature. Sweep and sensitivity settings are obtained in one motion, without clicking through many positions. The operating condition is clearly displayed by illuminated tabs. Unintentional settings are harder to make. For lab use, the scope may be ordered without the programing feature, at reduced cost, but programability may be added later with plug-in boards and cables.

Twelve calibrated sensitivity ranges are provided, from 5 mv/cm to 20 v/cm, with vernier extension to 50 v/cm. Eighteen calibrated sweeps range from 50 mv/cm to 0.1 µsec/cm, with vernier extension to 0.25 sec/cm, at the slowest, and a X5 expansion speeds the fastest sweep to 20 µsec/cm. Automatic triggering is included.

Model 155A is priced at $2,450. Model 1550A programer is $600. First deliveries in May. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif., 94304. [375]

Expanded-scale frequency meter

Type FMS46 frequency meter, using solid state electronics to achieve 0.5 cps resolution, 0.1% accuracy and maintenance-free operation, linearly measures and displays the 375 to 425 hz frequency range. It is connected in parallel to the frequency source (100 to 130 v rms) and requires less than 2 watts of power from the source. Mounting hardware and bezel are available for recessed mounting.

This 400-cps meter is priced at $84 and is available from stock. Airpax Electronics Inc., Seminole division, P.O. Box 8488, Fort Lauderdale, Fla., 33310. [376]

Vacuum plus ceramic adds up to a new line of Jennings vacuum relays that brings you (1) High voltage hot switching capability (2) Highest RF current carrying ratings (3) Shock resistance (4) Small size and light weight (5) Greater reliability (6) Low unchanging contact resistance. These new relays eliminate the necessity to redesign circuits in order to avoid difficult switching problems. Now small lightweight systems can be designed in the sure knowledge that the new Jennings vacuum relays offer as much as or more reliability and high performance than any other component in the circuit.

The RF10A relay features high power dc interrupting capability up to 50 KW.

The RJ2A and RJ1A are essentially rf relays capable of withstandng high voltage and carrying high rf currents. Even so the RJ2A will interrupt a rather remarkable 1 amp at 1000 volts for many thousands of operations. Jennings also offers many glass vacuum relays, each designed to provide maximum performance to the particular segment of the electronic field for which they were created. Our new catalog 102 describing our complete line of vacuum relays is available at your request.

Jennings Radio Manufacturing Corporation — Subsidiary of International Telephone and Telegraph Corporation, 970 McLaughlin Avenue, P.O. Box 1278 San Jose, California 95108.

Circle 187 on reader service card 187

Jennings
The old master has met its match.

For more than twelve years, our 250 DA Universal Impedance Bridge ruled supreme in its field. No instrument could match its measurement performance.

Now along comes a serious challenger—our new 250 DE (at right). It has all of the reliability and accuracy of the classic model. As you can see, they look alike from the outside.

But inside, we've made many improvements. The new 250 DE is completely self reliant on its four flashlight batteries. It has a new solid-state detector with greatly improved sensitivities: better than 20 microvolts on DC, 10 microvolts on AC. For simplicity, there is a single meter null detector on the front panel. And for versatility, some useful front terminals have been added.

Why did we improve on the old master when it has delighted so many thousands with its performance in countless plants, laboratories and schools? Well, we figured eventually somebody would make a truly portable impedance bridge even better than the 250 DA. And we wanted it to be us. ESI, 13900 NW Science Park Drive, Portland, Ore. (97229).

250 DE Portable Universal Impedance Bridge Specifications

- Range:
  - Resistance: 0 to 12 Megohms
  - Capacitance: 0 to 1200 Microfarads
  - Inductance: 0 to 1200 Henrys
  - Resistance: 0.1% ± 1 dial division
  - Capacitance: 0.2% ± 1 dial division
  - Inductance (Series and Parallel): 0.3% ± 1 dial division
- Sensitivity: Better than 20 microvolts
- Frequency: 1 kc internal
- Batteries: 4 D size flashlight batteries
- Weight: 12 lbs. Price: $470.00

New Subassemblies and Systems

Laser system offers high repetition rate

The LE-4 is a high repetition rate laser system featuring excellent reproducibility. It has an output of 3 joules minimum at pulse repetition rates of one pulse per second. At two pulses per second, output is 2 joules minimum.

The system consists of a water-cooled single elliptical cavity laser head and a 1,600-joule power supply. The LE-4 can be modified for short pulse operation with any type—mechanical, electro-optical or passive—Q switch and can operate at the same repetition rates as in normal use.

Single shot laser energy outputs are in excess of 4 joules, and maximum output energy in the one pulse per second mode is approximately 3.75 joules.

The LE-4 is presently being used in such micromachining applications as watch balancing and resistor trimming.

Price of the system is $6,255 with delivery in 60 to 90 days.

Digital computers for military use

Model R-11 digital computer, for military applications, features a very high speed memory—650 μsec full memory cycle—in a 1.9 cu ft package.

Designed for such tactical command and control functions as ground and airborne weapons control, the R-11 is a real time general purpose computer built to military specifications. It has an 8,192-word memory with 24 bits plus parity per word. It weighs 100 lbs. Enclosed in the package are the memory unit, a central data processor, and a power supply available in both 60 and 400 hz (cycles per second) models.

The system can perform very high speed arithmetic operations including multiplication of two 24-bit words in 5.6 μsec in conjunction with digital computers for military use.
with all necessary memory accesses and register transfers. Two 24-bit words can be added or subtracted in 1.9 μsec.

Available to the programmer are 70 commands including arithmetic, transfer, store, logical and shift functions. The R-11 features memory data protection in case of power failure and real time inputting at 25 megabits per second.

Missile Systems division, Bedford Laboratories, Raytheon Co., Bedford, Mass. [383]

**Digital-to-analog converter module**

A digital-to-analog converter has been added to the company's standard family of digital logic modules.

The DA-101 module consists of a precision resistor matrix and 10 voltage-switching circuits designed to perform digital-to-analog conversion. The module has 10 digital inputs and one analog output. Conversion accuracy is ±0.05% of full scale; settling time is less than 2 μsec. Several modified versions are also available.

Control Equipment Corp., 19 Kearney Road, Needham Heights, Mass., 02194. [384]

**All-band receiver for field operation**

The SR-219 receiver is a portable unit operating off self-contained rechargeable nickel cadmium batteries with frequency coverage from 2 MHz to 4 Ghz by means of plug-in tuning heads. Only 10 in. wide, 3½ in. high and 17 in. deep, the receiver has a built-in battery charger. It provides a-m, f-m, c-w and pulse reception.

I-f bandwidths of 1 khz to 20 khz are available for the h-f heads and

---

**taking a low-cost look at memory cores is no longer a problem**

For 8 years most progress in high speed handling of ferrite memory cores has been due to the innovations of Ramsey Engineering. In 1966 over 4,000,000,000 cores will pass through hundreds of Ramsey handlers operating in every major computer facility throughout the world. The CH 100 is Ramsey's most advanced handler. It is made of cams, linkages, drives, probes, contacts, and 8 years of know how. It processes 60,000 ferrites per hour and has just reduced the overall cost of core testing.

COMPUTER TEST CORPORATION

CHERRY HILL, NEW JERSEY

Electronics | April 18, 1966
Semtech Corporation offers the industries FIRST complete line of Nano-second Reverse Recovery Silicon Rectifiers in medium power ranges. The four unique configurations are designed to meet any packaging problem with improved performance. Standard units are available with ratings 1 amp from 50 to 1000 volts, 0.5 amp from 2500 to 25,000 volts.

All rectifiers have rugged solid internal construction, combining high mechanical strength, superior thermal shock resistance, hermetically sealed, high dielectric strength and excellent thermal conductivity properties. Operating temperatures from $-55^\circ$ to $+175^\circ$C. Reverse Recovery $(T_{rr})$ is measured on each junction, 0.5 amp forward to 1.0 amp reverse, recovery time measured when rectifier recovers to 0.25 amp.

Send for Technical Bulletins

**New Subassemblies**

from 20 khz to 4,000 khz for the vhf and uhf tuning heads. Offering completely solid state and modular type construction, the equipment weighs only 15 lbs with batteries and plug-in tuning head. The front panel contains both a tuning meter and signal strength meter plus mode selector, audio, video, r-f gain, and power switches and a carrier operated relay sensitivity adjustment.

