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Improving the braided memory: page 121
Managing thermal design: page 129

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HI-FL

MINIATURE MIL TYPE

CHOPPER

Transistor output; matches any PP transistor to 4, 8, 16, 11 speaker. Primary 48, 36, 12 Ω C.T.; 20 to 20 KC; 40 watts.

Metal case hermetically sealed to MIL-T-278. Gold Dumen leads spaced on 0.1 radius, for printed circuit application.

Magnetic shielded plus electrostatic shield for voltage isolation of 2×10⁴. Primary 200K C.T. to within 0.1%. Secondary 50K.

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CATHODE FOLLOWER OUTPUT

Low distortion 2.5 KW output transformer, PP 450 TH's 18,500 ohms C.T. to 24.6 ohms, 20 KV high. 520 lbs.

Provides equal voltages to 5 loads. Primary inductance maintained to 5%, with 20% change in DC unbalance and 30% change in AC voltages.

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Exceptional quality and reliability is provided in all UTC designs. Over 30 years of engineering knowledge and experience substantiated by extensive field performance assure the highest quality and most reliable components in the industry. Complete environmental testing facilities are incorporated to prove out new designs. Full analysis and evaluation of materials are conducted in UTC’s Material and Chemical Laboratories. Rigid quality control measures coordinated with exhaustive statistical findings and latest production procedures results in the industry’s highest degree of reliability. Range covered in Audio Transformers is from 0.1 cycles to 400 MC . . . microwatts to 50 KW.

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POWER TRANSFORMERS • AUDIO TRANSFORMERS • INDUCTORS • PULSE TRANSFORMERS • ELECTRIC WAVE FILTERS • LUMPED CONSTANT DELAY LINES • HIGH Q COILS • MAGNETIC AMPLIFIERS • SATURABLE REACTORS • REFERENCE UNITS

UNITED TRANSFORMER CO.
DIVISION OF TRW INC. • 150 VARICK STREET, NEW YORK, N. Y. 10013

Circle 900 on reader service card
The new HP 8441A Preselector offers an effective solution to the cluttered-screen problems often encountered in broadband spectrum analysis. Used with the HP 851/8551 Spectrum Analyzer, the preselector covers 1.8 to 12.4 GHz with simple, straightforward operation. Broadband and multiple signal displays are now far easier to interpret.

The preselector is an electrically tuned RF filter preceding the analyzer’s RF input. It electrically tracks the analyzer’s sweep and therefore passes only the instantaneous frequency to which the analyzer is tuned as it sweeps through its selected scan. The rejection of other strong signals prevents the generation of distortion products in the analyzer’s mixer. Elimination of these distortions from the display increases the analyzer’s effective dynamic range because the analyzer can now handle input signals of higher levels. This permits easy comparison of large and small signals.

Because it rejects interfering signals, the preselector is an indispensable tool in such applications as RFI measurements and test of frequency multiplier chains. Ask for Application Note 63B, which describes the uses of this new and versatile instrument. Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

**HP Model 8441A Preselector**
- **Frequency Range:** 1.8 to 12.4 GHz, electrically tuned.
- **Nominal 3 dB bandwidth:** 40 MHz.
- **Rejection:** At least 35 dB for out-of-band signals. May be internally or externally tuned or swept.
- **Price:** $2950.
Sweep Oscillator gives top performance in the 100 kHz to 110 MHz range

All solid-state Hewlett-Packard 3211A Sweep Oscillators with RF and marker plug-ins meet virtually all of your swept frequency testing requirements. Variable bandwidth markers permit accurate, well defined marking under a variety of test conditions.

The main frame of the 3211A contains everything you could hope to find in a sweeper. RF plug-ins operate at fundamental frequencies with good linearity and spurious mixing products are eliminated. Plug-in markers offer not only variable bandwidth, but also Z-axis or pulse-type marking. An accurate 59-db attenuator makes the unit a valuable tool for testing both high- and low-gain circuits.

Priced at less than $1,000, the 3211A is ideal for general testing in the video to VHF range where flat, linear output and an accurate marking system is required. Typical applications are: alignment, calibration and design of FM tuners and receivers and testing filters, amplifiers, transformers, resonant circuits and IF sections of TV receivers, radar and communications systems. For complete specifications, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N.J. 07866.

HEWLETT PACKARD

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To the Editor:

The brazen impudence of the present—and recent past—FCC commissioners has never been more adequately documented than in the alleged quotation of Commissioner Lee [June 26, p. 143] when he said, "We finally changed our minds and decided that we had jurisdiction over CATV because it has the potential to destroy local broadcasters. Although CATV does serve previously unserved markets, and has a useful place in the communications industry, the FCC is trying to protect the status quo of the broadcasting industry."

Why is there something evil about the "potential to destroy local broadcasters?" Isn't it self-evident that such a potential exists only to the extent that the broadcasters do not provide what the customers want? Why not minimize the potential with service, instead of regulations. Or better yet, why doesn't the FCC enforce the existing standards upon which licenses are granted but which are never heeded except by lip-service and some large stations—which is why people prefer them on the cable to the local money-grabbers.

"Although CATV does serve previously unserved markets . . ." is another admission of the failure of both the commission and the industry to serve an important segment of America and then, when something ingenious is done about the contrived situation, to try and legislate the solution out of existence to protect the vested interests.

". . . the FCC is trying to protect the status quo . . ." May I ask a question? Where did the Congress slip that sentence into the Communications Act? It is not the duty of the FCC to protect the status quo of anything; rather it is their sworn duty to see that the public is served and that the quality of that service is continually improved. Their present obstructionism to improved public service should be a matter of grave concern to the Congress.

Finally, let me point out how very glad we should be that this insolent attitude did not prevail in governmental bureaucracy when
New from Sprague!

This Resistor has 5 Times the Resistance of a Conventional Metal-Film Resistor of Equal Size!

<table>
<thead>
<tr>
<th>Type</th>
<th>Wattage Rating</th>
<th>Size</th>
<th>Maximum Resistance</th>
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<tbody>
<tr>
<td>Extended-Range</td>
<td>1/10</td>
<td>.095&quot; D. .250&quot; L.</td>
<td>1.5 MΩ</td>
</tr>
<tr>
<td>Filmistor Resistor</td>
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</tr>
<tr>
<td>Conventional</td>
<td>1/10</td>
<td>.095&quot; D. .250&quot; L.</td>
<td>0.3 MΩ</td>
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<tr>
<td>Metal-Film</td>
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This Resistor is 21 Times Smaller than a Conventional Metal-Film Resistor with Equal Resistance Value!

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum Resistance</th>
<th>Wattage Rating</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended-Range</td>
<td>1.5 MΩ</td>
<td>1/10</td>
<td>.095&quot; D. .250&quot; L.</td>
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<tr>
<td>Filmistor Resistor</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Conventional</td>
<td>1.5 MΩ</td>
<td>1/2</td>
<td>.250&quot; D. .750&quot; L.</td>
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<tr>
<td>Metal-Film</td>
<td></td>
<td></td>
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</tbody>
</table>

Both Resistors are one and the same...they’re Sprague’s new EXTENDED-RANGE FILMISTOR® METAL-FILM RESISTORS

Substantial saving of space in all wattage ratings—1/20, 1/10, 1/8, 1/4, 1/2, and 1 watt—with absolutely NO SACRIFICE IN STABILITY!

New manufacturing techniques at Sprague Electric have made possible a major breakthrough in resistance limits for metal-film resistors. Extended-Range Filmistor Resistors now offer, in addition to accuracy . . . stability . . . reliability . . . extended resistance values in size reductions which were previously unobtainable. Size and weight advantages of Filmistor Resistors now make them the ideal selection for applications in high-impedance circuits, field-effect transistor circuits, etc., where space is at a premium. Many designs which previously had to settle for the higher temperature coefficients of carbon-film resistors in order to obtain required resistance values can now utilize the low and controlled temperature coefficients of Filmistor Metal-Film Resistors.

Other key features are ±1% standard resistance tolerance, low inherent noise level, negligible voltage coefficient of resistance, and tough molded case for protection against mechanical damage and humidity.

Over 100 different models of GR oscillators, signal generators, and synthesizers are listed in our catalog. These sine-wave signal sources provide a wide choice of frequencies, power outputs, and modulation and sweeping capabilities. For instance:

Included among the oscillators are our four new "sync-able" oscillators, each a small (8 x 6 x 8 in.) self-contained unit with a sync jack for phase-locking to an external signal. These oscillators offer a wide choice of performance: fixed frequencies (to 10 kHz) or continuous tuning (to 2 MHz), up to 1-watt output, as much as 0.001 % short-term frequency stability, and distortion as low as 0.05 % or less.

If you need a high-resolution signal source with a wide choice of operating features, you can satisfy your need with one of the 80 versions of our frequency synthesizers. Their modular construction makes it possible to order any of the four basic models with from three to seven manual step-decade modules, programmable modules, and with or without a continu­ously adjustable decade module that provides additional resolution and sweep capability. Upper frequency limits of the four basic models are 100 kHz, 1 MHz, 12 MHz, and 70 MHz with maximum possible resolutions of 0.0001, 0.001, 0.01, and 0.1 Hz, respectively.

The newest addition to our ensemble of sine-wave sources is the 1026 Standard-Signal Generator. This unique instrument puts out ½ watt into 50 Ω (10 V behind 50 Ω, 5 V when modulated), has excellent output leveling, and has true single-dial tuning over its entire 9.5- to 500-MHz frequency range. The ease of operation and outstanding performance of the 1026 in the most critical applications must be experienced to be appreciated. Request a demonstration and see for yourself.

Prices for GR sine-wave signal sources range from $225 for a "sync-able" audio oscillator with 11 fixed frequencies to $7515 for a full-complement, 70-MHz frequency synthesizer. For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX (710) 347-1051. Sales Engineering Offices are located in major cities throughout the United States and Canada.
Henry Ford started making automobiles. If it had we would still be riding horses (have to protect the status quo, you know) and billions of horseshoes would be stockpiled in warehouses all around the country.

If the established communications media can not, or will not, provide what the public wants, and CATV can, then the old must perish before the onslaught of the new. And if as a consequence the FCC dies too, so be it. We don’t have to preserve the status quo in government either.

Richard G. Devaney
Kingsport, Tenn.

Direct application
To the Editor:

We agree with the general trend of thought of the editorial “Partners in progress: doctor and engineer” [July 10, p. 23]. It is our opinion that engineering techniques should be applied directly to the problems of disease and disability. This would be more effective than the present practice of trying to apply engineering techniques to the problems posed by doctors. Can you imagine how far Thomas Edison would have gotten on his “light” project if he would have been forced to work with the gas company to produce a brighter, more efficient gas flame?

Dr. Joseph Battocletti
Kenneth Kayser
Badger Meter Manufacturing Co.
Milwaukee

Research as a luxury
To the Editor:

Your editorial [July 10, p. 23] omits one very great difficulty in the cooperation of engineers with physicians: money.

Many physicians do research as an avocation—a labor of love. They do it for free or for a nominal sum. A doctor can afford this, since his principal source of revenue is elsewhere.

He may consider that since he, the physician, is donating time, surely other professionals, like engineers, should do the same.

There are signs of change however. Many hospitals do have engineers on staff; physicians budget for engineering on their grants, much more so than in the past.

Really, I have observed that in the past five years there has been an order of magnitude change for the better in this important region.

H.H. Schwartz
Montreal, Canada

It takes three kinds
To the Editor:

The difficulties with IC voltage regulators for automobiles [June 26, p. 23] missed an important point.

You stated “Application of electronics in areas that have been traditionally nonelectronic is a job requiring two kinds of people: those who understand electronics technology and those who understand the application.”

You omitted the integration people, those who understand the interaction of environments and electronics. They are needed even for introducing IC’s into automobiles.

Of course, it is well known that one of the important environments is the electromagnetic environment. Therefore, one of the integration people should be an electromagnetic compatibility engineer since electrical “noise” is ever present.

Anthony G. Zimbalatti
Hempstead, N.Y.

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Electro Scientific Industries
ESI®

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): 0.5% + 1 dial division
Sensitivity: Better than 20 microvolts DC, 10 microvolts AC
Frequency: 1 kc internal

(External terminals provided.)

Batteries: 4 D size flashlight batteries provide 6 months of normal service, Weight: 12 lbs. Price: $475.00

Note: The 250 DA features exactly the same accuracy specifications as the 250 DE. However, the 250 DA is AC line-operated. Price: $550.
TAC miniature solid tantalums are precisely molded for automatic insertion; tubular axial-lead epoxy case is only .105" dia. by .290" long.

Test proved for excellent stability of capacitance, DC leakage and dissipation factor on extended life and humidity exposure.

Rated $-55^\circ C$ to $+85^\circ C$ at full voltage, $+125^\circ C$ at $\frac{2}{3}$ nominal voltage. Values from 18 mfd, 3 volts to .47 mfd, 50 volts.

Get all the news on new TAC's from Mallory. Write for Bulletin 4-82. Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

People

The Eastern operation of Sylvania Electronic Systems in Needham, Mass., has often been out of phase with the rest of the industry. Sometimes the aberration was a happy one; in 1963, when most of the defense electronics industry was hurting, Sylvania Systems East was hiring. But during 1966 and early this year the plant was laying off while most were hiring.

"We are now stabilized, and have been for months," says William S. Wheeler, the new vice president and general manager of the Eastern division of Sylvania Electronic Systems, an operating group of Sylvania Electric Products.

Stabilization was achieved before Wheeler took over, but keeping the company in phase with projected growth curves becomes the responsibility of the 45-year-old vice president. The major involvement in the division's recent history was in the Minuteman program, principally as contractor for the ground electronics. Everyone knew that the Minuteman program had peaked, but the downward turn was steeper and faster than expected. Sylvania, like others, was also caught in the cancellation of several large strategic-type programs.

Shift in emphasis. "We've swung over more to the tactical systems. They're smaller, but there are more of them," says Wheeler.

The division is still doing work in strategic-weapons control, such as Minuteman, but it is also teamed with Burroughs as a contender for the Army's tactical weapons-control system, Tacfire. Wheeler sees long-range growth in training systems for complex defense equipment. His division is a prime competitor in the satellite earth station business, in over-the-horizon radar, and phased-array antennas. Other areas of concentration will include search-location-rescue equipment such as Syl-
Helipot's New Model 77P
Cermet Trimming Potentiometer

Here's the new Model 77P, the first low-cost, general purpose trimmer with a sealed housing and cermet resistance element! DESIGNED to wider performance parameters than any other adjustment potentiometer in its price range. It is directly interchangeable with competitive Models 3067 and 3068—SEALED to permit p.c. board solvent cleaning and potting without trimmer contamination or failure—DELIVERED from local stock at the low list price of $1.95. In large quantities, Model 77P sells for as little as $1.10. Compare Model 77P specifications with those of unsealed trimmers, then call your local Helipot representative for an evaluation sample.

<table>
<thead>
<tr>
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<th>Helitrim Model 77P</th>
<th>Model 3067 Wirewound</th>
<th>Model 3068 Carbon</th>
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<td>Resistance Range, ohms</td>
<td>10 - 2 meg</td>
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<tr>
<td>Resolution</td>
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<tr>
<td>Sealing</td>
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<td>Power Rating, watts</td>
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<td>0.2</td>
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<tr>
<td>Maximum Operating Temp. °C</td>
<td>105</td>
<td>85</td>
<td>85</td>
</tr>
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</table>
Only from Sprague!

DIGITAL-TO-ANALOG HYBRID D to A CIRCUITS
with precision components not found in monolithic integrated microcircuits

FOUR BIT SERIES

<table>
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<tr>
<th>Bit</th>
<th>0</th>
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| UT-1000 LADDER NETWORK
| UT-1001 LADDER NETWORK
| UD-4001 LADDER SWITCH
| UD-4024 BUFFER AMPLIFIER

FIVE BIT SERIES

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| UT-1000 LADDER NETWORK
| UT-1001 LADDER NETWORK
| UD-4001 LADDER SWITCH
| UD-4036 LADDER SWITCH
| UD-4037 BUFFER AMPLIFIER

Up to 12 bits with less than ½ bit error!

- Improved tracking over temperature range of -55 °C to +125 °C.
- 3 to 1 size reduction over conventional converters using discrete components.
- Reduced handling of components ... fewer external connections ... lower assembly costs.
- Silicon-base hybrid microcircuits in hermetically-sealed flat packs.

- 4-bit series expandable to 8 or 12 bits ... 5-bit series expandable to 10 bits.
- Combination of precision thin-film tantalum nitride resistors, nickel-chromium resistors, and active devices of planar construction.
- Packaged for compatibility with monolithic circuits.


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RESISTORS
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FUNCTIONAL DIGITAL CIRCUITS
MAGNETIC COMPONENTS
CERAMIC-BASE PRINTED NETWORKS
PULSE-FORMING NETWORKS

SPRAGUE COMPONENTS

THE MARK OF RELIABILITY

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People

vania’s rescue radio, the PRC-63.

Wheeler is hard at work trying to reduce the number of projects his division will get into. “In today’s defense business,” he says, “I don’t know of any company which does not make a substantial financial contribution of its own in contract-definition work. So you can’t jump into all of them. You can only afford so many at a time.”

Trying to give solid state devices an inside track with railroad equipment, the General Electric Co. has put F. William Gutzwiller in the engineer’s seat at its Transportation Systems division in Erie, Pa. Gutzwiller previously was manager of semiconductor applications at GE’s Auburn, N.Y., facility. A member of the team that developed the first commercial silicon controlled rectifier, Triac, and other thyristors, he specializes in semiconductor applications, particularly in power systems.

Gutzwiller was a prime mover in developing scr’s and electronic subsystems for motor controls, lighting systems, toys [See related story on page 46], and other areas once the exclusive preserve of relays, vacuum tubes, and mechanical and other conventional devices.

Express. “My new mission,” says Gutzwiller, “is to bring solid state electronics to railroad cars and locomotives, diesel-engine drives, motor-control systems, and oil-well drilling and earth-moving equipment.” Traditionally, makers of such equipment have been wedded to mechanical, hydraulic, pneumatic, and electrical systems. Winning them over to solid state devices won’t be a simple task.

One of his first assignments is to develop electronic motor-control systems for the Northeast Corridor experiment, a Government-sponsored project to explore the feasibility of running high-speed trains between Boston and Washington.
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MACHLETT ML-5681
HIGH POWER
TRANSMITTING TUBES
HAVE JUST LOGGED
170,000 HOURS.

These 14 New Devices Make RCA the Triac Leader of the Industry

Now, RCA offers you the industry’s broadest line of Triacs, with an unmatched choice of ratings and triggering characteristics in space-saving packages ... all at truly economical prices! Triacs are today’s most modern, effective component for ac phase-control and load switching. Because they can perform the functions of two SCR’s, Triacs make possible new economies in full-wave power circuit design and cost for industrial and commercial applications.

So for efficient, inexpensive solid-state control of motors, lighting, and heating, look to RCA, the Triac Leader. Your RCA Sales Representative will be happy to give you more details, including price and delivery. Also, ask him about RCA’s complete line of SCR’s. For additional technical data, write RCA Commercial Engineering, Section RN9-3, Harrison, N.J. 07029. See your RCA Distributor for his price and delivery.

*Priced in quantities of 1,000 and up.

<table>
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<tr>
<th>Current Rating</th>
<th>Low Voltage (100V)</th>
<th>120V Line (200V)</th>
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<td></td>
<td>TO-66</td>
</tr>
</tbody>
</table>

*RCA Electronic Components and Devices

The Most Trusted Name in Electronics
**Sensitive-Gate Triacs under $1.00**

Extremely high gate sensitivity...rms (on-state) current = 2.5A...and a price level that makes possible a new generation of controls for small appliances, induction motors, and sensing circuits. Maximum gate sensitivities of 3 mA or 10 mA are actually many times greater than that of conventional Triacs! This means simplified triggering circuits and reduced component costs. The 100V versions (40525 and 40528) sell for $0.95; the 200V types (40526 and 40529) are priced at $0.98; and the 400V units (40527 and 40530) are available at $1.40!

**6A Triacs in 2-lead TO-5 to Control up to 1440 Watts**

With the new 40485 and 40486 6A Triacs, RCA doesn't have to use an expensive press-fit package to control a lot of power. Both types employ the low-cost TO-5 case which can be easily mounted on heat spreaders using mass produced pre-punched parts and batch soldering techniques for improved heat-sinking ability. The 40485 sells for only $1.50 and controls 720 watts. The 40486 can control 1440 watts and sells for $1.98. And reliability is assured with surge current protection up to 100A!

---

**Low-Cost 6A Triacs with Integral Trigger to reduce design problems and save money**

Because the triggering device and the firing characteristics of the 40431 and 40432 Triacs are coordinated inside a compact TO-5 case, you don't have to worry about designing in additional triggering components. You benefit further from reduced circuit and assembly costs, plus improved packaging densities! So if your ac-load control circuits require a trigger, why not have it built-in for you? The 40431 controls 720 watts at 120V and costs $1.80; the 40432 controls 1440 watts at 240V and costs only $2.48.

**15A Triacs for Load Control up to 3600W**

RCA developmental types TA2834 and TA2835 Triacs extend solid-state control way up into the kilowatt range. These powerful TO-66 units have surge current protection up to 100A, plus all of the other design benefits of RCA's lower current Triacs. Possible applications include power supplies, heating controls, motor drivers, and many other industrial and commercial usages.

**6A Triacs in Popular TO-66 Package**

Need full-wave control of up to 1440 watts in a TO-66 package? RCA 40429 and 40430 Triacs are your answer...they feature high gate sensitivity, symmetrical triggering characteristics (IgT = 25 mA max), and surge current protection up to 80A. The 200V 40429 costs $1.50, the 400V 40430 only $1.98.
Meetings


International Broadcasting Convention, Electronic Engineering Association; Royal Lancaster Hotel, Lancaster Gate, London, Sept. 20-22.


Power Generation Conference, American Society of Mechanical Engineers and IEEE; Statler Hilton Hotel, Detroit, Sept. 24-28.


Electronics Show, Electronic Industries Association of Japan; Minato International Trade Fair Grounds, Osaka, Japan, Sept. 28-Oct. 4.


Industry and General Applications Group Meeting, IEEE; Pittsburgh Hilton Hotel, Pittsburgh, Oct. 2-5.

Active Sonar Classification Symposium, Department of the Navy; Naval Postgraduate School, Monterey, Calif., Oct. 3-5.

Ultrasonic Symposium, IEEE; Bayshore Inn, Vancouver, Canada, Oct. 4-6.


Machine Tool Conference, IEEE; Cleveland Sheraton Hotel, Cleveland Oct. 9-11.


Short Courses

Symposium on physics and nondestructive testing, Physics Department and the Nuclear Science Center of Louisiana State University, Baton Rouge, Sept. 19-21; $50 fee.

Modern electroanalogic simulation techniques in engineering design, College of Engineering and the College of Applied Science and Engineering of University of Wisconsin, Madison, Sept. 25-26; $50 fee.

Process dynamics and control, Purdue University's School of Engineering, Lafayette, Ind., Sept. 25-30; $150 fee.

Calls for Papers

Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; Chase-Park Plaza Hotel, St. Louis, April 28-May 1, 1968. Oct. 1 is deadline for submission of abstracts to Technical Program Committee, Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, Ill. 60056.


* Meeting preview on page 16.
WIN A WHOLE BASKET OF GOURMET FOODS!
(Everything from imported sardines and pâté de foie gras to Beluga caviar. Shipped to you direct from Vendome's Gourmet Foods in Beverly Hills, Calif.)

Now that we've whetted your appetite, a few well chosen words about the entreé—our connectors. You'll need to know about these before you can stuff yourself.

It all started like this: We eliminated the contact spring member normally found in socket contacts by creating a breathing helical spring principle on the pin contact. Smaller. More durable. More economical. The result was the best family of rack/panel and strip connectors on the market. Some of the high density applications for TWIST/CON include connections for IC's, interconnecting of printed circuit boards, edge-on connections for PCB boards, and on modules with connectors welded to hybrid circuits. Single pins are being used for high density line splices. TWIST/CON is usable with 22 AWG to 30 AWG standard wires. Next, we applied the TWIST/CON principle to LEPIA/CON—WORLD'S SMALLEST FULL 50 OHM COAX

OD is 1/8 inch and mated length is about one inch. That makes it the smallest. And the completely protected contacts also make it the most reliable. The size means you can use a much smaller OD cable for even greater weight/size reduction in your package. The price is as low as $1.07 in nominal quantities. You can get straight plugs, jacks, bulkhead jacks, right angle plugs, or printed circuit receptacles. Screw-on or slide-on versions in entire line. That's the menu for today.

BIG WINNERS!
But everybody who enters receives a photo of Squozen's high density packaging solution. Five lucky entrants will receive the cases of gourmet foods. All you have to do is (a) study the information about our Twist/Con and Lepra/Con connectors, and (b) write an appropriate caption or problem statement for the sardine can, working in at least one of the two connectors we've talked about. Contest closes October 1, and is not valid anywhere where it is considered illegal, immoral—or fattening.

MICRODOT INC., 220 Pasadena Avenue, South Pasadena, California 91030
Dear Microdot:
Enclosed find my entry in your high density packaging contest

□ Enclosed find my entry in your high density packaging contest

□ Enough of this foolishness. Just send me literature on (circle) TWIST/CON

□ I have a connector application for high density packaging. Get somebody over here.

□ All your connectors

□ State Zip Code

□ Name

□ Title

□ Firm

□ Address

□ City

□ Telephone

□ Ext.

□ Lepra/Con and Twist/Con are registered trademarks of Microdot Inc.

Circle 15 on reader service card
**Meeting preview**

**New heights**

Since its inception, the International Electron Devices Meeting has always provided prestigious technical programs, and this year is no exception. In fact, the upcoming meeting, scheduled for Washington from Oct. 18 to 20, is surely the best ever on two counts: the breadth of the subjects to be considered and the technical importance of the papers.

As usual, those attending will find it impossible to sit in on all the sessions; at least three and sometimes six will be going on at the same time. The perennial topics are solid state devices, integrated electronics, and electron tubes; the newer categories cover display and pickup devices, quantum electronics, and energy conversion devices.

In the display-and-pickup group, J. R. Hansen and R. J. Schneeberger of Westinghouse Research Laboratories will describe a recording device based on liquid crystals that change color as an impressed electrostatic field is varied. The device provides a multicolor image in real time.

In another of the 18 papers in this category, C. E. Land of Sandia Laboratory will tell how ferroelectric ceramics are used to modify the transmission characteristics of a film when electric fields are applied. Land says the technique could permit the storage of as many as 1 million bits per square inch.

Yielding LSI. One of the deterrents to the applications of large-scale integration has been low device yields. A.G.F. Dingwall of RCA will discuss recent advances in processing that have boosted yields to the point where the interconnection of LSI arrays is feasible. Beam leads, new mounting and bonding techniques, and other routes to LSI will also be covered at the meeting.

Three-quarters of the 24 papers in the quantum electronics category are on lasers—both carbon dioxide and ion.

The subject of the other papers is photodetectors, including silicon carbide, indium antimonide, and gallium arsenide-cesium types.
There's a Tektronix Field Engineer in your area

His knowledge of the Technology of Measurement can work for you

While the Tektronix Field Engineer is familiar with many engineering and scientific disciplines, he also has a discipline of his own... the technology of measurement. His specialty is knowing how to measure electrical and physical phenomena and helping you present this information as a useful display on the oscilloscope.

Tektronix believes you have a right to expect high technical competence from the men who sell and service oscilloscopes. Tektronix Field Engineers, each of whom has a substantial background in electronics, receive thorough product training before they come in contact with you, and are constantly kept abreast of new instruments and new measurement techniques.

Call on your nearby Tektronix Field Engineer when you need assistance in selecting the proper oscilloscope for your measurement problem, or when you need help in operating or maintaining it.

You can count on his help when you need it.

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97005

Don Hofmann of Philadelphia, Pa.—One of the Tektronix Field Engineers serving you from 43 U.S. Field Offices and in more than 29 countries around the world.
At these prices, you try one of these schemes now and then.
nobody will holler if shift registers on a wild

**MM500 50 bit shift register $9.85**

**in 100 lots**—It's very fast, uses low power, and, similar to all our other shift registers, has the lowest operating voltage around. It's organized as a dual 25 bit element. The unit uses -10 volt VDD supply voltage and 16 volt clock amplitudes. Power dissipation at 10kc is a typical 28 $\mu$W/bit. And guaranteed operation is at 1 MHz in a temperature range of 0°C to 70°C.

**MM502 100 bit shift register $14.80**

**in 100 lots**—Power dissipation for this one at 10kc is a typical 16 $\mu$W/bit. Otherwise, specs are about the same, except there are 50 more bits. This one is organized as a dual 50 bit unit. They're available right now at any of our distributors, or call National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 (408) 245-4320.

**National Semiconductor**
To get high energy circuitry at the lowest cost: start here.

Application of Delco high voltage silicon power transistors
Start with circuit designs using Delco high voltage silicon power.

The simple switching regulator in the diagram at left turns out 200 watts (2 amps) output at efficiencies exceeding 85%. And it does it with just one series element working directly from rectified line voltage: the new Delco DTS-410 transistor at just $1.95 each*.

Or if you need regulation of 250 volts DC and 400 watts output, the DTS-411 may be your answer. Cost? Just $3.15 each*. And for extra-high voltage applications, there's the DTS-423, now priced at $4.95 each*.

Now combine our new low prices with these other cost-cutting advantages of Delco high voltage silicon power transistors: you can reduce the number and complexity of input, output and filtering components. This means more compact circuitry, greater reliability and lower assembly costs.

These NPN silicon transistors are packaged in a rugged TO-3 case for low thermal resistance. Inside, they are mounted to withstand mechanical and thermal shock because of special bonding of the emitter to base contacts.

There's no need to be concerned about delivery. They are available right now in production quantities. Call us. Or order samples from your Delco distributor.

For details on the switching regulator circuit ask for application note number 39.

*Prices shown are for quantities of 1,000 or more.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Vces</th>
<th>Vces (max)</th>
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<td>100W</td>
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</tbody>
</table>

DELCO RADIO
Division of General Motors, Kokomo, Indiana
RCA's new 6LQ6 Novar Beam Power Tube for Horizontal-Deflection Service in Color TV

withstands 200 W plate dissipation for 40 seconds

Position of getters and subsequent flash improves heat transfer from screen-grid radiators to glass envelope.

Cavity plate made of heavy-gauge carbonized nickel and subjected to special vacuum-firing process. Combination of material and special processing reduces level of occluded gas and minimizes gas emission during periods of high-overload-temperature.

Larger diameter of screen-grid wire reduces screen-grid temperature and improves high-voltage cutoff characteristic.

Cavity plate designed for better heat dissipation,

Major innovations in materials, design and processing techniques make it possible to provide outstanding heat dissipation capability in the new RCA-6LQ6.

You can specify RCA's new 6LQ6 for the demanding horizontal-deflection-amplifier socket of your color-television chassis *with full confidence* that it will provide dependable, high-level performance from tube to tube and throughout life.

The 6LQ6 is a direct replacement for the 6JE6A and 6JE6B.

For complete information on the new RCA-6LQ6 family of Novar Beam Power Tubes, call your nearest RCA District Office or write to RCA Commercial Engineering, Harrison, New Jersey 07029.


RCA Electronic Components and Devices, Harrison, N.J. 07029
No mutual benefit

In Wall Street this summer, brokerage firms had so much business they couldn’t handle the paper work for all the stocks that were bought and sold. Trading on the New York Stock Exchange passed 10 million shares a day so often that the Exchange had to shorten the trading day. One of the reasons for the gargantuan volumes—only a few years ago a five-million-share day was considered a bonanza on the Exchange—is that the mutual funds are doing a lot more trading. They’ve grown so big that they have huge resources of cash and many have changed their main objectives from buying stocks with long-term growth possibilities to buying and selling shares over the short term, hoping to pick up a few points per share. What they are doing is having a deleterious affect on many electronics firms.

Instead of studying the long-term prospects of a company’s stock, the mutual funds are more interested in what it will do this week, next week, or this month. By next month, they’ll be on to another stock. To someone raised amid conservative financial men, what the mutual funds are doing would better be called gambling than investing. Only the kindest observer can even call it speculation because the funds sometime operate on the slimmest of tips or the most unconfirmed rumors.

To better serve this adventurous spirit, many Wall Street firms have established special research organizations to sell information just to the funds. Some of the firms have gotten so specialized that they will have an analyst who follows only integrated circuits, not caring what’s happening to discrete semiconductor devices even though they may more affect a semiconductor company’s current situation than ic’s. Selling good, bad, and terrible information has become big business on Wall Street.

Electronics companies, and especially the semiconductor firms, have been the subject of a lot of such stock dealings this year. For one thing, the concept of integrated electronics has excited the imagination of financial people. It’s a young field and nothing looks more attractive to a stock speculator than a ground floor opportunity. Also, profits among the semiconductor companies have been hurt disproportionately by the slump in consumer electronics sales. So their stocks are under scrutiny. And finally, the increase in numbers of conglomerate corporations such as LTV and ITT, companies that are not in one business but in many, has limited the number of companies whose futures and stock performance reflect the success of new technical developments.

All this activity in the investment world would be only of academic interest to engineers, even at the companies involved, if it weren’t affecting the day-to-day operations of these companies.

The performance of the stock causes management to tune its operation so the company looks attractive to stock buyers. When profits are hurt, say by a slump in consumer electronics equipment, a semiconductor company can offset the slide by drastically curtailing research and development expenditures. At one semiconductor company whose performance on Wall Street has resembled a rollercoaster during the past six months, a top executive expressed his concern. “Even under the best circumstances, it is difficult to determine how much money should be spent on R&D. But you can’t base such expenditures on the daily performance of the stock and hope to survive in the semiconductor business,” he says. The company has to pay dearly for the savings in R&D in a few years when it doesn’t have the new products that should have evolved but didn’t.

The sharp fluctuations of stock also work a devastating effect on key engineers and managers who have stock options. Considering the situation on Wall Street today, another electronics executive asked, “How do those important engineers feel about their options—and the company—when the stock drops 20 or 30 points in one day? Do you think they do their best work when all the incentives have gone down the drain?”

The press to win acceptance among the security analysts sometimes causes companies to make premature announcements of products. Since the announcements are never marked: “Financial community only—security analysts please note and recommend your customers buy our stock,” design and application engineers often find themselves trying out products that are not ready for use, do not have anywhere near the reliability needed or the performance promised. Or they find themselves chasing promises that are never realized in hardware.

To see just how ridiculous the situation has become, you have only to examine how the stock market has reacted to companies that build integrated circuits with metal oxide semiconductor techniques.

The rumor that a company can add four or eight bits of data capacity to an MOS chip can boom the company’s stock 8 to 12 points—even though there may not be any customers for or production of such a circuit. When the rumor mill reported that Fairchild Semiconductor Division was having troubles making some MOS ic’s, its stock dropped almost 20 points in two weeks, even though there are few customers around now for production runs of MOS circuits. You can appreciate how silly all this is only when you understand that almost all the business in MOS circuits today is research and development contracts, and the total dollar volume is miniscule compared to that of digital ic’s sold by the same firms.

All this is leading electronics companies—and the mutual funds that started it—into dangerous territory. Customers of electronics products are growing leary of the official pronouncements that come from electronics companies. Electronics companies are pushing their operations to make their stock attractive on the market rather than to build a stable corporate base and a solid business. And the gambling on electronics stock by funds is making electronics companies unattractive to the investment community, so it is increasingly difficult to start or finance new electronic operations.

For the sake of the future growth and well-being of most companies, more managers are going to have to run their businesses as if Wall Street didn’t exist.
When it comes to resisting demagnetization, new Indox® 7 is in a class by itself.

Summa Cum Oersteds.

With a coercive force of 3200 oersteds, Indox 7 has a higher resistance to demagnetization than any commercially available magnetic material except costly platinum-cobalt. It also has a high peak energy product and high intrinsic coercive force.

New Indox 7 requires no critical materials, is light weight and has high electrical resistance. Indox 7 opens new possibilities for designs and applications where greater resistance to demagnetization is required, or where the magnet length is limited compared to the magnet area.

Indiana General pioneered ceramic magnets, developed the first ceramic magnet for PM motors, and continues it's leadership in magnet technology with this new high in ceramic magnet materials. For a copy of the new bulletin on Indox 7, write Mr. C. H. Repenn, Manager of Sales, Magnet Division, Indiana General Corporation, Valparaiso, Indiana.

INDIANA GENERAL

1967, The Indiana General Corporation
Industry insiders say that General Electric is working feverishly to produce the industry's first under-$50 black-and-white 12-inch television receiver in time for the Christmas market. Dubbed the Adventurer, the transistorized receiver will sell for $49.95.

A flexible memory control technique that replaces conventional read-only memories has been incorporated in a research computer built by Automatic Electric. Conventional read-only memories cannot be easily altered; the new technique uses separate, replaceable printed-circuit cards for each instruction. Automatic Electric, the manufacturing arm of General Telephone & Electronics, will probably design the concept into its line of process control equipment within a few years. A paper on the new memory will be presented at the Fall Joint Computer Conference, Nov. 14 to 16.

Under the new method, called Picoprogram control, the complete sequence of steps taken to execute a particular instruction is stored on a single printed-circuit card. Different instructions—such as "compare" and "store"—address different cards; the cards for similar instructions—such as "add" and "subtract"—are physically distinct but resemble one another closely. The instruction repertoire of the machine can thus be changed simply by changing cards, making the computer extremely flexible.

Conventional third-generation computers have read-only memories in which a sequence of addresses prescribes the sequence of steps. Different instructions use different sequences, but the sequences for similar instructions overlap considerably. This minimizes the total number of words in the read-only memory—the number need not be much greater than the number of different instructions. But the overlapping also means that almost the entire memory has to be changed if the instruction repertoire is changed.

Also, if any particular step generates an error, the new machine stops in its tracks without completing the instruction in progress and this vastly simplifies trouble-shooting.

Within the next three or four years the Bell System will begin to install automatic equipment to locate and diagnose failures in its nationwide communications network. Work on the computer-operated checkout system should be completed within 10 years. Essentially all of the Bell System's fault-location and switching, to sidestep an out-of-commission line or microwave transmitter, is currently done manually. Top Bell engineers are quick to point out that, although some automatic checkout systems are being used for a few test functions, they leave much to be desired.

Westinghouse thinks it has a sure candidate for the Air Force's 621B satellite navigation program [Electronics, Aug. 21, p. 40], which seeks to provide quick, accurate fixes for supersonic craft. The potential Westinghouse entry, so far just an in-house study of accurate navigation techniques, has design goals that make it a natural for 621B: accuracy.
within 30 feet, simultaneous use by an unlimited number of planes, continuous service, rapid fixes (about a tenth of a second), immunity to interference, and service to the polar regions.

The Westinghouse investigation revolves around the use of interferometric antennas placed on widely separated satellites in synchronous orbit. Families of satellites—three or four to a family—provide two interferometers that establish a line of direction; the craft's position is determined from them. The reason for the accuracy is the wide spacing of the antenna satellites (about 5.5 miles), which provides greater sensitivity.

Design-it-yourself oscilloscopes have that common touch

By offering something no other oscilloscope maker has—commonality of internal parts, a refinement of the venerable plug-in technique—Measurement Control Devices Inc. is keeping its line competitive with the big instrument makers. MCD offers seven chassis and a wide choice of interchangeable printed circuit boards. The result is innumerable combinations that can be tailored to a user's specifications.

Major benefits, says the Philadelphia firm, are savings when building the circuit boards and purchasing parts; assembly according to sales; quick response to orders for custom scopes; and modifications accomplished simply by changing a value of some component on one of the signal-conditioning or amplifying p-c boards.

Bell System to use new magnetic alloy

A newly developed magnetic alloy will replace Vicalloy in the permanent memory portion of the electronic switching systems being installed in U.S. telephone exchanges. Developed at Bell Telephone Laboratories, the alloy of cobalt, iron, and gold is described as more ductile than Vicalloy and therefore more easily made into complex shapes, fine wires, or tape. Some of the Vicalloy magnets in the electronic switching systems' twister memories have lifted from the cards because of the mechanical stresses exerted during erasure and rewrite processes.

Three Bell Labs researchers told the International Congress on Magnetism in Boston last week that the magnetic properties of the new alloy change only slightly under high tensile loads and that the gold content will permit more careful control (by heat treatment) of the magnet's coercive force, which is the energy necessary to change the flux from positive to negative [For more on the Magnetism Congress, see page 45].

Although there has been considerable criticism of NASA's manned space programs, there has been little argument with NASA's contention that those programs produced valuable biomedical spin-offs. However, there's a growing feeling that the space agency does more talking about such benefits than is warranted by results.

The latest challenge came at the Engineering in Biomedicine Conference in Washington from John Lyman, a professor of engineering at the University of California at Los Angeles. He said that engineers working on space and defense projects don't look for biomedical spin-offs. Except for such concepts as microminiaturization, he pointed out, little of medical value has been gleaned from manned space programs. And much of his audience agreed.
All components shown actual size

Only the new Allen-Bradley Type S cermet trimming resistors have all these features

The Allen-Bradley Type S is a one turn cermet trimmer in which you will find incorporated a wider range of features than in any other trimmer now on the market. Here are a few of the more important features.

- **COMPACT**—body is ¾" dia.
- **BUILT FOR EITHER TOP OR SIDE ADJUSTMENT**
- **50 OHMS THRU 1 MEGOHM**
- **THE SEALED UNIT** is immersion-proof
- **TEMPERATURE COEFFICIENT** less than 250 ppm/°C over all resistance values and complete temperature range
- **UNIQUE ROTOR DESIGN** provides exceptional stability of setting under shock and vibration
- **SMOOTH CONTROL**, approaches infinite resolution
- **PIN TYPE TERMINALS** for use on printed circuit boards with a 1/10" pattern
- **VIRTUALLY NO BACKLASH**
- **WIDE TEMPERATURE RANGE** from -65°C to +150°C
- **RATED ½ watt @ 85°C**
- **EXCEPTIONAL STABILITY** under high temperature or high humidity
- **MEETS OR EXCEEDS ALL APPLICABLE MIL SPECS**
- **COMPETITIVELY PRICED!**

CERAMIC MAGNETS

Remington takes advantage of the high energy of Allen-Bradley ceramic permanent magnets to achieve the small size required for the ideal performance of their 500 Selektronic shaver

This custom designed ceramic magnet is the result of cooperative efforts by Remington and Allen-Bradley engineers. Despite the complex geometry of the magnets, Allen-Bradley was able to achieve high volume production at reasonable cost.

Allen-Bradley MOS-C ceramic permanent magnets are radially oriented and can be furnished in segments for d.c. motors measuring no more than 3/4" diameter up to a maximum rating of 10 hp. Coordinated and adequate manufacturing facilities at Allen-Bradley and tight quality control assure delivery in quantity - on time!


TYPE MOS-C CERAMIC PERMANENT MAGNETS

Typical Characteristics—stated values have been determined at 25°C.

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
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<tr>
<td>Residual Induction (Br)</td>
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<tr>
<td>Coercive Force (Hc)</td>
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<tr>
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<tr>
<td>Weight per Cu. In.</td>
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</tr>
</tbody>
</table>

The 500 Selektronic shaver features a unique dial which adjusts the shaving heads to four shaving positions for any combination of skin and beard, plus TRIM position for sideburn trimming and CLEAN position for instant cleaning. The shaver operates on its rechargeable energy cells or from an electric cord.

ALLEN-BRADLEY
QUALITY MOTOR CONTROL
QUALITY ELECTRONIC COMPONENTS
STOP HIGH ENERGY TRANSIENT DAMAGE WITH NEW ZenGard* SUPPRESSORS

Protect entire electronic systems subject to damage or destruction from random power surges up to 12 kW with the new line of MPZ5 series ZenGard transient suppressors!

Their compact size (each occupies less than 2 cubic inches) belies their impressive advantages over conventional suppressors:

- predictable temperature sensitivity and relatively constant breakdown voltage over a −65° to 175°C operating range
- inherent parameter stability over long-term use
- absolute non-existence of ringing
- low 50 μA quiescent current

Sharp reaction time and clamping factors \( \frac{V_s(\text{max})}{V_s(\text{min})} \) as low as 1.25 mean significantly lower overshoot voltages, consequently less chance of component degradation and burn out.

Economical, ZenGard transient protection for virtually any high-energy application (1000 W units have been supplied to hi-rel requirements) is made possible by the Motorola-originated Multi-Cell technique of mounting individually matched zener diodes on a common heat sink. The same desirable, sharp, controlled reverse breakdown characteristics as Motorola's other 250 mW to 50 W zener diodes are ensured.

Evaluation units available now! . . . non-standard voltages, lower clamping factors and higher power units can be supplied to specific needs!

FAST PHOTO SENSORS AID LIGHT-ACTivated DESIGNS

A tiny photo detector — type MRD200 — and a sensitive phototransistor — type MRD300 — now provide opportunities to simplify light-activated designs!

Functional and compact (only 0.060" diameter), the MRD200, two-terminal unit serves where small size, precise alignment and high density arrays are required such as high-speed tape and card readers and rotating shaft information encoders.

It displays linear characteristics over the dynamic range—ideal for reading film sound tracks. Total \( t_{on} \) and \( t_{off} \) is only 6.5 μs (max.) allowing faster reading than any mechanical contacts. And, its extremely narrow field of view minimizes cross-talk.

With equally fast rise and fall time, the MRD300 utilizes a TO-18 case with external connections for added control and excels in applications where high sensitivity is essential. It responds to modulation well above the audio spectrum.

Both units operate from 1 V to 50 V power supplies and are compatible with most transistor circuits. Low leakage permits use in direct-coupled designs for low-signal-level operation.

Evaluate them now! . . . Send for Introduction to Optoelectronics and a new data sheet!

Use the reader service card for complete data on these products or write Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

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<th>TC 15°C to 25°C max</th>
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<td>16.3</td>
<td>0.15</td>
<td>5.5 μA/mW/cm² (min)</td>
<td>10 μA/mW/cm² (typ)</td>
</tr>
<tr>
<td>MPZ5-251 B &amp; A</td>
<td>350 V</td>
<td>25.1</td>
<td>0.25</td>
<td>12 μA/mW/cm² (min)</td>
<td>20 μA/mW/cm² (typ)</td>
</tr>
<tr>
<td>MPZ5-166 B &amp; A</td>
<td>500 V</td>
<td>35.0</td>
<td>0.50</td>
<td>15 μA/mW/cm² (min)</td>
<td>25 μA/mW/cm² (typ)</td>
</tr>
</tbody>
</table>

MRD300 combined with 2N4198 ELF* SCR (600 V) gives total \( t_{on} \) of 300 ns. Single light source coupled by multiple-output fiber optic bundle transmits light to photo transistors. Fast \( t_{on} \) is accompanied by gate isolation advantage.

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†Patents Pending

Circle 29 on reader service card

Circle 31 on reader service card→
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Computer

Little brother

When the Hewlett-Packard Co. introduced its 2116A computer at last year's Fall Joint Computer Conference, it stressed that the machine was specifically designed to handle data from instrumentation systems. And so it was. But at the upcoming FJCC, Nov. 14 to 16, H-P will unveil a companion to the 2116A, a stripped-down version with almost the same capability but costing considerably less. And now the company makes no bones about its intentions. "The elaborate software program we developed for the 2116A suits it for a much bigger market—the general-purpose market," says Tom Perkins, marketing manager of H-P's Dymec division.

The announcement marks Dymec's entry into the field of general-purpose computers.

The new machine, called the 2115A, will be available early next year at a price of about $16,500 including a teletypewriter, and will compete with the Digital Equipment Corp.'s PDP-8. Its introduction runs counter to the recent trend among makers of small digital computers, who have generally been tying their products into instrumentation systems [Electronics, April 17, p. 161]. Hewlett-Packard found that half its sales of the 2116A were for general-purpose computation.

**Bilingual.** The 2115A retains a feature of the 2116A that made it especially attractive for instrument systems: input-output channels are controlled by plug-in cards, rather than by resoldering. But H-P is offering both Fortran and Algol compilers with the new computer to make it useful for problem-solving as well. Algol will also be available with one 2116A, and H-P may offer still another language, reportedly the General Electric's Basic, at a later date.

At its price, says Perkins, the 2115A affords an attractive alternative to time-sharing for general-purpose computing. Hewlett-Packard itself currently uses about 20 remote stations linked to a GE computer in Berkeley, Calif., but Perkins says the 2115A will almost certainly be used to augment this computational capability.

**Narrowed ranges.** The 2115A looks like its big brother, differing from it only in physical size and in a few specifications. Operating temperature limits are only 15° to 45°C, against the 2116A's 0° to 55°; cycle time is 2 microseconds instead of 1.6; all other speeds are also 25% slower; core memory is 4,096 or 8,192 bits instead of 4,096 bits expandable to 32,000; and the 2115A will accept only eight input-output plug-ins at a time, down from the 2116A's 16. Both machines have 16-bit word lengths.

By cutting down on memory space and the racks for plug-in boards, and redesigning the power supply, H-P managed to pack the 2115A into a box 16¾ inches wide, 12½ inches high, and 24¾ inches long. Since its logic structure is the same as the 2116A's, however, any program written for the larger computer will work with the smaller.

The 2115A is by no means a final step. "We envision a family of computers using the same software package," Perkins states. He clearly implies that H-P has set its sights on producing an even less expensive general-purpose computer.

**Logical steps.** Dymec, which makes data acquisition systems, got into computers 2½ years ago when Kay Maglesby, the division's engineering director, saw that if Hewlett-Packard were to continue as a leader in the instrumentation field, it would have to produce machines.
capable of handling increasingly complex instruments. Dymec began at that time to develop a small process control computer. "The aim was to make one that would operate as simply as a microscope," Maglesby says. The resulting 2116A had an extremely sophisticated software package for a small computer, a factor that may have added to its cost but also allowed for the development of a family of machines.

But the 2116A was designed to operate in the severe environments that its associated measuring instruments had to endure. The cost of providing a 0 to 55° temperature range contributed considerably to the 2116A's main-frame price of $22,000.

The 2115A, on the other hand, is designed for more friendly environments. And to emphasize its commitment to the computer field, n-p is providing the smaller computer with a retinue of peripheral devices for its EJCC debut. These include:

- A high-speed disc memory with 150,000-word storage, made by Data Disc Inc. (with an optional direct access module so that memory can be transferred directly from disc core);
- An extended arithmetic unit, with plug-in hardware to replace software routines, that can speed some operations by a factor of 10 and save some core space;
- A high-speed line printer built by the Data Products Corp.;
- A high-speed card reader from Soroban Engineering Inc.

### Manufacturing

#### Retreading bad IC's

Considering integrated circuit manufacturing costs and the number of imperfect circuits that have to be thrown out, it's no wonder that IC makers continually search for ways to boost yield. National Semiconductor is using a new way to keep down its throwaway rate: retreading rejects with a laser resistor-trimming technique.

The circuits are hybrid IC operational amplifiers with loose specifications—high-input offset voltage, for example. For good performance, this specification should be as low as possible. By trimming one of the circuit's two input resistors, the Danbury, Conn., firm is cutting offset voltage to almost nothing.

Results have been so encouraging that the firm may market hybrid op amps with offset voltage well below 1 millivolt—a level formerly approached only by discrete component op amps. Offsets as low as 50 microvolts already have been easily achieved experimentally.

**Unyielding.** National Semiconductor turned to the new technique because of the difficulty encountered in achieving the specified 1 mv offset for its premium op amp, the 7560A. Most of the IC's had offsets of 4 to 10 mv. As a result the company was forced to sell these op amps as its second line, the 7560, at half the $45 price of the premium model.

The laser system has doubled the yield of 7560A's. This, in turn, has resulted in delivery time being cut to one month.

Each IC is placed in a jig in the trimmer, power is fed to the IC, and an operator vaporizes the resistor material until the required offset level is reached. This fine tuning during circuit operation is possible only with the laser technique. Other methods, such as sandblasting or sending voltage or radio-frequency surges through resistors, can either contaminate or overheat other circuit components. Builder of the laser trimmer was Spacerays Inc. of Burlington, Mass.

The system uses a pulsed-ruby laser, and is part of a family of four trimmers now being marketed by the firm. The trimmers can be adapted to either manual or automatic operation, and can also be used for discrete cerment, wire-wound, and thick- or thin-film deposited-carbon or metal resistors.

**Busy signal.** Western Electric in North Andover, Mass., has also purchased a Spacerays trimmer and may use it in the production of precision voltage-divider IC's in the Bell System's forthcoming T2 pulse-code-modulation telephone carrier system.

Western Electric is now trimming glass-encapsulated, deposited-carbon resistors with the device. Indications are that the company has achieved tolerances well below 1% in some tests. Before trimming, the resistors were often more than 10% off the mark.

### Advanced Technology

#### Righter light

Solid state lasers now have a chance of achieving the efficiency of carbon-dioxide lasers, which can convert more than 30% of their input to coherent light. If they succeed, the major reason will probably be a new breed of pump lamp developed by the Xerox Corp.'s subsidiary, Electro-Optical Systems of Pasadena, Calif.

Eos has done what others have tried and failed to do: it has built a pump lamp with an emission spectrum that can be tailored to the absorption spectra of various laser crystals. In one of the company's experiments, it matched a lamp to neodymium-doped yttrium aluminum garnet (Nd:YAG), one of the most efficient laser crystals available.

**Waste not.** Commonly used xenon arc lamps emit 95% of their light at wavelengths Nd:YAG can't absorb; eos's lamp can put 30% to 50% of its output on or near the absorption lines of Nd:YAG. The company's light source engineering department, under its manager, David Pollock, used a mercury arc lamp to which had been added small equal amounts of the iodides of sodium, potassium, and rubidium.

Both Raytheon and Eos &c, one of the nation's largest pump tube supplies, tried to develop such matched light sources and failed. Stanford University and the National Aeronautics and Space Administration also met with mixed results.

These researchers may have been stymied by absorption of light by atoms of the very elements used to generate desired wavelengths.
In most laser pump lamps, light originates in highly energized atoms in the electric arc along the axis of the tube. But to reach the laser rod, the light must pass through a layer of cooler atoms near the glass tube envelope; these cooler atoms absorb much of the desired light.

Eos found that by adding the desired elements as iodides, this reabsorption didn't occur. Light could still be generated in the hot area of the arc whose energy would break up the iodide molecules, freeing the atoms to emit at the desired wavelengths. The additives stay in molecular form in the cooler area near the envelope and therefore do not absorb the desired wavelengths.

The company's lamp blankets three of Nd-YAG's four absorption wavelengths: 5,000, 5,800, 7,400, and 8,100 angstroms. These absorption lines are bigger targets than they appear to be; eos has found them to be about 200 angstroms wide, and adding a small amount of chromium to the rod broadens the lines even further.

The 5,500-angstrom line is served by one mercury and two sodium emission lines at 5,780, 5,880, and 5,890 angstroms. The 7,400-angstrom line is pumped by two potassium lines at 7,500 angstroms and 7,600 angstroms. The 8,100-angstrom line benefits from rubidium's 7,950-angstrom emission and sodium's light at 8,195 angstroms.

**Waiting.** All this potential is going to waste. Vietnam work has pushed laser research into the background—so far in fact that the new tube has yet to be tested in a laser.

But lamps like it may soon see service as reconnaissance light sources in Vietnam. Eos has several classified contracts for lamps that would emit only at specific wavelengths to supply covert illumination for tactical photography.

### Attractive memory

When it was discovered several years ago that europium oxide (EuO) was ferromagnetic—the atoms line up in a common direction in a saturating magnetic field—it was predicted that EuO film would be valuable for a laser-beam addressable memory since the laser's heat affects the material's magnetic state. What made it attractive was the fact that EuO is one of a few materials that is both an electrical insulator and transparent to many optical frequencies.

Last week in Boston at the International Congress on Magnetism, two researchers reported success with the material. "It can maintain small magnetization reversals, and it requires low energy for readout purposes," said George Y. Fan of IBM's Yorktown Heights, N.Y., Watson Research Center.

In most efforts on laser memories, the beam writes on a photosensitive material. The EuO film memory under development by Fan and J.H. Greiner at IBM employs heat writing and a magnetooptic readout.

It operates at liquid nitrogen temperature, but it is working on selective doping, which could lessen this inconvenience. The doping method may substantially increase the material's Curie temperature—the point at which ferromagnetism disappears and the magnetic moments become disordered.

**Heat wave.** While in a magnetic field, the EuO film is cooled below the Curie point, making it ferromagnetic. When the saturating field is removed, the film remains ferromagnetic. Then a small biasing field is applied in the opposite direction and when a focused laser beam hits a spot on the film, the temperature of that spot is raised above the Curie point and the ferromagnetism is destroyed. When the spot cools down, the ferromagnetism returns but the direction of bias field at that spot has been changed with respect to the rest of the film.

For readout, laser light is transmitted through the film or reflected by it. In either case, magnetooptic effects are detected. The difference in the state of magnetization at a spot changes the plane of polarization of the readout light, and this either lets light through or blocks it. In the experimental setup, a photomultiplier detects these ones and zeroes after the signal is trans-
mitted through the polarizer.

Quick reading. With thermal writing, says Fan, a low-power semiconductor laser beam can provide nanosecond nondestructive readout of a small bit size. The researchers have written bits of less than 3 microns in diameter with a 1-milliwatt laser in 10 nanoseconds.

In high-speed reading experiments, says Fan, a good signal-to-noise ratio was achieved by a 1-milliwatt gallium arsenide laser pulse of a few nanoseconds duration. Initial experiments indicate that the magneto-optical effects in EuO—particularly the change in polarization of light when directed at a magnetized film—are greater than in garnets. “And the greater the polarization change,” Fan points out, “the better the signal-to-noise ratio.”

Fan sees a potential for this type of storage in a medium, dense, high-speed memory, which would offer a unique combination of size and speed.

Close look in 3D

Within five years, NASA officials believe, every circuit made for a space mission will probably undergo a super-inspection by nondestructive microscopic techniques that aren’t available today. The agency’s Electronics Research Center is working on two tools for nondestructive screening of monolithic integrated circuits: holographic microscopy and scanning electron mirror microscopy.

“It’s no good that 99 out of 100 IC’s are flawless. All must be screened and all must be flawless,” points out Kenneth G. Carroll, a staff physicist at the Cambridge, Mass., center.

The microscopic techniques being refined for nondestructive screening of tiny circuits will also yield new kinds of information on blood cells and in other areas of the life sciences.

In fact, the application of holographic microscopy to molecular biology preceded the present attempt to develop this tool for detecting circuit flaws and processing defects.

“Through holography, a living cell can be examined in great detail before and after it splits, or before and after it moves,” says Raoul F. vanLigten, a research scientist at the American Optical Co., Framingham, Mass. “Holographic microscopy offers a similar possibility for integrated circuits. When you energize a chip, the result is similar to a living cell in motion. You can compare it, in three dimensions and in great detail, with itself as it was before the change was made.”

Below the surface. VanLigten, who has been working on holographic microscopy for biological applications since 1965, has a NASA contract to explore the tool for inspection of IC’s. Two approaches, using lasers, are planned: output in the visible spectrum and in the infrared. Since silicon is transparent to infrared radiation, this technique is expected to go beyond surface symptoms and disclose what is going on inside an activated circuit.

Many microscopic techniques developed in recent years can be employed to compare circuits with the norm. Stress will be put on the possibility of obtaining signatures in the form of interference patterns, formed when a coherent wavefront carrying information about a standard reference circuit is made to interfere with one bearing information on a circuit under inspection.

“The patterns will be like contour maps. Bumps caused by thermal expansion at hot spots, for example, will cause changes in the interference fringes,” says vanLigten.

Unique approach. Signatures of a different nature are expected from a scanning electron mirror microscope. The unique technique, being explored under a NASA contract by the Advanced Metals Research Corp. of Burlington, Mass., would add a scanning feature to the electron mirror microscope to combine high resolution with nondestructive inspection.

With this technique there is no bombardment of the sample by the electron beam. The sample is kept slightly negative to the beam, which is reflected from an equipotential field located above the surface.

Voltage between sample and ground sets up an electric field, which is an electron mirror of the sample. The instrument will scan the field and measure the gradients. These slopes will be displayed on a television-type monitor to provide a signature of the sample. It’s believed that the fine-scanning beam will provide a resolution of better than 500 angstroms, 1/20th of a micron.

Consumer electronics

Toying with SCR’s

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Electronics Review

blenders, auto turn signals, and a host of other consumer devices, is turning up inside a turtle.

In a simple but ingenious application, Remco Industries Inc. of Harrison, N.J., one of the leaders in the multimillion-dollar toy industry, has put a 27-cent SCR into a toy turtle that’s going to list for $14.95. The trick is that the SCR is turned on and off—making the toy move and halt—by voice command.

Whoa. A short burst of sound in the 800-hertz range turns on the SCR through a sound transducer. The SCR starts and stops a battery-operated motor that drives a gear train which propels the turtle. Thus, it can start moving at a shout of “Go!” or stop at a shout of “Stop!” It even responds to a whistle supplied with the toy.

Pat Tomaro, Remco’s engineering vice president, said that the company wanted a toy that would operate via an audio signal and a small current. “We tried out a relay-operated circuit,” he says, “but it was too costly and slow to react.” He consulted General Electric where applications engineers suggested the SCR approach.

Capsule operation. The SCR can be turned on by a small current from gate to cathode, and turned off by removing the load current or dropping it below the SCR’s minimum holding value. The SCR cannot be turned off by removing the gate current.

In the accompanying schematic, the SCR’s gate is shown grounded through the switch assembly and the sound transducer. When activated by a sound, the transducer momentarily breaks the ground and the SCR turns on to energize the motor. As the motor starts, it trips a shaft that moves the lever of the make-before-break switch, S2, from A to B, routing the SCR’s load current through the transducer. Upon activation a second time, the transducer opens the load circuit, the motor turns off, and the switch lever is reset to position A. The cycle is repeated as often as the transducer is operated.

The turtle operates from a pair of D-size dry cells that provide about 40 hours of operation.

On the go

Transistorized auto ignition systems require no servicing and hold a fairly flat performance curve over a period of time because they maintain a fairly constant ignition voltage. But there are some serious drawbacks: at high engine speeds the systems lose power, and they’re generally inefficient at low speeds. In addition, they have trouble restarting flooded engines in cold weather. While some individual designs overcome some limitations, the only real improvement is the quite expensive capacitor discharge system.

O.K. Nilssen, director of research for Motorola’s Automotive division,
variable viewing time  5 cm/µs stored writing speed

split-screen displays

all in the Tektronix Type 549 Storage Oscilloscope

Waveform display showing train of pulses. Upper screen in the stored mode shows three pulses with falltime of the pulse trailing edge showing system deficiency. Lower screen in conventional display mode shows the same pulse train with corrections applied to provide a well formed pulse shape. Pulse width shown is 8 µs with risetime of 0.1 µs. Vertical deflection factor is 0.5 volts/cm. Horizontal deflection factor is 10 µs/cm. Repetitive sweep used for both displays.

The Type 549 allows up to one hour of continuous visual storage, giving you ample time in most applications to measure and analyze stored waveforms. Stored displays can be erased in less than one-quarter of a second.

**Split-screen displays**

Unique with Tektronix storage oscilloscopes, split-screen displays bring you many advantages in waveform-comparison applications. You can use either half of the 6 cm by 10 cm display area for stored displays, the other half for nonstored displays, with independent control of each half. You can also use the entire screen for either type of display.

**Variable viewing time**

Variable viewing time — an outstanding feature of the Type 549 — allows you to automatically store displays, view them for a selected time, then automatically erase them on either or both halves of the screen. Two modes of operation are possible. In the After-Sweep Automatic Erase Mode, the selectable viewing time of 0.5 s to 5 s begins at the end of each complete sweep. After the viewing time, the display is automatically erased and the cycle begins again when the next sweep is triggered by a signal.

In the Periodic Automatic Erase Mode, the sequence of storing, viewing time and erasure is continuous and independent of the sweep or signal. In this mode, the viewing time can also be varied from 0.5 s to 5 s.

There is no degradation of stored traces during the selected viewing time, in either mode, and you can retain or erase displays manually whenever desired.

For a demonstration, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

**Bistable storage advantages**

With bistable storage oscilloscopes, such as the Type 564 and Type 549, the contrast ratio and brightness of stored displays are constant and independent of the viewing time, writing and sweep speeds, or signal repetition rates. This also simplifies waveform photography. Once initial camera settings are made for photographs of one stored display, no further adjustments are needed for photographs of subsequent stored displays.

Tektronix bistable storage cathode ray tubes are not inherently susceptible to burn-damage and require only the ordinary precautions taken in operating conventional oscilloscopes.

**Plug-in unit adaptability**

Vertical deflection characteristics of the Type 549 are extremely flexible through use of any of the Tektronix letter- or 1-series plug-in units. These include multi-trace, differential, sampling, and spectrum analyzer units. Depending upon the plug-in being used, bandwidth of nonstored displays extends from DC to 30 MHz.

Among other features of the Type 549 are 5 cm/µs stored writing speed, calibrated sweep delay from 1 µs to 10 s, sweep speeds to 20 ns/cm, amplitude calibrator from 0.2 mV to 100 V, and locate zone for easy positioning of stored traces.

**Tektronix Type 549**

Type 549, without plug-in units  $2475
Type 1A1 Dual-Trace Plug-In Unit  $625
DC to 30 MHz at 50 mV/cm; DC to 23 MHz at 5 mV/cm.
2 Hz to 14 MHz at 500 µV/cm, single-channel.

U.S. Sales Prices, FOB Beaverton, Oregon

For a demonstration, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

**Multi-trace, differential, sampling and spectrum analysis**

...in all Tektronix 530-540-550-series plug-in oscilloscopes
and J.F. Ziomek of Ford Motor's Product Research office have developed a new design for transistorized ignition systems that is an improvement over current designs. In a paper scheduled for delivery at the IEEE Automotive Conference in Detroit this week, they describe a simple ignition system using a saturable transformer in the positive feedback path of a one-shot transistor switch.

This approach, they claim, reduces power dissipation in the ignition coil as well as in the other circuit components because of its low current drain during stall. It also provides high electrical efficiency, and does not lose power at high engine speeds.

Their conclusion: the new ignition system can give 100,000 road miles of trouble-free operation.

Despite these improvements the auto firms are still reluctant to switch to transistorized systems because they are nearly twice the cost of conventional units.

**Good timing.** In another paper to be delivered at the conference, R.L. Ronci of Ford discusses a new breakerless trigger for a transistorized ignition. It eliminates periodic setting of the breaker point gap—there are no points—and engine retiming.

He has developed a relatively simple oscillator circuit capable of high average current drain achieved by using a transformer feedback arrangement. When there's no oscillation, the transistor is biased slightly into conduction. The small collector current established by the diode and the emitter resistor provides enough gain to start the circuit oscillating.

Once begun, oscillations build up without further cam movement beyond the critical point corresponding to unity loop gain. The circuit is put into the distributor housing in place of the breaker points. Rotation of the cam in the air gap of the trigger transformer causes the circuit to go into and out of nonlinear oscillations, producing a square wave through the 100-ohm resistor. The breaker trigger also can be used as a proximity switch for general automotive and industrial control applications.
1000 MHz
Frequency Synthesizer
80 dB Suppression of Spurious—Resolution 0.1 Hz

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Type XUC/ND30M provides frequencies to 1 GHz with 3 V output and 80 dB suppression of spurious signals. Here-tofore only low frequency synthesizers with a built-in X10 multiplier stage (which increases spurious and noise) were available. Now, with a TRUE UHF frequency synthesizer, Type XUC/ND30M supplies signals without this degradation in spectral purity.

Generation of higher frequencies can be accomplished in two ways using the XUC/ND30M:

a) Multiplication: Lower multiplication factors result in better S/N, for instance 60 dB at 10 GHz.

b) Synchronization: XUC permits continuous tuning. Synchronizes to any frequency up to 80 GHz. Positive synchronization without ambiguity and with better stability obtained by use of higher fundamental frequencies, larger output and improved S/N.

Applications include checking selective 2 and 4 terminal networks, frequency measurements, microwave spectroscopy, nuclear magnetic resonance, synchronization of microwave generators and tubes, etc.
resulted in a product that was too thick to be practical. The problem was solved by cutting down on the thickness of the Mylar. Further, the new tape requires no redesign of recording equipment; the operator need only rewind the tape or twist it to record or play back on the opposite side. Meyers notes, however, that recorders could be built with heads to pick up and play both sides simultaneously or separately.

Meyers estimates production costs at “not significantly more” than those of conventional tape. He believes the major market will be the entertainment field, but says the tape could also be of considerable value in computers and spacecraft, where storage space is at a premium.

He developed the process while working with Doris V. Stage, a chemistry professor at Madison, on an in-house grant to study photomagnetic phenomena. They have filed for a patent on the process and Meyers says several manufacturers have expressed interest in producing the tape.

**Little ears.** Although the Defense Department won’t discuss details for obvious security reasons, many features of the system can be predicted.

Detection must be covert, and the system will therefore use only sensors that are buried or camouflaged; this eliminates big radars from consideration. The sensors must be already operational, or nearly so, to meet the three- to six-month deadline set by the Pentagon. Also, facilities must be available for large-scale production.

The system will consist of many short links because most sensors operate best at short range, and because the division of the barrier into small sectors will make it easier to pinpoint attempted breakthroughs.

Each sector will be guarded by at least two kinds of sensors so that a false alarm by one can be canceled or clarified by the other. Also, a variety of sensors will be employed in a random mix so the discovery of one won’t reveal the nature of the others. And there will be a large number of decoys.

**Booby traps.** An elaborate telemetry network will tie every sensor to a central control station, and also, in some cases, to a mine or other kind of destructive trap. Thousands of telemetry receivers, fuses, and servo controls will be needed for the traps.

A battery of displays will be installed in the central station. If simple displays are used, reports will be ambiguous. To avoid numerous sorties by troops to confirm alarms, the shortcomings of each type of sensor might be programmed into a computer with instructions to check one sensor’s blind spots against information from other sensors. Since many combinations of detection devices are possible, programming the network will be a big job.

A number of anti-intrusion sensors are already, or nearly, operational. They include active-infrared, seismic, pressure, magnetic, strip, acoustic, and simple breakwire devices [Electronics, Aug. 7, p. 46].

The Army’s Ft. Monmouth is directing the project.
The only diodes we know of that are bottled-in-bond.

As a matter of fact, "bottled" is sort of a crude word for the way we fuse our diodes in glass. But it is a way to illustrate an important point.

In the Unitrode diode, the silicon die is metallurgically bonded at 1150°C to two terminal pins of exactly the same diameter and thermal coefficient.

This gives you a bond that is stronger than the silicon itself. So much so that the silicon will break before the bond does. Then the bonded unit is placed in a hard glass sleeve which is fused at 850°C to the entire surface of the silicon, giving you a voidless, monolithic structure.

It's true this is a lot more complicated than bottling, but it accomplishes a lot more than bottling, too.

In the first place, the unit is almost indestructible. The machine hasn't been built that can fail a Unitrode diode in acceleration, vibration, and shock tests.

And then, because both pins and glass match the silicon's thermal coefficient, even the tiniest Unitrode diode can withstand a one microsecond surge of 600 amps. And the largest (which is pretty small, too) can take 4000.

Every Unitrode can handle as much energy in the avalanche as in the forward direction, and still meet initial spec limits after 2000 hours of life-testing.

What else?

Well, you can apply full PIV at high temperature to a Unitrode diode for weeks at a time, and it's just a waste of good current, because it doesn't move it.

All of which isn't to say that some of the other things that are bottled-in-bond haven't got some pretty interesting characteristics. But they're hardly in competition.

There's one thing they do have in common, though. "Bottled-in-bond" on the label usually means you can rely on the quality. We try to build the same idea into our parts. It's true, we end up with a product that may be better than some applications really need. But we're willing to accept that. You can't sell everybody...

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The wide variety of plug-in oscillator accessories and range modules makes the Model 6000 adaptable to a number of jobs in the field and in the laboratory. Portable, battery operated with rechargeable batteries.

Model 6000 with 601A charger, less plug-in modules $195.00

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Electronics Review

For the record

Car tests. Using what its maker bills as the first computer system for checking auto health, two diagnostic centers have opened in Elizabeth, N.J., and Chicago. The developer is Universal Testproducts, a subsidiary of Allen Electric and Equipment Co. of Kalamazoo, Mich. At the centers, an Allen 1280 digital computer produces a printed readout grading the car good, failing, or marginal in 150 tests ranging from air conditioner to windshield washers. On another front, the Pontiac Motor division of General Motors plans to offer its 3,400 dealers a new electrical diagnostic system called Sercon (for service connection). It plugs into bulkhead connectors and checks out a car's major wiring in a single test instead of having a mechanic check the battery, horn, and so on individually.

On track. Drivers on superhighways may soon be leaving the driving to electronics. Two independently developed automatic control systems, which will be described at the IEEE Automobile Conference in Detroit next week, can keep a car on course and properly spaced in high-speed traffic. At Oklahoma State University, engineers have tested a guidance control system that features an electronic eye which tracks a line painted down the highway. The system steers and brakes the vehicle. Meanwhile, an Ohio State University team has developed a system, using infrared radar, for automatically spacing cars.

Light touch. The fast-spinning turbine spools of jet engines may soon be balanced and freed from vibration and the job will be done with lasers. For $69,000, Spacerys of Burlington, Mass., is building a prototype production line balancing system for the Allison division of General Motors, a major jet engine producer. The pulsed laser system will remove excess metal from turbine spools as they rotate at operating speed; these spools are the largest, heaviest candidates to undergo laser dynamic balancing yet.
Two 100-megawatt modulator waveforms can’t indicate your best choice in a switch tube. But our unbiased advice can.

That’s because we’re experts in both high-vacuum power tubes and hydrogen thyratrons for pulse modulation. So we play no favorites when it comes to helping you with tube selection. In fact, we work directly from your particular application requirements in specifying or designing the right tube for the job.

We’re used to solving problems in existing systems, too. For example, negative grid current in high-vacuum power tubes. It was a characteristic that had been causing excessive equipment downtime in LORAN navigation transmitters...until we developed the Type F-1086 vacuum tube in which there is no negative grid current throughout the operating range of the equipment.

We’ve been just as busy in ceramic hydrogen thyratron R&D. For Type 8479/KU-275A, we perfected a new keep-alive electrode. It allows the tube to switch up to 100 megawatts and maintain less than 0.15 microseconds variation in anode delay time over a wide range of operating conditions. The result: a “repeatable” tube for the largest linear accelerators.

By applying a new gradient technique from our F-1087 100-KV thyratron development, we are developing a tube that will have almost four times the current carrying capability as the KU-275A...and with even greater voltage hold-off.

And we’re doing a lot more in the gas-and-power-tube field to benefit your design needs. Ask us for general information or specific answers. Write: Dept. EL, Electron Tube Division, International Telephone and Telegraph Corporation, P.O. Box 100, Easton, Pa. 18043.
Wayne Kerr
B801B VHF
Admittance Bridge

±2% ... 1-100 mc

...Balanced or Unbalanced Measurements on Antennas • Cables • Transmission Lines. Also, Input Impedances of Amplifiers and Receivers • Transistor Parameters • VSWR, etc.

Versatile describes the features and performance of the new Wayne Kerr B801B VHF Admittance Bridge.

Alone, the B801B provides ±2% accurate measurements of antennas, cables and transmission lines, as well as input impedances of amplifiers and receivers over the frequency range 1-100 mc. It can also be used for checking transistor parameters, VSWR, and a wide variety of component measurements, including shunt capacitance of coils.

In conjunction with the Wayne Kerr Q801 Adaptor, the B801B provides a most convenient means for performing both grounded-base and grounded-emitter measurements of all common small-signal AC transistor parameters, from 1-100 mc.

Of particular importance, two-terminal balanced or unbalanced measurements and three-terminal measurements are easily performed, and thumb-wheel-activated dials permit rapid bridge balance and direct readout of admittance in terms of conductance and positive or negative capacitance.

Weighing only 9 pounds, the B801B is readily portable to remote locations such as field antenna sites, cable runs, and transmission lines.

B801B in conjunction with Wayne Kerr SR268 Combined Source and Detector, with single dial tuned system to provide ganged tuning of source and detector from 100kHz-100MHz simultaneously in one operation.

For literature and detailed specifications, write:
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INNOVATIONS IN INSTRUMENTATION

Electronics Review

Day in court. The Radio Corp. of America has successfully defended its ownership of one of the basic color-television patents. The 65-page ruling of the Federal District Judge Caleb N. Wright in Wilmington, Del., went against Philco-Ford, whose attorneys have not yet decided whether to appeal.

Radar award. The Radio Corp. of America will get an initial $2.5 million Air Force contract to build the FVS-95, an over-the-horizon radar to be installed at undisclosed sites overseas as part of the 466L/440L electromagnetic intelligence system [Electronics, May 1, p. 48]. The office of the Air Force Secretary predicts the total value of the contract will run to about $8 million. In the competition for the order, RCA beat out General Electric, ITT, and a unit of Sylvania Electric Products.

Happy landings. Space agency officials this month nervously sat through two missions that experienced technical hitchles but finished strong. Surveyor 5, despite fuel system problems that seemed for a while insurmountable, soft-landed on the moon within 18 miles of its target site. The television cameras aboard immediately began to transmit high-resolution pictures described as "best yet from a Surveyor," and the magnetized leg of the craft picked up a generous supply of magnetic particles from the lunar surface. Over the same weekend, communications problems and a tropical storm in the recovery area caused Biosatellite B—with a passenger list that included plants, beetles, wasps, and fruit flies—to be returned to earth after two days in orbit instead of the scheduled three. An Air Force plane snared the encapsulated specimens in mid-air and flew it to Hawaii. The purpose of the mission was to determine the effects of weightlessness and radiation on living organisms. NASA's relief after the tense weekend was more than understandable as each of the satellite's predecessors had failed; Surveyor 4 crashed on the moon in July and the first Biosatellite wound up stranded in orbit last December.
Why buy price at any cost

To pay too little is to obviously speculate. To spend too much is to be foolishly extravagant. The real value of any purchase is determined in performance, not price. Resistors are like this also.

For years, Stackpole fixed composition resistors have been the standard of value for many leading manufacturers of electrical and electronic equipment. Engineers have become familiar with the testing and evaluation that go into each Stackpole resistor order. Purchasing people know they can expect prompt delivery. And management is assured of complete, in-depth service backed by sixty years of experience.

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Uniformity is a known characteristic of Stackpole resistors. Unique production methods coupled with thorough testing assure you absolute performance. You can rest assured that the Stackpole resistors you order today will be identical in every way, order after order.

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TODAY, A LARGE PERCENTAGE OF "GREATER PERFORMANCE"
SILICON TRANSISTORS MAKES USE OF
ONE OR BOTH OF THESE TWO KEY INVENTIONS.
BOTH ARE PATENTED BY MOTOROLA.*

*Field Relief Electrode — Patent #3,302,076
Annular Structure — Patent #3,309,245 and #3,309,246

—where the priceless ingredient is care!
EFFECT:

...Total NPN/PNP Silicon Transistor Coverage

No matter what your application, chances are Motorola has a Silicon Annular transistor to fit it. The charts above are indicative of the broad voltage and current ranges covered. All are fabricated using the Annular Process, Field Relief Electrode or both. Result: State-of-the-art devices -- free of failure due to surface or bulk defects!*

If you've been hemmed-in by designs that you had to put "on the shelf" for lack of an appropriate or inexpensive Silicon transistor -- drag 'em out and dust 'em off! We've prepared a simplified, yet comprehensive cross-reference and selector guide for all types of Silicon transistors -- General Purpose Switches and Amplifiers, Saturated Switches and Small-Signal RF devices -- that shows you the kind of performance available. Send for it.