The low noise plug-in tuning heads are designed for installation in the receiver without adjustment or alignment of any kind. They have age to permit handling of large r-f signals.

Astro Communication Laboratory, Inc., 801 Gaither Road, Gaithersburg, Md. [385]

**Modular supplies**

offer dual output

The PSD series units, PSD12-300 and PSD15-300 are dual output modules supplying $\pm 12 \text{ v}$ and $\pm 15 \text{ v}$ at 300 ma, respectively, and feature automatic self tracking to maintain the relative accuracy of both outputs. The compact modules are designed for system integration in critical applications. They feature 0.1% regulation, 0.5 mv ripple, remote sensing, and operate in environments up to $+71^\circ$C without derating.

The series contains automatic short circuit protection to protect the supply against overloads and guarantee long and dependable service. The units measure 5 in. high x 4½ in. deep and 3¼ in. wide. They can be mounted for use either horizontally or vertically and can be provided with barrier strips.
solder lugs, or octal sockets to fit desired applications.
Price is $115 for quantities of 1 to 8, and as low as $100 for 50 or more units. 
Trygon Electronics, Inc., 111 Pleasant Ave., Roosevelt, L.I., N.Y., 11575. [386]

Small power supply
for industrial use

Miniature model PS10 industrial power supply features a small modular cabinet with carrying strap. The supply is variable from 0 to 10 v, contains a precision voltmeter and ammeter, and has optional rack mounting brackets.

The unit has low ripple and short circuit protection, and is designed for use as a power source for transistor and integrated circuits. Input is 105 to 130 v at 55 to 65 cps. Line and load regulation is 0.05% +5 mv. Ripple is 2 mv.
Maximum current is 600 ma. Other optional ranges from 0 to 50 v are available. Size is 5 in. high x 8 in. wide x 8 in. deep. Weight is 9 lbs. Price is $124.95 each in single quantities; delivery, 3 weeks.
United Computer Co., 930 W. 23rd St., Tempe, Ariz., 85281. [387]

Function generator
is highly accurate

Model 530 is a two-channel function generator for analog computation of sines and cosines. This

General Electric is geared to produce a broad line of semiconductor parts. Make G.E. your one source for all components such as:

Component Assemblies—Semiconductor lead-in wires—Dumet "slug" leads—molybdenum "slug" leads—whisker welds and other 2 or 3 part welded lead wires—molybdenum diode slugs—plastic transistor headers—plastic integrated circuit packages.

Lead and Interconnection Wires—Tungsten, molybdenum, and borated Dumet wire for glass to metal sealing—unborated and gold plated Dumet for interconnections and "pigtaiI" leads—tungsten and molybdenum whisker wire, bare or gold plated.

Sheet and Discs—Molybdenum and tungsten sheet—molybdenum and tungsten discs (punched, pressed and sintered, cut from rod).

Evaporative Sources for Functional Coatings—Stranded tungsten metallizing wire and coils—tungsten and molybdenum boats.

And More! Get all the data. Write or call for our new booklet "Products for the Semiconductor Industry." General Electric Lamp Metals & Components Dept., 21800 Tungsten Rd., Cleveland, Ohio 44117. Tel: (216) 266-2970

Progress Is Our Most Important Product

GENERAL ELECTRIC

Electronics | April 18, 1966

Circle 191 on reader service card 191
Choice of three — Portable 444, Ruggedized 414 or 1000-speed 447

The Model 444 precision, 6 channel, wide-band recording oscillograph features big performance in a small package. Superior optics and a low-heat tungsten light source mean less DC power, less cost, less weight. The Model 414 is designed to perform under adverse conditions of humidity, shock, vibration and acceleration; provides 14 channels of data in a small, light-weight package. The Model 447's highly precise electronic drive permits selection of any 12 of a possible 1000 speeds (.1"/sec to 100"/sec). The 447 also features Automatic Record Length based on time and Continuously Variable Remote Speed Control. (These three are just part of the line — our Model 409 is a standard in the industry for airborne recording, for example.) Write to us indicating your areas of interest. We will send you complete specifications.

New Subassemblies

p-c card module is compatible with the manufacturer's other series 500 elements operating at ±100 v output and rounds out a full analog capability. The 530 may be mounted in the model 560 cabinet with power supply, multipliers, amplifiers, and fixed function generators.

The new function generator features maximum static error of less than 25 mv, and zero signal error is less than 2 mv. Its sine capability is ±270° and cosine capability is +180° to -270°. Operational amplifier output generates -sinX and -cosX in the range of ±100 volts.

An active error suppression method is used for an accuracy of better than 0.025%. Built-in amplifiers provide very stable and accurate line segments in the critical portions of the nonlinear curves and resistor-diode network drift becomes negligible. Economy and reliability result from this design advancement.

Availability of model 530 sine-cosine generator is 30 days and single quantity price is $700. Zeltex, Inc., 2350 Willow Pass Road, Concord, Calif. [388]

Disk file system offers mass storage

An on-line, real-time mass storage disk file system is capable of storing 3.8-billion bits of data with an average access time of 100 msec, and an estimated cost-per-bit of 0.0044 cent. Designated the model 2A, series 4000 disk file system, the module on-line mass memory system is available in three basic machine sizes with the company's standard electronic interfacing. Each basic machine size is mod-
TC Assured to ±10ppm

IRC Type AS Resistors Save Space and Money, Too

These precision power resistors are now available with an assured maximum hot side temperature coefficient of ±10ppm/°C in standard ranges above 50 ohms. This offers greater design stability with the added benefits of miniaturization and economy.

Type AS resistors provide the stability, close tolerances and superior performance of premium metal films costing 20% to 45% more. And at comparable prices you can replace axial lead vitreous enamel types with space and performance advantages.

Special AS resistors can be used as squib fuses. Inductive designs are also available for fixed rise time applications. Send resistance, wattage, frequency and rise time requirements for evaluation samples.

Write for literature and prices to: IRC, Inc., 401 North Broad Street, Philadelphia, Pennsylvania 19108.

**CAPSULE SPECIFICATIONS**

<table>
<thead>
<tr>
<th>POWER:</th>
<th>1, 2, 3, 5, 7, 10, 15 watts @ 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOLERANCES:</td>
<td>±0.05%, ±0.1%, ±0.25%, ±0.5%, ±1%, ±3%, ±5%</td>
</tr>
<tr>
<td>TEMPERATURE COEFFICIENT:</td>
<td>±10ppm/°C above 50 ohms ±20ppm/°C below 50 ohms</td>
</tr>
<tr>
<td>RESISTANCE:</td>
<td>0.1 ohm to 175K ohms</td>
</tr>
<tr>
<td>MIL-R-26:</td>
<td>Characteristics G and V, Withstands 350°C hot spot.</td>
</tr>
<tr>
<td>MIL-R-23379:</td>
<td>RWP18, 20, 21</td>
</tr>
<tr>
<td>LEADS:</td>
<td>Alloy-coated copperweld. Special types available.</td>
</tr>
</tbody>
</table>
"bugged" BY A PRINTED CIRCUIT PRODUCTION PROBLEM?

BRING IT TO CHEMUCUT

Whether it's a microminiature or mammoth board, Chemcut has the spray etcher to produce it for you—accurately and economically. Chemcut, the pioneer and leader in the spray etching field, has units ranging in size from laboratory models to fully automatic, conveyorized systems for high volume production. (Model 502 horizontal, conveyORIZED etcher is shown at left.) Also available is a complete line of Chemcut equipment for printing, developing, resist removal and other auxiliary functions. There are over 1800 units in use throughout the world. One that will fill your production needs is available through your nearby Chemcut distributor.

HOW ABOUT PART PRODUCTION?

With continued emphasis on miniaturization, manufacturers of electronic devices are finding spray etchers ideally suited to the production of a variety of parts. We welcome the opportunity of exploring your part production problems with you.

CHEMUCUT Corporation
500 Science Park, State College, Pennsylvania 16801.

Pulse oscillator for p-c application

The L80A is a miniature, highly stable, solid state, negative pulse oscillator package with 10-v peak output. It is designed to work into a 10,000-ohm load in printed circuit applications. It is available in frequencies from 1 HZ to 10 kHz and maintains an accuracy of ±0.1% over a 0°C to 50°C operating temperature range.