*Motorola's Annular Process transistors are free of failure due to surface or bulk defects; MIL-qualified雪山 exceptions.

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Two words caught in the semantics squeeze.

Should you be looking for components that won't ever fail? Is failure rate the only measure of reliability? Is confidence in a supplier bred only by statistical accumulation?

Today, there's no such thing as a part that can't fail. And "statistical confidence" from millions of test hours is economically prohibitive because as failure rates decrease, the cost-of-proof increases sharply.

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For the first time, you can attach a recording oscillograph directly to a data tape recorder or telemetry system without attenuation or external signal conditioning equipment.

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The advance has been made possible through the use of five new CEC high impedance galvanometers: Type 7-601-0001 (0 to 100 Hz); Type 7-602-0001 (0 to 500 Hz); Type 7-603-0001 (0 to 1000 Hz); Type 7-604-0001 (0 to 2000 Hz); Type 7-605-0001 (0 to 3000 Hz).

Now consider the advantages which these galvanometers share in common.

D-C sensitivity: ±1.414 volts will produce ±2 inches, ±5% deflection. Input impedance to high impedance galvo: 100,000 ohms minimum.

And here are the oscillographs!

CEC's new 5-124A-H and 5-133-H are not only the first high impedance oscillographs — but are "first" in other ways as well.

The portable 5-124A-H is the ideal answer to a host of industrial problems. It provides up to 18-channel print-out recording, 10 speed ranges, and record drive systems with 16 options from 0.25 ipm to 128 ips. And—with CEC's DataFlash Takeup Accessory, the 5-124 A-H requires only 1 second to readout.

The advanced 5-133-H utilizes two galvanometer magnet assemblies. Galvo recording lamp intensity is individually controlled so as to permit recording from either magnet assembly, or both. Thus two data setups can be made at one time and recorded simultaneously, or be made alternately and recorded sequentially utilizing full chart width for each. Furthermore, if so desired, standard CEC galvanometers may be used interchangeably with the high impedance units.

The 5-133-H offers 5 recording modes — 3 direct writing and 2 develop-out, and is available in 12-, 24-, 36- and 52-channel configurations. Graphic reasons why the new 5-133-H is the logical choice for FM data analysis, telemetry discriminator output recording and communications applications.

For complete specifications and all the facts about these new high impedance oscillographs, write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Ask for Bulletin Kit 351-X4.

CEC/DATAGRAPH PRODUCTS

Bell & Howell
Electronics | September 18, 1967
Kick the hot-tube habit.

Elgar's new 500-VA precision AC power source has all-silicon, solid-state circuitry for continuous, trouble-free operation. It's just 7 inches high by 9 inches wide by 18 inches deep or standard rack mounting.

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Polaroid needed a battery for the Swinger that wouldn’t blow its cool.

Mallory made it.

What can we do for you?

Polaroid needed a battery for the Swinger, its new 15-second film camera. A battery to power the Swinger’s flash unit by night. A battery that could also work in its electric eye system by day. Yet a battery that could keep its cool—last for at least a year’s average service.

Mallory made it. The battery—a Duracell® alkaline battery. It packs enough energy in its penlight size to flash over 1400 bulbs (an ordinary battery would flash less than 500). It provides steady, reliable power for the electric eye system. And it can be stored for 2 years and still retain 85% of its original capacity.

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We're committed to the manufacture of the industry's finest line of 930 DTL integrated circuits.

Our customers know they could buy these monolithic integrated circuits elsewhere, but here's why they don't.

No one else has a better or more modern facility devoted exclusively to the manufacture of microcircuits.

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No one else has provided better delivery.

No one else offers better prices on the same quality products.

And no one else has a more substantial name behind them than the "Stewart-Warner" name—for more than eighty-five years a leader in the manufacture of quality products.

Our customers are pleased with the superior quality of our products. If you try them, we know you will be pleased, too.

Why not talk to one of our representatives? And, meanwhile, let us send you our 20-page "Composite Data Book" with the industry's most complete coverage of 930 series Flat Packs, Dual In-lines, and TO-5's.
If Freon® is the “high-priced” cleaning agent

...how come it paid for itself in one year at Hazeltine?

Nearly all the printed circuits produced by Hazeltine at its plant in Riverhead, New York, go to customers in the space industry...who demand flawless components in spotlessly clean circuits.

Until two years ago, Hazeltine cleaned its printed circuits manually in other solvents. This system was effective, however, it was not very efficient... too expensive and time-consuming. In the spring of 1965, a new Branson printed-circuit-board cleaning system using FREON® TMC was installed. This new system cleaned 50 pieces of equipment in the same time it took the old system to clean one. The total outlay for the new equipment was less than $5,000. By the following spring it was completely amortized. Since then, FREON has been making money for Hazeltine.

The entire cleaning operation is done with the dissipation of only three gallons of FREON a day, compared with 28 gallons of the former solvent, which had to be discarded daily because of contaminant buildup. The reason for the better than nine-to-one advantage is that FREON itself can be cleaned. A small distilling and filtration tank reclaims FREON and returns it to the vapor degreaser crystal-clear.

How fast can FREON, the “high-priced” cleaning agent, pay for itself in your operation? Your first step in finding out is to write: Du Pont Company, Room 5321, Wilmington, Delaware 19898. (In Europe, write: Du Pont de Nemours International S.A., FREON Products Division, 81 route de l’Aire, CH 1211 Geneva 24, Switzerland.)
Washington Newsletter

September 18, 1967

Navy okays LSI for data system

The Navy is about to launch what is believed to be the first application of large-scale integration in operational military hardware. Preliminary studies by prime contractor Litton Industries convinced the Naval Air Development Center that using LSI in the AN/ASW-27 two-way digital data link is feasible. Navy representatives and engineers from Litton’s Data Systems division met last week in Van Nuys, Calif., to decide where large-scale integration could be used and what functions should be allotted to specific chips.

FAA reconsiders Comsat plan for airlines’ satellite

Comsat’s proposed aeronautical services satellite, twice shot down by the FAA, has a new lease on life. Reason: a new proprietary technical approach by Comsat has considerably reduced the estimated price tag. The FAA returned two preliminary proposals by Comsat—the first time for cost and technical reasons, the second time for cost alone [Electronics, Aug. 7, p. 65]. Comsat has quietly submitted a detailed proposal for the satellite which would relay vhf communications between transoceanic airliners and ground stations. A decision by the FAA is expected in about two months. Comsat told the FAA that the satellite could be operational by 1970.

Improved avionics for Navy’s A-6A

Improving the mean time between failures (MTBF) of the search radar and the computer on the A-6A Intruder is a key goal of the $4.5 million redesign contract awarded to Grumman. Replacement of the craft’s Litton computer with an IBM 4-Pi Model CP [Electronics, June 26, p. 59] is expected to boost the MTBF from 20 hours to as much as 2,000 hours. Norden, current radar supplier, will improve the MTBF on its radar from the present 10 hours to 90 hours. Grumman figures that even with the improvement the avionics will still cost a bit less than the current $2 million a plane. The Navy contract is seen as an indication that more A-6A’s will be ordered, especially since production plans for the troubled F-lllB are still nebulous.

U.S. seeks peace as cable-satellite war heats up

The White House has told the FCC to arrange a quick, quiet settlement of the escalating battle between cable and satellite interests. The Government doesn’t want a full-blown squabble in the U. S. just when it’s promoting international satellite communications to strengthen the U. S. position before renegotiating the Intelsat agreement in 1969.

AT&T and other U.S. carriers want a new 720-circuit cable (TAT-5) between Rhode Island and Cadiz, Spain, to be in service by 1970 at a cost of about $75 million. Comsat hotly opposes the measure and it’s speeding plans for Intelsat 4 [Electronics, Aug. 21, p. 59], a 10,000-circuit satellite to go in service about the same time. Planning for the new cable, progressing secretly between the carriers and Spain, Portugal, Italy and Great Britain for several months, brought some sharp behind-closed-doors criticism from satellite backers.

The carriers and Comsat have now both prepared economic justifications of their systems and the FCC is likely to order all rates reduced so both systems will have enough traffic.
Pay tv hearings to Congress

Don’t look for any shift in the Federal Communications Commission’s plan to approve over-the-air pay tv as a result of hearings opening Oct. 2 [Electronics, June 12, p. 47]. The FCC sessions are expected to represent little more than an effort by the agency to placate Harley O. Staggers (D., W. Va.), chairman of the House Commerce Committee, who complained that the commission was planning to authorize over-the-air pay tv without consulting him. The FCC isn’t expected to issue formal approval until next year, thus giving critics in Congress time to have their say.

Aide who quit takes temporary Government post

Even though Chalmers W. Sherwin said he wasn’t “enthusiastic about going back to work for the government” when he quit the Commerce Department after being bypassed for its No. 1 science job [Electronics, Aug. 7, p. 65], the government apparently is still enthusiastic about him. Sherwin has been hired as a consultant by the President’s Office of Science and Technology to devise equipment and software standards for his ambitious plan to make national and international data retrieval systems compatible.

The job will be finished in about three months but Sherwin, who played a key role in linking the NASA and Defense Department computer systems that store research data, is being wooed for a permanent job in the science and technology office.

One for all

NASA is eyeing a unified space applications mission—combining a number of earth-sensing missions on a single unmanned satellite—as an approach that should appeal to a budget-minded Congress. IBM’s Space Systems Center will submit its report to NASA in mid-October on the feasibility and the tradeoffs necessary. The proposed system [Electronics, Jan. 23, p. 60] would combine such earth-sensing applications as earth resources, navigation, geodesy, communications and atmospheric sciences.

Industry wins delay on FCC study

The industry has wangled a four-month extension from the FCC for its comments on computers in communications. The complexity of the FCC probe and its far reaching implications are likely reasons for the delay. The FCC first asked for comments 10 months ago and set an October deadline. At the request of the major trade associations—including the Electronic Industries Association—the agency has pushed back the deadline to Feb. 5, 1968.

Senate majority claimed for SST

Backing for the supersonic transport has firmed in the Senate, despite the continuing opposition of critics led by Senator William Proxmire (D., Wis.). An informal poll, according to Senator Henry Jackson (D., Wash.), shows that more than 80 of the 100 senators will back Government funding of the SST program. The House recently trimmed $56 million off the appropriations bill but approved $142 million, enough to keep the program on schedule [Electronics, July 24, p. 50].

The present timetable calls for the Senate to get the supersonic transport bill late this month or early in October.
Today's Series 54/74 ICs point the way to the next dramatic step in solid state...MSI and LSI integrated equipment components.

Although vastly advanced in circuit complexity, this next generation of semiconductor devices will have much in common with today's Series 54/74 circuits (shown at left above), including utilization of the same basic TTL logic building blocks. In this and other ways, IECs will be natural extensions of today's Series 54/74 family of 39 functions and 180 device types.

By far industry's most complete logic line, Series 54/74 has been consistently expanded since the introduction of a few basic devices in 1964. The new high-speed and low-power circuits shown on the following pages are further additions to this growing family.

This provides you with new design opportunities now...and it also assures you a better interface with the TTL trends of the future.
New TTL additions to industry’s most complete logic family

Industry’s broadest family of TTL integrated circuits is now more complete than ever. To help you simplify designs, improve performance and reduce overall costs, we have added new circuits to our Series 54H/74H and 54L/74L lines.

New Series 54H/74H high-speed circuits feature 6 nsec propagation delay

New additions bring the number of circuits in this line to the 18 shown on page C. Series 54H/74H circuits offer the highest speed available in saturated logic today...six nanoseconds per gate.

This means that, by using 54H/74H in the critical logic paths of your digital systems, you can achieve advanced levels of performance with minimum design complexity.

The circuits may also be combined with standard speed and low-power TTL circuits in a single system...giving fast response while keeping overall system power consumption low.

Check number 100 on the attached TI information service card for comprehensive data sheet.

New Series 54L/74L low-power circuits feature 1 mW per gate power drain

Six new additions bring the number of circuits in this line to the ten shown on page D.

At 1mW per gate, Series 54L/74L circuits offer a ten-fold power savings...yet are approximately twice as fast as other circuits with similar power dissipation.

This line is specifically designed for space systems, avionic systems and other applications where power consumption and heat dissipation are critical.

Check number 101 on the attached TI information service card for comprehensive data sheet.

Complex-function ICs help you reduce costs

You cut costs two ways when you use Series 54/74 complex-function integrated circuits in your designs. Overall savings in excess of 50 percent are often possible!

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Second, fewer packages also help you realize big savings at your plant...in inspection, handling, assembly, and inventory costs.

You also simplify designs because TI has already done a lot of the design work...and you improve reliability because more circuits per package mean fewer soldered joints and plug-in connectors.

Series 54/74 family is industry’s most complete

Your new system can perform better and cost less when you employ Series 54/74 ICs, since you have the broadest choice of speed, power dissipation and cost-per-function available. Now you can tailor the characteristics you desire into your system...to a degree never before possible.

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High-speed TTL

Series 54H/74H offered in both dual-in-line and flat packages
"Tougher than military"

Recently-completed reliability tests, such as the one for temperature-cycling shown here, have proved the ruggedness and durability of TI's plastic dual-in-line package for integrated circuits. Now you can take advantage of reduced initial costs—plus big savings in handling, assembly and testing—without compromising essential reliability.

Many of the tests in TI's plastic package reliability program far exceeded the requirements of applicable military specifications (such as MIL-STD-750A and 202C). For example, evaluations were made for shock to 5500 G, constant acceleration to 100,000 G, temperature cycling from -65° to +250°C and flammability to +1100°F. Units were exposed to salt, moisture and detergent bombs. They were vibrated at 60 G over a 100 to 2000 Hz range. They were subjected to solder-heat tests at 350°C. They were also life-tested for a total of 479,000 successful device-hours.

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8-input NAND gate

SN54L54R/SN74L54R
2-wide 3-input AND-OR-INVERT gate

SN54L55R/SN74L55R
2-wide 4-input AND-OR-INVERT gate

SN54L51R/SN74L51R
2-2-3-3 input AND-OR-INVERT gate

SN54L71R/SN74L71R
R-S master-slave flip-flop

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With our new PG-13 you can get ±100V or, as a current source, ±2A pulses. And 10 ns rise and fall times; repetition rate 1 Hz to 25 MHz; duty cycle 50% at 1A out with a pulse width to 5 ms. No hedging. The specs are real specs: when we say ±100 volts we mean ±100 volts; 10 ns rise time means 10 ns rise time, worst case, at 100 volts. So if you need a truly fast high-output pulser for, say, magnetic core testing, radar pulse simulation or similar applications you would do very well to consider the PG-13.

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Mallory Capacitor Company, manufacturer of these tantalum capacitors, relies on GAF Industrial 'H-D' x-ray film to detect inclusions, excess bonding material, and check casing element clearances on all electrical connections.

To quote Mr. John E. Beckley, Quality Control Supervisor, "Only Industrial 'H-D' is used to radiograph our capacitors. It's the one x-ray film producing the definition, sensitivity and contrast that reveals minute detail within tiny components."

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Adlake Mercury Displacement Relays
-Application Data

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Varying ambient temperatures have little or no effect on Adlake Mercury Displacement Time Delay relays. From the graphic illustrations, ambient temperatures up to 200°F or down to 

-37.8°F (freezing point of mercury), the change in timing is less than 10%.

Adlake relays have been subjected to temperatures well below 

-37.8°F for extended periods. Upon raising the temperature to a point above the freezing point of mercury, the relay will again become operative. The relay will not suffer any damage as a result of the extended exposure to low temperature. This portrays the ruggedness of Adlake Relays due to their simplicity of design.

Mercury Displacement Relays — Temperature vs. Time Delay

Effect of increased temperature on time delay characteristics. Curve is typical for a normally open, slow-make relay having nominal time delay of 1.25 seconds.

Effect of decreased temperature on time delay characteristics. Curve is typical for a normally open, slow make relay having nominal delay of 160 sec.
Why the big swing to silicone molded devices?

Electrically stable materials over a wide range of temperatures from low to high frequencies—as shown graphically above. Silicone molded packages do not limit the design or performance of high frequency semiconductor devices. Design characteristics will not drift due to changing electrical properties of the molded package.

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No derating necessary. Devices packaged in silicone molding compounds can be operated at their full power potential. This enables designs with a higher device density per given volume. For example, one manufacturer reduced the size of a power diode to 1/30th of its glass packaged counterpart. Compared to other plastic materials, the package size is from 1/5th to 1/3rd smaller, since derating due to package stability is not required.

No cracking — Dow Corning silicone molding compounds—unlike other organic thermal setting plastics—are virtually unaffected by heat and thermal shock. For example, a power resistor molded in Dow Corning® 307 molding compound was subjected to repeated cycling from -65°C to 350°C without damage to the packaging material or the device. Dow Corning® brand molding compounds subjected to 1000 hours at 300°C (572°F) show no significant change in physical and electrical properties.

Will not burn. Silicone molding compound is inherently non-burning. Thus components packaged in silicone molding compound will not constitute a fire hazard. No flame snuffers are needed ... a source of ionic contamination for devices packaged in organic plastic materials. With silicone molding compound there are no ionic or polar constituents when properly used, to affect junction performance.

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For technical data on why the swing to Dow Corning silicone molding compounds in device packaging, write Dept. 3721, Electronic Materials Division, Dow Corning Corporation, Midland, Michigan 48640.
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You can mount up to 4 units in a standard LRA-1 or LRA-2 rack adapter.

Other features
- Regulation (line or load): .01% + 1 MV.
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- Temperature coefficient: .015% + .5 MV/°C.
- CV/CC with automatic crossover.
- A-C input: 105-132 VAC 45-440 Hz (ratings based on 57-63 Hz operation).

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*Overvoltage Protection available as an accessory—$40.00 each.

1Prices are for non-metered models. For metered models, add suffix (FM) and add $10.00 to price.
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September 18, 1967 | Highlights of this issue

Technical Articles

Linear IC's: part 3
Differential amplifiers
at work
page 96

The differential amplifier is one of the most versatile components electronics engineers have, and happily, it lends itself to easy fabrication by integrated techniques. Once in integrated form, it finds new applications that range from narrow band to video.

Integrated circuits
in action:
Cutting costs on
the factory floor
page 114

The user of integrated circuits often doesn't care what family of circuitry he uses as long as it does the required job. So the designers of a coordinate-measuring machine that inspects machined parts used both diode-transistor logic and transistor-transistor logic in an amiable mixture: low cost DTL gates drive high performance TIL flip-flops. The resulting product, which replaces one built of discrete semiconductors, is a shining example of what integrated electronics can do to an industrial machine: the new unit weighs one-sixth as much as one made of discrete units and costs only half. Yet its performance is as good or better than its predecessor. The cover photograph shows the new small-sized inspector at work.

Weaving a braided memory
that's fast and inexpensive
page 121

A new technique that reduces parasitic capacitance makes the braid memory even more attractive because it boosts cycle times to as fast as 300 nanoseconds. In addition, specially designed looms can now weave the memories efficiently. The combination converts the braid memory developed at Massachusetts Institute of Technology [May 1, p. 88] into a practical commercial device.

Problems of heat removal
chill progress in IC's
page 129

All too often after a design has weathered the tests of logic, electrical function, and costs, it fails the environment test mainly because of its inability to withstand temperatures in a system environment. This happens because too many designers don't understand the intricacies of thermal management. Integrated electronics make great space reductions possible and the temptation is to squeeze the system into as small a space as possible. But under such conditions traditional methods of cooling fail to perform as expected and trouble results.

Coming
October 2

- Microwave stripline for IC's
- Using K-trees for theoretical design
- A digital-data modem

←Circle 280 on reader service card
Linear IC’s: part 3
Differential amplifiers at work

With some juggling of components and connections, the basic differential-amplifier configuration serves in linear circuits for operations ranging from narrowband up to video

By J. P. Keller
RCA Electronic Components & Devices Division, Somerville, N.J.

When you talk about linear integrated circuits, you focus on their primary building block: the differential amplifier. The versatility and signal-processing advantages afforded by this configuration account for its popularity, and differential stages are found in nearly all linear IC’s, from simple audio amplifiers to multifunction, high-frequency communications networks.

The circuit can perform linear and complex functions from d-c to 300 megahertz; it amplifies, mixes, detects, limits, modulates, compares, and controls.

Its frequency response can be tailored to the processing of narrow pulses or broad signals. The choice of load components, such as tank circuits or resistors, peaks or flattens the gain characteristic over selected frequency ranges.

A primary function of the differential amplifier is the amplification of differential-mode input voltages and the suppression of interfering common-mode input signals. In the differential mode, two unlike signals applied to the double-ended input result in an output proportional to their difference; in common mode, like signals result in a negligible output. In practical terms, the circuit selects, compares, and amplifies low-level signals in noisy environments.

The amplifier consists of two symmetrically arranged half-circuits, and a balance exists to the degree that these halves match. Balance thus reflects how alike the transistors are, and how alike they remain through environmental changes. This matching in linear IC’s is an order of magnitude closer than the best match possible with discrete components.

Balance is enhanced by the arrangement of the output; each half-circuit response can be summed at the output in such a way that unwanted changes (such as increased leakage) offset one another, and desirable changes (higher gain with rising temperatures, for instance) complement each other.

The circuit provides excellent electrical tracking, maintaining balance in the face of changes in signal levels and temperature. It also provides uniform linearity in the reproduction of input signals, and can compensate for such changes as temperature variations and power supply shifts.

The amplifier features d-c coupling and avoids the use of large resistors. Capacitive elements aren’t needed on the chip, and biasing and coupling are generally simplified.

By any other name

There are many designations for the sundry linear IC’s that employ differential configurations [Electronics, Aug. 21, p. 76], but most of the circuits can be categorized, arbitrarily, as either video or narrowband amplifiers. A video-type differential amplifier has a flat gain-versus-frequency response extending from d-c well into the very-high-frequency region. Narrowband units exhibit a bell-
shaped gain response that rapidly converges to cover a very narrow frequency spectrum—typically a megahertz or less.

The two categories embrace all major IC differential-amplifier types—wideband, pulse, r-f, and ordinary comparator circuits. The video amplifier is characterized by diffused resistors in the collector leg, the narrowband by collectors that are uncommitted and available for external connection.

Though the video and narrowband types include units at opposite ends of the linear IC scale, they aren't antithetical. Either form can be converted into the other by the rearrangement or addition of external components.

This duality stems in part from common monolithic fabrication. The video is really a more complex version of the narrowband type. Passive components determine the gain-vs-frequency response; resistive elements provide a flat response, and capacitive elements introduce frequency breakpoints that narrow the response.

A narrowband amplifier can be converted to a video amplifier by the simple addition of external collector resistors. Conversely, capacitive coupling of a video amplifier converts it to a narrowband amplifier. Also, a video-type amplifier with high input and output impedances is suitable for use in parallel-input and tuned-output applications, jobs for a special class of narrowband amplifiers.

Both circuits typically offer single-ended and double-ended output connections. In single-ended or push-push operation, the output is taken from one collector; in double-ended or push-pull operation, it is taken from two collectors. The single-ended mode eases interfacing but has a higher net feedback capacitive element. In double-ended operation, the capacitive effect is reduced, isolation is higher, and the frequency response is a little wider. Although harder to interface with, the double-ended mode doesn’t require a bypass capacitor for coupling to another circuit, whereas single-ended operation does.

**On a pedestal**

An ideal differential amplifier would have these characteristics:

- Zero output with zero input (zero offset)
- A gain constant with temperature and time, and independent of input level (zero drift)
- An output that is an exact amplified reproduction of the input
- An infinite bandwidth
- Perfect balance

Among the real-life limitations that thwart the attainment of this ideal, the most common is drift. Besides reflecting changes in gain with temperature and time, drift can be viewed as an over-all performance index indicating circuit capabilities and imbalances.

Drift is largely due to changes in the transistor elements’ parameters, mainly \( \Delta V_{BE}/\Delta t \) and \( \Delta h_{FE}/\Delta t \). Here \( V_{BE} \) is the d-c base-to-emitter voltage.

**Gain- versus-frequency**

characteristic of differential amplifiers is used to distinguish major types.

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**Gain- versus-frequency**

characteristic of differential amplifiers is used to distinguish major types.
the differential transistors are balanced, and half the total current $I_o$ flows through each transistor. This condition represents the quiescent operating point for a linear differential amplifier.

When $V_{in} = V_{ib}$, the differential-amplifier input voltage is defined as $V_{1a} - V_{1b} = V_{Rea} - V_{Reb}$. When $V_{1a}$ is made more positive than $V_{1b}$, $I_{cb}$ increases and $I_{eb}$ decreases until $V_{1a} - V_{Rea} = V_{1b} - V_{Reb}$. This is called the threshold condition.

At this point, the current through $Q_{ib}$ is at a maximum ($I_{cb} = I_o$) and $Q_{ib}$ is off. When $V_{ib}$ is made more positive than $V_{in}$, the process reverses. Maximum current then flows through $Q_{ib}$, and $Q_{ia}$ is cut off. These characteristics, shown on page 99, give the amplifier its application flexibility.

**On the slopes**

The transfer characteristics are linear on both sides of the operating point. At room temperature, this linear region corresponds to an input-voltage swing of approximately 50 mV peak to peak. The maximum slope of the curves occurs at the operating point and defines the effective transconductance of the differential amplifier.

The slope at any other point depends on the value of the total current, $I_o$, supplied by the constant-current sink. The slope of the transfer curves can be changed without altering the linear region by varying the value of $I_o$, implying that automatic gain control is inherent in the differential amplifier when $I_o$ is controlled.

The transfer characteristics and the slopes are also functions of the gain (beta) of the transistors, of temperature, and of two physical constants, $q$ and $K$; $q$ is the electron charge and $K$ is Boltzmann's constant. Since gain and temperature variations are predictable, so is circuit performance in various applications.

The differential amplifier is a natural limiter; when input excursions exceed $\pm 4KT/q$ (approximately $\pm 100$ mV in the model), no further output rise occurs.

The output current of any amplifier is the product of the input voltage and the transconductance. In the differential amplifier, the transconductance is proportional to the controllable current $I_o$. If $I_o$ is simply made a multiplicand and the input waveform a multiplier, the circuit can be used for mixing, frequency multiplication, modulation, or product detection.

Also, because half the input voltage and half the source current $I_o$ are present in each transistor of the differential pair at the operating point, the effective transconductance value of the amplifier is one-fourth that of a single transistor for a given value of $I_o$, and the circuit gain, consequently, is also less.

In the double-ended differential amplifier, the load is placed between the two collectors and the output voltage is measured between them. The output voltage, therefore, is twice that obtainable with single-ended operation.

Since the dynamic range of the input is limited,
Transfer. Linear region of differential-amplifier transfer characteristic is 114 millivolts wide; as input signals exceed that range, limiting action comes into play.

it is sometimes desirable to increase the linearity range of the transconductance parameter before limiting occurs. This can be achieved by emitter degeneration—making \( R_a \) and \( R_b \) the same finite value. These emitter resistors reduce the transconductance and, hence, the gain, but further linearize both the transfer characteristic and the transconductance. Typical results when employing emitter resistors are shown above at the right.

Separating the modes

In both double-ended and single-ended amplifiers, the differential-mode (\( DM \)) signal is out of phase at the two inputs, and the common-mode (\( CM \)) signal is in phase between the two amplifier input terminals and ground.

When a \( DM \) signal is applied, the voltage at one terminal increases and the voltage at the other decreases by an equal amount. If the transistors are operated in the linear region, the collector current of one transistor increases while that of the other transistor decreases; the changes are offset at the common emitters.

When a \( CM \) signal is applied, the voltage at both input terminals increases and both collector currents rise. These currents are then additive, a negative feedback is developed across the common-emitter resistor, and the \( CM \) gain is substantially reduced.

Because \( DM \) and \( CM \) signals can be present simultaneously, differential output is more difficult to analyze than, for example, the output of a single-ended cascade amplifier. Taking into account unavoidable imbalances in the circuit symmetry (for example, resistor ratios other than unity, and \( h_{RE} \) and \( V_{BE} \) differences), unwanted \( DM \) outputs may result from a \( CM \) input. Additional gain relationships must be defined to reflect this limitation:

\[
A_{de} = \frac{V_o(CM)}{V_i(DM)} = DM-to-CM transfer gain
\]

\[
A_{de} = \frac{V_o(DM)}{V_i(CM)} = CM-to-DM transfer gain
\]

Subscripts \( o \) and \( i \) refer to output and input signals, respectively; \( A \) is a gain term.

As the \( DM \) output signal alone is desired, the \( A_{de} \) factor should be minimized. A performance parameter, the common-mode rejection factor, \( CMR \), can be defined as the ratio of the \( CM \) input voltage to the \( DM \) input voltage that produces the same \( DM \) output voltage. Mathematically, the common-mode-rejection ratio, \( CMR \), equals \( A_{de}/A_{de} \), where \( A_{de} \) is the differential-mode gain.

Predictions of the circuit's behavior can be made in this fashion:

- For analysis, the network is split into two equivalent half-circuits;
- Circuit imbalances are accounted for by adding interaction generators, resulting in two additional half-circuits;
- Sets of equations are derived through the analysis of these four half-circuits.

Typical results of such a procedure are shown on page 100. These relationships express balanced and unbalanced differential-amplifier performance, and can aid in systems design.

Characterization in toto

In a discrete amplifier, circuit behavior is predicted by characterizing individual components with respect to changes in temperature and frequency. To do this with an integrated circuit, however, would require the employment of techniques used to study distributed elements, such as transmission lines, assuming that their values as discrete components could be measured or calculated.

To get around this problem, the integrated-circuit amplifier is characterized by its total external effect rather than by the magnitude of its individual components. Using \( y \) or \( s \) parameters, circuit behavior can be completely and accurately determined; the measurement includes both desired and parasitic elements within the circuit.

Unfortunately, these parameters are a function of the amplifier connection. For example, the \( y \) parameters for the basic differential-amplifier configuration differ from the \( y \) parameters for the same \( IC \) connected in cascade. Power gain, noise figure, and automatic gain control (age) characteristics are also functions of the application, and supply voltage as well. However, it's rarely necessary to build specialized circuits to measure the latter.
The performance of the differential amplifier configuration reflects the degree of balance between each half-circuit. Below are the relationships governing overall circuit performance in cases of perfect match and of imbalance. The δ term indicates a small imbalance in a particular parameter; SE and DE refer to single-ended and double-ended operation, respectively.

1. Collector current, \( I_c \) (\( R_4 = \infty \)):
   \[
   I_c = \frac{\delta (V_{1a}-V_{1b})}{1 + \frac{\delta}{R_1}}
   \]
   \( \delta = \frac{\alpha I_b}{1 + \frac{\delta}{R_1}} \)

2. Transconductance, \( g_m \):
   \[
   g_m(\text{SE}) = \frac{\alpha I_b}{4K T R_1}
   \]
   \[
   g_m(\text{DE}) = \frac{\alpha I_b}{2K T R_1}
   \]
   \[
   g_m(\text{EE}) = \frac{g_m(\text{SE})}{1 + 2R_1 g_m(\text{SE})} \quad (R_1 \neq 0, R_4 = \infty)
   \]

3. Common-mode gain, \( A_{cm} \):
   \[
   A_{cm} = \frac{\alpha R_2}{R_1 + 2R_3}
   \]

4. Differential-mode gain, \( A_{dd} \):
   \[
   A_{dd} = \frac{\alpha R_2}{R_1 + 2R_3} \quad (R_1 \neq 0, R_4 = \infty)
   \]

5. Common-mode input impedance, \( Y_{cm} \):
   \[
   1/Y_{cm} = (\beta_1 + 1)(R_1 + 2R_3)
   \]

6. Differential-mode input impedance, \( Y_{dd} \):
   \[
   1/Y_{dd} = (\beta_1 + 1)R_1
   \]

7. Differential-mode rejection factor, \( \text{DMR} \):
   \[
   \frac{1}{\text{DMR}} = \left( \frac{\delta R_2}{R_1} \right) + \left( \frac{R_1 + 2R_3}{R_1} \right)
   \]
   \[
   = \frac{R_1}{2\alpha R_1 + 0.5R_4} + \frac{\delta R_2}{R_2} + \frac{\delta R_3}{\beta_1 (1 + \beta_2)}
   \]

8. Common-mode rejection factor, \( \text{CMR} \):
   \[
   \frac{1}{\text{CMR}} = \frac{R_1}{R_1 + 2R_3}
   \]

9. Input voltage imbalances, \( \Delta V_e \):
   \[
   V_{oa} - V_{ob} = \frac{R_3 R_2 I_c}{(\beta_1 + 1)} \left[ - \frac{\delta I_b}{I_b} - \frac{\delta R_3}{R_3} \right] + \frac{\delta R_2}{R_2} \right]
   \]
   \[
   = \frac{\alpha R_1 R_2 V_{BE}}{R_1 + 2R_3} + \frac{I_c R_4}{R_1 + 2R_3}
   \]

10. Constant current source, \( I_c \):
    \[
    I_c = \frac{R_3}{R_1 + R_3} \left[ R_2 (E - E_2) - V_{BE} (R_1 + R_3) \right]
    \]
two factors; the relationships are depicted on data sheet curves.

Equations 1 through 6 in the panel on page 100 are applicable to balanced conditions, and equations 7 through 9 show the effect of small imbalances in a given parameter. For example, equation 9 indicates the effect of imbalances in $L_1$, $R_2$, $V_{BE}$, $R_3$, $\beta$, and $B_1$, especially on the collector operating point. Changes in the offset current will be most pronounced with a high source resistance, $R_s$, for instance. The effect is lessened if a high-current-gain ($h_{FE}$) transistor is used or if low-collector-current ($I_c$) operation prevails. Similarly, imbalances in $R_1$, $R_2$, $h_{FE}$, and $V_{BE}$ must be minimized if high common-mode rejection is the goal.

Another factor relating to improved common-mode rejection is the common-emitter resistor, $R_3$. The performance of the system would be enhanced by making $R_3$ as large as possible, but the resistor's value is limited by the magnitude of the supply voltage, $E_2$. Nevertheless, the effective resistance can be increased without boosting $E_2$ by replacing $R_3$ with a constant current source—a current sink. This procedure, shown on top of page 102, presents a d-c resistance equal to $R_3$, but a finite a-c impedance many times its d-c value. The a-c-to-d-c impedance ratio of $R_3$ can be further increased by negative feedback of the common component; common-mode rejection as high as 140 decibels has been realized with this technique.

Use of a current sink offers other advantages. For one thing, modification of the current in the sink can yield automatic gain control, or squelch. Since $I_s$ is not only a function of the resistors but also of $E$—the potential at which the divider is returned—a change in $E$ will change $I_s$.

Also, the current sink compensates for changes in temperature-sensitive parameter values—mainly $V_{BE}$ and $h_{FE}$ drifts—if nonlinear forward-biased diodes are used in the current-sink biasing network. Good over-all temperature tracking of differential-amplifier gain is a result.

Because the collector impedance of the constant-current source, $Q_b$, is high, the a-c signal is delivered to the emitter of $Q_{1b}$ from $Q_{1a}$ because the impedance looking into the emitter of $Q_{1b}$ is low.

The differential amplifier in this case operates as a common-collector stage driving a common-base stage, a configuration that holds certain advantages. The reverse and forward transconductance and the input admittance are lower than those of a single transistor, and the output admittance is higher. In terms of frequency response, the presence of the collector capacitance, $C_c$, produces a major corner (frequency breakpoint) where the reactance magnitude equals that of the resistive component. This capacitance limits the upper frequency response in double-ended configurations, but can be ignored in single-ended modes.

Also, good isolation exists between input and output in single-ended operation, resulting in a higher 3-dB point, and the upper frequency is limited only by the collector-to-substrate capacitance, the input capacitance, and the distributed capacitance of the resistors. These capacitances are lumped together in the ic, so designers can deal with a simple over-all effect.

Applications in video

A typical video-type amplifier application—a wideband, RC-coupled feedback amplifier—demonstrates the systems-oriented role differential stages can play. The ic used, the Radio Corp. of America's CA3000, is a multi-stage differential amplifier preceded by input emitter-followers and controlled by a constant-current source. This ic has a push-pull input and output capacity, a minimum input impedance of 70 kilohms, and a low-frequency output voltage swing of more than 10 volts.

Operation from either one or two power supplies is optional. The magnitude of the supplies and the biasing of the constant-current source de-
Current sink. Use of constant current source in place of large resistor in the common-emitter circuit improves common-mode rejection and simplifies monolithic fabrication.

terminate the amplifier's gain, output voltage, output-voltage swing, and power dissipation.

Both single-ended and double-ended modes of operation are available, depending on the pin arrangement. The latter affords higher gain but more restricted access. In single-ended operation the IC has a voltage gain of 31 db, an output voltage operating point of +2.3 volts, a voltage swing of ±3.7 volts about this point, and a total power consumption of 40 mw for supply voltages of +6 and -6 volts.

In the arrangement, shown below, employing a pair of CA3000's, the first is connected as a double-ended differential amplifier and the second in a single-ended configuration. The RC interconnecting networks are used for frequency shaping.

The load consists of the internal diffused resistors plus external resistors R12 and R13, all 8 kilohms. The total mid-band open-loop gain is 62 db.

The amplifier has a corner at 1 MHz caused by the input stage of the second IC. The addition of a capacitor, C3, staggers the high-frequency roll-offs of the amplifier and improves stability. This capacitor, in connection with the internal resistors, creates a corner at 200 kilohertz.

The low-frequency rolloff is determined by the interstage coupling; a corner exists at 22 hertz because of the combined effect of one internal resistor plus, R12 and C1. Amplifier gain drops at a rate of 12 db per octave as a result of the 1-MHz corner. The rate can be cut to 6 db per octave over a portion of the gain range by adding a small resistor in series with C3.

The amplifier's over-all gain and bandwidth can be changed by feedback from the output of the second stage to the input of the first stage. In the mid-band region, the gain of such a feedback amplifier can be calculated by a single expression involving resistor ratios.

As the gain is decreased, the bandwidth is increased. The gain can be reduced by applying a voltage to the age terminal located in the first stage.

Narrowband operation

The narrowband IC amplifier differs from the video-type amplifier in that its two collectors have no internal load. This permits the use of tuned load circuits in the collectors, and gives the network versatility.

There are many ways the circuit can be connected, as shown on the facing page. Besides amplifying, it can perform gain-control, mixing, oscillating, and conversion functions. In each case, the resistors are determined by the biasing conditions, and the tuned circuits by the desired frequency and bandwidth.

In multistage discrete amplifiers, the feedback influence of load on input and source on output complicate the tuning and aligning process. Because the differential-amplifier and cascode-amplifier configurations in IC form have lower feedback factors, they are suitable for r-f applications without neutralization.

The main problem faced when reducing the gain of any high-frequency amplifier is performance degradation stemming from nonlinearity of the transfer characteristics and from signal-handling limitations. Changes in characteristics appear in the form of cross-modulation—the transfer of modulation from an undesired signal to a desired signal—or intermodulation, the action that produces harmonics of the desired modulation. The use of the cascode connection in recent IC's eliminates
A narrowband amplifier works...

... as a balanced amplifier...

... as a converter...

... as a cascode amplifier...

... as a mixer...

... as an agc circuit...

... and as an oscillator.

Broad base. The application versatility of the narrowband differential amplifier is largely due to its uncommitted collector arrangement. Relatively few changes are required in terms of the lead pins used; designers merely alter the external network connected to the IC to meet various applications. The unit shown here is the CA3020, popularly known as the universal IC.
these difficulties because the current through the input transistor is kept constant throughout the gain-control range.

A typical application for a narrowband differential amplifier is in a medium-gain f-m, i-f strip. Such a network would be used, for example, in a standard receiver with a 10.7-MHz center frequency and 200-kHz bandwidth. The desired voltage output of the tuner is 25 microvolts, with a frequency deviation of ±75 kHz, and the level of the recovered audio should be 155 mV at a point 3 dB below the knee of the transfer characteristic.

Assuming that audio output required a signal of 2 volts rms across the primary winding of the discriminator transformer, a gain of 98 db is necessary with a 25-µV input voltage. Only two stages of gain would be used.