The oscillator package is especially applicable to computer reference standards that normally utilize tuning fork oscillators and offers the added advantage of noise-free operation. It operates from a 12-v, d-c source (nominal) power supply. Domino shaped, its dimensions are 1.20 in. long x 0.8 in. wide and 0.48 in. thick. It is equipped with conventional terminal pins for mount-
Plug-in oscillator for control chassis

A plug-in sweep oscillator now offered can cover an entire frequency octave of 500 Mhz to 1,000 Mhz in a single sweep. As a plug-in unit for the SM-2000 control chassis, the VR-50M oscillator can sweep any frequency width from 5 Mhz to the full 500 Mhz, manually or automatically at rates from 0.01 to 100 hz. The range and versatility of the new unit makes it especially useful for testing broad-band video, i-f, and r-f devices, both wide and narrow-band.

A solid state unit, the VR-50M combines uhf transistors with varactor tuning. Since the output of the sweep generator is at the fundamental frequency of the oscillator, its output signal is exceptionally clean, with a flatness better than 0.75 db at maximum sweep width. The VR-50M also features a built-in, variable frequency marker covering the complete 500 to 1,000 Mhz range.

How to convert resolver and synchro angles to digits (and vice versa)

North Atlantic now brings you a new family of solid-state analog-to-digital and digital-to-analog converters for resolver and synchro data. They offer a major advance in conversion accuracy in modern navigation, simulation, data processing and measurement systems.

Typical of these new instruments is the Model API-5450 shown here. It provides both continuous and command conversion of both resolver and synchro angles, accommodates all line-to-line voltages from 11.8 to 90 volts at 400 cps. Output data is in decimal digits and is presented both as a Nixie-tube display and a five-digit printer output with supplementary print command. Accuracy is 0.01° and update time is less than 1 second.

All instruments in this family are designed to MIL-T-21200 and feature all solid-state circuitry and precision transformers—there are no motors, gears, or relays. Their flexible plug-in modular circuit design permits a wide range of variations to suit your specific requirements. For example:

- 18 bit or 10 second accuracy and resolution
- binary, BCD, or decimal inputs/outputs
- multiplexed channels
- multi-speed inputs/outputs
- high conversion speeds
- other signal frequencies

Your North Atlantic representative has complete application information. He'll be glad to help you solve interface problems in measurement and data conversion. Simply call or write.

Electronics | April 18, 1966
If you are in the Electronics Industry... you probably belong in MARYLAND

**Avaliability of Labor**

The availability of personnel, particularly engineers and scientists, is recognized as a chief criterion governing the location of an electronics firm. There are almost 30,000 scientists and over 25,000 engineers living and working in Maryland and the District of Columbia. And the number is increasing every day.

**Proximity to Federal Agencies**

Proximity to major decision makers in the industry, such as federal agencies in Washington, D.C., afford the unique advantage of constant personal contact, which is considered an increasingly important locational criterion.

No other state is as convenient to as many Federal agencies as Maryland. For example, Maryland's major government scientific installations include NASA, AEC, NIH, the National Bureau of Standards, plus some 20 others.

**These Prime Requirements, (plus others) CAN BE MET IN MARYLAND!**

Get All The Facts

Write, Wire or Phone Collect

MARYLAND

DEPARTMENT OF ECONOMIC DEVELOPMENT

Division 3, State Office Bldg., Annapolis, Md.

---

**New Microwave**

**Miniature triode operates in X band**

A miniature, ceramic planar-triode is now available for service at frequencies in X band. As an oscillator, the developmental tube can produce about 20 milliwatts of continuous wave power over a frequency range of 9.35 to 9.45 gigahertz (gigacycles per second).

Its manufacturer, the Tube Department of the General Electric Co., sees good potential for the tube since it is smaller than a klystron, does not require a highly regulated power supply, operates with only 4 watts of d-c power and is cheaper than a comparable solid state oscillator. It is approximately half the size shown in the photograph.

Operating life is relatively long. GE claims that a few tubes of this type have performed for as long as 1,500 hours. However, the company indicates that in the present stage of development only about 500 hours can be assured, and no guarantee is given. Previous miniature planar-triodes developed by GE for operation in X band had lives of only 50 to 100 hours, and developed only 4- to 10-mw outputs.

GE says the new tube is the highest-frequency triode available and one of the highest frequency triodes ever constructed. Also under development, but not for sale, are tubes which can produce about 10 mw at frequencies from 16 to 18 Ghz.

A cathode current density of 1.2 amperes per square centimeter is required to produce a useful output at X band. To obtain this density and still maintain good tube life, the heater and the cathode were redesigned. The heater is a flat spiral which is bonded with ceramic to the cathode cup. This construction improves heat transfer, eliminates hot spots on the cathode and permits the cathode to operate at lower temperatures than normally would be required. The heater construction also results in a warmup time of only 3 to 4 seconds instead of the 20 seconds required with conventional heater designs.

The tube can be used in miniature equipment and in systems operating at elevated temperatures, under severe gravity (g) loading or at high radiation levels. It works at temperatures as high as 500° C. In a simulated soft moon landing, it withstood impact shocks of 3,000 g for 3 milliseconds.

GE envisions commercial applications in burglar alarms and personnel detector systems. A possible military application is hand-held radar.

The developmental X-band triodes cost $100 each in small quantities.

**Specifications**

<table>
<thead>
<tr>
<th>Type</th>
<th>Developmental ceramic planar-triode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Oscillator</td>
</tr>
<tr>
<td>Frequency</td>
<td>9.35-9.45 Ghz</td>
</tr>
<tr>
<td>Typical operating conditions</td>
<td></td>
</tr>
<tr>
<td>Plate voltage</td>
<td>150-165 v</td>
</tr>
<tr>
<td>Cathode current</td>
<td>20 to 25 ma</td>
</tr>
<tr>
<td>Power output</td>
<td>20 mw</td>
</tr>
<tr>
<td>Heater voltage</td>
<td>6 V</td>
</tr>
<tr>
<td>Heater current</td>
<td>200 ma</td>
</tr>
<tr>
<td>Price (1 tube)</td>
<td>$100</td>
</tr>
</tbody>
</table>

General Electric Co., Tube department, Owensboro, Ky. [395]

**Swept oscillators offer high accuracy**

The model 570 series, a new quality standard in microwave swept oscillators, provides frequency co-
erage from 1 to 40 GHz (gigacycles per second) in the L, S, C, X, Ku, K, and Ka bands. The units feature better than 1% specified accuracy and stability over the entire frequency band and at all power levels.

These instruments require only 5¾ in. x 19 in. of panel mounting space; less than any other similar unit, according to the manufacturer. Output power capability has been increased (for example, 50 mw power minimum in the 8 to 12.4 GHz band). Five independent frequency controls, each with 3-digit display, are continuously adjustable over the bandwidth of the instrument. Push-button start-stop band selection provides sweep coverage between any two of the five frequency settings, while markers are generated at the remaining three settings. With the point of interest bracketed between two markers, two buttons are depressed to sweep between the markers, without disturbing the other frequency settings.

For operating convenience, these compact sweepers also offer the following: blanked retrace select, manual sweep with frequency change; pen lift, sweep, stop pulse, and marker outputs; a wide range of sweep speeds; programmable output frequency and power.

Price is $3,460 to $6,870 depending on frequency band selected.

E-H Research Laboratories, Inc., Oakland, Calif. [396]

**Traveling-wave tube delivers over 10 kw**

A high-gain, metal-ceramic traveling-wave tube has been designed for satellite ground terminal transmitters. The tube, designated model 614H, covers the entire...
What puts the flash in flash bulbs?

One of the big reasons for the dependable performance of many of today's flash bulbs is the Zirconium foil you see inside the bulb. Zirconium foil, Hamilton's Zircoflash®—only .0008" thick—is delivered in quantity and on time by Hamilton Precision Metals.

There are 7 proprietary metals, 112 commercial alloys and 12 pure metals now available. With expanded production facilities, Hamilton Precision Metals is now producing these metals in quantity. Strip and foil are available from 0.10" thick down to 0.000080" thin, and from 1/8" to 12" in width—wire in diameters from 0.1870" to as fine as 0.0010".