Coupled by a transformer, two IC’s can provide 100 db of gain. To get the same characteristics with a discrete semiconductor design, four or five transistor stages would be needed, along with coupling transformers between each stage.

**Tandem**

The impedance levels of the RCA CA3028 and CA3012 integrated circuits suit the interface requirements of this arrangement at the input, on both sides of the transformer, and at the load. The 3028 is employed to provide routine differential amplification; the 3012 provides a limiting action as well as i-f gain.

The CA3028 has a typical gain of 39 db with a 3-kilohm load. In the schematic of the proposed amplifier shown below, the networks on the secondary winding of T4 constitute the standard loading of the ratio detector and provide a symmetrical skirt of the pass-band. Rg is the detector load, and R1 and C1 comprise the de-emphasis network. For minimum distortion, the primary impedance of T4, Rg, must not exceed the ratio of Ve to Ip. Here, Ip is the maximum current through the T4 primary, and Ve is the d-c supply voltage. Ip is determined by the nominal load, which is indicated on the CA3012 data sheet curves.

The CA3012 consists of a series of three basic differential amplifiers coupled by emitter-follower stages, a configuration aimed at signal limiting. The supply voltage to each amplifier is controlled internally by voltage regulators formed by two diodes and a transistor.

With the 3-kilohm load of T4, the voltage amplification is 71 db. For effective limiting with this gain, the CA3012 input voltage should be 400 µV.

Interstage transformer T3 also reduces the gain of the system. The primary and secondary impedances measured at the taps are 3 kilohm and 1 kilohm, respectively. The insertion loss of T3, resulting from the transformer itself and the impedance match, is calculated to be 9 db and should be included in the gain calculation.

The voltage gain of the CA3028 is the forward transadmittance, y21, divided by the sum of the output admittance, y22, and the transformer load, yL.

---

**Diagram:**

- **CA3028**
- **CA3012**
- **R3**
- **R5**
- **R4**
- **C1**
- **C4**
- **Rf 0.001 µF**
- **Ce 0.01 µF**
- **T3: INTERSTAGE TRANSFORMER TRW NO. 22486 OR EQUIVALENT**
- **T4: RATIO DETECTOR TRW NO. 22516 OR EQUIVALENT**

**I-f strip.** Two IC’s and associated circuitry are all that’s required for a complete 10.7-MHz intermediate-frequency amplifier strip. The first unit is a simple differential amplifier; the second is a high-gain i-f amplifier with three differential stages.
### Key differential-amplifier parameters

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Application category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input bias current</td>
<td>Comparator Video Wideband Narrowband Audio Pulse</td>
</tr>
<tr>
<td>Input offset current (for high-impedance source)</td>
<td></td>
</tr>
<tr>
<td>Input offset voltage (for low-impedance source)</td>
<td></td>
</tr>
<tr>
<td>Input signal level</td>
<td></td>
</tr>
<tr>
<td>Common-mode input voltage range</td>
<td></td>
</tr>
<tr>
<td>Output quiescent point</td>
<td></td>
</tr>
<tr>
<td>Common-mode output voltage</td>
<td></td>
</tr>
<tr>
<td>Maximum output voltage swing</td>
<td></td>
</tr>
<tr>
<td>Single-ended voltage gain (open loop)</td>
<td></td>
</tr>
<tr>
<td>Power gain</td>
<td></td>
</tr>
<tr>
<td>-3-db bandwidth</td>
<td></td>
</tr>
<tr>
<td>Distortion</td>
<td></td>
</tr>
<tr>
<td>Common-mode rejection ratio</td>
<td></td>
</tr>
<tr>
<td>Single-ended input impedance</td>
<td></td>
</tr>
<tr>
<td>Single-ended output impedance</td>
<td></td>
</tr>
<tr>
<td>Y- or s-parameters</td>
<td></td>
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<tr>
<td>Noise figure</td>
<td></td>
</tr>
<tr>
<td>Agc range</td>
<td></td>
</tr>
<tr>
<td>Pulse response</td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td></td>
</tr>
</tbody>
</table>

For this circuit, the voltage gain is calculated to be 37.5 dB; input voltage is 15 µV, well within the 25-µV specification originally called for.

As for the other components in the schematic, R3 and R4 establish the bias point for one side of the differential amplifier, R5 balances the other side, and R6 and Cb provide the 7.5-volt bias required by the CA3012.

### Evaluating parameters

Designing with the four other IC differential-amplifier types—wideband, audio, pulse, and ordinary differential-comparator circuits—usually calls for procedures similar to those used in the general cases of video and narrowband types. However, each of the six categories should be treated separately when it comes to evaluating parameters.

Some parameters—input bias current, input offset voltage and current, output voltage swing, impedance levels, and power dissipation—are essential in all six applications. On the other hand, such factors as noise figure, age range, and distortion are paramount in some applications and unimportant in others.

Pulse response, which reflects rise time, delay time, fall time, and narrowband distortion, is important in video amplifiers as well as in the obvious pulse-amplifying application because video types operate at a d-c level proportional to the pulse input. But wideband applications feature a-c coupling, and output quiescent point is therefore not a key parameter. Input signal levels are important in all but comparator applications because clipping at the input results in distorted outputs except in that one case.

The table above lists the important parameters for each type of application. Measurement of these parameters requires relatively little in the way of equipment; most of the necessary test gear can be found in the typical laboratory.

### Bibliography

- J.J. Robertson, "Design of High-Frequency Tuned Amplifier," Motorola IC design course, section 29.
Circuit design

Designer's casebook

IC operational amplifier makes supply short-circuit proof

By Robert D. Guyton
Mississippi State University
State College, Miss.

An operational amplifier built with integrated circuits and inserted in a regulated power supply makes the unit short-circuit proof. The supply features variable voltage, low output impedance, low noise, and low a-c ripple. It's inexpensive to build too, with only a few external components.

Power transistor Q1 is a shunt regulator for the 30-volt supply; its output drives a Fairchild µA709 IC operational amplifier. Zener diode D1 acts as a voltage reference, and potentiometer P1 varies the gain of the operational amplifier and, in turn, the output of the power supply through Q1's base. Capacitors C1 and C2, along with IC stabilizing components, prevent low-amplitude, high-frequency oscillations from disturbing the circuit's operation. The +15- and -15-volt sources required by the µA709 are obtained from external low power zeners.

The power supply's output voltage ranges from 6 to 25 volts and is adjusted with P1. When adjusted for 15 volts, the supply provides load currents from 0 to 60 milliamperes with little change in voltage. Under short-circuit conditions, maximum current is limited to 120 milliamperes.

Resistor R1 is selected to minimize the power supply's drift, and it controls the current in D1. It is thus possible to vary the zener temperature characteristic to compensate for the drift of the supply. With an R1 of 620 ohms, a temperature coefficient of less than 1 millivolt per degree centigrade is achieved.

The design can be modified to yield higher output currents simply by lowering the values of R2 and R3 and adding another low-power transistor in a Darlington amplifier arrangement between the IC and Q1.

FET source follower enhances single-sideband

By Ahti Aintila
Helsinki, Finland

A field effect transistor in a source-follower configuration gives the fast rise time needed in an automatic volume control for single-sideband reception. The FET enhancement mode of operation provides a threshold action that maintains the receiver's sensitivity to signals buried in the noise.

The demodulated audio signal feeds the voltage doubler, composed of capacitors C1 and C2, and diodes D1 and D2. The rectified output is developed across C2, which stores the peak value, and controls the p-channel enhancement mode FET. Then the signal is delivered through a filtering circuit to the avc lines of the receiver.

Time-control pulses that determine the avc's speed are generated in an external unijunction transistor-relaxation oscillator. The optimum repetition frequency depends on the mode of trans-
Pulse control. Audio input voltage is rectified, doubled, and appears across capacitor \( C_1 \). The FET provides a low impedance output to the avc line, and external time-control pulses feed switching transistor \( Q_1 \), discharging \( C_2 \).

---

Unijunction trigger boosts ignition reliability

By Francis Honey

Denver Research Institute
Denver, Colo.

A hot engine or a cold battery in a car can cause intolerable variations in ambient temperature or supply voltage level, which adversely affect the capacitor-discharge ignition system. These difficulties are eliminated by replacing the usual diode-resistor-capacitor triggering network with a unijunction pulse generator.

In most capacitor-discharge ignition systems, a silicon controlled rectifier is the switch that discharges a capacitor into the ignition coil to produce the spark. When the pulses, which trigger the scr, are generated by a conventional diode-resistor-capacitor network, the pulse quality varies with changes in supply voltage and ambient temperature. The system’s reliability is further eroded by the gate sensitivity of the scr, which also varies with temperature and differs from unit to unit.

The trigger circuit has been incorporated in a special high-energy ignition system designed to meet the stringent requirements of a race-tuned two-cycle engine. During extensive environmental tests, the circuit operated reliably over a temperature range of \(-30^\circ\) to \(+160^\circ\) Fahrenheit with simultaneous supply voltage variations of \(-50\) to \(+30\%\). The circuit’s dependability is largely due to the temperature stability of the unijunction transistor that generates the triggering pulses.

The entire ignition system, which costs less than $50, has been installed on production sports cars. Some of the cars that ordinarily need a tune-up every 5,000 miles have been driven over 30,000 miles without noticeable deterioration in performance when equipped with the new ignition system. Some race cars that previously required several plug changes during a six-hour race have completed an entire season with one set of spark plugs.

In the circuit, the 27-volt supply is obtained from the primary winding of a d-c to d-c converter,
used elsewhere in the system, which is rectified by diodes $D_1$ and $D_2$, filtered with network $R_1$, $C_1$, and $R_2$ and regulated to 13 volts with diode $D_3$. Sufficient current, supplied from the battery through $R_3$, assures reliable contact.

With the points closed, transistor $Q_2$ is cut off and capacitor $C_2$ charges to approximately 5 volts. When the points open, $Q_2$ saturates so that the potential at point $P$ drops to 6 volts and fires the unijunction transistor, $Q_1$. As long as the points remain open $Q_2$ remains saturated and prevents $C_2$ from recharging. When the points close again, $Q_2$ turns off, and the potential at point $P$ rises. Capacitor $C_2$ is then recharged through resistors $R_3$, $R_1$, and $R_2$ to complete the cycle.

The time constant $R_3R_6C_2$ introduces a delay of one millisecond before $C_2$ accumulates sufficient charge (approximately 4 volts) to fire the unijunction, $Q_1$, when the points open; thus, transients caused by contact bounce shorter than one millisecond, do not cause multiple triggers on opening, or unwanted triggers on closing.

---

**Pulse-saving network permits signal switching**

By Charles A. Walton

International Business Machines Corp.
San Jose, Calif.

A fast, floating switch that chops analog signals without introducing common-mode noise is constructed by connecting a pulse-saving network across the secondary of a small pulse transformer. Chopping is performed by switching a field effect transistor on and off with the network’s output voltage. The circuit’s pulse transformer, whose voltage-time product is less than 100 volt-microseconds, is capable of maintaining 6-volt on or off signals for longer than 100 milliseconds.

At time $t_0$, the circuit is quiescent with no charge on capacitor $C_1$ and no voltage at terminals 3 and 4 of the pulse transformer. A negative 8-volt step, applied across input terminals 1 and 2 at time $t_1$, saturates the transformer to produce a negative pulse at output terminal 3. The negative pulse forces the potential at point 5 to approach $-8$ volts. As this potential approaches $-8$ volts, zener diode $D_1$ conducts, and clamps point 5 to $-0.6$; thus, when the negative pulse reaches its peak shortly after $t_1$, point 5 is clamped at $-0.6$ volt by the zener while point 3 is held at $-8$ volts.

When the negative input step reaches $-8$ volts, shortly after $t_1$, the transformer’s flux collapses and the voltage at terminal 3 drops to zero, completing the negative pulse. However, the voltage across $C_1$ cannot change instantaneously; hence, point 5 rises toward $+8$ volts. When the voltage at point 5 reaches 6 volts, zener diode $D_1$ breaks...
High speed multivibrator controlled by single ECL

By Akio Tojo
Electrotechnical Laboratory, Tokyo, Japan

An emitter-coupled monolithic logic circuit enables the engineer to design either a simple astable or a monostable multivibrator having fast operation, externally controlled repetition rate, and multiple input start-stop oscillation control.

Voltage V supplies a base-biasing current through R1 and R2 for a current conducting switch. The base voltage of a conducting switch is held constant at -1.6 volts plus approximately 0.65 volts, forward diode drop by diodes D1 and D2.

With all inputs at their low voltage state the circuit oscillates freely, but when any one of the four input levels, G1, G2, G3, or G4, is high, oscillation stops. The input voltage for gating is compatible with that of conventional ECL's (-0.75 v and -1.55 v). Assuming the voltage across R1 and R2 is large compared with the output level, the circuit's repetition rate is given by:

\[ f = \frac{1}{R_1C_2 + R_2C_1} \times \frac{V - V_1}{\Delta V} \]

where \( V \) is the output voltage swing.

The pulse width of the output waveform is slightly unsymmetrical, because of unequal values

---

**Waveforms.** Negative steps in command voltage \( e_1 \) turn the FET off and positive steps turn it on to pass the analog signals.

down and clamps the point-5 potential. Since the pinchoff voltage at the gate of \( Q_1 \) is 4 volts, the voltage at point 5 holds \( Q_1 \) off.

The 6-volt potential at point 5 decays very slowly due to low leakage current through \( C_1, D_1 \), and \( Q_1 \). However, voltage at point 5 can be readily maintained above the FET-pinchoff voltage for longer than 100 milliseconds when \( C_1 \) is a Mylar capacitor. The decay time of the potential at point 5 determines the maximum off time for the FET. Since the circuit is capable of indefinite on times, the circuit's response to nonsymmetrical waveforms is limited only by the decay time of the potential at point 5.

When a positive input pulse is applied to terminals 1 and 2 at time \( t_1 \), the voltage at terminal \( 3 \) is driven toward 8 volts so that point 5 also moves positively. When the voltage at point 5 reaches 6 volts, zener diode \( D_1 \) breaks down and clamps the point-5 potential.

Upon completion of the pulse (shortly after \( t_2 \)), the potential at terminal 3 drops to zero. As the charge on \( C_1 \) cannot change instantaneously, the potential at point 5 tries to move toward -2 volts. When point 5 begins to go negative, \( D_1 \) conducts and clamps the point-5 potential at zero. With point 5 at zero, \( Q_1 \) turns on and passes any analog signals applied to its drain or source terminals. Transistor \( Q_1 \) conducts until the next negative pulse.

The pulse transformer is the Pulse Engineering Co.'s model 2228 and the circuit has been operated at rates from 10 to over 1,000 pulses per second.
of $R_3$ and $R_4$. These are required to maintain identical signal levels at the NOR and OR outputs when the ECL is applied as a logic gate. For symmetrical pulse widths, the value of $C_1$ should be 10% greater than $C_2$.

If the ECL is rewired, a monostable multivibrator is obtained. A germanium diode $D_1$ and a silicon diode $D_2$ give the appropriate voltage difference between the bases of the conducting and open switches in the quiescent state. A trigger signal applied at any one of four inputs initiates oscillation. The input level is also compatible with the conventional ECL output voltage.

Multivibrators designed around integrated circuits offer exceptionally fast, simple-gated operation. In addition, variations in element characteristics and changes in temperature have little effect.

![Image](image.png)

### Waveform generation eased by two timing networks

**By Larry Blaser**

Fairchild Semiconductor Division of the Fairchild Camera & Instrument Corp., Mountain View, Calif.

A nonsymmetrical, free running multivibrator capable of off-to-on-time ratios as large as 500 to 1 are achieved by switching a diode between two timing networks. Time constants of the networks have ratios proportional to the desired duty cycle of the output waveform and the circuit's pulse repetition frequency (PRF) is independent of changes in supply voltage. In addition, the potential at the supply may drop nearly 50% with little effect on the frequency of the output pulses.

The pulse generator was constructed with inexpensive epoxy transistors and noncritical passive components. To start the cycle, transistors $Q_2$ and $Q_3$ are on and capacitor $C_1$ charges toward the supply voltage, $V_s$. The current charging $C_1$ flows through $Q_3$, $D_1$, and $R_2$, and is negligible through $R_1$. While $Q_3$ is on, the output voltage is at $V_s$, as shown in the output waveform diagrams.

When the potential on $C_1$ reaches $\frac{2}{3}V_s$, transistor $Q_1$ turns on, and $Q_2$ turns off. With $Q_2$ off, transistor $Q_3$ turns off and the output voltage drops to ground, completing the pulse.

![Image](image.png)

Non-symmetrical multivibrator. Capacitor $C_1$ is charged through $D_1$ and $R_2$ until $C_1$'s potential reaches $\frac{2}{3}V_s$.

![Image](image.png)

Output waveforms. When the potential at the base of $Q_1$ reaches $\frac{2}{3}V_s$, $Q_1$ turns on, $Q_2$ turns off, and the output drops to ground, completing the pulse.
voltage rises to $V_s$, starting a new output pulse.

The charge times for capacitor $C_1$ are

$$t_1 = R_1 C_1 \ln 2$$

and

$$t_2 = \frac{R_1 R_2}{R_1 + R_2} C_1 \ln 2$$

when the values of resistors $R_3$, $R_4$, and $R_5$ are equal. The duty cycle is given by the relation

$$\text{duty cycle} = \frac{t_2}{t_1 + t_2} = \frac{1}{2 + \frac{R_3}{R_2}} \times 100\%$$

and the pulse repetition frequency is expressed by

$$\text{PRF(Hz)} = \frac{1}{t_1 + t_2} = \frac{1}{R_1 (1 + \frac{R_3}{R_1 + R_2}) C_1 \ln 2}$$

For a low duty cycle, $R_1$ is chosen much larger than $R_2$ so the expressions for duty cycle and pulse repetition frequency become

$$\text{duty cycle} = \frac{R_2}{R_1} \times 100\%$$

and

$$\text{PRF(Hz)} = \frac{1}{R_1 C_1 \ln 2}$$

For reasonable accuracy and reliable circuit operation with a supply voltage between $+12$ and $+24$ volts, the value of $R_1$ should be between 20 and 100 kilohms, and the value of $R_2$ should be between 0.2 and 100 kilohms. For these $R_1$ and $R_2$ values, the duty cycle range falls somewhere between 0.2 and 45%.

The performance curves illustrate the astable multivibrator's operating characteristics when the values of $R_1$ and $R_2$ are made 51 and 1 kilohms to yield a 2% duty cycle. The value of $C_1$ is 0.047 $\mu$F, giving a calculated $\text{PRF}$ of 600 Hz. The measured 10- to 90%-rise time of the pulse is 0.3 microsecond and the fall time is 4 microseconds.

---

**FET cuts down crystal loading**

By Fred B. Cupp

Clevite Ordnance, Cleveland, Ohio

**Crystal oscillators** can be built with conventional bipolar transistors, but the low input impedance of the bipolar units loads the crystal. Using a field effect transistor with its high gate-to-source impedance, however, minimizes crystal loading.

The design is a multiplier stage in a local oscillator injection chain of very-high-frequency/ultra-high-frequency receivers. Oscillation at the desired crystal frequency is achieved only when the tank circuit in the source lead is tuned to about 0.7 times this frequency. This condition must be satisfied to give a phase lag that offsets the phase lead due to the gate-to-source capacitance.

---

**Active element.** Use of FET simplifies crystal loading in oscillator-multiplier design. Values shown are suitable for fundamental operation at 40 Mhz, tripling to 120 Mhz.

The drain tank may be tuned to a desired harmonic of the oscillator frequency, such as the third, and the output may be taken from either the drain tank with link coupling, or from the drain lead by capacitive coupling.
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Integrated circuits in action: part 7
Cutting costs on the factory floor

Marriage of diode-transistor and transistor-transistor logic in a redesigned coordinate-measuring machine provides greater reliability at a sharply reduced price

By Michael French
Potter Instrument Co., Plainview, N.Y.

Makers of industrial equipment are always striving to improve their products. Some work for greater reliability, some aim at price reductions, and others go for a smaller-sized unit. The Potter Instrument Co. tried for all three and achieved a notable success by using IC's and a congenial mixture of logic types when it redesigned its coordinate-measuring machine for inspecting machined parts.

The machine—the Picomm II—sells for less than $8,000, half the cost of its discrete-component predecessor. It now weighs 550 pounds as against 3,400 pounds, and the specifications of the revamped unit match or surpass those of the older system. The electronics, which previously filled three bulky drawers, now are packed into a handsome console that can be carried by hand.

The radical cut in price is possible because only 1/6th the number of parts are needed than before, and labor costs are pushed down because so much less effort is required to count, assemble, insert, and inventory components. Of course, fewer parts mean far less solder and cable connections—both potential trouble spots.

The design of the electronics is an example of how compatible types of IC logic may be used to the best advantage. Instead of relying on a single logic type, the IC's in the measuring machine include diode-transistor logic (DTL) gates driving transistor-transistor logic (TTL) flip-flops. This mix was selected because TTL's are low-priced and the TTL flip-flops are needed to drive high-capacity loads.

Measuring dimensions.

Inspecting machined parts is a critical function in many production processes. A part turned out quickly by a numerically controlled machine tool may take hours to inspect manually. With a coordinate-measuring machine the job is accomplished in minutes.

The part, or workpiece, to be inspected is strapped down on the work table shown on page 115. A bridge over the table supports a movable probe that can be moved to any point on the workpiece's surface. To increase the size of the work area, the Picomm II mounts a probe on each side of the bridge. The operator switches from one to the other to increase the measuring area from 18 x 18 to 18 x 31 inches.

Starting at a reference point, which can be set anywhere, even off the part, the probe is moved from one critical point to another. As this happens, three transducers connected to the probe sense its movement along the x, y, and z directions. Low-level electrical signals from the transducers are processed and used to indicate the probe's position on digital displays.

D-c amplifiers boost the transducer signals from 50-millivolt to 4-volt levels and they are fed to analog-to-digital converters. The digital output from the converters is then applied to bidirectional decimal counters which activate the displays.

The author

Michael French, an electrical engineer with Potter for the past 2½ years, designed the electronics in the Picomm II measuring system. He received his bachelor's degrees in arts and electrical engineering from Brown University in 1962.
In the Picomm II, there is one display for the horizontal x axis, and another display that is switchable to read out dimensions on either the horizontal y or vertical z axis. The reference point may be set so that the numbers on a readout—referring, for example, to the distance between the centers of two drilled holes—correspond exactly to the dimensions on a blueprint or inspection sheet. The machine inspects printed circuit boards or intricate electronic assemblies, as well as castings and machined parts.

A special optical attachment, used for inspecting circuit boards, enlarges and projects the board pattern onto a viewing screen, shown on the cover. Instead of moving a probe, the operator moves a reticle over the critical points. Dimensions are read out on the digital displays in the same way as with the mechanical probe.

System design.

There are two sets of optical transducers—one set for each horizontal axis—as seen in the system block diagram on page 116. A third electromechanical rotary encoder on the z axis, used because it takes up less space than the optical units, senses vertical displacements. The horizontal encoders cover an 18- x 31-inch area; the vertical encoder measures heights to 7 inches.

Each horizontal transducer consists of a strip of glass, 22 inches long by 1½ inches wide, on which are scribed fine opaque lines, 500 to the inch. This glass strip extends the length of the work area. Separated from it by a few thousands of an inch is a 1½-inch-square piece of optical glass also scribed with the same density of lines.

The glass square, together with an incandescent lamp and two photocells, sketched on page 117, rides on the support bridge along with the movable probe. Its lines are always parallel to the lines on the glass strip. Light from the lamp passes first through the glass square, then through the strip and, finally, onto the photocells.

Detecting the sine waves

Outputs from each of the two cells are sine-like waves, due to the variation in light intensity caused by the movement of one set of scribed lines on the other. The frequency of the waves, between d-c and about 20 kilohertz, depends on how fast the probe is being moved. Because of the way the cells are
On location. D-c amplifiers are so small they can be mounted on the bridge inches from the optical transducers.

placed, the waves are in quadrature. Thus, for each 0.002-inch displacement of the probe, there are four zero-crossing points of the sine waves, two from each photocell. The resolution of the measuring system, using zero-crossing detectors, is 1/4th of 0.002, or 0.0005 inches. Zero-crossing detectors on the outputs of the z-axis rotary encoder similarly produce 0.0005-inch resolution. This is about the limit for this type of encoder.

For higher resolution, the two photocell outputs are mixed in a precision-resistor ladder network to give equal-amplitude phase-shifted signals. If five signals, 0, 36, 72, 108, and 144 degrees apart, are produced there will be 10 zero-crossing points to detect and the resolution will be 1/10th of 0.002 or 0.0002 inches. For a 0.0001-inch resolution, 10 phase-shifted signals and 20 zero-crossing points are produced in the ladder network.

The resistor ladder network is part of the analog-to-digital converter of the coordinate-measuring system. Usually such a converter takes a single analog signal and quantizes it into digital signals representing different voltage levels. However, here the analog-to-digital conversion takes the two data waveforms—the 90% phase-shifted signals from the photocells—and separates them, not by

System design. Both the horizontal x- and y-axis of the machine sense probe movement with linear optical transducers and convert signals to digital form. The z-axis uses rotary position encoder to save space.
Space saver. Picomm II requires only about 40% of the area needed in the discrete component system.

level but by phase. Then their zero-crossing points are detected to produce trains of output pulses for each sine-wave cycle.

Each phase-shifted output signal from the resistor ladder network is fed into DTL level-detecting circuits. These are simple DTL gates which switch from their high to low state as the analog input varies. A 0.2-volt swing through the zero-crossing point switches the gate. The level detector on each signal yields a square wave for each sine-wave cycle. The first transition of the square wave turns the flip-flop on, the second turns it off.

Outputs from the DTL gates are fed to TTL flip-flops which produce clean square waves. Series LC networks differentiate the waves and produce positive pulses that are fed to the bidirectional decade counter. Whether the pulses should be counted up or down is determined by a sequence detector consisting of an array of DTL gates.

TTL flip-flops are used because of the capacitive loading—up to 500 picofarads—of the differentiating network. The high output impedance of the DTL gate, which is 2 kilohms compared to the TTL gate's 60 ohms, coupled with this load would degrade the rise time of the output square wave.

**System electronics**

Integrated circuits are used in the d-c amplifiers, analog-to-digital converters, bidirectional decimal counters, and logic circuitry. These elements contain four types of integrated circuits:

- 946-type two-input quad DTL gates
- 962-type three-input DTL gates, three gates on a chip
- SN7473 dual J-K TTL flip-flops
- NE505 linear operational amplifiers

There is a drastic reduction in both the number and type of circuits that make up the coordinate-measuring system, and the space occupied by the electronics, as illustrated above.

For example, the transistor circuitry in the older system used 2,200 components; the new system has only 331. The 2,200 components consisted of six types of transistors in 254 places, 660 diodes, and about 1,300 resistors and capacitors.

With IC's the same circuits are put together with only 136 IC's, 90 diodes, and 105 resistors and capacitors. The area of printed circuit boards containing the electronics in the new system is 580 square inches; in the old it's 1,450.

**Tradeoffs**

Conflicting factors had to be balanced in choosing a mix of IC's for the Picomm II's electronics; they are noise immunity, speed, and fan out.

The electrically noisy factory environment where the measuring machines operate ruled out resistor-transistor logic (RTL) which is relatively inexpensive. Maximum noise immunity of RTL gates is only about 400 millivolts, which is, unfortunately, of the order of the noise anticipated. Diode-transistor and transistor-transistor logic, with their noise immunities ranging from 800 millivolts to 1 volt, were obviously the better choices here.

In general, noise was much less of a problem in the redesigned IC system because the voltage and

**Optical transducers.** A variable amount of light passed through a grating of opaque lines impinges on photocells to produce approximately sinusoidal signals spaced 90 electrical degrees apart.
current spikes during switching are smaller than those in the transistor circuits. The small size and great packing density of IC's also reduces noise pickup. Maximum distance between signal circuits is only 6 to 8 inches compared with 2-foot-long lines in the discrete design.

In the IC counter, for example, the maximum noise on the positive supply voltage of the counter with respect to ground is a 60-nanosecond ringing between 0.6 and 0.8 volt in amplitude. In the older Picomm's transistor electronics, the flip-flops generate a 200-nanosecond ringing varying between 2.5 and 3.0 volts.

Noise susceptibility of the transistorized system restricted its maximum speed, so that using the fastest transistors was avoided because noise immunity margins were reduced. With IC's, such considerations are no longer important.

With respect to fan out, TTL's ability to drive 10 to 12 elements rates better than the six-to-eight-element capability of DTL. However, the machine's logic circuitry in only a few cases required a gate to drive more than four elements. Thus, DTL, even with its lower fan out, was adequate.

In addition, the DTL gates allow a wired OR function, something not possible with TTL. For the same reason, Sylvania ultrahigh-level logic circuits, (SUHL), which are a type of TTL and have high speed and good fan out, were rejected.

### Counting speed

The counting speed in the system was set at 1 megahertz, a factor of 10 improvement over the 100-kilohertz speed of the bidirectional counters in the older systems. The faster speed doesn't provide any more measurement resolution, but rather reduces from 10 microseconds to 1 microsecond the minimum time required between pulses so that the counters don't lose count. This, in turn, allows much greater leeway in the adjustment of the machine. A customer's semiskilled personnel can unpack and plug the system together.

Another advantage of the higher circuit speed is that the probe can be moved much faster without losing position count. The maximum speed was increased from 900 inches per minute to 5,000 inches per minute. This top speed is impossible to maintain over any distance, but such a rate can be reached if the stationary probe is moved suddenly, or the moving probe is brought abruptly to rest.

The 1-megahertz speed can be easily handled by the DTL gates, and by SUHL and Motorola emitter-coupled logic (MECL) as well. However, at $1 per package, the DTL was considered the best buy. (In addition, DTL needs but a single supply voltage, unlike MECL, which operates with two levels.) Gates with 6-kilohm output resistors were selected instead of 2-kilohm resistors, also available, because the higher resistance reduced the drain on the power supply and allowed a fan out of six to eight elements, rather than four to six.

In a few places, transistors had to be used because of very high fan-out requirements. For this purpose, a transistor with characteristics closely matching those of the IC gates was chosen. One such transistor is the 2N3646 with similar switching levels, propagation, and switching times. By matching the discrete transistors with the IC's, interfacing problems were eliminated.

Although the 930-type DTL offers a great variety of gate types, all are inverting—NAND for positive logic, NOR for negative logic. This was at first thought to be disadvantageous because it would require additional circuits. However, externally connecting the outputs of the gates on a chip produces a wired configuration with which logic AND and OR functions can be readily performed.

### System construction

The electronics is divided into functional blocks contained on 5½-x 7½-inch printed circuit boards. All of the up-down decades in the decimal counters are on a separate board. So are the analog-to-digital converters. The decade boards also contain the high-voltage transistors for driving the display tubes mounted on the board.

Arranging the system in function blocks enhances flexibility. Sections can be upgraded separately, as
new components become available, without affecting other circuits.

It's also easy to provide performance options, such as better measurement resolution. For example, to go from a resolution of 0.0005 inches to 0.0002 or 0.0001 inches, all that's needed is a 3½ x 7½-inch circuit board. Each board contains the complete analog-to-digital converter, the resistor ladder network for mixing the output signals from the photocells, the level detectors and flip-flops, and the differentiating networks. Although twice as many signals must be handled for 0.0001-inch resolution as for 0.0002, the IC's still fit on a single board.

The space saved by the IC's also permitted a self-testing circuit to be built on one of the p-c boards. Consisting of a free-running 1-MHz square-wave generator made of two inverting gates, the circuit triggers all the counting decades in the machine at their maximum rates. Such a circuit would have been too bulky for a discrete-component system.

In discrete components the d-c amplifiers had to be put in the main electronic package, about 6 or 7 feet from the position transducers. Now, the d-c amplifiers—NE505 linear operational amplifiers manufactured by Signetics Inc., a subsidiary of the Corning Glass Works—are small enough to be mounted next to the movable probe on the support bridge, only 6 or 7 inches from the transducers, pictured on page 116.

Another plus for the functional blocks is that semiskilled people can maintain the system. Plug-in function boards are substituted until the faulty one is isolated and replaced.

Most of the IC's in the system are packaged in a 14-pin dual in-line epoxy plastic package. The exception is the NE505 amplifier. So far, this device comes only in a 10-pin TO-5 can.

The dual in-line package was chosen over both the TO-5 can and the flatpacks mainly because it handles easily in production. It's also about half the price of the flatpack and can be flow-soldered onto the p-c board. Its leads don't have to be carefully cut and spread, as with the TO-5 can and, of course, it has more leads than the can has.

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Computers

Weaving a braided memory that’s fast and inexpensive

By reducing parasitic capacitance between the wires, a read-only memory can achieve cycle times as fast as 300 nsec; specially designed loom weaves the braid.

By John J. Marino and Jonathan J. Sirota
Memory Technology Inc., Waltham, Mass.

Braid memories have long held out the promise of low cost. But, for the most part, it was an empty promise because of the knotty problem of coming up with a memory fast enough to be practical. Now, with a technique that greatly reduces the parasitic capacitance between the wires in the braid, transformer read-only memory systems are being produced that can operate in cycle times as short as 300 nanoseconds and cost about 2.5 cents per bit. The braid itself costs about 1 cent per bit, and this cost is expected to be cut in half.

Comprising a series of linear-ferrite cores—each with its own winding—and a bundle of word wires, the memories are being manufactured by Memory Technology Inc. The wire braids are woven on a specially designed loom [see “From the loom of MTI...,” p. 126], assembled onto the cores, which have air gaps, and incorporated into modules. These modules are built into memory systems.

Previous theoretical designs couldn’t operate at speeds much under a microsecond, because the capacitance had to be charged at the start of each cycle. And prior to xrr’s loom, only one machine had been built that could weave braids for memories—but that was an unwieldy laboratory device.

Data in a braid

Basically, the memory contains one wire for each word to be stored and one core for each bit of the output word. The linear magnetic material of the core doesn’t switch; the core acts like a transformer. Information is stored by the relative position of each word wire with respect to each core, making the memory electrically unalterable or read only. If a particular word wire passes through a particular core, a 1 is stored in the bit position represented by the core. But where the wire is threaded around the core, a 0 is stored.

Binary information is stored this way because of the high inductive coupling of the wire threaded through the core and the multiturn-sense winding. If the word wire is threaded around a particular core, the inductive coupling is low. Thus, when a current pulse passes along a word wire, the threaded cores produce large-voltage pulses on their sense windings, and the bypassed cores produce either small voltage outputs or none at all. By monitoring the outputs of all cores simultaneously, the data is read out.

The linear magnetic material used in the transformer memory can be used in cores that contain...
Diode matrix. In conventional design, one transmitter and one receiver send current through a single word line. The diodes block parallel paths through adjacent wires for any given transmitter-receiver combination. Matrix is used to minimize the number of components, thus holding down costs. Diodes and word lines are in color.

Parasitics. Grouping of wires in conventional design creates capacitances (in color) distributed over the full length of the lines. It's the capacitance that slows the memory's operation.

Air gaps without significantly affecting its magnetic properties. This allows the wires to be woven into a braid to separate them into the 1 and 0 positions for each bit in every word. The braid is then placed into U-shaped cores, which are then capped with ferrite material.

Parasitic capacitance

In the conventional design of word-organized memories, both read-only and read-write, the parasitic capacitance between groups of wires seriously restricts the speed. This is a consequence of the diode matrix that isolates the word lines from one another.

In the simplest matrix, where word currents are unidirectional, one diode is in series with each word line. The lines are then connected into a matrix as shown at left, in such a way as to enable address bits to locate one of \(2^n\) word lines with only \(2^{n/2}\) current transmitters and the same number of receivers. With both ends of the word lines separated into groups, the capacitance between the groups stems from the proximity of the wires. Thus, current passing along a wire must first charge the capacitance before reaching the other end.

An obvious way of reducing parasitic capacitance is by connecting one end of each wire to a common point. Such a connection implies an individual transmitter connected to the other end of each line, but this is obviously far too costly. To hold the number of components at an acceptable level, the matrix arrangement must be preserved.

**Design for high speed**

In MTR's high-speed organization, a two-input AND gate is used in each word line. The two sets of inputs are connected together in a matrix. To minimize the unwanted capacitance, the word lines share a common connection to a current supply at the end opposite the AND gate. Both the inputs must be on for current to pass through a particular gate and word line. A memory containing \(2^n\) lines requires \(2^n\) AND gates and two sets of \(2^{n/2}\) selectors.

Because of the large number of AND gates, an inexpensive gate design is necessary. The simplest design is a single transistor having its collector in series with the word line and its emitter and base connected to form the matrix. Additional \(2^{n/2}\) transistors, controlled by one of the two sets of selectors, serve as current sinks.

In the configuration on facing page, all inputs from both sides of the matrix drive only the bases of switching transistors. Thus, the transistors need provide only a small amount of current, about 15 milliamperes, and can therefore be connected directly to the outputs of commercially available integrated circuits.

Since all the word lines in this arrangement are connected to the same potential at one end, capacitance between lines is kept to a minimum. And it's primarily because of this one design feature that the memory is capable of achieving a high speed. Simplicity is achieved by eliminating the discrete-component transmitters and receivers required in the conventional design. Selectors can be built of integrated circuits.

**Braid modules**

MTR's memory contains 512 wires and 128 cores. The wires are connected to 32 small termination boards, each containing terminations for 16 wires. Called the braid, this module and a transistor matrix for line selection are mounted on a printed-circuit motherboard to form the braid assembly. This assembly is essentially a 32-by-16 matrix with an AND gate at each of its 512 intersections. Each gate is connected to a wire storing 128 bits of information. One edge of the assembly is the con-
Common connection. A positive signal at X, forward-biases the first current-sink transistor. This provides a ground connection for the top row of transistor AND gates. A positive signal at Y, permits current to pass through only the first gate. Thus line 1 is selected. The word lines are in color.

The assembly is placed on top of the cores, which are mounted on a sense-gate board containing output windings and diode-transistor-logic sense gates. As many as four braid assemblies can be placed on the cores in this manner. Shaped like the motherboard, the sense-gate board also has a connector on one edge. The braid assemblies, cores, and sense-gate board is sandwiched by two pressure plates to form what MTI calls a pluggable "Memory Pac." With four braid assemblies, the Memory Pac has a capacity of 2,048 words of 128-bits each, or a total of 262,144 bits. The motherboards' connectors are for input and the sense-gate board's connector is for output.

Because it is modular, the system is easily maintained. The Memory Pac can be unplugged, disassembled, and any part—cores, braid assembly, or sense-gate board—can be replaced. Even the information in the braid assembly can be modified—by merely removing the braid from the motherboard and replacing it with another.

Many words per wire

Multiple words are stored on each word line for two reasons. First, long wires are just as easily

Transformer memory. In this word-per-line organization, current through any one word wire generates a voltage pulse in the sense wires of those ferrite cores that the word wire passes through. The cores are U-shaped with ferrite caps to complete the flux path.
woven as short ones, and memories made from a few long wires cost less to build than those of many short ones. Second, the probability of a wired-in error is approximately proportional to the number of wires, so that the risk of error is lessened with the multiple-word approach.

With this arrangement, a single cycle reads out all the words on a single wire. An additional selection circuit at the memory’s output routes one of these words to the computer or other digital assembly served by the memory. The remaining words are discarded.

For example, a braid memory containing 4,096 words with 32 bits per word could be made of 512 wires, each storing eight words. Each wire is connected to the collector of one transistor in a 16-by-32 array, the bases and emitters of which are connected to address-selection circuits. To select a word, a 12-bit address is required. Nine of these bits select one wire, causing its transistor to be forward-biased and thus enabling current to flow through the line. The remaining address bits select one of the eight words, which are read out in parallel. The desired word is then routed by the output selector.