Check with Hamilton Precision Metals on your electronic metals requirements of precision strip, foil or wire. Write today for completely new brochure. It gives you complete information on our capabilities as well as detailed properties on over 100 metals.

HAMILTON PRECISION METALS
division of Hamilton Watch Company • Lancaster, Pa.
Ulano's technical center in Switzerland is headed by the very capable Mr. Henri Kunz. He is qualified by his many years of experience in the Screen Process and Graphic Arts fields. Demonstrations and technical seminars are held in many languages throughout the year. Complete laboratory facilities have been installed to provide demonstrations of the complete Ulano line. Large stocks of all famous Ulano films are available for immediate delivery to all parts of the world.

You are invited to contact Mr. Henri Kunz at ULANO A.G., Untere, Heslibachstrasse No. 22, Kusnacht 8700, Switzerland, Telephone 905959. It is our pleasure to serve you.

DO YOU USE SCREEN PROCESSING IN THE PRODUCTION OF COMPLEX PRINTED CIRCUITRY?

TWO NEW PRESENSITIZED FILMS TO SPEED PRODUCTION – LOWER COSTS

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HEAVY-DUTY INDUSTRY PROVED
Presensitized photo film used by many leading electronic firms for clean, sharp, tough, durable, almost indestructible screens of unmatched quality. Adheres tightly to wire, silk, nylon and dacron.

PREP®
PRESENSITIZED FOTO FILM
.002 Polyester support guarantees good register. Does not require a dark room. Very good resolution—suitable for halftones. Excellent adhesion to silk, nylon, dacron and metal mesh. Tough, strong emulsion—good for machine printing and long runs.

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Prices reduced on all Radiation digital equipment

Increased reliability and accuracy offered by digital data acquisition and processing is now practical for all your requirements. Prices on industry's finest line of digital equipment have been substantially reduced. That's because of increased production, and lower cost of Radiation plug-in logic modules used in the design of these units.

For example, Radiation's Model 5516 A/D Converter is priced at only $3,025, and Model 5611 D/A Converter at only $2,950. In addition: Model 5710 Multiplexer Programmer is now $1,225, Model 5416 16-Channel Unity Gain Multiplexer is $1,350, Model 5817 Read/Write Electronics (for 7-track requirements) has been reduced to $3,350, and Model 5819 (for 9-track) to $3,790.

Write for data sheets on Radiation digital equipment, or phone for detailed information.
**NEW PRODUCTION EQUIPMENT**

**TEMPERATURE-SENSING BONDER**

An automatic bonder that can join different metals in five different ways owes its versatility to an infrared detector. The detector determines the temperature of the joint during bonding and adjusts the heating current to compensate for variations in the heat-sinking capacities of the joint materials.

The Model 730 bonder will join component leads, integrated-circuit leads and wiring in assemblies, or component and leads to printed-circuit cards or to thin films. The joints can be formed at temperatures of 300° to 1,400° F, allowing the machine to be used for bonding, brazing, welding or hard and soft soldering.

Once the controls have been set for the bonding mode and temperature, operation is automatic. The infrared detector allows the machine to control temperature of the joint to within 3%. The power supply delivers up to 10,000 watt-seconds (500 amps at 2 volts for 10 seconds) to the bonding electrodes. Either parallel-gap electrodes, for surface bonding, or opposed electrodes can be used.

The bonders are priced in the $2,000 range.

*Industrial Products Group, Texas Instruments Incorporated, 3609 Buffalo Speedway, Houston, Tex. 77006 [401]*

**ELECTRIC HAND TOOL CRIMPS TERMINATIONS**

An electric hand tool weighing 4 lbs. can make hundreds of terminations an hour and features a quick-response cycle control. Company engineers say it is the first all-electric portable hand tool designed for crimping terminals and contacts.

One model can be operated from...
a 110-v outlet. Another can be powered by a portable battery pack which makes it possible to use the tool in areas where electricity is not available or practical. The batteries are rechargeable and have sufficient energy for a minimum of 1,000 cycles.

The product to be crimped can be individually hand-fed into the crimping die, or manually tape-fed from 100-piece boxes mounted on the tool.

The A-AMP electric hand tool features Ceri-Crimp tool performance through the use of quick-response cycle control. Tool jaws stop instantly upon release of the trigger. This cycle control assures complete and positive bottoming of the crimping dies and simultaneously prevents the dies from coasting through the completed crimp cycle.

The tool also incorporates provisions for changing the crimping head quickly and easily; and it will accommodate a wide range of individual or tape-mounted items. It has a wire range of 26-10 Awg.

AMP, Inc., Harrisburg, Pa. [402]

Traversing station applies photo resist

Absolute thickness control for photo resist and other special coatings can be maintained with a new automatic traversing spray station. The station provides programmed simultaneous motion of circuit substrates and the spray head of the manufacturer's Vapor Spray coating system. Even through-hole plated boards can be coated to precise tolerances without hole plugging or puddling. The equipment has also proven valuable for memory planes and

Traversing station applies photo resist

You can depend on us!

The above photograph shows a Thermal Circuit Breaker Calibration Test. All units are adjusted to trip within specified trip bands and hold 100% of rated current with ultimate trip at 135% of rated current. Transfer of auxiliary contacts for remote indication is also checked during this test.

There are other specs and other tests, lots of them, but they all have one purpose in common—to assure the most reliable performance in the industry. If it's by Wood Electric—you can depend on it!

Wood Electric also manufactures a complete line of Magnetic Circuit Breakers that hold 100% of rated current indefinitely and operate at specified trip settings regardless of ambient temperatures. Choose from a wide variety of proven commercial and military type Circuit Breakers to meet the specific needs of your application. Models are available with ratings from 0.5 to 50 amps . . . AC or DC . . . single pole, two pole and three pole.

Write for Circuit Breaker Catalog CB-10-65
MAGNETIC SHIELDS TO YOUR SPECS

About 80% of all magnetic shield designs now in use originated here.

Maybe it's because our designs work. Maybe our designs work because we've had the most experience. All are good reasons to contact us.

Netic and Co-Netic magnetic shields are the recognized standard all over the world for military, laboratory, industrial and commercial applications. They are insensitive to ordinary shock, do not require periodic annealing, and have minimal retentivity. A few typical applications are illustrated. Our design department is yours.

Production Equipment

microelectronics.

In programing the machine, functions that can be preset include: rate of speed of the spray gun over the substrate, amount of overlap between adjacent spray passes, and number of coats. Thus, the inherent ability of the Vapor Spray process to provide high purity coatings free from surface defects can be utilized with minimum concern for operator errors.

The automatic traversing spray station can be mounted inside a laminar flow white booth for maintenance of clean room conditions while coating. All controls and function indicator lights are contained in a separate cabinet for external installation.

Complete facilities are available at the company for coating sample circuit boards to evaluate the applicability of the technique to specific customer requirements.

Zicon Corp., 63 E. Sandford Blvd., Mount Vernon, N.Y., 10550 [403]

Machine applies p-c board coating

A machine has been developed for continuous coating of copper printed circuit boards with protective solder alloy. The solder coating is said to give a far longer storage life and better assembly characteristics than varnish. Only the copper on the board becomes solder coated.

The Boltinner machine has two rollers between which the boards are fed, circuit downwards. The lower roller, which runs in a bath of molten solder, coats the circuit with solder. Continuous production can be carried out at a speed...
of 6 feet a minute, using boards of any length and up to 13 in. wide and ¾ in. thick.

The upper roller, which is of stainless steel, is spring-loaded to allow for differences in board thickness. The complete roller unit can be removed for maintenance.

Solder is heated by a 1.5 kw thermostatically controlled heater normally preset at 250°C. A safety device prevents the rollers from turning before the solder is at a safe working temperature.


High vacuum coater for microelectronics

The vacuum coater illustrated was designed to deposit substrate material a millionth of an inch thick for microelectronics and optics equipment. The NRC 3116 high vacuum coater is priced at about $4,300—approximately one-third the cost of customer units providing similar performance features.

Included among the unit's features are wide vacuum range (to 10⁻⁸ torr), log and linear scaled ionization gauge control, a new 6-in. vacuum pumping system and a liquid nitrogen baffle. All controls are conveniently grouped in an easy-to-read, one-position control panel.

High vacuum is essential in microelectronics and optics operations to assure freedom from gases in the atmosphere and contamination, and to assure precisely controlled, repeatable products.

National Research Corp., a subsidiary of Norton Co., 160 Charlemon St., Newton, Mass., 02161. [405]

NEW! EXCLUSIVE!

1-INCH CUBE, 10 AMP RELAY

Extra compact, high-reliability 4PDT relay. Assembled under rigid white room conditions. Designed to MIL-R-6106E. Rated for 50,000 operations, 10 amps resistive at 28v dc or 115/200v 400 cycles. Weight only 3.2 oz. Type FCM-410.

NEW! COMPACT!

2PDT, 10 AMP AC, DC COILS

Hermetically-sealed. Rated for 10 amp resistive loads at 28v dc, or 115v 400 cycles. Designed to MS 25273. Type FC-402-1 with d-c coil nominally rated at 28v, 0.25 amp. Type FC-402-2 with self-contained rectifier for a-c operation at 115v, 400 cycles, 0.07 amp.

PLUS . . . a full line of other miniaturized relays, including . . .

STRUTHERS-DUNN, Inc.

Pitman, New Jersey 08071
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Electronics | April 18, 1966
New Materials

Encapsulating grade molding epoxies

Two soft flow, encapsulating grade epoxy transfer molding powders are called Randac S-7033 and S-7034, the epoxies operate with short molding cycles resulting in higher production rates and higher operating temperatures for encapsulated electronic components. Both retain the soft flow molding characteristics, humidity resistance and electrical properties of earlier Randac molding powders.

The S-7033 is a one-component, mineral-filled epoxy molding powder. It is recommended for molding resistors, capacitors, diodes and other small parts with relatively thin-wall sections.

The S-7034 is an encapsulating grade, flaked glass reinforced epoxy transfer molding powder. It is designed for transfer molding encapsulation of solenoid, ignition, transformer and similar coil windings.

Mitchell-Rand Mfg. Corp., 738 Torne Valley Road, Hillburn, N.Y. [406]

Glass paper laminate is epoxy-bonded

Grade FR16 is a thermosetting epoxy-bonded glass paper laminate offering several property and economic advantages for use in electrical and electronics applications.

The new material, using a reinforcement of oriented glass fibers produced on a modified paper-making machine, is bonded with a flame-retardant epoxy resin. It provides designers and end-users with a glass fiber reinforcing material that fills the gap between cellulose paper-epoxy and glass fabric-epoxy.

Advantages include excellent mechanical strength and machineability in combination with the outstanding electrical properties of woven glass laminates. In addition to lower initial cost, the material also offers economies in fabrication.

Specific gravity of the material is low because of high resin content, making it attractive for airborne electrical insulation applications. The insulation resistance of FR-16 approaches that of grades C-10 and C-11 (glass fabric-epoxy grades).

The manufacturer is producing FR-16 in sheets from $\frac{1}{8}$ in. to 1 in. thick, with copper-cladding on one or both sides.

Synthane Corp., Oaks, Pa. [407]

Resistive pastes for microelectronics

A line of ceramic resistive pastes is available for silk screen printing. The resistive glaze compositions feature superior heat stability, greater resistance to severe moisture exposure and improved long-time electrical load stability as compared to other available coatings. They may also be used for making a variety of discrete resistors or as part of a thick-film hybrid circuit.

The manufacturer is initially offering standard sheet resistivities in the decade ranges from 10 to 20,000 ohms per square. Extension of these resistance values by as much as two decades in either direction is available on an experimental basis.

The new pastes may be intermixed in all proportions, and are fired at peak temperatures of 750° to 850°C for 10 to 20 minutes. Resistance value and related characteristics vary according to the substrate, the method of application and firing conditions. Temperature coefficients generally under 300 ppm/°C are usually obtained for the normal resistance ranges, according to the company. The man-
Manufacturor's silver, platinum-gold or palladium-gold conductive terminations may be used.
Electro-Science Laboratories, Inc., 1133 Arch St., Philadelphia 7, Pa. [408]

Conductive paint
for high temperatures

A silver-filled, polymer-in-solvent paint has been developed for high-temperature applications requiring electrical conductance. The paint should be allowed to air-dry for removal of the solvent, then heated to 500°F for 15 to 20 minutes to obtain maximum adhesion and conductivity.

Dynaloy 2510 is self-priming, and may be applied to any dry, clean surface by dip, brush, silk screen or roller. Thin films dry tack-free in 30 minutes, and show no weight loss at 1,200°F. Coverage (1-mil dry film) is 600 sq ft per gallon, and the operating temperature range is -60 to 1,500°F.

Other tests show the volume resistivity for Dynaloy 2510 to be 0.02 ohm-cm for a film air-dried at 70°F, and 0.003 for a film baked at 500°F. Shelf life is a year for closed containers.

Dynaloy, Inc., 408 Adams St., Newark, N.J., 07114. [409]

High-purity metals
in wire and foil form

Ultrahigh purity metals are available in wire and foil form for use in the aerospace and electronics fields. Copper, gold, silver, aluminum, niobium, tantalum, zirconium, titanium, vanadium, iron and nickel, in nominal purities up to 99.999%, are available for off-the-shelf delivery.

Wire diameters of 5, 10, 20, 30 and 50 mils and foil thicknesses of 1, 5 and 10 mils are the standard sizes. Other sizes are available on special order.

These materials are all processed under clean-room conditions to maintain original purities, making the materials ideal for both experimental and production applications where it is essential to eliminate the variables due to high interstitial and high substitutional impurities.

Materials Research Corp., Orangeburg, N.Y., 10962. [410]

MEPCO introduces...

S.M.A.C.
Simultaneous Mass Attachment of Components
for the mass-production of
FILM HYBRID MICROCIRCUITS

It's new from MEPCO ... the major key to Mepco's breakthrough in the art of mass-producing film hybrid microcircuits.

Ask about S.M.A.C. today.

Find out what it can mean to your present and future production schedules.

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MEPCO, INC.
MANUFACTURERS OF PRECISION ELECTRONIC DEVICES

Circle 205 on reader service card
Design your circuit, breadboard it with discrete components, thoroughly test it for system compatibility and environmental performance—then let NSC microminiaturize your exact design with CHIC.

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In the table at the right are some typical device types available in NSC customized CHIC circuits.

**TYPICAL NSC DEVICE TYPES**

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- Small Signal PNP
- Medium Power NPN
- Medium Power PNP
- Medium Power Switching NPN
- Medium Power Switching PNP
- High Speed Switches NPN
- High Speed Switches PNP
- UHF Small Signal NPN
- VHF Small Signal NPN
- Inch NPN
- Inch PNP
- Single Ended Choppers NPN
- Single Ended Choppers PNP
- Differential Amplifiers NPN
- Differential Amplifiers PNP

**RESISTORS**

- Resistances: 10 Ohms to 3 Meg Ohms
- Resistivities: 10 Ω/square to 100 KΩ/square
- Untrimmed Tolerance: ±10%
- Trimmed Tolerance: ±1%
- Temperature Coefficient: Typically 200 ppm/°C from 0 to +125°C
- Voltage Coefficient: ≤0.02% per volt
- Power Dissipation: Up to 25 W/in.²

**CAPACITORS**

- Capacitance: 10 pf to .1 μf
- Working Volt: 50 VDC Max.
- Temperature Coefficient: ≤300 ppm/°C from 0 to +125°C

**PACKAGES**

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New Books

Impact theory
Atomic and Ionic Impact Phenomena on Metal Surfaces
Manfred Kaminsky
Academic Press, Inc., 402 pp., $14.50

Here is an extensive compendium on the title subject. Kaminsky's work represents a significant updating of Chapter IX of H. S. W. Massey and E. H. S. Burhop's 1952 work, "Electronic and Ionic Impact Phenomena."

Particular emphasis is given to surface ionization and neutralization phenomena, sputtering, and electron emission due to atomic and ionic impact on metal.

Because of the great improvements in vacuum techniques and surface preparation, it has become possible to perform more definitive experiments on gas and solid phenomena. The book provides excellent coverage of such recent work within its area of emphasis and reflects the author's extensive knowledge and participation in this field of research.