**Five different modules**

The system at top of facing page can be made with just five basic modules:

- Current source and control—containing a pulsed current source and the circuitry required to produce five different timing pulses for the read-only memory.
- Selector gate—a modified decoder that can have up to eight inputs, and produces both NAND and AND functions at the outputs.
- The braid assembly—consisting of a braid containing up to 512 wires with 128 bits per wire. The matrix of 512 transistor switches used for selection is also included. If a specific system requires

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**Sense gate module.** This one printed-circuit board can sense up to 32 eight-bit words, or one 256-bit word, or anything between.
fewer wires, only the necessary transistors would be included here.

- Sense gate—containing up to 128 output sense windings, 128 two-input sense gates, and 128 U-shaped cores. This module together with the braid assembly module and a substrate holding 128 ferrite caps for the U-shaped cores make up one Memory Pac.
- Flip-flop—containing 12 set-reset flip-flops, which hold the data for the computer.

The selector-gate module decodes the input address and produces pulses that drive the word-selection transistor matrix. Each module contains an inverter for each input signal, AND gates to form various combinations of the inputs and their complements, and another inverter for each combination. All eight combinations of the first three input bits are decoded by the selector gate and fed into an AND gate along with either the true or complemented form of the remaining five bits. For the latter, jumpers connect one or the other form into the selector gates on a particular board. Thus, two similar modules could have the same inputs yet produce different output functions because of different internal connections of the five bits. The connections enable this module to be used in any matrix up to a 256-by-256 array.

Sensing the output

The sense-gate module contains the output windings mounted on U-shaped ferrite cores, the sense gates, and the gates required to combine up to 16 sense signals on one line.

In the module, the strobe inputs to eight adjacent sense gates are all connected to one pin. The module, therefore, contains 16 strobe connections that, if kept separate, can provide 16 words of eight bits each. The array on preceding page has 128 signals from the braid under control of 16 strobe lines. The outputs of these gates are combined to produce the eight-bit words. All wired on connections—outputs of NAND gates tied together—are made with jumpers. By removing the jumpers and connecting together some of the strobe lines, longer words can be read out in parallel.

The sense-gate module can therefore organize the braid memory into any of several formats:
- 512 words of 128 bits per word
- 1,024 words of 64 bits per word
- 2,048 words of 32 bits per word
- 4,096 words of 16 bits per word
- 8,192 words of 8 bits per word

MTI also produces a smaller braid memory with a total capacity of about 20,000 bits in which a single 10,000-bit module combines all the functions of the five modules in larger memories. The braid contains 128 wires and 80 cores.

Simple and flexible

The modular approach to braid-memory design provides simplicity and flexibility. And, at the same time, it leads to improved system capability. The Memory Pac concept improves the electrical characteristics of the system by reducing capacitance and inductance, eliminating discrete-component drivers and receivers, and using single-ended selection of word wires.

Also, because it is modular, the memory's size...
From the loom of MTI . . .

Capable of weaving braids of up to 256 wires each at 60,000 bits per hour, Memory Technology’s loom combines modern electronic instrumentation with the centuries-old technique of textile weaving. For a 512-line memory, two 256-wire braids—to be placed onto each leg of the U-shaped core—are encapsulated as a single unit. Heart of the loom’s electronics is a paper-tape reader, error-checking circuitry, and power supply.

Data to be stored in the braid is read from the paper tape and stored in a small buffer memory. Binary 0’s in the memory cause control rods to be pulled to one side. This motion establishes one separation of 1’s and 0’s in the braid. A mechanical arrangement measuring about 18 by 10 by 4 inches then lifts the control rods that have been pulled aside. To maintain the separation, the operator inserts a temporary separator between the raised wires and those that are not. Later, a U-shaped core will fit into the space where the temporary separator is inserted.

The mechanical apparatus also feeds back the separation to the electronic portion, for comparison with the data read from tape. The operator can, if he wishes, set the controls before starting to weave a braid so that if an error occurs, the loom automatically repeats the selection.

The process is then repeated for the next separation.

The predecessor of MTI’s table-top loom was the big Jacquard loom at the Massachusetts Institute of Technology’s Instrumentation Laboratory. Unlike that machine, which was designed for textile work and modified for braid weaving, the loom used at MTI was designed specifically for braid work. Controls on the loom are electrical. Because hydraulic or pneumatic equipment isn’t needed, the loom’s speed and reliability are enhanced.

Braids in context

The MTI loom, shown above, is weaving braids for applications ranging from microprogram storage in general-purpose computers to constant-function generators in digital filters. And the trend toward using more read-only memories in computers should give the loom plenty of additional work in the future.

Computer designers are turning to read-only memories to simplify the setting up of computers for special applications. The memories reduce the amount of software needed. Braid memories have an edge in this application. Since their construction can be programmed automatically, they are easy to make. And, they are less expensive than other forms of read-only memories.

For example, rope memories, another form of transformer memory, cost several times as much as braid memories. The rope design calls for a core that switches, so the core cannot have an air gap and must be annealed before the memory is assembled. As a result, the cores must be made in one piece and the wires threaded through the cores one by one—an expensive procedure compared with weaving.

Braid memories are also more economical than diode arrays, which cost about 10 cents per bit for the array, plus the cost of the sensing and driving circuits. Read-only memories have generally been used in applications requiring no more than 1,000 bits, such as character generators in display systems. However, integrated-circuit techniques are expected to drive down the cost of diode and other semiconductor memories.

The other two major competitors are resistive and capacitive memories, both of which can be made cheaply by etched-circuit techniques. Resistive memories cost only a few cents per bit, but have poor signal-to-noise ratios. Capacitive memories compete on the basis of speed.

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Packaging

Problems of heat removal chill progress in IC's

Uncertainties in analysis and gaps in design and test data force designers of integrated electronic systems to use thermal management techniques rooted in the transistor era.

By Allen B. Chertoff and James J. Foti

After months of work, a project engineer plunged the new airborne computer into boiling oil to begin testing its ability to operate well in the extreme temperatures of a jet aircraft. In the sealed housing were crammed 2,000 integrated circuits and heat exchangers so efficient the IC junctions couldn't get hotter than 125°C.

But after a year of operational trials, the computer was rejected because of poor thermal design. During most of the test period, the IC's continually heated up to 100°C although the air temperature around the computer rarely exceeded 35°C; 100°C was too hot for long-term reliability. The production contract was won by a competitive design that allowed junction temperatures to rise to 150°C during the brief periods the aircraft traveled at top speed at very high altitudes, but held junction temperatures below 90°C in day-to-day operation.

What went wrong? Whoever insisted on the worst-case design didn't realize that a cooling system can be highly efficient in one environment, but inefficient in another. The convective cooling capacity of the air in the normal environment wasn't considered in the high-altitude design.

While the example is fictitious, the problem is not. Such pratfalls occur because thermal management in integrated electronics systems is not a well-defined field nor is it well understood by specialists in other engineering disciplines. Evidence of this is the fact that even IC manufacturers do not supply packaging engineers with the IC thermal characteristics needed to do a good design job, and that system designers may unthinkingly specify inappropriate packaging configurations and hardware.

Although the IC era is now some five years old, packaging approaches are mostly throwbacks to the transistor era. There have been few fundamental advances. Thermal management techniques now lag so far behind IC developments that they represent a serious impediment to general progress in integrated electronics. Equipment made with today's IC's rarely achieves the hoped-for increases in reliability and decreases in size and weight—which should temper the optimism about tenfold improvements in reliability and packaging density with large-scale integration in the near future.

Accomplishments have been few because most of the effort and money lavished on IC cooling studies has been spent on only part of the problem. Thermal analysis has reached a new high in popularity, while thermal design and tests, needed to prove out designs, are virtually ignored. The reason is obvious—thermal analysis is quicker and less expensive than devising new thermal management systems and adequate test criteria.

Thermal analysis is undependable for accurate design because too many variables are unknown when analysis is made. If a design is based on analysis alone, the uncertainties can easily add up to an error of 25%. This forces overdesign that may make the cooling system bulky and introduce failure-prone mechanical parts. The only way to get an accurate design today is via the painstaking route of analysis, preparation of a thermal mockup, testing the mockup, refining the design, and finally verifying the design in long-term operational tests.

No substantial progress is likely until the industry recognizes that thermal management is at an early stage of evolution. It may then support thermal management programs of the type that made radio-frequency-interference control, reliability, and maintainability well-defined disciplines. Criteria for
analysis, design, and testing must be developed and coordinated, and time and manpower provided for exploring and evaluating new cooling techniques, such as direct immersion in dielectric liquids.

**Interface uncertainties**

Thermal analyses are not inaccurate because of lack of knowledge about the principles of convective, conductive, and radiative heat transfer. There are dozens of formulas that can be used. Designs based on such analyses are risky, however, because many assumptions must be made about factors that are uncontrollable in equipment production, installation, and operation.

In the first place, a mix of heat-transfer modes is probably involved in a design, and the actual heat-flow paths are always somewhat different from the generalized paths used in an analysis. No general expressions covering all the modes have been devised because the key variables of each mode are different. The thermal resistance of a radiative heat-transfer system varies as the cube of the mean temperature. If convection is employed, resistance depends upon air temperature and the difference between the temperatures of the air and the surface being cooled. In conduction cooling, the main variable is the temperature of the conductive medium.

Moreover, many of the so-called constants in the formulas are actually low-order variables. Selecting the right values of these variables depends in part on the analyst's experience and judgment. Also, form factors in electronic equipment rarely fit the geometric shapes upon which convection formulas are based. Finally, the calculations can be upset by variations in power dissipation from IC to IC, and even by such seemingly minor things as differences in clamping pressures in a conductive cooling path, or in the mounting torque of stud-mounted devices, and by variations in the dimensions and conductivities of hardware in the heat-conducting paths.

Assumptions must also be made about the operating environment. Unless a new avionics system, for example, directly replaces earlier equipment, the thermal interfaces between the system housing and the aircraft must be guessed at.

Suppose the heat is to be radiated from the housing. Usually, the designer has only rough information on view factors (how much of the radiation will be blocked or reflected by adjacent structures), on aircraft skin or bulkhead temperatures, and on emissivities of surrounding surfaces. The mounting method may not have been decided, if the aircraft is a new one, and even if the mounting is specified, the designer must estimate such factors as thickness of conductive greases or adhesives, and how much of the mounting area is covered.

**Fahrenheit's laws**

Despite their shortcomings, formulas must be used by the designer because cookbook solutions are of less merit. When a designer relies upon the literature, he chooses his thermal resistance values arbitrarily. The raw data available on heat conduction and convection applies only to specific equipment configurations, environments, and uses.

A design that depends upon conduction for heat transfer must allow for contact resistances between materials in the heat path. The data in the literature are for particular alloys, particular mating methods, particular temperature ranges and atmospheres, and so on. The probability of a new design meeting all these particulars is small, yet a change in any parameter significantly changes contact resistances.

Most designers start with the values for thermal resistances that, from experience, approximately fit the contemplated design. Uncertainties are cleared up, when necessary, by bench tests and the use of thermal mockups. Component temperatures can then be calculated by applying the heat-transfer equivalent of Ohm's law.

The equations in the table on page 133 for formulas are given for forced convection, since the texts are full of them.

**Forced convection**

Solutions obtained from forced-convection analyses are almost always less accurate than those obtained for other modes. Among the reasons are:

- Coefficients and exponents are different for flows over exterior and interior surfaces. If the designer considers the cooling air or liquid to be flowing on the exterior of the circuit boards, he'll get one answer. If he considers the flow as being inside the system housing, he'll get a somewhat different answer.
- It is almost impossible to calculate the air velocity at each point in the flow path. Velocity varies with blow speed, cross-sectional area of the flow path, and with smoothness of the surface being cooled. Some components may not be swept by the air stream because it is obstructed.
- The equations are based upon empirical data obtained with regular geometric shapes. Electronic assemblies are rarely perfect planes, spheres or cylinders.

Nevertheless, the designer of IC cooling equipment must frequently rely on forced-convection systems. In compact equipment, free air space may be insufficient for natural convection, and at high altitudes the air is too thin. Natural convection between boards packaged in conventional card files drops by 25% between sea level and 15,000 feet of altitude, and ceases entirely at slightly above 20,000 feet.

The unwary designer can be misled by specifications requiring that the mean time between failures (MTBF) of components be proven in tests at sea level rather than at operational altitudes. Suppose analysis indicates that junction temperatures will not exceed 90°C at operating altitude. Sea-level tests confirm this but the junctions actually heat up
Thermal design formulas

Natural convection

\[ \Delta T_{p-a} = \frac{QR}{R_e} \]

\[ R_e = 4.4(QZ_a)^{-0.2}T^{0.2}(A,K_a)^{-0.8} \]

where,

- \( \Delta T_{p-a} \) = temperature difference (°F) between the surface being cooled and ambient air
- \( Q \) = heat dissipation, in watts
- \( R_e \) = natural convection thermal resistance, °F/watt
- \( Z_a \) = \( gBp\rho_a^2/\mu_a^2 \)

\[ R_v = 4.4(QZ_a)^{-0.2}D^{0.2}(A,K_a)^{-0.8} \]

\[ A_r = \text{area of radiating surface for parallel flat surfaces or projected area of non-parallel surfaces, ft}^2 \]

\[ T_m = \text{mean temperature between the radiating surface and ambient, °R} \]

\[ \text{Since } T_m \text{ depends on the temperature difference that is being solved for, it is found by an iterative method. The temperature difference is repeated for until the assumed and calculated values are approximately equal. For example, let} \]

\[ \Delta T = 100 \text{ °F} \]

\[ \Delta T = 560 \text{ °R} \]

\[ \epsilon_1 = \epsilon_2 \]

\[ A_r = 1 \text{ ft}^2 \]

\[ Q = 20 \text{ watts} \]

\[ R_v = \frac{QR}{T^{0.2}} \]

\[ \frac{A_r}{T^{0.2}} = 5.9 \times 10^8 \]

\[ \frac{T_m^3}{T^{0.2}} = 5.9 \times 10^8 \]

then:

\[ R_v = 4.9 \times 10^8 \left( \frac{10.9+0.9-1}{0.9+10} \right) \]

\[ \frac{1}{T_m^3} \]

\[ R_v = 610 \]

\[ 2.58 \]

\[ 52 \]

\[ \Delta T \]

\[ \Delta T \]

\[ 100 \]

\[ 610 \]

\[ 2.58 \]

\[ 52 \]

\[ 60 \]

\[ 590 \]

\[ 2.88 \]

\[ 58 \]

\[ \text{therefore}: T_m = 59 \text{ °F} \]

Contact resistance

Thermal resistance across a metal-to-metal interface in a vacuum is approximated by

\[ R_{ev} = \frac{(8+0.6)(Y_o \times 10^{-3}+16)^{0.54}}{(3 \times 10^6)(8.9+0.1e^{34})} \]

where

- \( R_{ev} \) = thermal contact resistance, °F-ft²/watt
- \( P_a \) = apparent contact pressure, psi
- \( d \) = distance between clamping points, in.
- \( S_t \) = surface finish of lower yield point surface, \( \mu \) in.
- \( Y_o \) = initial yield point of material on hot side of interface, psi
- \( W_o \) = initial total flatness, in.

\[ R_{ev} = 0.5+0.1P_a \text{ when contact pressures are between 2 and 10 psi} \]

\[ R_{ev} = 0.55+P_a \text{ at contact pressures between 10 and 30 psi} \]

\[ R_{ev} = 1.85+0.03P_a \text{ at contact pressures above 30 psi} \]

\[ G(S_t) = 1.0 \text{ for surface finishes between 12 and 46 microinches} \]

\[ G(S_t) = 0.64+0.03(S_t \times 10^6) \text{ for surface finishes below 12 } \mu \text{ in.} \]

\[ G(S_t) = 0.79 - 0.0046 (S_t \times 10^6), \text{ above 46 } \mu \text{ in.} \]

In air the thermal resistance of a metal-to-metal interface is approximated by

\[ R_{ea} = \frac{R_{ev}}{W_o} \]

\[ (W_o + 32R_{ev}K_a) \]

where

- \( R_{ea} \) = thermal contact resistance in air, °F-ft²/watt
- \( K_a \) = thermal conductivity of air (evaluated at the mean interface temperature), Btu/hr-ft-°F

Thermal characteristics of devices from the same production run can vary as much as 5:1, as indicated on the upper sketch in the diagram on page 132. Different packaging methods can result in a 15:1 variation. This causes problems in reliability analysis as well, since IC failure rates cannot be determined if junction temperatures are unknown. To make sure MTBF is adequate, safety factors must be applied to the cooling system design—in other words, the system must be overdesigned.

IC manufacturers don’t want to commit them-

...
selves to a specific junction-to-case thermal resistance because that may prevent future changes in materials, die sizes, processes, or bonding methods. However, such changes can cause major problems after a thermal design is frozen and a long production run begins. The system contractor could approve thermally unacceptable changes; in fact, most procurement specifications do not cover control of thermal characteristics.

The oversight can be corrected by making reasonable requirements part of the purchase order—for example:

- Junction-to-case thermal resistance shall not exceed 500°C/watt when the only heat-removal surface is the IC package base.
- Thermal resistance of each lead, including lead-to-die bond, shall not exceed 4,000°C/watt/inch measured from the package centerline. This may be ignored if the leads are not used as heat paths.

These particular requirements can assure junction temperatures 30°C lower than the worst case. Reliability will be higher. In some cases, the designer could avoid using an air blower or cooling fins.

Choosing a design

The family of curves on page 133 have helped the authors to weigh qualitative relationships between design options. Similar groups of curves have been developed for different device packages, coolants, and assembly configurations.

The curves represent the cooling capability of each method when heat sinks are not used. With heat sinks, each curve shifts to the right an amount depending on the type and location of the heat sinks. Each clockwise step from curve to curve represents an incremental decrease in maintainability. Natural convection requires no moving parts, forced convection requires a blower, immersion cooling usually takes pumps, seals, and heat exchangers, and evaporative cooling demands the equivalent of a refrigerating system or a replenishable coolant supply.

Each step from curve to curve also represents a step down in system size, due to higher cooling efficiency. Note the dramatic improvement in efficiency that is possible with liquid cooling. Large-scale integration will probably force further development of immersion and evaporative systems, leading to equipment that is higher in reliability although more trouble to maintain.

With such curves, a designer can quickly weigh tradeoffs. Suppose he wants to make sure that IC package temperature will not exceed 300°F at a power dissipation of 1 watt. If he selects natural convection, he must use heat sinks. If he selects forced convection, he pays a maintainability penalty but gains a safety factor of 50°F, since forced convection holds package temperature to 250°F at 1 watt dissipation.

Thermal mockups

Whenever feasible, the analysis and paper design should be backed up by testing of thermal mockups. Subassembly and assembly models such as those on page 134 are used at Loral Electronic Systems so that thermal analyses can be checked early in the development cycle. The models can be built before the circuit designers have completed their work.

The flatpacks in the circuit board mockup contain resistors whose power dissipations equal those of the ICs to be used. The resistors are silicon monolithic types made with the same die size and packaged by the same processes as the ICs they represent. The resistors are connected to appropriate power supplies and test instruments by etched wiring.

Junction temperatures in the model will be essentially the same as in ICs. Resistor values can be monitored to detect heating that would affect an IC's transfer function; silicon resistors have a high thermal coefficient of resistivity. If a resistor becomes too hot, it will fail like an IC because the die bonds or chip metalization is degraded. Package temperatures, heat flows and hot spots are determined by any of the common techniques, ranging from the use of sensors to plotting thermal patterns with infrared scanners.

Assembly mockups are used to determine such
Commonly used values of convection variables

<table>
<thead>
<tr>
<th>Altitude</th>
<th>T</th>
<th>ρ</th>
<th>μ</th>
<th>K</th>
<th>B</th>
<th>gBρ²/µ²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F</td>
<td>lb/ft³</td>
<td>lb/ft-hr</td>
<td>BTU/hr-ft-°F</td>
<td>°F⁻¹</td>
<td>1/°F-ft³</td>
</tr>
<tr>
<td>Sea level</td>
<td>25/77</td>
<td>0.074</td>
<td>4.5 × 10⁻²</td>
<td>0.0149</td>
<td>1.87 × 10⁻³</td>
<td>2.24 × 10⁶</td>
</tr>
<tr>
<td>Sea level</td>
<td>35/95</td>
<td>0.072</td>
<td>4.6 × 10⁻²</td>
<td>0.0153</td>
<td>1.77 × 10⁻³</td>
<td>1.95 × 10⁶</td>
</tr>
<tr>
<td>Sea level</td>
<td>55/131</td>
<td>0.066</td>
<td>4.9 × 10⁻²</td>
<td>0.0160</td>
<td>1.71 × 10⁻³</td>
<td>1.30 × 10⁶</td>
</tr>
<tr>
<td>Sea level</td>
<td>71/160</td>
<td>0.064</td>
<td>5.0 × 10⁻²</td>
<td>0.0166</td>
<td>1.63 × 10⁻³</td>
<td>1.22 × 10⁶</td>
</tr>
<tr>
<td>Sea level</td>
<td>95/203</td>
<td>0.060</td>
<td>5.1 × 10⁻²</td>
<td>0.0174</td>
<td>1.52 × 10⁻³</td>
<td>8.50 × 10⁵</td>
</tr>
<tr>
<td>10,000</td>
<td>53/128</td>
<td>0.046</td>
<td>4.8 × 10⁻²</td>
<td>0.0161</td>
<td>1.71 × 10⁻³</td>
<td>6.54 × 10⁵</td>
</tr>
<tr>
<td>10,000</td>
<td>68/155</td>
<td>0.044</td>
<td>4.9 × 10⁻²</td>
<td>0.0165</td>
<td>1.64 × 10⁻³</td>
<td>5.48 × 10⁵</td>
</tr>
<tr>
<td>10,000</td>
<td>93/199</td>
<td>0.041</td>
<td>5.0 × 10⁻²</td>
<td>0.0174</td>
<td>1.52 × 10⁻³</td>
<td>4.18 × 10⁵</td>
</tr>
<tr>
<td>50,000</td>
<td>20/68</td>
<td>0.0086</td>
<td>4.4 × 10⁻²</td>
<td>0.0147</td>
<td>1.90 × 10⁻³</td>
<td>2.98 × 10⁴</td>
</tr>
<tr>
<td>50,000</td>
<td>35/95</td>
<td>0.0081</td>
<td>4.6 × 10⁻²</td>
<td>0.0153</td>
<td>1.77 × 10⁻³</td>
<td>2.34 × 10⁴</td>
</tr>
<tr>
<td>70,000</td>
<td>10/50</td>
<td>0.0034</td>
<td>4.3 × 10⁻²</td>
<td>0.0144</td>
<td>1.97 × 10⁻³</td>
<td>5.14 × 10³</td>
</tr>
<tr>
<td>70,000</td>
<td>35/95</td>
<td>0.0032</td>
<td>4.6 × 10⁻²</td>
<td>0.0153</td>
<td>1.77 × 10⁻³</td>
<td>3.61 × 10³</td>
</tr>
</tbody>
</table>

factors as adequacy of selected heat sinks and air blowers, and the best circuit board mounting arrangement.

**Preferred designs**

When a thermal design proves itself adequate in one system it should naturally be considered a candidate for use in similar systems—with appropriate modifications. The use of preferred designs may not advance techniques to the theoretical ultimate, but they make for system effectiveness. Besides, the time and money needed to work up and prove out totally new designs is rarely available.

The mockups on page 134 are two of Loral's preferred designs. The board is a multilayer one, with the top layer used as a heat conducting plane. Heat flows through the metal strips under the flatpacks. The strips are generally aluminum ⅛ inch wide and 0.010 inch thick. Thermal resistance of the configuration is 17% less than a solid alumina substrate 0.050 inch thick, and only slightly more than a beryllia substrate.

Clamped metal-to-metal interfaces transfer the heat from the strips along the board edges to a card file and then to the assembly case. The case is the heat sink. Heat is removed from the case by convection and radiation.

The chevron card arrangement in the second photo on page 134 will, on the average, keep components about 4°F cooler for each 10 watts of power dissipation in a forced-convection system than mounting the cards in the usual way. Conventionally, the cards are mounted in a manner that requires the airstream to make one or more 90° turns. Angling the cards makes them catch the breeze better, but there is a more subtle reason for the better cooling.

Increasing the turn radius to 120° reduces the turn angle to 60°. The drop in air pressure is lower than in a 90° turn, and the air velocity is 30% higher. Therefore, the air can pick up heat from the components more efficiently (air's heat transfer coefficient varies with velocity). The temperature difference between the air and the component surfaces decreases by 6.8%, and the components are correspondingly cooler.

**Designs not preferred**

Mechanical design of equipment packaging often precedes thermal design, and sometimes parts requiring long lead times are ordered before the thermal design is established. This causes more delay and higher costs than when the two designs are worked out jointly.

More often, the designer must use thermally inadequate parts because they are the ones readily available. Typically, a decision is made to plug circuit boards into available card files. These
are expected to serve as primary heat paths, although they conduct heat poorly. As a result, the designer must rig up alternate conducting paths or resort to blowers, so system effectiveness suffers.

Another reflex use of stock items is the selection by electrical engineers of power supplies with 10% regulation. In many cases, a system would be more reliable and less expensive if extra money were paid for 5% or 1% power supplies. Components would run cooler and the cooling system would not have to be beefed up to allow for overloads up to 10%.

Components such as power transistors sometimes pump out more heat than the cooling paths can readily handle, creating hot spots. Heat sinks or finned cooling devices can spread the heat. Thermoelectric coolers should be used only as a last resort. The coefficient of performance of thermoelectric devices decreases exponentially as the temperature difference across the device increases. Since development of a temperature difference is the reason for using the device in the first place, relatively low coefficients must be accepted. In practice, a reasonable upper limit is 0.5—that is, for every watt removed from the hot component, 2 watts must be removed from the thermoelectric cooler. Thus, the hot spot may reappear at another location, which will not be very far from the original spot because thermoelectric coolers are planar devices whose hot and cold sides are close together.

Thermoelectric devices, moreover, are characterized by high currents and low d-c voltages. A single couple has a voltage drop of about 0.1 volt; currents of 10 amps or more are normal. Since the quantity of heat to be pumped governs the number of couples, the d-c supply voltages needed may not be available from the equipment power supply. A special power supply may be required adding to the system weight, size, and power dissipation. Cold plates are also generally undesirable. They
should be used when they provide the only system interface—for example, when avionics equipment must depend on a central heat exchanger in the aircraft or missile. To save weight and lower component temperatures, the coolant should be in contact with heat dissipating components whenever possible.

A typical cold plate is a hollow metal chamber through which a cooling fluid circulates. It acts as a buffer between the heat dissipating components and the coolant. The heat follows a tortuous path before reaching the final heat sink. This buffer always absorbs a substantial portion of the temperature difference between the components and the coolant—a difference that is usually limited at best in military equipment.

**Worst-case design**

Thermal designs based on worst-case environments will invariably result in x̄′s being lower than if the design were based on the normal operating environment. The design goal should be the lowest component temperatures in normal use. Backing off from this to minimize the temperature rise in worst-case environments makes the cooling system less efficient in other environments.

While most jet aircraft, for example, operate at altitudes above 30,000 feet, the cockpit is usually pressurized to the equivalent of 10,000 feet. The equipment must be able to operate during a decompression, but that environment will exist for only a small part of the equipment life.

A design based on the high-altitude, decompression condition would use only conduction and radiation, because the air density above 30,000 feet is too low for natural or forced convection cooling. If the designer depends on air cooling during pressurized operation, he can lower component temperatures. Naturally, he'll also make certain that component temperature limits are not exceeded during decompression.

Fin spacing is a good case in point. Fins intended for convective cooling at high altitude are widely separated. Widely spaced fins transfer heat at low

---

**Temperatures in an avionics system**

<table>
<thead>
<tr>
<th>Environment</th>
<th>Worst-case temperatures</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;95% of components</td>
<td>&lt;5% of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>components</td>
</tr>
<tr>
<td>Sea level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_s = 95 \degree C$</td>
<td>120</td>
<td>155</td>
</tr>
<tr>
<td>Sea level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_s = 35 \degree C$</td>
<td>63</td>
<td>98</td>
</tr>
<tr>
<td>10,000 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_s = 35 \degree C$</td>
<td>68</td>
<td>104</td>
</tr>
<tr>
<td>70,000 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_s = 35 \degree C$</td>
<td>105</td>
<td>140</td>
</tr>
</tbody>
</table>

Heaters. Thin-film resistors can be deposited on hybrid circuit substrates to control their temperature by controlling power dissipation. These experimental circuits contain extra heating resistors.
altitudes—but not as efficiently as a larger number of fins placed closer together.

Another consideration is the relationship between the component population and the maximum component temperature. It may not be necessary to insure that all components remain cooler than the component temperatures required for reliability. Again, the only qualification is that no component be allowed to exceed its temperature limits.

Statistical methods of determining reliability show little difference in XRF for the following two cases: 100% of the components no hotter than 30°C above ambient; or 95% within 30°C, 3% within 50°C and 2% within 100°C. Designing for the first case instead of the second means paying unnecessary penalties in cost, size, weight, or maintainability.

The table on page 135 represents an actual case—a system designed to operate in a pressurized cockpit. The data represents component temperatures for all pertinent conditions and shows that the equipment will operate satisfactorily in a MIL-E-5400 Class 1 environment. A rise of 35°C above ambient was the temperature limit established by MTF requirements. The highest temperature allowed for semiconductor devices was 175°C.

The specifications prohibited the use of blowers. Heat was transferred by conduction from all components to the outer surface of the assembly. The rear of the assembly and the rear two thirds of two sides were finned, with fin spacing optimized for an altitude of 10,000 feet. Components with high power dissipation were mounted directly to the finned surfaces. During pressurized operation natural convection transfers the heat from the assembly surfaces to the air, with a negligible assist from radiation. In high-altitude, unpressurized operation, radiation becomes the primary mode of heat transfer.

Putting heat to work

If the temperature of critical circuits must be kept fairly constant, the simplest and most reliable method is to control their power dissipation. Then, the thermal resistance of the cooling system does not have to be made variable to offset fluctuations in ambient temperature—a requirement that made it impractical to put the sensor in the circuit, a thermostat can be placed near it in the heat flow path. Thermo-couples are economical, but the heat path must be well-defined, which often bars their use in convective cooling systems.

Any of these three methods can control an IC's temperature to ±15°C with less than a watt of power. Consider an IC that dissipates 0.2 watt of power through a normalized thermal resistance of 100°C per watt. At an ambient temperature of 25°C, therefore, the IC temperature will be 45°C. If the ambient drops to −55°C, the temperature can be maintained at 45°C by having the IC dissipate 1 watt—that is, by supplying 0.8 watt to the heating elements.

The higher the thermal resistance of the heat-conducting path, the less heater power is required. A 0.2-watt IC's temperature can be maintained at about 45°C in a −55°C ambient with 0.65 to 0.75 watt when cooling is by convection or conduction, and with 0.4 watt if cooling is by radiation alone. In practice, the value would be somewhere between, because all three modes would be involved.

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James J. Foti, who is developing a hybrid packaging concept, was formerly consultant to the Navy's ad hoc packaging committee. Before that, he managed packaging and thermal design projects in the Apollo, Polaris, and F-111 programs.
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Electronics | September 18, 1967
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For complete information call your local HP field engineer or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

HEWLETT PACKARD

Model 5061A Primary Standard with new built-in clock and standby battery options.
EFFECTIVE OCTOBER 1, 1967

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Patents

Japan’s calculated risk

Hayakawa will try to run Texas Instruments’ patent blockade of key U.S. market when it exports an IC-equipped calculator this fall; move could bring legal battle

By Charles L. Cohen
Tokyo bureau

Within weeks, Japan will try to neutralize the basic patent on integrated circuits held by Texas Instruments Incorporated, which has effectively, if informally, kept Japanese ic-equipped electronic goods out of the U.S. As a test case, the Hayakawa Electric Co. will export a desk-top calculator built with integrated control circuitry made by the Mitsubishi Electric Corp. Barring an unexpected agreement at the ministerial trade conference in Washington this week, Hayakawa could start shipping its calculators by the end of this month.

The dispute between Japan and Texas Instruments has been simmering since 1964, when the country’s powerful Ministry of Trade and Industry rejected the company’s bid to establish a wholly owned manufacturing subsidiary there. In addition, the government has wrapped TI’s applications for Japanese patents on its semiconductor achievements—particularly bipolar techniques—in miles of red tape, hoping that local firms would have caught up technologically by the time the patents were granted. As a countermove, TI has held off on licensing any Japanese firms to use its U.S. patented techniques.

The Japanese fear that selling IC equipment in the U.S., without an agreement with TI, might violate the company’s basic patent.

But time is running out. Most Japanese electronics firms have to sell abroad, and the U.S. is their biggest customer. Hayakawa, for example, expects to export 70% of its new calculators to the U.S. and Europe; the company aims to produce IC calculators at a rate of 5,000 a month by next spring.

I. Reluctant dragon

Hayakawa isn’t particularly keen on its prospective test-case role. The company simply wants to sell its CS-32 export calculators, which are similar to units introduced in Japan last month.

There are, of course, enormous risks involved in bucking TI—not the least of which is the possibility that the U.S. firm will get a court order to seize all imported IC merchandise at ports of entry.

But Hayakawa, Japan’s leading calculator company [Electronics, Aug. 21, p. 189], won’t have to go it alone in the U.S. The Japanese government, with the ubiquitous MITI, will back its play with cash and political pressure, as will trade groups and other electronics concerns. As a matter of fact, the government has subsidized the development of the electronic calculator industry in Japan since 1964. Aid, which will continue at least

For openers. Tadashi Sasaki heads Hayakawa division making IC calculators that will be Japan’s first assault against Texas Instruments’ patent wall.

Electronics | September 18, 1967
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Trygon Gmbh & Munchen 60, Haidelweg 20, Germany

... trade talks are unlikely to provide a solution to the TI-Hayakawa problem...

through 1969, now aims at mass production and the use of ic's.

Waiting game. Hayakawa is holding off a formal announcement of its export plans to avoid embarrassing its government before the trade talks between the U.S. and Japan. It's unlikely that the meetings will provide any immediate solution to the impasse. According to a U.S. State Department source, Cabinet members will confer with their Japanese counterparts only on broad topics and avoid specific irritants like the prospective Hayakawa-Texas Instruments hassle. However, a Commerce Department spokesman says that while the patent dispute is not on the agenda, the positions of all interested parties could be discussed.

II. Paper tiger?

In taking up the cudgels, Hayakawa has the strong support of matsushita, a sort of superagency that regulates just about every aspect of Japan's economic, commercial, and technological life while setting the ground rules for foreign investment. The trade ministry is openly anxious to see TI's response to exports to the States of equipment with component ic's. Calculators in general and Hayakawa's latest offering in particular offer an immediate and potentially advantageous opportunity to confirm some observers' opinion that TI's bark is worse than its bite.

Deferment. Consumer goods afford a less conclusive testing ground than business machines. Purchasers don't insist on ic's and manufacturers have still to be sold on such devices. An executive at the Matsushita Electric Corp. says divisional managers want high reliability, small size, and low cost in components. Integrated circuitry now satisfies only the first two requirements. Japanese managers are sometimes willing to put perhaps one ic package into a television set even though costs may run as much as 10% higher than those of the replaced components. They figure that prices should go down in the long run and that ic's provide an opportunity for some advertising mileage. However, if any problems crop up, conventional circuitry immediately gets the nod.

Japanese computer makers aren't ready to jump into the U.S. market at all, let alone with ic equipment. They have their hands full producing third-generation machines for their domestic market. The industry has exported a few units to countries new to the computer on the chance that Japanese machines might be made the future standard. But the larger and more mature U.S. market offers no such opportunity. In addition, imports of computers and related items require government approval because the Japanese industry is still weak. If the country were to mount even a token export effort in the U.S., they would be hard put to justify their own restrictions.

III. Competitive edge

However, U.S. demand for electronic calculators is beginning to boom [Electronics, March 6, p. 217], and Hayakawa wants to get into the market while the getting's good. Moreover, integrated circuitry can be employed to advantage in calculators, and customers are vitally interested in such equipment.

Manufacturers have about the same operational goals and work from essentially the same block diagrams. Thus, those skillful enough

The fittest

One observer speculates that natural selection may have had something to do with the emergence of the Hayakawa Electric Co. as Japan's first champion in the impending brawl over integrated-circuit patent rights. Certainly, he says, the company has the required nerve. Hayakawa is now exporting calculators incorporating Nixie-like tubes to the U.S. despite the fact that it has made no royalty arrangements with the Burroughs Corp. Ironically, Hayakawa is one of the Japanese firms approached by Burroughs representatives seeking to buy calculators for resale in the U.S.
to come up with special ic's that save on the package count and cut costs find themselves with a best-selling item.

Short count. The 16-digit calculator Hayakawa intends to export contains only 22 bipolar integrated control circuits paired with ferrite-core registers. The ic packages are the identical quadruple dual-input, transistor-transistor-logic gates used in the memory register of an earlier 14-digit version [Electronics, Feb. 20, p. 295].

In view of the small number of ic's in Hayakawa's machine, which also has 1,200 diodes and 300 transistors, some observers feel the company would be better off buying standard bipolar devices from TI and other U.S. sources. American firms have been hawking their wares in Japan lately on the promise that products using them could be exported to the U.S. with no fuss.

But Mitsubishi modifies the circuits it supplies Hayakawa to provide better noise immunity—a feature which makes the devices easier to use. Mitsubishi also sells its ic's for slightly less than U.S. firms and, of course, is immediately available for consultation should any problems arise. Finally, and perhaps most important, Hayakawa is not about to give up the technical edge it thinks it has because of its virtually proprietary devices.

If Hayakawa thought the CS-32 was an ultimate product, it might readily settle for U.S. devices. But in a year or so when the price of bipolar ic's comes down further, Hayakawa will switch to a completely new calculator in which custom circuitry may well prove competitively decisive. Next month, the company will introduce a smaller machine using metal oxide semiconductor ic's. There are no standard devices for such a product, and Hayakawa worked very closely with its supplier to develop the circuits. It would be difficult, if not impossible, for the company to work with overseas sources to develop a complete family of new circuits. Either Hayakawa uses Japanese semiconductors or it loses much of its design freedom.

IV. Twain meets

Further confusing the issue is the mixed motivation of all the

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This unusual, highly complex contact design provides the necessary balance between contact pressure and insertion force required by a unique PC edge connector application. Its complexity made economical production doubtful...then Cinch tool design engineers tackled the problem.

RESULT: An 18 station, high speed progressive die that holds contact tolerance to ± 0.003” through eleven bends in four directions. Individual sections of the die can be adjusted or replaced without removing the die from the press—thus assuring maintenance of tolerances as the die wears.

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parties involved in the dispute. Clearly, MITI is intent on advancing Japan’s international trade interests. At the same time, however, the agency is anxious to delay TI’s local debut until such time as domestic electronic firms have developed a competitive IC capacity. To these ends, the trade ministry has buried TI’s application for Japanese IC patents in so much bureaucracy that they may not be granted for five years, and has consistently rebuffed the company’s request to establish a wholly owned subsidiary in Japan.

Back at the ranch. Despite the liberalized policies that went into effect this summer, the best terms the U.S. company can get at this point are a 50% joint ownership with Japanese interests. Moreover, TI would have to share its technical knowhow with competitors and limit production until Japanese firms could compete.

An executive at the Nippon Electric Co. believes that the biggest reason for keeping TI at bay for the time being is the prospect that, once in, the company might go on a price-cutting spree. This would stunt Japanese growth in the IC field, authorities feel, and eventually make the local computer industry dependent upon U.S. devices. In addition, if the trade ministry were to make an exception in the case of Texas Instruments, it would be hard put to rationalize its gradual liberalization of foreign investment in other sectors of the economy.

Inscrutable Texans. For its own part, TI obviously wants a piece of what promises to be a lush IC market in Japan. But according to one American authority who has closely followed the company’s war of nerves with Japan, there is considerably more to the situation. “The management down there is just too conservative to give up any control, much less go for a joint venture,” says this source. “And it’s no accident TI didn’t follow aggressive outfits like Fairchild into Taiwan, Korea, and Okinawa. These Texans know Japan’s still going to be there in 50 years. But they want in only on their own terms.”