One of Kaminsky's stated purposes is the facilitation of inter-disciplinary contact between different fields. The technical material selected for inclusion is of common interest to many areas, including the following: plasma physics, thermonuclear reactions, thermonic energy conversion, ion propulsion, sputtering corrosion of surfaces of satellites and ion engines, ion getter pumps and deposition of thin films. To more fully achieve the interdisciplinary objective, it would have been advisable, however, to show by examples how an understanding of the basic experiments and phenomena lead to a better insight in certain areas of application.

Of particular value is the extensive bibliographical material (807 references) which is truly international and interdisciplinary in scope. A reasonable balance is achieved between the theoretical and experimental, with emphasis on experimental techniques and results. Frequently, equations are quoted with a minimum of explanation. Although this was undoubtedly necessary to limit the size of the book, a more thorough theoretical development would have been desirable for the student audience. However, the book is primarily designed for the research worker in a related field and presupposes a thorough knowledge of quantum and statistical physics. As an example, the Saha-Langmuir equation is used repeatedly and a knowledge of its basis in statistical physics is assumed.

The general plan is good. It consists of several introductory chapters devoted to the development of a model of a metal surface including a clear discussion of the concept of work functions, binding forces between adatoms and surfaces, and thermodynamics of surface reactions. The Sommerfeld quantum model of electrons in a metal is employed with the assumption that the reader is familiar with it.

A short introductory section on methods of preparing clean metal surfaces is also included. Each of the subsequent chapters is devoted to a particular atomic or ionic impact phenomenon at a metal surface. Within each chapter, a short introductory theoretical section is followed by a section on experimental methods and then by one on experimental results.

However, the narrative on various surface phenomena would appear more unified if there were a final chapter showing the respective contributions to a theoretical model of a metal surface.

The surface phenomena which receive the greatest attention are thermal accommodation, positive ion emission due to particle impact, sputtering by ion bombardment and potential, plus kinetic, emission of secondary electrons due to atom/ ion impact including resonance and Auger processes. Metal surfaces are typically considered and discussed in three conditions relative to the above processes. These are: clean single crystal surfaces, clean polycrystalline surfaces and surfaces with a layer of adatoms.

Kaminsky's work is highly recommended to the research worker in the fields covered by the book as a comprehensive treatment, with special credit to the author for a truly gargantuan bibliographic effort.

L. Lesensky
Raytheon Co.
Waltham, Mass.
Technical Abstracts

High-frequency head
Magnetic scan head for high frequency recording
Marvin Camras
IIT Research Institute, Chicago

High frequency magnetic recording at high density by conventional methods requires scanning velocities in the order of hundreds of miles per hour, head gaps measured in microinches and magnetic tape of exceptional ruggedness and precise dimensions.

Although another alternative exists in the form of electron beam scanning, the method requires the use of specialized vacuum tubes which are still only in the developmental stage.

A new magnetic head has been designed which uses a different principle to obtain rapid scanning of slowly moving tape, while the head remains stationary. The head is built of stacked Permalloy laminations which define a gap of about 0.25 mil, extending across a relatively wide tape. The number of laminations determine the lateral resolution of the system; a horizontal video line requires about 350 elements.

On the head are three windings. One is for the signal and the others for the sweep. The signal winding links magnetically with a main magnetic circuit and with the gap.

The main magnetic circuit also includes smaller magnetic circuits which may be locally saturated through the sweep windings, thus interrupting the main circuit. As the tape moves slowly past the head, each lamination is activated in turn and then deactivated by the sweep circuit, selectively controlling the permeability between the signal coil and the gap.

Several experimental heads of this type were built. One video head was swept laterally at 15,750 lines per second, with its signal coil energized by the output of a television receiver. The result was a recorded tape having 60 frames per second, the magnetic counterpart of an 8-mm movie, when the images were developed with iron powder and viewed under magnification.

Another head was operated with digital input as a tape memory.
Presented at the IEEE International Convention, New York, March 21-25.

Digital image storage
Drum scanning techniques for digitizing and recording image data
W.L. Gilman
Systems Development Division
International Business Machines Corp., Kingston, N.Y.

An experimental system has been built that combines facsimile techniques with digital processing to provide a scanning, digitizing and playback system for the recording of displays.

Work in digital mapping and other related image-processing tasks has demonstrated a need for scanning and reproducing equipment with high resolution, and speed that matches that of data-processing systems. The experimental equipment described scans photographic or other image data, converts the gray-shade information to digital data, and stores this data on magnetic tape. Additionally, computer-generated data can be converted to photographs.

Particular emphasis was placed on high resolution and the ability to handle large formats. The equipment is capable of digitizing pictorial information in 16 discrete gray levels, at a density of 1,000 elements per inch in both horizontal and vertical directions. Formats up to 9 x 18 inches can be handled.

The images attached to the drum are scanned and a number representing reflective density, is assigned to each picture element by a quantization process. This number is stored on magnetic tape. A scan line consists of one revolution of the drum past the head; the line is stored on tape and represents 9000 picture elements.

Image data on tape, generated by computer processing can be recorded on film by the system at the same resolution and gray-shade range. In this mode, unexposed film is attached to the drum and resolved under the scanning head. A point source of light is modulated in proportion to the gray scale digits on tape for each picture element; the film is exposed and the image data stored on tape is revealed on the film.

A signal processing element is included in the equipment to enable corrections to be applied either to scanning or recording.
Presented at the IEEE International Convention, New York, March 21-25.

CAT detectors
Investigation of techniques for detecting clear air turbulence
Wilbur H. Paulsen, Air Force Cambridge Research Laboratories
Bedford, Mass.

Both ground-based and airborne equipment are sought as CAT (clear air turbulence) detectors. Ground equipment would pose little problems in size or weight, nor would it be limited in possible frequencies, but it could produce reliable data only on conditions in its immediate vicinity. Apparently, only an on-board airborne system could provide detailed, information to a pilot.

Sonic techniques were discarded with the development of supersonic aircraft. Star tracking or scintillation techniques are intriguing, but require the ability to detect the star field on the horizon directly ahead of the aircraft. In daytime this is difficult, and high level clouds obscure star fields. Infrared and microwave radiometric techniques of measuring air temperatures ahead of the aircraft are being studied. These techniques assume a correlation between temperature discontinuity and clear air turbulence, an assumption not proven.

Details of low-frequency bistatic ground radar, airborne radar and optical (laser) radar systems are discussed. The author says that although each of these systems has made significant sightings of CAT, none meets an adequate level of reliability. What is needed is an instrument to detect clear air turbulence 20 miles ahead, twice the range of any present system.
**New Literature**


**Sample-and-hold amplifier.** Pacific Data & Controls, 6406 S.E. Foster Rd., Portland, Ore., 97206, has available a bulletin describing the model 102 sample-and-hold amplifier with built-in floating power supply. [421]

**Ceramic capacitors.** Republic Electronics Corp., 176 East Seventh St., Paterson, N.J., 07524, offers its 1966 catalog B-1 (12 pages) describing a complete line of subminiature ceramic capacitors in a vast choice of values, lead arrangements, lead material, physical and electrical properties. [422]

**IC test system.** Optimized Devices, Inc., 220 Marble Ave., Pleasantville, N.Y. Model 5000, a complete system for high-speed testing of integrated circuits, micromodules and circuit cards is described in a six-page brochure. [423]

**Universal counter-timer.** Transistor Specialties, Inc., Terminal Drive, Plainview, N.Y. A preliminary data sheet covers the model 600 series of counters and plug-ins—versatile, all-silicon, solid state digital instruments capable of accurately and easily performing precision measurements for a variety of applications. [424]

**Integrating dvm's.** Hughes Instruments, Hughes Aircraft Co., 2020 Oceanside Blvd., Oceanside, Calif., 92054. Two-color brochures provide information on the features, operating principles and specifications of the all-electronic, solid state models 5000A and 5200 five-digit integrating digital voltmeters. [425]

**Transducer equations.** Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles, Calif., 90064. Instrument Notes No. 38 reviews the electrical aspects of the transducer bridge, general bridge theory, and gives complete bridge equations for various combinations of active and inactive bridge elements. [426]

**General-purpose relay.** Sigma Instruments, Inc., 170 Pearl St., Braintree, Mass., 02185, offers a catalog bulletin on a one-ounce, general-purpose economy relay for switching 1-amp commercial loads from 90-mw input signals. [427]

**Transducer.** Dynisco division of Abex, 40 Ames St., Cambridge, Mass., 02142.

Bulletin 410 describes a transducer that measures melt pressure and temperature at the same point in plastic extrusions. [428]

**MOS FET circuits.** General Instrument Corp., 600 W. John St., Hicksville, N.Y., has available an eight-page technical bulletin entitled "Designing with MOS Field Effect Transistors." [429]

**Teflon sockets.** Barnes Development Co., Lansdowne, Pa., 19050. Bulletin 178A describes the MGR series of Teflon sockets for transistors and TO-cased integrated circuits. [430]

**Elapsed time indicators.** The A.W. Hayden Co., 232 No. Elm St., Waterbury, Conn., 06720. Bulletin M1 602 covers the 4200, 23200, and 25200 series of hermetically sealed, subminiature elapsed time indicators for operation on 28 v d-c, and 115 v a-c, 60 or 400 hz. [431]

**Miniature crt socket.** Connector Corp., 6025 No. Keystone Ave., Chicago, Ill., 60646, offers data sheet 35A on the type 646 miniature crt socket with simplified cost reducing design for mating with the new miniature JEDEC E7.91 basking c't's. [432]

**D-c digital voltmeter.** Ballantine Laboratories, Boonton, N.J. A two-page technical data sheet describes the model 353, a 0.02% accurate, but low-priced, solid state d-c digital voltmeter. [433]

**Thermocouple references.** Acromag, Inc., 15360 Telegraph Road, Detroit, Mich., 48239, has published technical bulletin 32-B describing the theory, operation, and applications of thermocouple references. [434]

**Digital strip printer.** Franklin Electronics, Inc., division of Anlex, E. Fourth St., Bridgeport, Pa., 19405. Bulletin 2045 describes a low-cost strip printer with a 63-chapter alphanumeric capability. [435]

**Temperature controllers.** API Instruments Co., Chesterland, Ohio, 44026. Bulletin 49 covers three principal types of the company's temperature controllers as well as several more specialized lines. [436]

**Differential amplifiers.** Dana Laboratories Inc., Irvine, Calif., 92664, offers a two-page data sheet covering its series 3800 direct-coupled differential amplifiers. [437]

**Porcelain capacitors.** Vitramon, Inc., Box 544, Bridgeport, Conn., 06601. Data sheet P10B covers the thin line YV porcelain capacitors with zero temperature coefficient. [438]
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CIRCLE 956 ON READER SERVICE CARD

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Electronics | April 18, 1966
THE G4 IS A COMPLETELY NEW MECHANICAL CHOPPER
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SPECIFICATIONS

CONTACT ACTION: SPDT, BBM
CONTACT RATING: 20V 1ma resistive
POWER CONSUMPTION: 200mw max.
CONTACTS TO GROUND: 5uuf max.
TRANSFER TIME: 5° minimum
Dwell Time: 165° ± 10°
DiSSymmetry: 10° maximum
Phase Angle: 75° ± 10°
VIBRATION: MIL STD 202B Method 204A, Cond. B, maximum contact derangement 7°
SHOCK: 100 G per Mil Std 202B Method 202A, maximum contact derangement 10°
INSUL RESIS.: 10 K meg. at 100 VDC
TEMPERATURE: -65°C to +125°C
CASE VOLUME: 0.11 cu. inches
WEIGHT: 8 grams
Three-in-one color gun

The untiring search by Japanese color television set makers for something better than the shadow-mask tube seems about to pay off with still another sophisticated small-screen tube. Sony Corp. has well along in development a one-gun tube it calls the Chromagetrón. The key idea: a color-switching yoke that makes a single gun act like three.

For all its merits, the shadow-mask tube that prevails in the United States has some major drawbacks. The mask that shepherds the electron beams from each of the three color guns onto the right phosphors blocks out about 85% of the electrons. It takes high voltages and high currents—high power in other words—to get adequate brightness. And using one gun for each color is a brute-force rather than an elegant solution.

Both Sony and the Yaou Electric Co. are already marketing sets with tubes that replace the shadow mask with a grid of fine wires. This technique of landing electrons on the right phosphors, called post deflection focusing, blocks out at most 15% of the electrons. The concept was first advanced by the late Ernest O. Lawrence, best known for his Nobel-prize-winning invention of the cyclotron.

On the grid. Elegant as the Lawrence concept is, it's difficult to put into practice. Fabricating wire grids that line up exactly with vertical phosphor color stripes on the tube is tricky. What's more, for a single-gun tube, two grids insulated from one another are needed. That's because the difference in potential between alternate wires has to be reversed to deflect the electrons left or right to land on the correct phosphors; with no potential difference between wires, the electrons pass straight through to hit the third color.

The Kobe Kogyo Corp. produces a 7½-inch one-gun tube for the Yaou portable set [Electronics, May 31, 1965, p. 81] but there isn't much chance that Kobe can make the tube much larger. Even if Kobe or someone else could pull off the feat, a set maker who tried to use a large single-gun tube would run into trouble with spurious radiation. For adequate resolution, dot-sequential operation would be required; the color-switching grid would have to be switched at a frequency of 3.58 megahertz (megacycles per second) so the beam would hit every phosphor stripe as it sweeps across a line. For small sets, low-frequency line sequential operation—scanning lines with just one color at a time—is satisfactory.

For its part, Sony has in production a 19-inch, three-gun tube with a post deflection focusing grid. Fabricating the grid for this tube—called the Chromatron—is relatively easy. All the wires operate at the same potential, so they can be welded to a rigid metal frame.

Troubles. Sony, however, ran into trouble when it tried to develop a mass-production method to turn out insulated color-switching grids for a one-gun Chromatron. Along with the difficulty of anchoring and at the same time insulating the wires by embedding them in a glass frit on a metal frame, Sony had to contend with a grid pitch twice as fine as used for the three-gun Chromatron. The one-gun Chromatron uses green stripes half as wide as the red and blue stripes, and one set of grid wires must be located in front of the half-width stripes.

Angles. The company hit on the Chromagetrón configuration of a one-gun tube and a single grid after Sony realized a landing compensation device it had developed for the three-gun Chromatron could shift the electron beam for each color. To the grid, the effect is the same as if the beam originated from three different guns operating in succession. The effect is obtained by feeding a step current to a horizontal yoke near the gun and a second step current in opposite phase to the deflection yoke. This changes the angle of the beam successively for blue, green and red phosphor strips. The same result could be obtained with the color and convergence yoke located between the deflection yoke and the grid. This would simplify the dynamic convergence circuitry, but mounting the yoke would be
more difficult in that case.

Inherently, operating a single gun in this fashion doesn't give as much brightness as three guns do. But Sony says there's enough room in the neck of the tube for a much larger gun that will make the display almost as bright as that of a three-gun tube.

Sony is developing a 12-inch tube using this concept. With color signals to the electron gun gated at horizontal sweep frequency, a line sequential display suitable for monitors in a closed-circuit entertainment system for aircraft can be made with little trouble. The tube also could be used for small-tube portable TV receivers.

The Chromagnetron concept, however, probably won't lead to a tube for large receivers. At the 3.58 MHz color switching frequency required for dot-sequential operation, the large yokes would radiate too much interference.

**On-time transistor**

For some six years, the Bulova Watch Co., with its Accutron, has had the "electronic" wristwatch market in the United States all to itself. Now Bulova will have to watch out—competition is on the horizon.

The Citizen Watch Co., a Japanese firm, plans to launch its X8 electronic wristwatch in Japan this spring; later it will move into export markets. Company officials haven't yet decided how to handle marketing in the U.S. Ironically, Citizen supplies conventional watch movements to Bulova for sale in the U.S.

Like Bulova's Accutron, Citizen's X8 uses a transistor circuit (neither watch is fully electronic), but there the resemblance ends. In the Accutron, a transistor-controlled electromagnet tuning fork replaces the balance wheel and hairspring. The watch uses a transistor circuit to power a balance-wheel pendulum assembly.