Though Texas Instruments stubbornly refuses to spell out its position, the company has dragged its feet in licensing negotiations with

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Japanese firms. In fact, these companies say TI ignores or sidesteps all their inquiries. Mitsubishi, complains that it has yet to receive a reply on a long-standing offer to hammer out a royalty arrangement.

**Skirmishing.** By the same token, there have been no formal complaints, or threats, against Japanese firms using ICs in the wares they sell at home. On balance, TI's menace seems more implied than substantive. Last fall, for example, the Sony Corp. put a pocket IC radio on the U.S. market [Electronics, Oct. 17, 1966 p. 222]. Shortly afterward, the company's American distribution arm began getting phone calls from TI. After the second, Sony sought advice from the New York office of the Electronic Industries Association of Japan. The company was told to ask TI to put its complaints in writing. There were two more calls but no letter.

**Confusion factor.** Subsequently, MITI told Japanese manufacturers to hold off on IC-equipped exports until the patent situation was unsmarled. Fairchild Camera & Instrument Corp. holds an uncontented Japanese patent on the planar process. The company and TI have a cross-licensing arrangement covering IC's but the pact specifically excludes Japan. However, a Fairchild license gives planar rights to the Nippon Electric Co., which, with government approval, has made sublicensing agreements.

Sony and Matsushita are the only outfits that haven't made their peace with Nippon Electric and Fairchild. Sony maintains that its devices don't infringe on the patent; it appears, however, to be having second thoughts on this at the moment. Matsushita is depositing amounts equal to potential royalties in a bank account but hopes to avoid a real outlay on the strength of its cross-licensing agreement with NV Philips, the giant Dutch concern. The terms of this accord specify technical assistance from Philips, including patents and licenses. Matsushita has been able to avoid paying royalties to the Radio Corp. of America for semiconductor devices because of a blanket cross-licensing arrangement between RCA and Philips. Meanwhile, Matsushita is going about its business as if there were no outstanding problems.

Now that the planar-process problem is all but cleared up, MITI is ready to lift its export ban on IC goods and test TI's will. Japanese firms desperately need U.S. sales to justify their vast investment in the production of IC-equipped goods. Mitsubishi, for example, has already spent $2.8 million at its main semiconductor plant near Osaka and on a satellite facility where it flies chips for bonding.

**V. Day of reckoning**

The company's outlays for IC production will eventually top $14 million. Production is now about 80,000 to 90,000 IC packages a month, but Mitsubishi hopes to up the rate to 500,000 by year end. However, some 80% of its output is necessarily for export goods. **Lone arranger.** Texas Instruments could hardly let Hayakawa's incursion go unchallenged since other Japanese firms are waiting anxiously in the wings; they figure to follow fast if a beachhead is established. But just what form of action TI might take is still unclear. Depending on TI's stance in a direct legal confrontation, Japanese interests might opt for any of a number of counter gambits. It might be possible, suggests a knowledgeable American source with a stake in the outcome, to attack TI's basic patent position. "What's so big a deal about fabricating metal plates with photographic techniques?" he says. Along these lines, some Japanese observers contend that Hayakawa's MOS calculator might have provided a better basis for a strong test case; they feel that TI's position in this area is more vulnerable than in bipolar IC's. But, warns a Nippon Electric official, patent litigation is a perilous proposition. Nothing is sure until the ruling is made.

**Logical contender.** On balance, however, the Japanese believe Hayakawa's CS-32 calculator will give a good account of itself. The machine incorporates IC's, but isn't merely a collection of such devices, they reason. Thus, TI might be open to antitrust charges of barring the product of other technologies on the basis of only one patent. Moreover, MITI believes TI would also risk a restraint-of-trade action in the U.S. should it refuse to license its bipolar patents now the Fairchild's planar process has been offered around.

An official with the electronics section of MITI notes that a lot of big U.S. firms, including Motorola Inc., the International Business Machines Corp., and the Signetics Corp., a subsidiary of the Corning Glass Works, have been peddling IC's in the U.S. without TI's blessings. There is, he says, no clear-cut evidence that Japanese outfits could not do likewise.
Radiation issue heats up

Congress moves to grant Federal powers to set standards for emissions from electronic goods; law likely by 1968

With Federal standards for the control of radiation emission from electronic products almost a certainty, all that remains to be answered is when and in what form.

In the wake of the confusion following the disclosure that the General Electric Co. had built 90,000 or so large-screen color-television receivers emitting excessive radiation [Electronics, May 29, p. 52], Congress has come up with two bills, held hearings last month, and scheduled additional sessions this month. With the exception of a few outspoken dissenters, the electronics industry's on-the-record response to Capitol Hill activity can best be described as phlegmatic.

"How can we say we're against the legislation?" asks one Washington-based observer. "It would be like damning motherhood."

At the moment, no one knows quite what to expect, but the industry is hoping for the best. All that is known for sure, is that the Department of Health, Education, and Welfare will be given sweeping regulatory powers over a big segment of the electronics industry.

Legislation. Rep. Paul Rogers (D., Fla.), who with Rep. John Jarman (D., Okla.) coauthored the House bill, is pushing hard to have the measure passed before the end of the present session. Rogers is hopeful hearings will be held before the full House Commerce Committee within a week or so. His sponsorship of the legislation stems, in part, from the runaround he feels he got from the Public Health Service last October. At that time, Rogers was told that there was no evidence of excessive radiation in the GE sets.

Despite the rush in the House, Sen. E.L. Bartlett (D., Alaska), who has submitted an almost iden-
tical bill in the Senate, wants to continue his investigation into next session. He has already indicated that there might be more hearings then. Most observers feel that even if the Rogers bill goes through the House this session, it won't clear the Senate; the measure has to go through Bartlett's commerce subcommittee.

I. New deal

The broad outlines of how new regulations for the electronics industry will operate are already visible. Responsibility for setting radiation standards will most likely be handed to the Public Health Service's National Center for Radiological Health. According to James G. Terrill Jr., director of the center, "We [the center] would do most of it ourselves, farm some of it out to other Government agencies, and probably award contracts for certain studies to universities."

Most wanted. Topping Terrill's list of priorities is the establishment of color-tv standards. Other potentially dangerous radiation sources cited by Terrill include: magnetrons; klystrons; regulator tubes; thyatron tubes; display devices; electron linear accelerators; amateur electronic apparatuses; electronic toys; microwave ovens; ultrahigh-frequency radar and tv transmitters; infrared lamps and grills; ultraviolet equipment; lasers; and ultrasonic gear.

Do-it-yourself. Concerning tv standards, Terrill says: "With 10 to 20 large companies putting out 20 to 30 models a year, we certainly cannot monitor every set nor every replacement tube going to the 100,000 outlets throughout the country. My idea is to get manufacturers together on these standards and have them do their own checking. In the long run it costs less for firms to check themselves."

Terrill, whose center has come in for criticism because of its less than instantaneous response in the GE case, admits to some sins of omission: "If you'd asked me six months ago if GE was testing, I'd have guessed that it was. We just assumed that testing was going on. We've learned a lesson, however. Now we know that manufacturers have been putting tubes in sets and, if the sets work, they deliver."

Most electronics companies
Timetable for trouble


Nov. 7: The acting Surgeon General tells Rogers that evidence suggests industry and the National Council on Radiation Protection and Measurements have studied the problem and kept radiation below the harmful level.

Jan. 1967: A regional representative of the National Center for Radiological Health is advised by the New York State Department of Labor that a possible radiation problem exists in GE sets.

April 10: General Electric informs James Terrill, KCHH’s director, that receivers with possibly hazardous tubes have been sold.

May 11: At Terrill’s request, GE makes a presentation to NCRH on the problem.

May 18: The New York Times asks GE for a statement about excessive radiation. GE issues a press release admitting some sets have excessive X-ray emissions. Terrill says there is no evidence to the effect that GE or other tv sets have “excessively exposed viewers.”

June 8: State health officers are asked by KCHH to assist in hunt for GE sets. Terrill reports that GE sets have exceeded recommended radiation limits.

July 21: The Surgeon General issues a statement telling owners of uncorrected sets to disconnect them.

Sept. 7: GE reports about 1,400 suspect sets and 6,400 replacement tubes still uncorrected.

are shirking their responsibilities in controlling radiation hazards, says Terrill. “With all the money that is going into electronics and so little going into this problem, we are heading for trouble.” Terrill believes that part of the solution will have to come from industry. “I don’t believe that most safety officers think in terms of radiation danger because they must worry about immediate things like electrical shock,” he says. “The electronics industry must develop a new group of technicians—the equivalent of the atomic industry’s health-physicists, who know the biological dangers of radiation.”

II. Mouthpieces

When the GE affair surfaced, tv makers quickly retained E. William Henry, former chairman of the Federal Communications Commission and now a Washington attorney, to represent their interests. Most of these manufacturers are members of the Electronic Industries Association. Two nonmembers—Admiral Corp. and Zenith Radio Corp.—also anted up.

Still small voice. The EIA has yet to appear at any hearings. James D. Secrest, executive vice president of the association, attributes the no-show to timing, explaining that it takes a long while to set an EIA policy for such things because of the various committees that must be cleared. “However, at a later date, we may testify,” he says.

Secrest claims the industry has always been aware of radiation-protection needs, but that the GE case and the ensuing publicity “probably made the field more alert to the problem.” He doubts standards will greatly affect the industry, “assuming that they are reasonable.”

Henry agrees: “Industry feels that the Government agency that will eventually handle the matter will be reasonable and we feel we’ll be able to cooperate.” He points out that industry has no argument with the Government’s interest. “Obviously, it’s a matter for Government concern,” he says.

III. Measuring sticks

Until recently, tv makers had a decidedly mixed bag of radiation standards to follow. According to Henry, the industry has been adhering to the Underwriters Lab-
**new disciplines in DC**

![Image of a DC power supply](image)

**take the models with magnified meter ranges**

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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.

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oratories requirements of 2.5 milliroentgens of emission per hour at 5 centimeters from any surface of a receiver. But, in testimony before the House subcommittee, he said the industry has also recognized as an appropriate guideline the recommendations of the nonprofit National Council on Radiation Protection and Measurements: 0.5 mrem per hour at 5 cm Effective Sept. 1, however, Underwriters Labs changed its tolerances to the 0.5 level.

Such wide disparities led a spokesman for the Admiral Corp. to say: “The big thing which the industry is looking to the Government for is an agreement on standards for radiation. We need a guideline, a place to begin and end. This thing is pretty wide open right now, and while it has made all of us more aware, there’s nothing we can do until we have more specific information as to what is expected of us.”

For the record. Confusion abounds, some observers fear, about just what’s at issue. The Raytheon Co., which makes a variety of radiation-producing items including X-ray tubes, magnetrons, and microwave ovens, cautions lawmakers against going over old ground. In preparing a single codifying document, says Charles H. Resnick, Raytheon’s general counsel, “it would be our hope that Congress would take full advantage of the massive investigative work that has already been done.”

Contradicting some assertions that “nothing has been done” to determine the potential hazards of microwave emissions, Raytheon safety director George Luedke points out that the Air Force in the late 1950’s conducted a five-year, $13-million tri-service study of the biological effects of microwave radiation, particularly around large radars. There were three basic findings, says Luedke: that the biological effects are thermal only; that they are noncumulative; and that man has a built-in alarm system and pain threshold that protects him.

The problem of ionization, or X radiation, is another story, says Luedke. X rays are cumulative and have penetrating and lasting effects. Massachusetts, he points out, has pioneered in drafting safety measures in guarding against harmful X radiation. State laws require badges to be worn wherever X rays are used.

IV. A little knowledge

Terrill believes the military should be consulted on radiation standards because of its experience in this area. But he, too, believes not enough is known about the biological effects of radiation. Says Terrill: “The military only wants to know how much radiation a man can take before he is no longer fit for combat.”

Lauriston S. Taylor, president of the National Council on Radiation Protection and Measurements, which sets some radiation standards for industry but is financed by Government grants, urges that there be no “approach by fear” to the setting of standards. He backs the Bartlett bill, but cautions against standards based on inadequate research.

At the bottom. Testifying about the existing standards for electronics, the National Council on Radiation Protection and Measurements.

At the bottom. Testifying about the existing standards for electronics, the National Council on Radiation Protection and Measurements.

V. Change in the scene

Leonard Horn, engineer-nucleonics at Underwriters Labs says: “We never see much of the equipment to be covered by the bill since we concentrate on consumer goods like tv sets, radios, phonographs, X-ray equipment, diathermy machines, and radar ranges. We test about 95% of the various types of tv sets produced in this country, which gives us a good idea of what is going on in the plants. But right now we’re in the process of revamping all our programs to make our standards more stringent and our tests more comprehensive.”

Horn doesn’t anticipate another CE-type affair. “The issue,” he says, “brought home the fact that companies, particularly large producers, were getting a little too relaxed in their attitude towards their products and safety standards. Periodically we need something to point up the fact that you must maintain continual vigilance.”

All TV device checks have been run at the labs; there has been no quality control program, per se. “In
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[Certificate image]

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Electronics | September 18, 1967
... laser researchers have been slow in responding to safety suggestions...

view of pending legislation however, it is evident to us that we will have to become more involved in a quality-control program,” says Horn. “We must change our standards, too.”

VI. Less than radiant

Among the more outspoken critics of the proposed Federal legislation is George Borg, manager of radiation and safety at Electro-Optical Systems Inc., a division of the Xerox Corp. Borg, a health physicist licensed by the state of California, administers a safety program patterned after that of the nuclear industry—a field which he maintains has compiled about the best safety record of any industry during the 21 years of its existence.

Borg fears restrictions inhibiting technology could follow Federal laws if those drafting the legislation aren’t technically oriented. He doesn’t think the X rays emitted by television sets are much of a problem, and when legislation results from an emotional reaction “it usually fouls up the works somewhere down the road.”

Eos makes such radiation-producing devices as electron-beam welders, electron microscopes, and lasers. Except for the lasers, these are state-licensed products for which Borg believes present standards are “very realistic.” The rules dictate that persons not normally working with radiation-producing devices may not receive more than 2 mR per hour, or more than 300 mR in a calendar quarter.

Exception. Borg does believe, however, that at least one segment of the electronics industry will have itself to blame if restrictive legislation is passed. He has been pushing laser researchers to establish standards. They have been slow to respond, and both state and Federal agencies are now investigating standards for lasers.

Fred P. Burns, manager of operations at the Korad Corp., a laser-making Union Carbide Corp. subsidiary, doesn’t think Federal legislation would significantly affect his operation—“if the legislation is sensible.”

Robert L. Mortensen, sales manager for Spectra-Physics Inc., a laser manufacturer, says: “Naturally we’re interested in people’s safety.” But he doesn’t see any big problems with lower power lasers. Mortensen doesn’t expect any serious changes in manufacturing from Government-imposed standards, but “it depends on what the standards are. If they’re reasonable, they won’t have a strong impact. Low standards would be worse,” he says. However, Mortensen does express concern over a new Illinois law that requires the registration of all lasers in that state.

Tolerable. John Olander, general manager of the Cryodyne Corp., a subsidiary of Armour & Co. that makes microwave ovens, says, “As far as we’re concerned, we meet the law on the amount of tolerable radiation.” The law he is referring to is an FCC regulation; the commission is concerned lest microwave ovens, which operate at 915 and 2,450 megahertz, interfere with other microwave signals. The FCC approves designs, but it does not police the regulations.

In any case, Olander says, the ovens are designed so that excess radiation is trapped. The Congressional hearings, he feels, are likely to have nuisance value only; they won’t affect oven design. The stray radio-frequency signals that would bother the FCC are not nearly so strong as the signals that would be hazardous to health.

But microwave devices remain a prime Terrill target. He points to a recent study purporting to prove that the risk of siring Mongoloid children is greater among men who have been radar technicians. He suggests that there is a crying need for research in this area. Microwave ovens are being used by people who don’t realize the potential dangers they face, he says.

Burton Silver, marketing manager of the Electron Tube division of Litton Industries Inc., says the hearings would definitely affect both his division and the Atherton division, which makes microwave ovens. “The hearings couldn’t have come at a worse time. Microwave oven sales were just beginning to grow,” Silver says.
PROBLEM: How to economically increase short-haul trunk capacity without replacing or expanding existing cable facilities.

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Low initial investment: The system needs only two pairs of ordinary cables for 24-channel carrier transmission, and existing cables can be utilized without modification. In the terminal equipment, all channels have fully transistorized logic circuits in common. Because of the standardization and low-cost cable installation, cost per channel is considerably lower than conventional systems. All-round miniaturization saves floor space... the 120-channel (five 24-channel units combined) standard terminal bay can be mounted in a rack, only 2750mm high, 520mm wide and 225mm deep.

Noise-free transmission: At each repeater, multiplied speech is amplified and isolated from all types of noise, then transmitted to the next repeater. That’s why this system can maintain high quality of speech even through poorer mediums.

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New integrated electronics

The swing to TTL becomes a stampede

Use is growing so fast that customers have trouble getting the circuits; the rush of new lines may satisfy the demand

Among engineers who design high-speed logic systems with integrated circuits, the current darling is transistor-transistor logic, better known as TTL. The biggest advantage of TTL is speed: 15-nanosecond propagation delays in the earlier products, as fast as 5 nsec in the newer ones. Buying interest is so great that customers have trouble getting TTL circuits these days.

Transistor-transistor logic is a direct fallout of a military program. Designed for the Phoenix missile, early circuits were built on a pilot line in 1963 by Sylvania Semiconductors, a division of Sylvania Electric Products Inc. Now the company has two lines—SUHL-1 (Sylvania Universal High-Level Logic), with an 11-nsec propagation time, and SUHL-2, with a 6-nsec propagation time. With 380 circuits in both lines, including gates, expanders, flip-flops, and functional arrays, Sylvania has probably the largest TTL line in the semiconductor industry.

Today, business is growing so fast that Sylvania has to allocate both SUHL-1 and SUHL-2 despite opening an IC-assembly plant in Bangor, Maine, last April, and a wafer facility in Woburn, Mass., a month later. But the short supply of TTL has prompted a flock of rumors that Sylvania cannot produce the faster SUHL-2 line.

Alvin B. Phillips, general manager of integrated circuits for Sylvania, pooh-poohs such talk. "The problem is the tremendous demand for such circuits and inability to expand fast enough to meet it. It's been a painful few months we've been going through."

Exploding demand. At Texas Instruments Incorporated, marketing men second Phillips talk of exploding demand. One application engineer estimates that 80% of new computer designs now call for TTL instead of the older diode-transistor logic (DTL), resistor-transistor logic (RTL), or direct-coupled transistor logic (DCTL).

I. Others follow suit

During the past 12 months, TTL has clearly been the fastest growing form of integrated circuits. Just a year ago, TTL represented 12% of total IC production. Now its share has doubled while total IC production has also mushroomed.

Sylvania's difficulties with deliveries have prompted most other semiconductor companies to rush out new lines of TTL, many of which closely resemble SUHL-1 or -2. Motorola Semiconductor Products, which has its own form of high-speed logic, called Motorola Emitter Coupled Logic, now supplies SUHL under a Sylvania license.

Two months ago, the Raytheon Co. started producing Sylvania's 50-megahertz dual J-K flip-flop and now offers it commercially.

Westinghouse's Molecular Electronics Division has put nine circuits of the SUHL-2 line in its catalog, including two J-K flip-flops, an expander, and gates of various input configurations.

Philco-Ford Microelectronics will put from eight to 10 circuits of the SUHL-2 line into commercial production in late autumn.

Although all of these second sources admit to copying SUHL products, each claims that its circuits are a little better than the original. Westinghouse, for example, boasts its TTL circuits use less power—4 to 5 milliwatts less per gate function—than the SUHL circuits it has copied. Raytheon believes it has improved the manufacturing process by easing the tight tolerances that SUHL circuits demand.

Eyeing LSI. A different approach to TTL has been taken by Texas Instruments with its 54/74 series. At Sylvania, high-speed was obtained by improved components. Texas Instruments, on the other hand, improved speed by increasing the complexity, putting more components into each circuit. With this circuit-development experience now behind it, TI believes that its approach to TTL is a workable way to move into large-scale integration (LSI) later.

At the same time, TI recognizes that Sylvania's approach has won the popularity contest among customers so far. This autumn, TI will launch an extensive marketing program to sell its kind of TTL after introducing new products gradually for most of the year.

Signetics Corp., a subsidiary of Corning Glass Works, also has a form of TTL that is part of its Designers' Choice Logic so that it is compatible with Signetics TTL circuits. It competes with SUHL-1 in speed, though its design approach is akin to that of TI. Because of a technical agreement with Signetics, the Sprague Electric Co. also offers Designers' Choice Logic. In
... some people wonder if everybody using TTL really needs it ...

Sprague's 8200 series, there are two TTL circuits; in the 8800 series there are 12 TTL circuits—all 15-nsec circuits.

At Wescon last month, Sprague started off on its own by introducing three circuits that didn't stem from Signetics development. Called Sprague Super-Speed Logic, they are: a flip-flop with a 60-Mhz binary toggle rate, a dual four-input gate, and a quad two-input gate. Each has a 5-nsec propagation delay. More circuits will be added to this line after the first of the year. Next month, Motorola, too, will introduce its own .5-nsec TTL.

Transistor Electronic Corp. participated in the original development of TTL and has specialized in that kind of logic ever since.

On the move. Fairchild Semiconductor, a division of Fairchild Instrument & Camera Co., was in on the original development of TTL for the Phoenix missile and did, in fact, build a few circuits in 1964 for that project. The company owns the patent on the multiple-emitter transistor that is central to TTL. But Fairchild never brought out a commercial TTL line until nine months ago, when it introduced the 9000 series having 10 circuits. This autumn, Fairchild will start unveiling additional circuits as part of a plan to catch up to Sylvania.

The reasons behind Fairchild's slow start in TTL were worries about production, the kind of thinking that has caused so many rumors about nondelivery of TTL circuits. Says Ben Anixter, Fairchild's marketing manager of integrated circuits: "From our work on Phoenix, we were convinced that you needed tolerances of 0.0001 inch, too hard to make commercially. So we sent the project back to R&D which found that 15- or 0.2-mil tolerances were perfectly good."

11. Gaining experience

Although Sylvania's Phillips stoutly maintains that demand has been the main problem—he says, "Despite rumors, we have in no way underestimated the complexities of these circuits"—others in the industry are willing to admit that yields of TTL circuits are still far under DTL, for example, so production is not running as fast as a lot of people would like. Admittedly, the companies have not yet built up as much production experience as they have with DTL. Transistor-transistor logic circuits require small geometries, thin lines, and shallow diffusions—all of which can cause trouble in production.

Off and running. Makers believe they are solving production problems by developing better masking techniques and better furnace control. Fairchild's Anixter insists that "we'll be making TTL until it comes out of our ears" this fall. And Sylvania's Phillips sees his allocations ending before the first of the year.

The big question to a lot of people, however, is where are all these circuits going? Phillips says Sylvania circuits have been specified for most advanced military programs, sophisticated systems such as Ihaas (Integrated Helicopter Attack Avionics System), the Mark II avionics system for the controversial F-111 aircraft, the avionics of the giant C-5A military transport aircraft, the computer for a tactical air-control system, and in the Navy Tactical Data System. At least half of the military and commercial applications use Sylvania 2-2. Phillips adds.

What has made TTL so attractive to so many people has been its faster switching speeds, better noise immunity, a higher fanout, and lower power requirement than DTL. But still some people wonder if everybody who is using TTL needs it. At Philco-Ford, J. Philip Ferguson, head of the microelectronics division, thinks that the great demand is somewhat irrational. "How much equipment operates at 10 MHz?" he asks. "People go to high-speed circuits without knowing what the problems are. Although TTL has high d-c noise immunity, it is very sensitive to voltage transients. Because TTL is so fast, a voltage spike could trigger a TTL circuit under circumstances that wouldn't give a DTL circuit enough time to change states. Then, too, there are some impedance-match-
In quartz oscillators, what more could you ask for than high stability, great spectral purity and fast warm-up?

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S/N exceeds 90 dB. Rated output is 1 V rms into 50Ω. Outputs are 5 MHz, 1 MHz, 100 kHz sine wave and 1 MHz or 100 kHz clock drive. Height is only 3½"; 105A weighs only 16 lbs.

Price: 105A, $1500; 105B (8-hour standby battery supply), $1800.

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Positive-pressure hood keeps work area free of airborne contaminants, with absolute air filter; quiet, spark-free blower. Meets or exceeds applicable MIL SPECS.

Five hot, cascading pure water rinses in lined monel tanks do a thorough cleaning job. Final rinse, measuring 18 megohms/cm @ 25°C and free of organics, gases, biologics — is much purer than demineralized water.

Purity meter checks quality of rinse water, both "upstream" and "downstream" from final rinse.

To make a few gallons do the work of thousands, water is continuously recirculated, repurified. System includes...


Costs hold key. Just how big an inroad TTL makes in the DTL business will depend ultimately on cost and application considerations. DTL has a three-year lead in design. It usually costs less because DTL yields average about twice as high as those for TTL circuits.

Still, the higher costs of TTL don't always show up on the bills. Fairchild now charges the same price for DTL and TTL, even though it costs the company more to make TTL. For example, Fairchild sells a dual four-input gate in lots of 100 or more for $4.40 when built to military specifications whether it be DTL or TTL. Explaining this strange behavior, Fairchild's Anixer says, "If DTL is already designed in, and you want to sell TTL, the only way is to offer it at the same price."

Fairchild is also betting that TTL yields will improve enough to match DTL yields by the spring of 1968. There's no reason why TTL should cost more than DTL he says.

As if all this bustling activity in TTL wasn't enough, most semiconductor producers have even more new products in the works for next year. Sylvania, which is still far ahead in number of TTL products, plans to introduce additional functional arrays such as a four-bit shift register, a binary counter, a decade counter, and a parity counter. In addition, Sylvania has already designed a low-power series of SNIL for avionics systems that do not require the highest speed but can dissipate only 1 or 2 milliwatts. Production is scheduled for early in 1968.

Planning a family. Fairchild, too, plans to introduce a line of low-power TTL in 1968. But one of the most attractive prospects for TTL at Fairchild is as a forerunner of large-scale integration. In a medium-density approach, 40 to 50 gates per chip, Fairchild talks of using TTL devices—characterized by multiple-emitter inputs and active pull-up outputs—for external contact, and DTL or even RTL devices internally. Thus the company will have a TTL family of circuits each with different internal logic.
When it comes to custom assemblies, we can solve millions of problems.

Like taking millions of plastic and/or metal parts made to the most exacting tolerances, fitting them into an assembly, sub-assembly or finished product, wrapping them, sealing them and shipping them.

Complex components like computer circuit boards, telephone switching equipment, memory core frames, computer control connectors, switches, contacts for plug assemblies, practically anything you specify, we can make and put together.

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Let us put our men, machines and plants to work for you. Give us your specifications, we'll do the rest. We've done it for a lot of others.

New Components Review

Designed for fast computer circuits, switches are moisture-proof and have less than 3%, contact bounce after transfer. B5200 and BW5200 series are rated at 3 amps resistive, 1 amp inductive, and 3 amp lamp-load at 28 v dc or 120v a-c. They are available in 3 circuit arrangements with 18 mounting styles. Controls Co. of America, 1420 Delmar Drive, Folcroft, Penn. [341]

A semiaassembled feed-through terminal is for installation in a 0.040-in. â€Œ0.02-in. thick chassis, mounting in a 0.136-in. hole. Designated FT-2-SM-1200, the terminal's 0.040-in. diameter gold-plated brass lug extends 0.100 in. above and below the Teflon bushing. The unit handles 5.5 amps and can be used from 65° to 200°C. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. [342]

Metal alloy film resistor MAL-20 is a 1/2 watt (70°C) semiprecision device for use in color-tv, computers, and industrial instrumentation. It has temperature coefficients of 100 and 150 ppm /°C, and resistance tolerances of 2 and 5%. The unit meets or exceeds requirements of MIL-R-22684. It is epoxy coated and stamped and color-coded. Mallory Controls Co., Frankfort, Ind. [343]

Plastic-cased electrolytic tubular capacitors with epoxy end sealing are designed for p-c transistor circuitry and miniature electronic assemblies. Type EKA units come in 11 different models with capacitance values from 5 to 250 µf; and in 3 sizes, the largest being 13/4 x 1 1/4 in. D-c voltage ratings include 3, 6, 10, 15, 25, 35, and 70. Aerovox Corp., New Bedford, Mass. [344]

Arc accuracy of 30 seconds is attainable with a series of Scott-T transformers. The miniature toroidal devices convert 3-phase synchronous inputs to 2-phase resolver outputs. Line-to-line input voltage is 11.8 v, rms output voltage 5 v. Operating frequency is 400 hz; temperature range is -55° to 125°C. Price is $70 for single units. Magnetico Inc., 6 Richter Court, East Northport, N.Y. [345]

Linear xenon flash tube model FX 81-4 has a 4-in. arc length. The 10 x 12 mm quartz device handles an energy input of 3,000 joules per flash with a pulse duration of 1.4 msc. Units can be used in environments ranging from ocean depths to outer space. Applications include laser stimulation, medical research, and satellite flashes. EG&G Inc., 160 Brookline Ave., Boston, Mass. [346]

Double tuned i-f transformers, with average dimensions of 0.097 x 0.75 in., can be mounted between hybrid amplifier cans. Operating frequency is 1 to 100 Mhz. Typical temperature coefficient is ±65 ppm °C from 55° to +125°C. The transformers can contain up to 4 windings, and are suited for r-f and i-f strips. Piconics Inc., North Billerica, Mass. 01862. [347]

Molded chokes come in 3 types. Models 3710-1 through -7 cover inductances from 47 to 150 µh in a 0.250 x 0.560-in. package. Q values range from 18 to 75. Models 3711-1 through -5 cover 180 to 390 µh, are 0.310 x 0.560- in. with 80 to 75 Q's. The 3712-1 through -5 cover 470 to 1,000 µh and are 0.375 x 0.625 in. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. [348]

New components

Plating sets gap in stereo heads

Process that cuts reject rate to 15% could trigger price reductions in home tape recorders and players

A Japanese firm's technique of plating metal on ferrite may bring about the long-awaited break in prices of home tape recorders. Despite the steady decline in the prices of other home-entertainment products, quality tape recorder prices have been difficult to budge. One of the major reasons has been the cost of record and playback heads, which is high compared with other components.

Foster Electric Co. says its plating technique cuts head reject rate by nearly two-thirds and eliminates a lot of manual assembly work. The company claims a reject rate of 15% or less for stereo cartridges, compared with the industry average of 40%. With less scrap to write off, selling prices can be shaved.

No shims. The main reason for rejecting a conventional ferrite head is that the air gap between the metal pole pieces is askew. These pieces are usually made from stacks of laminated material, such as Permalloy. The gap is set by inserting a shim of copper between the pole pieces, after which the assembly is encapsulated in plastic and ground to shape.

Because the surfaces of the individual pole pieces aren't always
Series TT ceramic capacitors in encapsulated radial and axial configurations have tolerances of ±0.25%, ±0.5%, and 1%; and a capacitance range from 1 pf to 200,000 pf as standard. Applications include delay lines, d-a conversion, precision filtering, timing circuits, and ratio matching. Capacitance range from 1 pf to 200,000 pf as standard. Applications include delay lines, a-d conversion, precision filtering, timing circuits, and ratio matching. Placement of the nickel-iron alloy.

Military relay type PF has contact ratings up to 10 amps, with operate and release time of 7 msec. Initial circuit resistance is 10 milliohms max., 20 milliohms max. after more than 100,000 operations at 10 amps, 28 v-d-c. Unit operates from −65° to +125°C, withstands vibration of 20 g at 10 to 2,000 cps. C.P. Clare & Co., 3101 Pratt Blvd., Chicago. [353]

An ultralinear variable magnetostriective delay line provides continuously variable delays from 2 to 35 µsec at frequencies up to 2 MHz. Unit operates in temperatures from −40° to 85°C and survives shocks of 600 g. Delay is varied by a shaft; normal performance is 167 µsc/m/s w/ linearity to better than 0.25%. Digital Devices Inc., 200 Michael Dr., Syosset, N.Y. [351]

Fired-film trimming pots for the industrial market, designated Accutrim, have all-welded construction with a stainless steel 1-piece lead screw and a slider that insures long resistance element life. They have infinite resolution, a range from 100 ohms to 1 megohm, and exceed requirements of MIL-R-22097, Characteristic B, Type R112B. Meprco Inc., Columbia Rd., Morristown, N.J. 07960. [354]

A resistor 0.040 in. in diameter and 0.130 in. long operates from 1 x 10⁶ to 1 x 10¹⁸ ohms with a tolerance of ±25%. It handles temperatures to 100°C and with a compatible epoxy can be readily encapsulated. The ends of the resistor serve as terminals for direct soldering to terminal board and circuit component connections. Pyrofilm Resistor Co., 3 Saddle Rd., Cedar Knolls, N.J. [355]

An interstage pulse transformer—1 cu. in. in volume and weighing 75 grams—operates up to 50,000 ft, withstands thermal shock and h-f vibration to 50 g, and environmental temperature from −54° to +110°C. With a working voltage of 10 kv d-c, it has a 1:1 ratio, a 0.05-µsec rise time, and meets MIL specs. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. [352]

Reed relay series 325-12-1A measures 1.4 x 0.25 in. sq. with 0.1-in. pin spacing for standard p-c layout techniques. Direct p-c mounting eliminates changes in reed characteristics caused by cutting and bending of axial-lead types. The spst contacts switch in less than 1 µsec, and are rated at 4 v-a into a resistive load. Self-Organizing Systems Inc., Box 9918, Dallas. [356]

Smooth, the gap formed by the shim can vary. Monaural recorders can tolerate a slight variation in air gap, but frequency response and amplitude linearity can suffer badly in stereo systems.

Instead of using stamped laminations, Foster plates the pole pieces directly onto ferrite, and then plates the heads with copper to provide the gaps. This is achieved in a three-step process that assures dimensional uniformity.

To make a stereo head, two pieces of ferrite and two coils are first clamped together, with the ferrite heads at the exact spacing required in the finished head. The clamp becomes a permanent part of the assembly, retaining the spacing through the next steps. Then the pole pieces and the copper spacer are plated. Finally, the heads are encapsulated and ground to shape.

Bonus. Foster says it can make the platings as thick as 2 millimeters, while controlling composition of the nickel-iron alloy.

As a byproduct of the plating approach, the company claims its heads will last three or four times longer than laminated heads. The reason: plated-pole pieces are harder—about Vickers 600 hardness contrasted with 120 to 150 for laminated heads.

Although Foster isn’t ready to

Japanese heads. Standard stereo, Cassette stereo, and film projector heads (from left to right) are being made with the new plating process.
how to measure resolver or synchro position with 30 second repeatability

In both production test and ground checkout systems, North Atlantic's high performance Angle Position Indicators provide exceptional operator ease and precision in the measurement of synchro and resolver position. Features include digital readout in degrees and minutes, 30 second resolution, continuous rotation, plug-in solid-state amplifier and power supply modules. Due to the design flexibility of these units, they can be readily provided with a variety of features for specific requirements. Typical units in this line incorporate combinations of the following features:

- Single Synchro or Resolver Input
- Dual Synchro or Resolver Inputs
- Retransmit Synchro, Resolver, Potentiometer, or Encoder
- 2-Speed Synchro Input
- Multi-frequency Inputs
- DC Input
- 0-999 Counter

**BASIC SPECIFICATIONS**

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<tr>
<th>Specification</th>
<th>Model KF-18502</th>
<th>Model KF-13101</th>
<th>Model KF-24501</th>
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<td>Power</td>
<td>115 volts, 400 cps</td>
<td>-60 dbm at 1 khz</td>
<td>2 micros</td>
</tr>
<tr>
<td>Size</td>
<td>API-8025 13½&quot;h x 9½&quot;w x 9&quot;d</td>
<td>API-8027 3½&quot;h x 4½&quot;w x 9½&quot;d</td>
<td>API-8027 3½&quot;h x 4½&quot;w x 9½&quot;d</td>
</tr>
</tbody>
</table>

Frequency response. Output versus frequency for three types of heads.

disclose prices for its heads, it says they will be competitive with conventional heads. Production on three heads started this summer, but hasn’t reached the point where the company will quote off-the-shelf prices. Foster prefers to negotiate prices with volume buyers. The three types are the KF-13101, an eight-track stereo head for playback only, the KF-18502, for Philips Cassette stereo record and playback machines, and the KF-24501, a single-channel record-playback head for 8-mm sound movie projectors.

**Specifications**

**Model KF-18502**

- Function: Cassette record and playback
- Gap: 1.5 microns
- Impedance: 400 ohms at 1 hz
- Bias frequency: 60 khz
- Bias current: 0.7 ma
- Record current: 100 µa
- Playback level: -75 dbm at 1 khz
- Crosstalk rejection: 45 db min. at 1 khz
- Track width: 0.023 in.
- Track spacing: 0.0345 in

**Model KF-13101**

- Function: 8-track, 2-channel playback only
- Gap: 3 microns
- Impedance: 2.5 kilohms at 1 khz
- D-c resistance: 550 ohms
- D-c resistance: 25 ohms
- Bias frequency: 60 db at 1 khz
- Crosstalk rejection: 60 db min. at 1 khz
- Track width: 0.05 in.
- Track spacing: 0.127 in.

**Model KF-24501**

- Function: 8-mm film record and playback
- Gap: 2 microns
- Impedance: 100 ohms at 1 khz
- Inductance: 14 mH
- D-c resistance: 25 ohms
- Bias frequency: 50 khz
- Bias current: 1.5 ma
- Record current: 200 µa at 1 khz
- Playback level: -75 dbm at 1 khz
- Track width: 0.023 in.

Foster Electric Co., 512 Miyazawacho, Akishima, Tokyo [357]
Remedy for nightmares:
AE's Type 45NC stepping switch with "shorting" levels.

Many of today's complex switching circuits look like an engineer's nightmare. Why not simplify them? You can replace whole groups of components with an AE Type 45NC "stepper."

This switch has normally closed ("shorting") levels. It's designed so that pairs of contacts open successively when the rotor is stepped.

The Type 45NC can solve almost any circuit-transfer or testing problem.

It's ideal for self-interrupted hunting, and you don't need auxiliary relays.

You get one or two electrical levels of either 26 or 52 point normally-closed contacts. For extra versatility, you can specify additional levels of normally-open contacts—on the same switch.

Contacts are gold-plated phosphor bronze. Contact resistance: a maximum of 50 to 100 milliohms, measured at 6 volts 100 milliamperes.

When you specify AE rotary stepping switches, you get the benefit of our continuous research—in design, in metals and insulating materials. All this plus positive positioning—a unique AE design feature that locks the rotor and makes overthrow impossible.

Find out more about AE rotary stepping switches—an economical, rugged and reliable way to simplify switching circuits. There's a lot of helpful application information in our new reference circular 1698-L. To get your copy, just ask your AE representative. Or write to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

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SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E
Our abrasion-resistant TFE wire keeps on flying after others call it quits.

Keeps flying up to 12 times longer, as proved in use on six leading types of commercial and military jets. Reason? It’s 100% more abrasion resistant than other airframe wires. Because it has a tough insulation core of mineral-reinforced TFE bonded between pure TFE layers.

Our wire also averages 50% smaller in diameter and 60% lighter in weight than comparably rated wires. It can operate continuously at 500°F and remain tough at −450°F. It’s nonflammable, nonhygroscopic, highly resistant to chemicals, has optimum dielectric properties and good flexibility.