**Sandwiched coil.** Basic oscillation in the X8 comes from a balance wheel with a hairspring; its period is 0.4 second. Below it lies a second balance wheel—without a hairspring—that drives a detached-lever escapement coupled to the gear train for the second, minute, and hour hands. Both balance wheels have platinum-cobalt permanent magnets fixed on them. Sandwiched between the wheels is a flat two-coil assembly.

One coil picks up a periodic voltage signal as the balance wheel assembly magnets oscillate back and forth over it. The signal is amplified by the transistor circuit and fed to the second coil to drive the pendulum assembly. Power source for the watch is a 1.5-volt silver cell, supplied by the Union Carbide Corp.; the cell lasts about a year.

As in a conventional movement, the hairspring of the X8 balance-wheel assembly can be adjusted to correct for fast or slow running; a variable resistor in the transistor circuit matches it to changed hairspring settings. The stem of the watch actuates a switch in the power-cell circuit so the watch can be stopped if desired.

**Priced to sell.** Citizen plans to produce one thousand X8's monthly at the outset and will sell them on the Japanese market for just under $89. By comparison, Accutron prices in the U.S. start at $125. When Citizen does tackle the U.S. market it will move into lush territory—Bulova has sold over a half-million Accutrons in the last six years.

But both Bulova and Citizen face a long-range threat from Swiss watchmakers, fiercely jealous of their reputation as world leaders in precision timepieces. The Swiss Federation of Clock and Watch Manufacturers has mounted a well-financed effort to develop an all-electronic watch at its research center near Neuchâtel.

**Great Britain**

**Thin lines**

The upsurge of interest in thin-film integrated circuits in Great Britain has touched off a scramble among some researchers to see who can scribe the finest lines the fastest. Deposited resistors and capacitors in thin-film circuits have to be scribed to adjust their values; the race is on to develop optimum production methods to do the job. Already, both government and electronics company laboratories have come up with improved scribing techniques using sparks, electron beams or lasers.

**Sparks.** Standard Telephones and Cables Ltd., an affiliate of the International Telephone & Telegraph Corp., appears to be the leader with
spark engraving. In its West England plant, STC adjusts resistors and tunes inductances in thin-film circuits by engraving them with sparks. Cutting speeds range up to 0.4 inches per second, with line widths as thin as 0.002 inch. Even thinner lines are possible, STC says, with specially shaped tips on the engraving probe or by operating the probe in a dielectric fluid. The dielectric cuts widths down to around 0.0004 inch.

To keep line-width to line-depth ratio high, STC keeps energy levels in the spark low. Penetration of the evaporated film is thus held as low as a few thousand angstroms for a width-depth ratio as high as 20 to 1. The spark source is a direct-current supply that charges a small capacitor through a high resistance; that way, discharge current is limited and the film doesn’t overheat when it’s engraved. Typical values used by STC are a 40-volt circuit with a capacitor of 100 picofarads charged through a series resistance of 1 megohm.

Along with the benefits, low sparks levels bring a problem—how to maintain gaps small enough so the spark will form. STC solved the problem by mounting the probe on a piezoelectric transducer. Energized at 10-kilohertz (kilocycles per second) frequency, the transducer vibrates the probe with a travel of about 0.001 inch.

**Electron beam.** Another way to scribe fine lines is by an electron beam, a technique used on a production-line basis with computer control in the United States by Hamilton Standard Div. of the United Aircraft Corp. Britain’s Royal Radar Establishment, however, has plans for a twist on the usual technique. Instead of a high-voltage, short-focus beam with accelerating voltages of 90 kilovolts or higher, RRE is developing a low-voltage (30 kilovolts) machine that operates as a high-resolution cathode ray tube.

RRE admits its low-voltage system has inherently lower resolution than a high-voltage electron beam machine. But there are advantages, RRE claims. A large scan area—up to 3 inches by 3 inches—is possible,
now have. With a 100-kilowatt transmitter, their tv broadcasts currently cover an area extending out 60 miles into the East German territory surrounding the West Berlin enclave.

“What we want is a concrete tower that will enable us to transmit deeper into East Germany,” says Werner Goldberg, director of West Berlin’s Fernsehturm GmbH, the television tower subsidiary of Radio Free Berlin. With a higher tower, Goldberg figures, the propaganda benefits of West German tv broadcasts could be extended to heavily populated areas around Leipzig and Dresden to the south, and to the Baltic coastal towns to the North.

An argument like that should get a sympathetic hearing from West Berlin occupation authorities, especially since the air-safety objection no longer is valid with a high tower now going up in East Berlin. Goldberg already has some possible projects in mind. One of the most recent calls for three 988-foot high concrete tubes with elevators running inside. A glassed-in observation sphere would be slung between the tubes near the top.

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**France**

**Changing exchanges**

The government-run French telephone network plans to turn to electronic switching to ease the strain on the sorely overtaxed exchanges in the Paris area.

Phone officials said, at a recent international conference of electronic switching experts, that a first computer-run switching center would be installed in the French capital by late 1968. Most likely the system will be a hybrid. It will be computer controlled but line crosspoints will be switched by reed relays.

At its Lannion facility in Northern Brittany, the French postoffice department’s research laboratory, Centre National d’Etudes de Télécommunications (CNET), has been looking into three different kinds of switching systems for telephone exchanges. In a program named Aristote, CNET has developed a 1,000-subscriber prototype exchange that uses pairs of transistors for the crosspoints. Concurrently, CNET developed Socrate, which has electronic program control but works with electromechanical crosspoints. Latest and most advanced is the Platon time-division system [Electronics, Nov. 16, 1964, p. 176].

**Leading candidate.** The exchange that Paris will get late in 1968 is called Pericles, almost certainly will be based on reed-relay experiments carried out as part of the Socrate development. Most likely candidate is the Artemis exchange, now well along in development at Le Matériel Téléphonique, an affiliate of the International Telephone & Telegraph Corp. LMT will have an 800-line prototype in service at its plant on the outskirts of Paris early next year.

The Artemis exchange differs in an important respect from the electronic switching system the Bell System has in full-fledged service on 7,000 lines in Saccasunna, N. J. and 4,000 lines in Chase, Md. [Electronics, Oct. 19, 1964, p. 72]. Bell’s system uses electrical latching, LMT’s magnetic latching.

**Open and closed.** In the Artemis exchange, a crosspoint consists of three reed relays. Two of them switch the phone lines; the third is scanned by the control circuits to determine if the crosspoint is occupied or free. Once a crosspoint is switched closed by a pulse to the electromagnets that actuate the reeds, it latches magnetically and remains closed without a holding current. It stays closed until a pulse to open it is transmitted. Along with the saving in current consumption, the magnetic latching circuit has the advantage of eliminating the need for a decoupling diode at each crosspoint.

Control functions in the Artemis exchange are handled by a computer developed by CNET for electronic switching systems. The computer has a semipermanent core memory to store the basic control program and a temporary memory to store data while calls are switched. Both these memories have a capacity of 4,096 words of 32 bits. A drum memory with a 16,000-word, 32-bit capacity stores the subscriber numbers for the exchange and records of subscriber’s accounts.

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**Switzerland**

**Bulls’ eyes**

An added occupational hazard is threatening burglars who practice their profession in Switzerland. Police forces in Zurich and some smaller Swiss cities soon will start testing an infrared scope that lets its user see at night.

The battery-powered scope looks like an oversized pistol and weighs about a pound. It can be held to the eye with one hand and needs no focusing. The lens, an integral part of the scope, has an angle between that of a normal camera lens and a wide-angle lens. With an infrared spotlight mounted on the patrol car to “illuminate” night prowlers, police can pick them out in the dark at ranges over 300 yards.

Albiswerk A.G. of Zurich built the device around a 1½-inch diameter infrared image converter tube it developed. The tube has a resolution of 650 lines per inch and a single image-converter stage. The acceleration voltage, higher than 10,000 volts, is developed in a transistor converter. Albiswerk says the image obtained is sharper than a television image.

The Swiss infrared scope differs in major respects from similar viewers produced in the United States for police work. The U.S. models have built-in illuminators. This is an advantage when a policeman has to leave his patrol car stalk a suspect at night.

On the other hand, the Swiss system based on a powerful infrared spotlight mounted on the patrol car has greater range. Range depends on the infrared illumination of the person or object viewed. And a scope without an incorporated illuminator, obviously, is cheaper.
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