Right now, it’s reducing wire replacements in aviation, mining, refining, ground transportation and railroad equipment manufacturing. It can do the same for your application. For a free test sample and further data, write: ITT Wire and Cable Division, International Telephone and Telegraph Corporation, Clinton, Mass. 01510.
**New Semiconductor Review**

**Series NL-C180** are silicon controlled rectifiers with voltage ratings from 100 to 1,300 v. Devices are all-diffused, shorted-emitter types with 235 amp rating. Minimum dv/dt rating is 200 v/µsec; maximum di/dt ratings, up to 100 amps/µsec. Peak on-voltage is 1.8 v. Hard solder construction yields low thermal fatigue. National Electronics Inc., Geneva, Ill. [436]

**Plastic complementary silicon transistors** rated at 360 mw with a maximum operating junction temperature of 150°C can be used to replace the standard 2N2222 series. The TO100 meets MIL-S-19000/255E, with a noise figure of 0.5 db and a minimum gain of 100 at 10 ka. Base-to-emitter voltage is matched within 2.5 mv. Sprague Electric Co., North Adams, Mass. [440]

**Sensitive gate scr’s 2N5060-2N5063** are rated at 800 ma (forward current rms) with voltage ranges from 30 to 150 v in a TO-92 Unibloc plastic package. Gate current requirement is 200 ma. Uses are in fractional hp motor controls, sensing and detection circuits. Prices range from 51 to 85 cents (100 and up). Motorola Semiconductor Products Inc. Box 13408, Phoenix, Ariz. [441]

**Fast recovery 12-amp silicon rectifiers** designated JAN 1N3889 through 1N3893 meet MIL-S-19500/304(EL) specs. The series is for high-reliability military equipment using high-frequency sine wave, square wave or pulsed inputs. Applications include inverters, modulators, converters, and accelerators. Electronic Devices Inc., 21 Gray Oaks Av., Yonkers, N.Y. 10710. [442]

**Photocontrolled resistor type 5082-4510** uses a cadmium-sulfide photo cell for stability in a changing temperature environment. Photocell resistance, when illuminated, changes typically by a factor of 1.5 with a variation in temperature from 25° to 65°C. Units cost $8 each in small quantities, and $6.80 for 10 to 99. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. [438]

**Current-regulating diodes** with working currents from 0.22 to 4.7 ma come in a 32-device series. The 1N5283 through 1N5314 are field effect diodes that provide constant currents independent of voltage. Devices offer a peak operating voltage of 100 v, 600 mw power dissipation. Prices are from $4.90 for 100 units. Motorola Semiconductor Products Inc. Phoenix, Ariz. [439]

**Hybrid IC, d-c wideband amplifier** HX610 is offered in a 10-lead TO-5 can. It has built-in by-pass capacitors and needs no external components when used as an amplifier with a voltage gain of 26 db. Maximum output voltage swing with no load is 20 v peak-to-peak to 8 Mhz, derating to 2.5 v p-p at 100 Mhz. Halex Inc., 139 Maryland St., El Segundo, Calif. [443]

---

**New semiconductors**

**Plastic transistor dissipates 1.6 watts**

By changing lead material, transistor passes heat out to circuit board

When it comes to transistors, encapsulating them with plastic isn’t the only thing Texas Instruments Incorporated is doing these days—it’s increasing the power-handling capability at the same time. With a new process to get heat away from the transistor [Electronics, Sept. 4, p. 26], TI can now dissipate 1.6 watts at 25°C case temperature in a TO-92 package. The first units in which the new process is used are silicon audio transistors for consumer electronics applications. Designated the TIS90, 91, 92, and 93 series, the small-

**Hand made. Collector lead is connected to area of copper in a circuit developed to test the power dissipation of the TIS90.**

Electronics | September 18, 1967 189
Doubt us if you dare...

We have made certain claims for the efficacy of our Airbrasive unit in certain applications—dicing germanium, for example, or cutting tungsten carbide...or stripping potentiometers...or what we call microdeburring. Airbrasive handles these and many other jobs with production line alacrity and reliability...at very low cost ($1,000 and you're in business).

Airbrasive is a device for directing a jet of fine abrasive powder for heatless, shockless cutting, abrading, drilling of hard, brittle materials.

If you have some such application, or if you think you might, we'll be pleased to demonstrate an Airbrasive unit to you at no cost or obligation. Even better, if you can make one of our seminars, you'll have an instructive time seeing all that the Airbrasive can do. For a demonstration, write. If you'd like to attend an Airbrasive Seminar, write. If you'd like to buy an Airbrasive unit, phone collect.

SEE US AT BOOTH #622 NEC SHOW AND BOOTH #2067 NEREM SHOW

S. S. WHITE COMPANY, INDUSTRIAL DIVISION, Dept. EU, 201 East 42nd Street, N.Y., N.Y. 10017, Telephone 212 661-3320

... try, try again
to dissipate heat...

signal units are for applications formerly restricted to metal-case, medium-power devices or where heat sinks had been used.

Many tries. When TI engineers started the project, they tried attaching a metal heat sink to a regular plastic unit. But this didn't prove too effective. The engineers found that most of the heat went out through the leads. Next they tried changing the plastic's formula, but this failed, too—all it did was change the electrical characteristics by lowering the volume resistivity. The third attempt, using an area of copper on the face of the etched circuit board as a heat sink, proved successful. And this process had a built-in bonus: no additional cost.

The selected area is connected to a high-conductivity collector lead that directs the heat away from the transistor. Continuous device dissipation of the series is typically 625 milliwatts at 25°C free air—double that of previously available plastic packages of the same size.

Silicon planar epitaxial transistors are available as npn types TIS90 and 92, and as pnp types TIS91 and 93. They are also available in matched complementary pairs—TIS90M/91M and TIS92M/93M—for low-cost audio driver and output circuits with up to 2 watts for phonograph and stereo applications.

Electrical characteristics include a minimum 40-volt breakdown voltage (collector-base and collector-emitter), and a maximum 400-milliamp continuous collector current. The maximum collector-emitter saturation voltage is 0.25 v, and the maximum junction temperature is 150°C. The package is TI's solid, transfer-molded TO-92 with in-line pin configuration or a 100-mil pin-circle arrangement. Prices range from 39 to 50 cents each in quantity.

More plastic. A series of 18 transistors for radio, television, and audio applications was also announced. These transistors are also encapsulated in the transfer-molded plastic package, but without the new heat-sinking design.

Eleven of these units—TIS83 to
If you’re going to spend hard cash for integrated circuits, you don’t want to play guessing games. You want a company you can have confidence in. A company like Signetics. Our integrated circuits go through one of the toughest quality assurance programs in the business. Signetics SURE program meets all the requirements specified by the military for TX (testing extra) device testing. Reliability documentation? It couldn’t be more thorough. Send for the SURE Bulletin #5001 and our latest reliability report. They give you good reason for confidence in Signetics, the world’s largest maker of integrated circuits exclusively. Write Signetics, 811 E. Arques, Sunnyvale, California 94086.
A BIG PUSH, PULL, TWIST OR TURN, IN A SMALL SPACE

Ledex solenoids can help you get a lot of work done in places where you don’t have much room. We make both push/pull and rotary solenoids in a wide variety of shapes and sizes to solve just about any actuating problem you have.

PUSH/PULL

Our push/pull solenoids are designed for fast response and high force-to-size. Generally, the flat face is best for big loads and short strokes, and the conical gives you more force with longer strokes. Here’s a performance comparison for a Ledex size 5 (1\frac{3}{4}” dia. x 1\frac{1}{4}”):

<table>
<thead>
<tr>
<th>STROKE</th>
<th>FORCE</th>
<th>FORCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>.020 inch</td>
<td>96 pounds flat-face plunger, 90 watts, 1/10 duty</td>
<td>35 pounds conical plunger, 90 watts, 1/10 duty</td>
</tr>
<tr>
<td>.120 inch</td>
<td>12 pounds</td>
<td>27 pounds</td>
</tr>
</tbody>
</table>

ROTARY

Ledex rotary solenoids are known best for their shock resistant ability and high torque-to-size rotary motion. For example, with a load that must be moved through a 25° arc, our smallest rotary solenoid (1” dia. x 5\frac{1}{4}” ) snaps 1.1 pound-inches, and our largest (3\frac{3}{4}” dia. x 2\frac{1}{4}” ) moves a hefty 117 pound-inches.

Because Ledex rotary solenoids have a relatively flat output torque curve, they are often used to move linear loads. They are also used for linear loads when shock conditions exist or when stroke length is beyond the efficient range of push/pull solenoids.

Call Ledex when you need a lot of power in a small space to push, pull, turn, twist, step, index, hammer, punch or trigger. For a quick start on your prototype, choose from over 350 different stock model designs. Or, send details and we'll custom design a space-saving solenoid for you.

New semiconductors

Diodes brighten way to IC displays

Improved efficiency cuts forward current, makes diodes IC-compatible

Diodes that emit 500 foot-lamberts of visible red light—a tenfold improvement in brightness—are being made by the Monsanto Co. Extra brightness isn’t the only reason company engineers arebeamming.

The new diodes require no more forward current than the 50-ft-l diodes, also made of gallium-arsenide-phosphide semiconductor material, which the company was selling for 18 months. Both reach maximum brightness at a forward current of 50 milliamperes. In addition, Monsanto has upgraded the original diodes so that they are now produced at half the previous cost—about $4 instead of $8—and emit 120 ft-l at 50 ma.

The greater efficiency stems
Put noise to work

DC to 50 kHz, HP now offers calibrated, repeatable noise patterns, random or pseudo-random, constant power and excellent Gaussian distribution.

The Hewlett-Packard 3722A Noise Generator now lets you harness noise so that it becomes a defined and calibrated input to your system. It allows you to synthesize and reproduce at will noise signals of constant noise power with a probability density function (pdf) in the classical Gaussian construction. This unique new instrument uses computer techniques to synthesize noise patterns of selectable length that are thoroughly defined and repeatable.

Because the 3722A employs a unique combination of digital and analog filtering, it is able to produce usable controllable power at low frequencies not previously possible. And, too, the digital nature of noise generation enables exact repetition of noise patterns of selectable length. This can save you hours of testing time, and you can test circuits, components or systems with confidence. System responses can be completely defined.

Ideal for such applications as control system response measurements, communications testing, acoustic measurements, temperature and flow fluctuations, study of air, water and earth turbulence—and other real-time analog simulation. HP 3722A, $2650.

For more information call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.
Need thirty different photocells?  
Or thousands exactly alike?

In either case, specify "Raytheon." Raytheon now offers standard and special types with cadmium sulfide or selenide sensors, TO-5 case or glass vial packaging, and a wide range of operating characteristics. These photocells are interchangeable with competitive types, available to MIL specifications, priced from 90¢ to $1.60 in production quantities.

All Raytheon photocells feature: rugged mechanical construction, small size, light weight. Low noise, completely ohmic light-dependent variable resistors, their characteristics and high voltage capabilities ensure fast switching, temperature stability and linear response to illumination.

Wide range of characteristics. Our CK1201, for example, features 150 ohms resistance at 100 ft. candles, rise-fall time of 3 and 60 ms, 75 mw power dissipation (maximum). And our CK1266 features 2500 ohms resistance at 100 ft. candles, rise-fall time of 1.5 and .6 seconds, and power dissipation of 100 mw maximum.

Send reader service card for data on the complete line of standard Raytheon photocells. Or tell us about your special requirements.

Raytheon Company, Components Division, Quincy, Mass. 02169.
If you make a product that needs control, and you are still using relays, the facts are, some of your competitors are using cheaper, more reliable, more versatile solid state circuits.

If you make equipment to control, or measure, or analyze, the facts are, some of your competitors are building small computers inside. You hard wire for one task, one purpose. They write programs for the computer that permit typed-in instructions for many tasks, many purposes.

Your customers increasingly know this. Digital techniques save them time, give them flexibility, and end up doing more and costing less. And in your quieter moments, we suspect you know it, too. Digital techniques are the wave of the future.

Digital Equipment's product line includes noise-immune solid state circuits for industrial controls, computer speed modules for interfacing and smaller instruments, analog to digital converters now no bigger than a circuit card. And the computers themselves. Digital Equipment is the leading manufacturer of small computers in the world. PDP-8/S, which sells for $10,000 before OEM discounts. PDP-8 at $18,000. PDP-9 and the time-sharing PDP-10 for bigger tasks.

We have literature on the products and the applications. Free for the asking.

How to automate
A Better Mousetrap
After millions of Mallory MOL's, here's where we keep our rejects.

Of the many millions of Mallory MOL metal oxide film resistors we've made in the past three years, not enough have come back to fill your vest pocket. The reason? Highly automated production with automatic quality control tests on every resistor.

MOLs have high stability. Resistance change on 10,000 hour load-life test is less than 5%.

Delivery is prompt. And the price is right.

No wonder most leading TV manufacturers use MOL resistors. Get the details. Write or call Mallory Controls Company.

New semiconductors

Square solar cells convert for less

Ceramic solar cells cost 1/10th as much as silicon for the same power output

Inexpensive ceramic solar cells developed at Japan's Matsusita Electric Industrial Co, wireless research laboratory may lead to many applications not practical with sili-
Buy this ten dollar
Philbrick
Operational Amplifier

...and let everyone think you paid twenty.
They'll believe it, when they see its performance.

*Plain language*—our low prices come from volume-production savings and new packaging efficiencies. Others achieve them by cutting corners—thereby making your design job more expensive, more difficult, and more restricted.

*Here's what we mean*—Economy-Grade Philbricks give you design resilience the others don't have. Things like:

Safe, conservative operation at any supply voltage between ±7.5 V and ±22 V; a full ±11 V output swing with a ±15 V supply (even more at higher supply levels); gain to spare—enough to let you take full advantage of their low offset drifts; remarkably low quiescent power; exceptionally wide stability margins.

*We know*—that nine times out of ten, you would save money if you paid twenty dollars for a resilient Philbrick—but we don't ask you to; just pay what you would for a narrow-margin stiff one. Call us—we've got what you want, at low prices you'll be surprised to find.

**EXAMPLE:** This new PF55AU preformed-case epoxy encapsulated miniature has open-loop gain of 40,000 driving 10kΩ, 1.5 MHz bandwidth, CMR of at least 1000:1, will slew at 1.5 V/µsec, 20 µV/°C offset limit, and all the resilience described above. It outperforms the cut-spec cheapies, yet it's a genuine Philbrick, through and through. PF55AU price: In lots of 1,000 ... $10.00 (even less in larger quantities.)


**GOING THE MICROCIRCUIT ROUTE?**

There's a resilient easy-to-stabilize Philbrick in a modified TO-5 package, too—at only $6.95 (less in 100-lot quantities or more).
Now Silk City Offers Complete Ceramic Production Facilities From Development Through Volume Production

Major Ceramic Services Offered By Silk City

**PROTOTYPE DEVELOPMENT**
In the development of precision prototypes for the electronic industry, we are equipped to offer multi-shaped parts and varied-ceramic formulations to meet every possible design and economy requirement. We produce precision ceramics that are machined from alumina, die formed, isostatic pressed, extruded, molded or cast. Materials range from high-aluminas through forsterite.

**PRECISION MACHINING**
Where the tolerance or surface finish is extremely critical, we are skilled and equipped to provide the necessary ceramic machining. We offer a complete range of grinding, polishing, lapping and ultrasonic machining.

**METALIZING AND PLATING**
We offer prototype development or volume production of metalized and plated ceramics for use in hermetic seals and other sub assemblies. Both high and low temperature metalizing are available. We prepare surfaces for customer brazing or numerous other sealing requirements.

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We produce complete sub assemblies to customer specifications, as well as provide a capability to design parts to meet your requirements. Final assembly includes brazing of ceramic to ceramic and metal to ceramic for either mechanical or hermetic seals.

**SHORT PRODUCTION RUNS**
After prototypes have been developed and approved, we are staffed and equipped to carry the item through to a test production run or fill initial stock orders. You are assured precision products that meet the highest quality standards.

**VOLUME PRODUCTION**
With the addition of our new plant in Hendersonville, North Carolina, we are now prepared to handle your full production requirements. Our present equipment will produce ceramic parts with diameters ranging from a fraction of an inch up to 15 inches.

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Phone 201-427-4211

OFFERING A COMPLETE CERAMIC SERVICE FROM PROTOTYPE THROUGH PRODUCTION

Substitute. Ceramic solar cells replace silicon at lower cost.

con cells. When solar cells first became commercially available it was thought that they could be used to heat homes, power cars and remote radio stations, and, in general, be a free source of power. But even after the development of the silicon cells, these goals were not achieved because of the high cost. Matsushita engineers say the cost-per-watt generating capacity of the new cells is about 1/10th that of standard silicon solar cells.

The base for the new cell is a sintered wafer of cadmium sulfide, which is a ceramic-like material. It can be made in almost any size or shape, unlike silicon which is limited to small wafers. The basic material costs only about $7 a pound.

**Conversion.** Sintered wafers are n-type semiconductors. The front surface is converted to a p-type semiconductor by immersion in a copper-sulfate solution. The reaction between wafer and solution converts the front surface to copper sulfide, which has p-type properties. The junction is between the copper sulphide and the cadmium sulphide, and is heterojunction rather than homojunction as in silicon and germanium solar cells. The back of the wafer is masked to prevent its conversion.

The converted layer is from 10 to 100 microns thick, depending on treatment time. This is much thicker than the layer above the junction in a silicon solar cell. One reason for the thickness is the granular nature of the material. Only the surface of individual
Here’s why you should now be using Datavue* Indicator Tubes

These indicator tubes—just a few of Raytheon’s wide selection—offer you advantages in design, economy and performance. For example:

You don’t need to revise designs. Raytheon’s Datavue round and rectangular end-view tubes conform to EIA ratings—interchange with other brands. And Raytheon also offers you a selection of side-view types—and "specials" with up to 12 characters, ± signs, symbols, etc., to your specifications.

You can buy them at low cost. All Datavue Indicator Tubes are priced competitively—or lower. Most side-view types, for example, cost less than $5 each in lots of 500 or more.

Reliably trouble-free readouts. All Datavue characters are fully formed—not segmented. The fully formed characters are brightly displayed and easy to read—at distances up to 30 feet.

They last for years. They’re made better because of Raytheon’s experience—40 years of producing more than 100,000,000 cold cathode gas-filled tubes with carefully controlled electrical performance. Ultra-long-life types, for example, have dynamic life expectancies of 200,000 hours or more.

They’re readily available—in sample and production quantities. For samples, prices, or technical information, call your Raytheon regional sales office or distributor. Or write: Raytheon Company, Industrial Components Operation, Quincy, Mass. 02169.

Raytheon* trademark of Raytheon Company

Industrial Components Operation—A single source for Circuit Modules/Control Knobs/Display Devices/Filters/Hybrid Thick-Film Circuits/Industrial Tubes/Optoelectronic Devices/Panel Hardware.

Electronics | September 18, 1967

Circle 199 on reader service card 199
This is not the place for imitators

The list of recent and current major developments born on the Niagara Frontier in avionics, electronics and other modern scientific fields makes eye-opening reading for any company seeking the right “climate” for a new research facility or manufacturing site.

Here too, the exciting combination of art galleries, sports, schools and universities, closeness to over 100,000,000 people and the availability of good plant sites makes the Niagara Frontier a sound choice for you. But the very special quality this area offers you is the “can do” spirit that sparks innovations and accomplishments. Get the whole story... it’s yours for the asking... simply send in the coupon below!

Mr. Edward Rath
Erie County Executive
Erie County Hall, Dept. E-77
Buffalo, N.Y.
O.K. Mr. Rath. Send me your new book that tells why the Niagara Frontier (Buffalo and Erie County, N. Y.) is a profitable spot for our plant.

The future is here on the Niagara Frontier (BUFFALO AND ERIE COUNTY, N.Y.)

The future is here on the Niagara Frontier (BUFFALO AND ERIE COUNTY, N.Y.)

Mr. Edward Rath
Erie County Executive
Erie County Hall, Dept. E-77
Buffalo, N.Y.
O.K. Mr. Rath. Send me your new book that tells why the Niagara Frontier (Buffalo and Erie County, N. Y.) is a profitable spot for our plant.

Name ____________________________
Title ______________________________
Address ________________________________________________________________
City ______________________ State ______ Zip ______

Check if you want convention information.

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Ceramic and silicon cells

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Silicon cell</th>
<th>Ceramic cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion efficiency (Incident radiation to electricity)</td>
<td>10-15%</td>
<td>5-8%</td>
</tr>
<tr>
<td>Open-circuit voltage</td>
<td>0.6v</td>
<td>0.45v</td>
</tr>
<tr>
<td>Short-circuit current</td>
<td>30 ma/sq.cm</td>
<td>30 ma/sq.cm</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>-0.5%/°C</td>
<td>-0.5%/°C</td>
</tr>
<tr>
<td>Cost per watt</td>
<td>$54 to $67</td>
<td>$54.90</td>
</tr>
<tr>
<td>Resistance to radiation</td>
<td>Poor</td>
<td>Good to excellent</td>
</tr>
</tbody>
</table>

Matsushita Electric Industrial Co., Tokyo [340]
SPECIFY EMC INTEGRATED LOGIC CARDS

Now available: a complete new family that gives you quality, flexibility and off-the-shelf logic design!

Quickly implement your designs either for breadboards or for production units with EMC's versatile new family of I.C. plug-in assemblies!

For greatest versatility, the 930 series of DTL and related compatible TTL circuits in the popular dual-in-line package form the nucleus of the components used in the assemblies. Standard +5.0 volts ± 10% power supply voltage; 0°C to 75°C operating range (−55°C to +125°C also available); 5 MHz nominal operating frequency.

AN EXTRA PLUS for you is EMC's policy which provides the flexibility often lacking in "off-the-shelf" products: in addition to offering standard families of I.C. function card assemblies, EMC offers a line of basic techniques with the ability to alter inputs, outputs and other parameters to better satisfy a specific need.

Your special logic function can be packaged with the same 2 to 3 week delivery as for standard cards.

Write today for a complete EMC I.C. catalog!
New Instruments Review

Guideline 9930 d-c current comparator potentiometer features a 7-figure readout without critical resistors. Linearity is 0.05 ppm over full range, and long term drift less than 0.1 ppm per year. The unit's resolution is only 1 part in 2 x 10^10 of full scale, and standard cell dial resolution is 0.1 ppm. Cost is $7,890. Hallmark Standards Inc., 145 Library Lane, Mamaroneck, N.Y. [361]

Portable transient generator model 4881 determines the ability of equipment and systems to withstand sudden changes in a-c or d-c power supply sources. Pulse amplitude is variable from 0.1 to 300 v; peak pulse power is 43 kw, 0.5-ohm load; and synchronous pulse positioning, 0° to 360° on power line waveform. Honeywell Inc., P.O. Box 391, Annapolis, Md. 21404. [365]

Functional tests of integrated circuits are normally made after packaging. Inductance and capacitance contributed by the probes used to make d-c tests on the wafer can cause propagation delays greater than those the tester is trying to measure. From necessity, manufacturers have learned to get along with d-c tests; yields after this stage—before scribing, bonding, and encapsulation—can run as high as 90%.

The faster and more complex IC's become, the less likely it is that d-c tests will weed out all the defective chips, and the manufacturer will have to go through the expensive packaging process before knowing which circuits are good.

Last fall, Sylvaniana Electric Products reported a pilot process for a-c testing on the wafer [Electronics, Oct. 17, 1966, p. 94.] And last month at Wescon, E-H Research Laboratories Inc. of Oakland, Calif., demonstrated the first commercial system for such testing. The E-H Series 4001 and 4002, based on two instruments that E-H introduced at the IRE show last March—a switching-time converter for making nanosecond time-interval measurements and a strobing

New instruments

A-c tests weed out defective chips

System tests IC's before wafers are separated and packaged, eliminating faulty circuits that pass the usual d-c tests

Digitally frequency difference meter model 9403 provides a rapid, digital intercomparison of 2 frequency standards. It measures frequency offset from 1 MHz reference to one part in 10^10. The unit is useful in the setting or calibration of secondary standards and in short- and long-term frequency stability measurements. RMS Engineering Inc., 486 Fourth St., N.W., Atlanta, Ga. [364]

Pressure sensor PSF100A senses level changes in liquids, granular powder semisolids, equivalent to 1/16 in. or less of water column or pressure/vacuum and differential in the same range. It is virtually insensitive to shock, vibration, and acceleration. It is 1 x 1 11/32 in., and weighs less than 10 grams. Fairchild Camera & Instrument Corp., 225 Park Ave., Hicksville, N.Y. [367]

Digital frequency difference meter

Lock-in voltmeter 131 measures very weak radiant energy. It operates with any detector over the spectrum from ultraviolet to far infrared. It is suited for general measurements of absorption, fluorescence, emission, reflectivity, and transmission. Frequency range is 1 Hz to 10 kHz; gain stability, 0.25%, Price is $2,150. Brower Laboratories Inc., Turnpike Rd. (Route 9), Westboro, Mass. [368]

Lock-in voltmeter

Suited for swept frequency measurements, model 1008 a-c/d-c converter has a 70-db dynamic range; frequency response from 5 Hz to 5 MHz, and a 300-pv sensitivity. It is applicable for audio and video measurements such as those encountered by telephone companies and filter manufacturers. Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. [366]

System tests IC's before wafers are separated and packaged, eliminating faulty circuits that pass the usual d-c tests
Hurling a challenge. The system got a mixed reaction from semiconductor makers, some of whom seemed to have given up on the idea of making a-c wafer tests and were reluctant to change their minds. There were a number of a-c testers on display at Wescon, but all except E-H’s were designed to accept finished packages. Such testers would be used as an adjunct to d-c wafer probes; circuits that survived the wafer tests and were packaged would be given final a-c tests before shipment. The company is, in effect, challenging the whole concept of d-c testing. “Except for leakage, we don’t see any reason to make d-c tests at all,” says applications engineer James E. Fisher.

Motorola Inc., for one, is reportedly interested in the E-H concept. Texas Instruments Incorporated assisted in the development stage of the system by providing data on required tolerances and parameters. The company has its own a-c tester for packages. Sylvania is still very interested in a-c wafer testing, but its system is still in pilot use for complex circuits.

The E-H system measures propa-
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gation delay, turn-on and turn-off delays, and rise and fall times on a single pulse. Two pulse-height discriminators at the probe itself enable the switching time converter to make accurate timing measurements. A sinusoid from the circuit under test will generate start-stop pulses at programed levels. The start pulse turns on a current that is fed into an integrator, which generates a voltage that rises linearly with time; the stop pulse turns off the current.

The strobing voltmeter behaves as a sample-and-hold meter with an aperture time (for data acquisition) of 4 nanoseconds. It provides a stretched and amplified version of the input signal at the output. The circuit is similar to that of a sampling oscilloscope, according to product line manager Doug Curé. But the design compromises are such that it can make single-point measurements on a single-shot basis, while keeping a d-c reference with the input.

"The single-shot measurements are not a synthesis, like a sampling scope's," Curé says. "A single-event—one logic cycle—can give all the parameters." That capability is important, he says, because it cuts down the time per test (the system can make 700 measurements a second), and because it tests the logic in the same way that a computer would use it. Circuits perform differently under a train of pulses and under a single pulse, he says.

Careful calculation. The inductance problems that plagued previous attempts to perform a-c tests on the wafer were critical, but posed no theoretical barrier, Curé and Fisher say. If physical and mutual inductance and capacitance are measured, the entire system may be treated as a transmission line and the characteristic impedance calculated from the relationship $Z = \sqrt{\frac{L}{C}}$. This "line" will have a transit time that can be taken into account in the measurements.

Prices of the E-H systems will range from $28,775 for the simplest version, to more than $100,000, for the fully automated ver-
sions having core-memory elements. Despite this sizable price tag, the company is convinced that the system can pay its way in cost savings, particularly for IC's that are fast and complex.

Sylvania's Richard Sirrine provides a succinct reason for a-c testing at the wafer. "When you take a complex circuit like a frequency divider, which has four flip-flops, you can't just test for input and output levels." But Sirrine, who worked on Sylvania's a-c system, doesn't believe a-c testing will completely replace d-c. There are some circuits, he says, that will perform functionally yet won't meet the manufacturer's specifications.

In any case, a-c testing performed on the wafer will save the packaging of defective circuits. The circuits on a wafer, Curé says, are worth only a few cents; in the package they may be worth several dollars.

**Instrument hookup.** The basic components of the E-H system are the model 153 strobing voltmeter, the model 142 switching time converter, the model 1420 timing unit, and the model 1139 pulse driver, all E-H catalogue items. The voltmeter's rise time is less than 3 nanoseconds, which is equivalent to a bandwidth of 100 megahertz, and its dynamic range is ±1 volt a-c or d-c. The strobe delay's range is from 100 nanoseconds to 100 microseconds, with an accuracy within 0.35% of full scale. Ranges of the time converter span from 1 nsec to 1,000 nsec in four decades.

E-H Research Labs Inc., 163 Adaline St., Oakland, Calif. 94607 [377]

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E-H Research Labs Inc., 163 Adaline St., Oakland, Calif. 94607 [377]

**New instruments**

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A major application is as a frequency reference subsystem for doppler radar.

In production. Off-the-shelf models are more attractive than the original instruments Beckman designed for use in its own plants.

testers on display at Wescon last month made side trips to a suite in San Francisco's Fairmont Hotel, where the Electronic Instruments division of Beckman Instruments Inc., a nonexhibitor at Wescon, was showing a stripped-down model priced at only $495. Beckman's "Volkswagen" makes d-c tests only, and is intended for the low-volume user of digital ic's. But Beckman expects it to compete with products costing five to 10 times as much.

"It's an instrument born of desperation," says Neal W. Vinson, chief of the laboratory instruments group at Beckman's Richmond, Calif., operation.

Beckman, which has been using more and more ic's in its growing line of instruments, could not find test equipment at a price that seemed reasonable for its still-modest ic purchases. The company therefore designed its own instrument, found that production and quality control departments in at least two divisions could use it, and decided to test the open market.

Vinson says that an operator can completely test about one circuit
Analog switching got you puzzled? Here's the answer — an integrated circuit with drivers and FET switches all in one package. Drive the input with almost any integrated logic — only 0.8 volt swing is required. The output FET with ON resistance as low as 80 ohms and leakage less than 1 nA can switch plus or minus 20 volt signals.

Pick the driver-switch combination for your application: 2 to 5 channels; inverting drivers or not; MOS or junction FETs — see table. These products add to the wide variety of Siliconix drivers and FET switches that are now available from your distributor. Write or check inquiry card for data.

Siliconix Driver-FET Switches

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of Channels</th>
<th>Logic Input for ON Switch</th>
<th>Type FET Switch</th>
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<tbody>
<tr>
<td>DG102F</td>
<td>2</td>
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<td>Jct</td>
</tr>
<tr>
<td>DG103F</td>
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<td>DG104F</td>
<td>2</td>
<td>0</td>
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<td>2</td>
<td>1</td>
<td>MOS</td>
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<tr>
<td>DG121F</td>
<td>3</td>
<td>0</td>
<td>MOS</td>
</tr>
</tbody>
</table>

* Differential — two common gate switches with common output.

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...sliding contacts for fast setup...

a minute with the instrument. For this reason, Beckman says that the 999 is suitable for both laboratory use and low-volume testing of incoming IC's.

Sliding setup. Beckman's model 999 provides exact d-c parameters, accurate to ±2%, on an analog meter. It is "programmed" by moving gold-plated sliding contacts (one for each IC package pin up to 16) over a printed circuit board that determines input voltages, ground, clock, and logic level voltages. Two bus lines on the p-c board also make it possible to connect pins on the IC package. Actually, supply, noise immunity, and truth tables are used to test input threshold levels, high and low output current, short-circuit output current, input forward current, fan out, power dissipation, and current drain.

Since Beckman's aim was economy, the 999 has few extras. "Still," says Vinson, "we've taken gate and flip-flop measurements right off Fairchild data sheets, and checked everything except propagation delay." In a typical setup, he adds, the operator might first determine logic levels by taking high and low values of V_IN from the data sheet, setting the matrix so that the input voltage V_CC and ground are on the correct pins, and monitoring the output pin while the corresponding input pins are being switched between the high and low values of V_IN. This operation verifies V_IN, determines the logic operation, and gives high and low output swings. Two other operations are required for input and output current.

Swinging clock. The 999 does not provide a frequency generator to sweep voltages. Instead, its 100-kilohertz clock swings between the actual logic limits of the package. For another $495, a buyer can have Beckman's 9010 frequency generator, which does provide the voltage sweeping function. The 999 also has a plug for more precise
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Programer, Operator sets up test conditions with contacts that are pushed by hand over printed circuit program boards.

external monitoring by an oscilloscope or a digital voltmeter.

The inside of the Beckman box is, as one might suspect, simple to the point of bareness. The 10-pound instrument contains four power supplies, control logic for the matrix, current sources and sink circuitry, the 100-khz clock (with 20-nanosecond rise and fall time), and metering circuitry. Only the clock contains integrated circuits; elsewhere, Beckman found it cheaper to use discrete components. All power supplies are current-limited, so that is is not possible to burn out a circuit under test without really trying.

The cost of IC’s depends on how many and what kinds of tests the manufacturer runs, so it’s to the advantage of users to make some, if not all, of the tests themselves. The 999, with its fast programing method, should find wide acceptance, especially with smaller companies.

Specifications

<table>
<thead>
<tr>
<th>Vcc</th>
<th>V t11</th>
<th>Meter ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 v ±2%</td>
<td>0-200 ma</td>
<td>0-200 ma</td>
</tr>
<tr>
<td>-12 v ±2%</td>
<td>0-200 ma</td>
<td>1 to 10 v, 2-500 ma</td>
</tr>
<tr>
<td>Power</td>
<td>50 µa to 100 ma, adjustable in 3 ranges</td>
<td></td>
</tr>
<tr>
<td>Current source and sink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(with 20-nanosecond rise and fall time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock</td>
<td>0 to 10 v adjustable; 0 to 50 ma; low, 0 to 10 v adjustable, 0 to 50 ma</td>
<td></td>
</tr>
<tr>
<td>Meter ranges</td>
<td>0 to 10 v ±2%; 0 to 2.5 v ±2%; 1, 10, and 100 ma full scale</td>
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<tr>
<td>Power</td>
<td>114/23 v a-c, 50 to 1000 hz, 10 w</td>
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</tr>
<tr>
<td>Operating temperature</td>
<td>0 to 50°C</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>16½ x 7 x 12¾ in.</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>$495</td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td>4 weeks</td>
<td></td>
</tr>
</tbody>
</table>

Beckman Instruments Inc., Instruments Division, 220 Wright Ave., Richmond, Calif. [378]
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According to St. John Martin, one of the engineers who designed it, the model 7870 metering panel is the first ever built with such capability. It is called a panel, rather than an rfi measuring system, since it can’t do the measuring job alone. While the meter determines the intensity of interfering continuous-wave signals, an oscilloscope or other external display finds the peak amplitude of pulsed signals, and the receiver itself is tuned to determine interference frequencies.

Incorporation. One advantage of making the receiver part of the rfi-measuring system is that it keeps the receiver part of the analysis loop. In some cases, this could lead to more accurate corrective measures for a specific receiver at a specific site. The customary technique of probing the electro-
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Two detection paths. Pulsed input signals are measured with slide-back detector. Either the peak or average value of continuous-wave signals can be measured in second detection circuit.

magnetic environment with independent instruments takes the receiver out of the loop. Also, the field engineer would have less to lug, since the metering panel weighs only 9 pounds.

Honeywell, however, expects to find the widest acceptance among operators of r-f testing laboratories and receiver manufacturers who want to stretch the usefulness of existing general-purpose units. They'll be able to convert standard receivers to tuned voltmeters and signal-strength meters, and measure the susceptibility of receivers to electromagnetic interference.

Field or lab, the main attraction is being able to put together a wideband instrumentation system for a small fraction of the price of conventional r-f measuring equipment. Honeywell plans to charge only $600 for the metering panel.

Signal splitter. Signals enter through a switch adjusted to match the meter's input impedance and the output impedance of the receiver's video or i-f stage. The operator sets an input attenuator so that high-level signals will not overload the measuring circuitry. Input levels can be as low as 20 microvolts, and gain can be varied as much as 25 decibels. One more step completes signal conditioning—removal of the carrier frequency added to the unknown signal by the receiver. This is done with an amplitude-modulation detector.

The input signal then passes through a wideband amplifier to a signal splitter. If the input is pulsed, it goes to a slide-back impulse detector; if it is continuous, it goes through an r-f voltmeter.

Forward and reverse. The slide-back detector is essentially a reverse-biased diode. The operator adjusts the bias voltage until it just cancels the input signal. The cancelling voltage is thus a measure of the input signal's threshold voltage. If the operator wants to determine peak amplitudes, he nulls the signal as usual and substitutes a calibrated signal source for the unknown input. Then he increases the signal level from the generator until the bias voltage is overcome and an output appears on the external display, such as an oscilloscope.

A continuous-wave input goes from the splitter through an impedance matching emitter-follower circuit, a peak detector, another emitter follower, and a low-pass filter on its way to the indicating meter. A front-panel switch bypasses the peak detector if the operator wants to measure the average value of the signal. Another switch changes the meter's sensitivity by a factor of 10.

Specifications

- Frequency range: 10 kHz to 65 MHz
- Input level: 20 microvolts
- Input impedance: 50, 93, 300, and 600 ohms
- Gain adjust: 25 db
- Video output: 2 v rms, into 50-ohm load
- Weight: 9 lb
- Size: 3 1/2 x 19 x 8 inches
- Price: $600

Honeywell Inc., Test Instruments Division, P.O. Box 391, Annapolis, Md. 21404 [379]
The new series 1000 from AAI tests integrated circuits at a rate of about 180 tests per second. At this speed, crisp, clear readout is imperative. That's one of the reasons AAI specified IEE rear projection readouts. It's the World's most readable readout, because of the exceptionally bright, single-plane display.

AAI also wanted a readout as attractive as their circuit tester. In addition, they needed displays in various sizes, colors, symbols, characters and words. This they could only get with rear projection readouts. And this they got with the IEE Series 340, 120 and 10.

If you design, manufacture or market a product requiring visual display, specify IEE readouts. They can't be matched for readability, aesthetics or versatility. That's what AAI discovered.

The Rear Projection Readout: When a lamp at the rear of the readout is lighted, it illuminates one of 12 film messages, focuses it through a lens system, and projects it onto the front viewing screen. The displayed message is clearly projected on a single plane, with no obstruction from unlighted filaments. It is extremely versatile, since anything that can be put on film can be displayed on an IEE readout.


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Systron-Donner Corporation, 888 Galindo Street, Concord, California 94520

Send for catalog.
**New Subassemblies Review**

**Frequencies from below 200 kHz to above 220 MHz are amplified linearly more than 50 dB to power levels up to 400 watts by the M404A laboratory amplifier. No tuning is needed. Applications include communications systems, RFID tests, antenna research programs, and nuclear magnetic resonance work. Instruments for Industry Inc., 151 Toledo St., Farmingdale, N.Y. 11735.**

**Battery-operated preamplifiers series PA uses a noise-canceling circuit and features an rms-integrated broadband noise level below 10 Hz. Input impedance is 1,000 megohms; frequency range, 0.2 Hz to 100 kHz. Models are available in fixed gains of 0, 10, 20, 40, and 60 dB, and variable gains of 0 to 20 and 20 to 40 dB. Agac-Derritrion Inc., 600 N. Henry St., Alexandria, Va.**

**Bidirectional reader/spooler model RRS-502B features a 500-character/sec reader and a 50-in./sec spooler equipped with 10½-in. diameter reels. Panel height is 21 in. Price is $3,580 in small quantities, with discounts for higher quantities. Delivery is 10 weeks. Remex Electronics Division, Ex-Cell-O Corp., 5250 W. El Segundo Blvd., Hawthorne, Calif.**

**Stabil-ac is a 14-oz d-c/a-c inverter that provides 400-hz output with ripple-free, low-noise characteristics. It is used with airborne, synchronous servo equipment. Frequency stability is ±0.25%. Adjustable output (±1%) compensates for mechanical tolerances in users' equipment. Price is $375 in quantities of 1 to 9. MIL Associates Inc., Dracut Rd., Hudson, N.H.**

**Ten-channel monitoring-recorder system PI-8010 meets MIL-E-14400 and will operate for 24 hours on a 10¼-in. reel of ½-in.-wide tape. Audio monitoring of any recorded channel is achieved by switch selection. Bandwidth capability is 2.7 kHz; a cueing system has forward and rewind modes. Precision Instrument Co., 3170 Porter Dr., Palo Alto, Calif.**

**Analog multipliers 610T(A) and 610T are for use in high-speed data-reduction systems. The 610T(A) accepts 2 signals in the range of 0 to ±5 V and its output is 1/5th the algebraic product; the 610T accepts signals of 0 to ±10 V and its output is 1/10th the algebraic product. Bandwidth is 500 kHz minimum. GPS Instrument Co., 188 Needham St., Newton, Mass.**

**Parallel entry data from a wide variety of devices is converted to serial presentation for teleprinters and card or tape punches by digital-data scanners called model 1300 Data Interfaces. Storage can be included in the modular designed units for automatic presentation of coded or informational data along with input data. Humphrey Electronics Inc., Box 9143, Raleigh, N.C.**

**Heavy-duty, solid state supplies series PSR-500 deliver continuously variable 500-w outputs with regulation of line or load to less than 1%, no load to full load. Ripple is less than 1% at max. rated current. Three models are available: 2-32 v d-c, 0-15 amps; 2-55 v d-c, 0-10 amps; and 2-125 v d-c, 0-5 amps. Electro Products Laboratories Inc., 6125 Howard St., Chicago.**

---

**New Subassemblies**

**Strain-gage readouts go all-electronic**

Tumbling prices of integrated circuits enable digital system to compete with electromechanical devices in process control

**Time—in the guise of integrated circuits—has finally caught up with the strain-gage readout equipment that is a basic building block in numerous kinds of industrial control systems. For decades, the readouts have had electromechanical innards. Now the readout is done with digital voltmeters.**

To protect its position as a major supplier of strain gage equipment, and to improve readout speed and resolution, BLH Electronics Inc. has come up with an all-electronic system. The company, a division of Baldwin-Lima-Hamilton Corp., considers it the first off-the-shelf electronic readout.

A year ago, explains Jack Joyce, instrumentation product manager at BLH, digital voltmeters costing less than $1,000 started appearing. “And now, one company is talking about a three-digit unit for $289—that’s cheaper than a good panel meter.” In the new system a dvm replaces the customary analog meter.

**Do-it-yourself.** Users have been putting together their own electronic systems, but until now the off-the-shelf market consisted of null-balance devices, Joyce points out. Null-balance readouts are set

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See Vactec's listing in EBG under "Semi-Conductors," and in EEM, Sec. 3700.

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Write for free 32-pg. catalog. Ideal Precision Meter Co., Inc., 218 Franklin St., Brooklyn, N.Y. 11222. (212) EVergreen 3-6904.

Circle 285 on reader service card

"... servosystems will be obsolete by 1968..."

manually, or by a servomotor, amplifier, gear train, and counter, to provide an odometer-type readout. At $1,500, the new all-electronic model is priced competitively with the electromechanical system and has better resolution and higher readout speed. "Our servo-type systems will be obsolete by 1968," Joyce predicts. Two years ago, he says, an electronic system would have cost $5,000 to $6,000.

"We are now able to build d-c amplifiers that operate in the microvolt region with excellent stability and temperature coefficients."

Load cells using strain gages as sensors operate on the Wheatstone-bridge principle, and the signal conditioning of the millivolt outputs from the sensors must be stable and linear to produce an accurate reading.

The 800-system design stresses versatility. Plug-ins will be available so the basic system can handle outputs of wire, foil or semiconductor strain gages, and special transducers. In each case, the sensor output will be read directly on a digital display.

Others in the works. By the time the series is complete, says Joyce, the company will have developed a strain-gage data acquisition system. The system will use switching and balancing units, and a scanner drive, so that it can feed 200 time-shared data channels. The user can attach a printer or a card-punching machine to the system, or feed the data directly to a computer. The binary-coded decimal output of the system is a natural input to computers, Joyce points out. Loop-closing low- and high-power analog outputs are also available to drive valves and other control equipment.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Input impedance</td>
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</tr>
<tr>
<td>Gage factor</td>
<td>0 to 10</td>
</tr>
<tr>
<td>Gage resistance</td>
<td>60, 120, 350, 500, and 1,000 ohms</td>
</tr>
<tr>
<td>Gage excitation</td>
<td>5 ± 1 v d-c</td>
</tr>
<tr>
<td>Output signal</td>
<td>0 ± 0.5 v at 2 ma</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>10 khz</td>
</tr>
<tr>
<td>Readout</td>
<td>4-digit and bcd output</td>
</tr>
<tr>
<td>Size</td>
<td>6 ⅞ x 17 x 19 ½/16</td>
</tr>
<tr>
<td>Power requirements</td>
<td>115/230 v, 60 hz</td>
</tr>
</tbody>
</table>

BLH Electronics Inc., 42 Fourth Ave., Waltham, Mass. [389]
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IC’s are disguised as relay logic

Sophistication avoided so technicians can design own systems

“Stone-age electronics” is how one engineer describes a series of digital-logic modules designed as building blocks of industrial control systems. “Electronics for technicians,” says a more charitable engineer.

Raven Industries Inc., doesn’t seem to care what people are going to say about its Wedge Logic modules. In fact, the company indicates that the module format is a great way of selling solid state logic assemblies in large quantities to customers who care little about sophisticated circuit design.

Although they are built with integrated circuits and other semiconductor devices, the modules are a replacement for the old-fashioned relay-tree design. They are slow, bulky, and cost about the same as relay logic assemblies.

Call the electrician. A plant manager who wants something like a small computer to control the operation of a bank of machines needn’t call in a consulting engineer. Instead, he can call in the company’s electronics technician to design the system, and the plant electrician to wire up and install the equipment in much the same way as in the days before sophisticated systems.

To make it easier for the technician-turned-designer, Raven Industries avoided the use of NAND or NOR gates. The modules are based upon AND and OR functions that are comparable to relay logic. This should, the company says, allow “the painless development” of special-purpose computers for plant-wide control and monitoring systems.

The fist-sized modules are keyed to plug into standardized mounting rails that accept 5, 10, or 20 modules. The rails are equipped with
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Raven Industries, P.O. Box 1007, Sioux Falls, S.D. 57101 [390]

printed circuits for power distribution, spring-clip module retainers, and cam clamps or wiring posts so extra wiring can be added up front. Any number of mounting rails can be interconnected to form a large-system panel.

Each module has a lamp that indicates the logic state and, in effect, acts as a hedge against installation errors. The lamp also serves as a maintenance aid. Trouble-shooting can be accomplished without test instruments. All module connections are labeled on both sides of the unit to avoid confusion.

What's available. At present, 16 modules are available, including AND, OR, and OR-NOT gates with several input arrangements, time delays adjustable in three ranges between 0.04 to 25 seconds, memory, five-bit counter, amplifier, reset, input, and output. Special modules, such as set-point inputs and specialized input and output functions, are expected to be made available soon.

The IC's are diode-transistor logic (DTL), chosen in preference to resistor-transistor logic because it has higher noise immunity. A noise immunity of 1 volt is needed in an industrial environment, the company says. Transistor-transistor logic was rejected because DTL costs less and is available from more suppliers. The main virtue of TTL—which is high speed—wasn't an attraction.

Electronics | September 18, 1967
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Electronics | September 18, 1967
New Microwave Review

A uhf/f-m transmitter for aerospace telemetry applications delivers 20 w minimum at S-band frequencies in the 2.2- to 2.3-Ghz range. The 3620-01 withstands 55 g shock, 20 g sine-wave vibration, and 30 g acceleration environments. Center frequency stability is within ±0.003% under all environmental conditions. Electro-Mechanical Research Inc., Box 3041, Sarasota, Fla. [401]

A rising sun magnetron that delivers 5-nsec pulses of 95-Ghz energy at 10 kw has a 3.2-mm wavelength output. Output figure of the DX287 lies in the center of an atmospheric window where the attenuation is much lower than that at other frequencies in the mm region. Duty cycle of 0.0002 allows repetition rates to 40 khz. Amperex Electronic Corp., Hicksville, N.Y. [405]

A line of waveguide isolators is based on a patented design that eliminates the external magnet. Series covers 5,925-7,125 Mhz frequency range. Units have 20, 30, or 40 db isolations with maximum losses of 0.5 to 0.8 db. Bilateral vswr is 1.15 maximum. Devices can be furnished with magnetic shielding. E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. [402]

Reflex klystron oscillators series EM-1149 are useful as pump tubes for parametric amplifiers. The 5,000-hr warranty tubes, operating from 12 to 18 Gzh, are available in 2 versions. One offers an output of 1 w over a 500-Mhz tuning range; the other, 1.5 w over a 100-Mhz range. The 7-oz tube mounts in any position. Varian Associates, 611 Hansen Way, Palo Alto, Calif. [403]

L-band signal generator model 1105 covers the 0.95 to 2.4 Gzh range. The manufacturer's Unidial control system provides single-band continuous tuning with digital frequency indication accurate to ±0.5%. Frequency stability is 0.0008% per volt change in line voltage and 0.005% per°C change in ambient temperature. Polarad Electronic Instruments Inc., 34-02 Queens Blvd., L.I.C., N.Y. [407]

A remote coaxial switch, with 10⁹ cycles minimum lifetime, is a spdt unit with a range of d-c to 12.4 Gzh. Isolation is 60 db minimum over entire range. Insertion loss as low as 0.3 db from d-c to 7 Gzh and 0.6 db from 7 to 12.4 Gzh are claimed. SR-2 series switches are available with N, TNC, BNC, or RSM connectors. RLC Electronics Inc., 25 Martin Pl., Port Chester, N.Y. [404]

Hybrid IC's win new support

X-band mixer is forerunner of commercial integrated circuit line that will feature beam-lead devices on ceramic substrates

For openers in its play to become a major force in the microwave integrated circuit market, a chip smaller than its model number—SYMS-00B—has been introduced by Sylvania Electric Products Inc. The circuit, an X-band balanced mixer, is the forerunner of a broad line of mixers and other microwave IC's that will be appearing during the next year or so.

The construction of the mixer underlines the dominance of hybrid IC's in microwave applications. Its elements consist of beam-lead semiconductor devices connected to microstrip conductors and photoengraved passive components on an alumina substrate. The substrate
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measures 0.7 by 0.5 inch and is 0.02-inch thick. The coaxial package is only about an inch square.

The beam-lead devices in the initial circuit are matched Schottky-barrier diodes. The leads are welded to the conductors on the substrate. Other beam-leaded semiconductors, for other circuits, are being developed. Unless another company steals a march on Sylvania, the mixers will be the first commercially available microwave ic’s with beam-lead components. Engineering samples of the mixer will be available in about two to three months and production will begin late this year.

Throwaway chip. The ic chip is designed to be thrown away to reduce receiver maintenance cost. Mixer burnout sometimes plagues receivers, so rather than substituting an entire mixer, the user would merely replace the circuit, diodes and all, and reassemble the coaxial package.

This feature exacts its price in performance, however. Voltage standing wave ratio (vswr) is high — about 2 to 1. Sylvania engineers aim to lower it to perhaps below 1.3:1 by redesigning the circuit board and improving ic-coaxial connector interfacings.

Noise is also higher than desired at 8 decibels over-all between 9 and 10 gigahertz. This also is to be reduced; 6-db noise figures have already been achieved in the lab.

What’s new? After the first X-band mixer is delivered, units for lower and higher frequencies should follow quickly. Sylvania’s aim is a mixer line extending from the uhf (below 1 Ghz) to Ku-band (15.3 to 17.2 Ghz).

Problems to be overcome lie in microwave-frequency filter design. Alumina substrates make high Q’s hard to attain and thus, filters with sharp bandpass characteristics are difficult to come by. Microstrip ic construction also makes couplers (power dividers) difficult to build. Even though Sylvania can achieve line-edge tolerances below 1 mil, a 3-db coupler that couples at exactly 3 db is a rare thing.

Beyond Sylvania’s mixers loom more complex subassemblies. Work on microwave equipment, however, is only in the design stage. A venue, Linden, N. J., is a registered trademark of Union Carbide Corporation.

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Nylafil is just one of the many fiberglass reinforced thermoplastics, pioneered and developed by Fiberfil. There is a full line of familiar structural plastics such as ABS, polystyrene, styrene-acrylonitrile and others, all incorporating glass fibers in the molding compound to give the molded part greatly improved physical properties.

Compare Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Unreinforced Nylon</th>
<th>Nylafil 6-10</th>
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</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>psi x 1000</td>
<td>8.5</td>
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<tr>
<td>Izod Impact Strength</td>
<td>ft lb./in.</td>
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<td>2.5</td>
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<tr>
<td>Coef. Linear Thermal Expansion</td>
<td>in./in./°F</td>
<td>5.5 x 10^-5</td>
<td>1.33 x 10^-4</td>
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<tr>
<td>Heat Distortion Temp. @ 86°F</td>
<td>°F</td>
<td>300°</td>
<td>437°</td>
</tr>
</tbody>
</table>

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... l-o will be added and combined with mixer ...

has already begun on a combination of a mixer and intermediate-frequency amplifier. Marvin Groll, marketing manager for microwave devices, also predicts a mixer will soon be combined with a local oscillator.

Certainly the groundwork is being laid. Brian Dale, chief engineer at Sylvania's semiconductor products facility has men working on transistors, p-i-n diodes, and varactor diodes—all in beam-lead configurations and suitable for receiver, local oscillator, or frequency multiplication applications. Meanwhile, Arthur Solomon heads an effort at the same plant that will take advantage of Dale's semiconductors and develop such components as sputter-deposited loads and terminations for microstrip circuits.

Specifications

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>9-10 Ghz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise figure, including 1.5 dB IF noise</td>
<td>8 dB</td>
</tr>
<tr>
<td>Mixer type</td>
<td>double balanced about 2:1 max.</td>
</tr>
<tr>
<td>VSWR</td>
<td></td>
</tr>
</tbody>
</table>

Sylvania Electric Products Inc., Semiconductor Division, 100 Sylvan Rd., Woburn, Mass. 01801 [409]

New microwave

Tiny switch couples IFF antenna pairs

IC's that can handle 3-kw peaks to replace mechanical switches

Work that proved too arduous for mechanical switches—shuttling kilowatts of power between aircraft antennas—doesn't faze a hybrid integrated circuit. The circuit, developed under an Air Force contract, was designed for use in IFF (identification friend or foe) transponders.

Microwave Associates Inc. plans to offer such IC's to companies designing microwave systems with IFF capability. It will also sell them off
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Specifications

<table>
<thead>
<tr>
<th>Frequency</th>
<th>L band (390 to 1,550 Mhz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power switched</td>
<td>250 w average, 3 kw peak</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>0.001</td>
</tr>
<tr>
<td>Breakdown voltage</td>
<td>600 v minimum</td>
</tr>
</tbody>
</table>

Microwave Associates Inc., Burlington, Mass. [410]

the shelf. The application the Air Force had in mind when it gave the company the development contract was radar-beacon assemblies for the military portion of the national air traffic control system planned for the 1970’s [Electronics, July 24, p. 141].

The circuit acts as a single-pole, double-throw switch between a transponder and two antennas. Some aircraft equipped with IFF have antennas on each side so the planes do not screen themselves from interrogating ground stations.

Replacements. When the Air Force decided that IC’s were the way to better reliability in microwave equipment, the natural starting place was switching circuits. There was a great deal of dissatisfaction with mechanical switches. In some aircraft, solid state circuits are already replacing mechanical switches. And, plans call for the eventual use of IC’s.

“A building block toward total integration” is how William J. Moroney, semiconductor development manager at Microwave Associates, views the switch. Circuits that are more difficult to design as IC’s can be built around it later, he says.

Beating the heat. At the power handled, heating can be troublesome. To minimize thermal effects on performance, organic materials were ruled out of the circuit because of their characteristics.

The thick-film hybrid is built on an aluminum-oxide substrate. After the circuit pattern has been photographically defined, including main transmission line and bias terminations, silver is sprayed on the transmission-mode microstrip. Thick-film capacitors are then deposited for biasing purposes. These consist of high-dielectric-constant glass coated on metalized pads and fired. Metal is deposited on top, and a coating of glass is added to protect the capacitors. The p-i-n diode elements, which are then inserted, consist of glass-coated silicon sandwiched between two metal pieces.
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New Production Equipment Review

Pulsemeter soldering system features pencil-type holder and miniature parallel-gap electrodes. Both time and current can be preset to control heat delivered. Time settings range from 0.1 to 1.0 sec; current settings, from 10 to 35 amps. Uses include IC flatpack soldering, and thin- and thick-film soldering. Development Associates Controls, 725 Reddick Ave., Santa Barbara, Calif. [421]

Pantograph reflow-soldering system RS-334 consists of a power supply, 2 reflow-soldering heads, a pantograph p-c board positioning mechanism, and an IC loading/placement fixture. It positions an IC on its mounting board and solders as many as 14 leads at once. Each soldering head has interchangeable electrode-tip configurations and sizes. Sippican Corp., Mattapoisett, Mass. [422]

Test chamber ZOHP-3 is designed to provide stable life-test temperature conditions for in-chamber parameter measurements of semiconductor and axial-lead components mounted to p-c boards. It provides for life-test temperature environments from 100°F to 400°F with a stability of ±0.25°F, utilizing a laminar air flow. Associated Testing Laboratories Inc., 200 Rt. 46, Wayne, N.J. [423]

Model 1400 console enables the welding of insulated tape cable to itself or to connector terminals without prestripping the insulation. It includes 2 a-c power supplies, 1 d-c supply, an a-c/d-c controller, and a weld head with 4 electrodes (2 above and 2 below the items being welded). Copper-to-copper welds take 1/2 sec. Wells Electronics Inc., 1701 S. Main St., South Bend, Ind. [424]

Temperature heating rate of −100°F to 200°F in 2 hours and cooling rate of 200°F to −100°F in 1 hour are featured in an environmental ThermaLine vibration chamber that is insulated with nonsetting, nonhygroscopic Fiberglas/Foamglas. Control is maintained to within ±3°F. Environmental Engineering Division, Bethlehem Corp., 222 W. 2 St., Bethlehem, Pa. [425]

Valve assembly V4-198 provides control of gas flow into a vacuum system or other chamber for thin-film sputtering, electronic-tube filling, test-chamber pressure regulation, arc melting, zone refining, and crystal growing. A replaceable, baffled, hot filament assembly removes impurities. Price is $425. Deliveries are from stock. Materials Research Corp., Orangeburg, N.Y. [426]

HD-3 remote masking-spray coater, TL-1 automatic tray-loading machine, and ML-1 magazine loader are for continuous automatic wet or powder application to axial-lead components. They handle from 3,000 to 10,000 components per hour, depending on sizes. After spray coating, the ML-1 stacks 40 loaded trays for baking or storage. Conforming Matrix Corp., Toledo, Ohio. [427]

Roller coater for applying thin-film photoresist materials to p-c boards has a double-pumping system for automatic cleanup, ground rolls, dial indicators for thickness adjustment, and separate drive systems for doctor roll and coating roll. Coater operates at any speed from 3 to 9 ft per minute. The unit will accept boards up to 1 in. thick. Union Tool Corp., Warsaw, Ind. [428]

New production equipment

Purer metals are worth the wait

Zone refining system takes a long time to clear impurities from thin-film materials, but it helps improve IC yields

Unkind words are often voiced by production managers saddled with vacuum-processing systems that must be pumped down for more than a few hours. Yet a ponderous system that chugs away for a couple of shifts before it goes to work is expected to find a welcome at plants producing electronic components.

The machine's job is purifying metals with an electron beam—a job it does better than anything anybody else has devised, according to Materials Research Corp. It will refine tantalum, for example, Refinery. Power supply and control cabinets flank the vacuum chamber.

Electronics | September 18, 1967
...impurities swept to end and then cut off...

to the point where the resistivity ratio—an electrical measure of purity—is 2,100. That, says MRC, is almost 10 times better than the best tantalum from other refiners.

Besides, the day or so spent in refining a metal rod can step up production. Suppose linear integrated circuits are being made. Scrap rates can quickly rise if contaminants start showing because of minor differences in composition of the materials deposited as thin-film elements. A half-pound rod shaped into a deposition source can keep a thin-film sputtering system fed for a year.

**Two to make ready.** The EBZ-95 system refines as well as it does because it is the first to add ultra-high-vacuum distillation to zone refining, the company says.

Zone refining is a method of sweeping impurities out of a rod. In the electron-beam version of the technique, the beam scans the rod slowly, causing a small, molten zone to traverse the rod. Soluble impurities collect in the zone, so they can be concentrated at one end, which is cut off.

While the beam is clearing away impurities having high melting points, impurities with relatively low melting points boil off in the vacuum. The higher a vacuum, the more impurities will boil off. The EBZ-95 attains a vacuum of $1 \times 10^{-11}$ torr in less than 24 hours.

**One to go.** Ceramics can be refined in the EBZ-95 with the aid of custom-grid assemblies. But MRC prefers a new cathodic system that prevents constituents like oxygen from coming out of the compound.

With a hollow cathode heating the material during the zone refining process, the chamber doesn’t have to be evacuated (an electron beam can only function in a vacuum). Oxygen can then be bled into the chamber to prevent dissociation of oxides. Conversely, hydrogen can be supplied if oxides must be reduced.

The price of the EBZ-95 is about $42,000, and delivery takes eight weeks.

Materials Research Corp., Orangeburg, N.Y. 10962 [429]
**NEW MINIATURE NYLON CONNECTORS**

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Circle 235 on reader service card
New production equipment

**Bonder reduces purple plague**

Preheating of devices is no longer needed in bonding gold wires

**Pulse heating** the tip of a thermocompression bonder isn’t new, but attempts to overcome some of the technique’s major problems—premature tip wearout, wobbly tip support, and ball-size inconsistency—have, for the most part, proved unsuccessful. But now, the Hughes Aircraft Co.’s Vacuum Tube Products division believes it has whipped these problems. It has come up with the xoscwa (for microcircuit welder/ball bonder), which the company believes will enable it to grab a share of the $4 million-a-year wire-bonder market.

The Hughes bonder handles gold-wire diameters ranging from 0.0007 to 0.005 inch without any preheating of the devices. Moreover, it can bond at any heat without requiring setup changes. These features, says Gary D. Wrench, manager of the division’s display and equipment operations, should make the bonder particularly attractive to makers of hybrid thin-film and thick-film devices.

By coupling a direct current nickel-cadmium battery power supply to a comparator circuit that compares the voltage across the tip with a preset value, Hughes is able to control the duration of maximum heat. When the voltage exceeds the preset limit, the comparator circuitry signals a bank of control transistors that reduces the power output. The sensing signal feeds back to the power supply every 25 microseconds. The significance of tip-temperature control, Wrench says, is that “it turns the tungsten-carbide tip down just before it goes to the red condition, thus lengthening tip life.”

In the work. Wrench says Hughes had been experimenting “off and on” for four years to develop the bonder. A concerted effort was made during the last
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**New Books**

From pipelines to space

Handbook of Telemetry and Remote Control
Elliott L. Gruenberg, editor
McGraw-Hill Book Co., 1300 pp., $35

Many engineers forget that telemetry developed as wired systems for remote instrumentation in the gas, electric, and chemical industries. This book does not. Though space telemetry now gets far more publicity, these first applications have grown in importance and therefore are not neglected by the author. Coverage is from a modern point of view of the unusual problems posed by industrial telemetry and remote control. The coverage of remote control as an extended version of feedback-control principles is authoritative and expertly done.

Since telemetry includes not only the measurement but also the transmission of data, the handbook also devotes much attention to the particular methods of communication that lend themselves to accurate, high-capacity transmission of data. It covers methods of modulating and multiplexing, such as fm-fm frequency-division systems, pulse-amplitude modulation, pulse-duration modulation, pulse-code modulation, time-division systems, high-efficiency systems and phase-locked loop systems.

The chapter on sampling and handling of information is done with great care and skill and, all in all, is the best short treatment of the subject so far published. However, little coverage is given to digital information processing, now a fast moving field with the upswing in the use of digital integrated circuits.

With a specialized subject and a high price, this book probably will find its way to the bookshelf of only a relatively few electronics engineers. It is, nonetheless, a useful reference work for those concerned with telemetry as well as people in all the other fields that have borrowed the techniques developed by workers in telemetry. The topics for each section cover the field well.

But, as often happens with books that are written by a large group
New Books

of authors—30 in this case—the quality of coverage is spotty; some portions are excellent while others are disconcertingly obscure. For example, the treatment of transistor telemetering circuits is well done, but the treatment of general design considerations for transistor circuits is inadequate. Typographical errors also mar a few of the chapters.

Walter C. Johnson
Princeton University
Princeton, N. J.

Recently published


This handbook is aimed at the user with professional training in a field other than programming. It provides a reference to current methods of programming and numerical analysis, and computer applications.


A handbook on the processing and instrumentation techniques for the fabrication, test, and failure analysis of IC’s. The book will be valuable to engineers in IC production and evaluation.


Static optimization procedures, adaptive control, and dynamic optimization are covered in this graduate-level text. Necessary mathematical background is included with emphasis on the time-domain methods and steady-state vector representations.


FET’s and monolithic IC’s are included in this text for college juniors. Thevenin’s and Miller’s theorems are used extensively in analysis of transistor and tube circuits. Elementary concepts in electronic quantum theory are also discussed.

Introduction to Dynamic Systems, J.B. Reswick and C.K. Taft, Prentice-Hall Inc., 294 pp., $8.95

This undergraduate text concentrates on developing simplified models of physical systems. Laplace transform techniques have been avoided, so that the student can better understand the algebraic basis of classical transient and steady state analysis. Complex frequency functions are discussed and a heuristic treatment of Fourier series is given.


Basic transistor physics is presented on an elementary level. This is followed by a discussion of the properties of transistors, covering the discrepancies between the physical devices and common simplified models, d-c and a-c characteristics, switching response, temperature sensitivity, and gain, distortion, and noise characteristics. Material is geared to the average graduate engineer.
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Immediate openings exist at Seattle on the SRAM, Minuteman and Lunar Orbiter programs. Assignments in test technology include data systems and instrumentation and test data handling and processing. Qualifications include a B.S. or M.S. in electrical engineering and two to five years applicable experience. Flight technology positions are available in flight control and flight mechanics. Qualifications include a B.S. or M.S. in electrical engineering with two to five years experience.

Additional Seattle openings exist in developmental design and electronic packaging. Design assignments are in airborne control systems, ground system electrical power systems, and environmental control, and require a B.S. degree in an applicable discipline plus related experience. Electronic packaging qualifications include a B.S. in electrical engineering plus applicable experience.

A number of openings also exist on the Apollo/Saturn V program. At Huntsville, assignments in flight mechanics and flight evaluation include operational trajectories, mission analysis, trajectory analysis, post-flight trajectories, flight simulation development, and flight dynamics. Qualifications include a B.S., M.S. or Ph.D. in electrical engineering. Openings also exist for electrical/electronic engineers at Kennedy Space Center.

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Handle with care

Evaluation of bulk and epitaxial GaAs by means of X-ray topography
Eugene Meieran
Fairchild Semiconductor Research and Development Laboratory, Palo Alto, Calif.

Even routine handling of a gallium arsenide wafer can damage its surface. The slightest touch with tweezers causes deep scratches, rarely less than 4 or 5 microns. Table tops and, surprisingly, filter papers also can cause scratches. Such scratches are invisible with a microscope, but a new method of X-ray topography brings them out, and allows study of other defects caused by crystal growing, sawing, mechanical polishing, and diffusion.

Saw damage usually is fairly shallow, about 10 microns, and consists of a skin of cracked GaAs which is somewhat polycrystalline. Mechanical polishing also leaves a polycrystalline surface, though a microscope will show no signs of damage. X-rays, however, reveal scratches about 10 or 20 microns deep.

An X-ray comparison of boat-grown GaAs with Czochralski crystals shows that the boat-grown crystals are superior. The Czochralski crystals have heavy segregation of dopants and large numbers of dislocations—effects which are not observed in boat-grown crystals.


Try phastor storage

The phastor, a simple analog storage element
D. Aspinall, University of Manchester, England
W.J. Poppelbaum, University of Illinois

An analog storage element was built with a simple voltage comparator circuit, a clock-pulse generator, a monostable multivibrator, and some gating circuits. The circuit, called the phastor, uses a time interval to represent the voltage and lends itself well to integrated circuit format. Its accuracy depends primarily on how high the clock frequency can be made.

One way to store some value of an analog voltage indefinitely is to compare it with a sawtooth waveform, produce a narrow pulse when the two are equal, and feed the pulse into a delay line whose delay is equal to the period of the sawtooth waveform: Thus, when a pulse leaves the delay line, the sawtooth is again at the voltage equal to the analog voltage. If the sawtooth is sampled at that instant, the analog voltage can be recovered.

The delay line, however, stores only one piece of information—it can be replaced with a simpler astable multivibrator whose period is equal to that of the sawtooth. The astable multi is held off until the analog voltage is equal to the sawtooth, and then the multi is
Technical Abstracts

allowed to oscillate freely. From then on, whenever the multi completes a cycle, the sawtooth waveform at that instant will again be at a voltage equal to the analog voltage.

Whether the sawtooth is perfectly linear or not is not important, so long as each cycle always repeats itself exactly. What is important is that the timing between sawtooth and multi remain coordinated.

The phasor eases the restriction on equality of the two periods by using a clocked system and a monostable multi instead of the astable. The monostable is triggered by the time coincidence of a clock pulse and the comparator output. The period of the monostable must nearly equal the period of the sawtooth. Specifically, it must be less than but within one clock pulse of the sawtooth waveform's period.

Once the original coincidence between sawtooth and analog voltage is sensed, and the multi switched, the clock pulses will, from then on, take over the timing and switch the multi at points in the cycle corresponding to the proper sawtooth voltage. Thus, the multi must switch over to its unstable state when hit by the first coincidence pulse, remain there, oblivious to the steady stream of clock pulses, and then switch back to its original state in time to be switched again by a clock pulse which is coming exactly one sawtooth waveform period later.

A breadboard model of the circuit was constructed using a 3-millisecond ramp. The circuit was able to store analog voltages to an accuracy of better than one part in 32 for several minutes. Work now is proceeding on using a higher clock rate, which would provide the analog memory with better accuracy.


Making microwave IC's

Fabrication of monolithic microwave integrated circuits: materials and process considerations
Robert C. Hooper, Charles A. Wheeler, Texas Instruments Incorporated, Dallas

A marriage of compatible techniques is the secret to fabricating microwave integrated circuits. Monolithic circuits for operation at microwave frequencies can be built by growing epitaxial silicon on a semi-insulating silicon substrate, fabricating high-frequency transistors in the epitaxial material, and then depositing thin-film resistors and capacitors. Amplifiers operating at 500 megahertz were made with this process.

The semi-insulating silicon substrate, which provides isolation between devices, is high-resistivity (300 ohm-cm) p-type silicon, which is masked with silicon dioxide and then selectively etched to form pockets about 10 microns deep. The pockets are refilled with epitaxially grown silicon.

Next, an npn transistor is diffused into the refill area, and a molybdenum-gold contact is deposited to...
produce low-resistance ohmic contacts to the transistors and to help form better thin-film capacitors. Finally, a film of SiO₂ is deposited over the surface. Typical transistors built like this had an fₐ of 2.5 gigahertz and a 500-MHz noise figure of 3.5 decibels.

Resistors are formed by vacuum-evaporated nichrome films. Thin-film capacitors are formed in windows cut in the protective SiO₂ down to the transistor expanded contacts. Such capacitors are the most difficult thin-film component to build successfully.

Thin-film capacitors fail because of rough substrates, contamination in the atmosphere and pinholes in the photoresist, but the most serious defects are related to the interaction of dielectric film and metal electrodes. If aluminum were used for the contacts, processing temperatures in the range of only 250 °C would cause the SiO₂ film to rupture, because of the thermal mismatch of coefficients of expansion of aluminum and the film. In addition, the aluminum tends to recrystallize during deposition of the film and produces a rough surface which can cause capacitor breakdown.

Making the bottom electrodes with molybdenum avoids the problems with aluminum, and produces capacitors with excellent characteristics. A minimum breakdown voltage of 60 volts was observed for 100-pico farad capacitors and the capacitors can be heated to 350 °C without failure.


Fast turnaround

Thick-film techniques and design criteria for space vehicle application

A.V. Ottaviano and J.J. Thomas
General Electric Co.
King of Prussia, Pa.

The General Electric Co.'s reentry systems department, in an operation about a year old, is fabricating prototype thick-film hybrid integrated circuits in three days. The department, concentrating on linear circuits not available as stock items, has produced 50 different circuits for use in reentry vehicles in the past six months.

Interface circuits like signal conditioners, secondary power supplies, and analog programmers are often the last in the system to be defined, demanding a fast turnaround time in the design-to-fabrication process. Typical circuits operating up to 400 megahertz have been processed from engineering layout to finished assembly in 24 man-hours.

One of the major problems was screen printing resistors. Depositing resistors to within ±10% of nominal value requires that the distance and parallelism between the bottom of the screen and the substrate surface be closely controlled, along with the squeegee angle and pressure. Adjusting squeegee pressure from 4 pounds to 7 pounds produced a resistance change of about 25%, and a 0.010-inch modification in screen-to-substrate distance introduced a change of about 10%.

Presented at Wescon, San Francisco, Aug. 22-25.
New Literature

Precision meter terms. Precision Meter Division, Honeywell Inc., Grenier Field, Manchester, N.H., 03105. Definitions of terms for electrical indicating instruments are spelled out in a six-page brochure. Circle 446 on reader service card.

Microwave relay equipment. RHP Electronics Laboratory Inc., 94 Milbr Blvd., Farmingdale, N.Y. 11735. Solid state, f-m microwave relay equipment is discussed in catalog 67b. [447]

A-c generators. Kato Engineering Co., 1415 First Ave., Mankato, Minn. 56001. An eight-page brochure covers the company's line of a-c generators with controls from 1 to 1,500 kw. [448]

Ultrasonic detection. Delcon Division, Hewlett-Packard Co., 333 Logue Ave., Mountain View, Calif. 94040. A 10-page brochure presents the growing uses of ultrasonic detection in 11 major industrial applications. [449]


Current sensors. American Aerospace Controls Inc., 129 Verdi St., Farmingdale, N.Y. Technical bulletin 109 describes the series 4008 clamp-on current sensors for measurement of d-c currents in the range of 150 to 5,000 amps. [451]


Scalar feed. TRG-Boston Division, Control Data Corp., 400 Border St., East Boston, Mass., has issued a four-page illustrated brochure on its model LS871/881 scalar feed horn. [453]

Connector assembly machine. Edward Segal Inc., 132 Lafayette St., Farmingdale, N.Y. has a catalog sheet describing a machine with automatic feed for the assembly of interlock connectors for tv sets and similar uses. [454]


Aerospace digital computers. Kearfott Group, General Precision Systems Inc.,...
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1150 McBride Ave., Little Falls, N.J. 07424, has issued a 24-page catalog describing nine aerospace digital computers and their variations. [456]

Adjustable crimping tools. Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N.J. 07083, An illustrated, six-page bulletin (TA 100) describes and gives specifications for a line of eight-indent, cycle-controlled crimping tools. [457]


Digital products. Digital Products Division, Vernitron Corp., 59 Central Ave., Farmingdale, N.Y., offers a digital products catalog listing its brush-type shaft encoders, as well as solid state digital-to-synchro and digital-to-resolver converters. [459]

Cooling fan assemblies. General Electric Co., 1635 Broadway, Fort Wayne, Ind. 46804. Publication GEA-8258 describes a line of blower units for computer and electronic equipment cabinets. [460]


Silicon rectifiers. Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. 06512. Bulletin 119 offers details on a line of subminiature, high-voltage silicon rectifiers. [462]

Current drivers. Computer Test Corp., 3 Computer Dr., Cherry Hill, N.J. 08034, has published a technical data sheet (bulletin 66-R) on a complete line of 20-nsec current drivers. [463]

Elapsed time indicators. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin M1603 describes miniature elapsed time indicators for operation on 400 hz, 60 hz, and d-c. [464]

Synchro simulator. North Atlantic Industries Inc., Terminal Drive, Plainview, N.Y. 11803, offers a data sheet describing model 532 synchro simulator that features 30-second accuracy. [465]

Flatpacks. Veritron West Inc., Chatsworth, Calif. A catalog details a wide spectrum of basic sizes of flatpacks for IC, hybrid and thin-film packaging. [466]

Antennas. RF Systems Inc., 155 King St., Cohasset, Mass. A brochure sum-
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New Literature

marizes and pictures military and commercial antennas and tower structures manufactured by the company. [467]

Microwave components. Bendix Microwave Devices Inc., Farmington Industrial Park, Farmington, Conn. 06032. A 44-page catalog (No. 14) contains over 1,000 models of directional couplers, circulators and isolators, r-f loads and terminations, power and vswr meters, switches, filters, and integrated devices. [468]

Shift register. Microelectronics Division, Philco-Ford Corp., 2920 San Ysidro Way, Santa Clara, Calif. 95051. Application Note 401 describes the pL5R100 MOS monolithic 100-bit shift register. [469]

Balanced mixers. Microwave Associates Inc., Burlington, Mass., has released a four-page technical bulletin on the Orthoote series hybrid balanced mixers with characterized diodes. [470]

Rotary stepping switches. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin CS902 describes series 42700 rotary stepping switches for operation on 12 or 28 v d-c, or rectified 115 v a-c, 60 hz. [471]

Linear integrated circuit. Fairchild Semiconductor Division, Fairchild Camera & Instrument Corp., 313 Fairchild Dr., Mountain View, Calif. Two technical publications examine consumer, industrial, and military applications for the μA703 linear integrated circuit. [472]


Ferrite core wires. Electronic Memories Inc., 12621 Chadron Ave., Hawthorne, Calif. A two-page application note describes how optimum wire sizes for a given ferrite core can be readily determined. [475]

Digital voltmeter. Dana Laboratories Inc., 2401 Campus Drive, Irvine, Calif., has published a brochure on the model 5700 digital voltmeter, which carries a one-year calibration guarantee. [476]

D-c/a-c inverters. Natel Engineering Co., 7129 Gerald Ave., Van Nuys, Calif. 91406, has issued a two-page data sheet covering a line of miniature d-c/a-c inverters. [477]
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RELIABILITY ENGINEERS BS plus two or more years experience with emphasis on electronic circuitry design and overall equipment design, analysis and review, experience in certain aspects of component engineering, prototype development and test evaluation. Experience in developing and implementing total Reliability Programs for proposal activity, including predictions, reliability demonstrations, tests and design review.

HUMAN FACTORS SPECIALISTS Degree plus 2 to 8 years experience. Positions will involve system analysis, optimizing man-machine relationships, design inputs, maximizing maintainability, task analysis and specifying qualitative and quantitative personnel requirements.

MAINTAINABILITY ENGINEERS BSEE plus two or more years experience in Maintainability Engineering—the concept, maintenance flow, throwaway vs. repair criteria, etc. Positions involve design input, analysis, MEARS, documenting, reporting, auditing and demonstration testing.

VALUE ENGINEERS BSEE, ME, IE. Assignment requires the analysis of both design and manufacturing procedures to improve overall product cost effectiveness. Will work in close conjunction with Design Reliability and Maintainability Engineers.

ADMINISTRATIVE ENGINEERS BSEE or BSME plus graduate work in Business Administration plus 2 to 5 years experience in engineering project control or major program scheduling and control. Basic knowledge of financial analysis, cost reporting and PERT required.

ELECTRONIC COMPONENTS ENGINEERS BSEE with 3 to 5 years experience in engineering, manufacturing, or major program scheduling and control. Experience in electronic manufacturing test or environmental test.

MANUFACTURING PROJECT ENGINEERS BS degree in EE, ME, IE or Industrial Management. At least 3 years experience in electronic manufacturing involving engineering liaison with production departments, manufacturing methods, pre-release design review, production area layout, process detail preparation, and technical assistance to assembly operations.

INDUSTRIAL ENGINEERS BS degree or the equivalent and five years experience in process specification, PCB fabrication or coil manufacturing and potting.

TEST EQUIPMENT ENGINEERS BSEE plus three years of intensive experience in the design of specialized production test equipment.

TEST ENGINEERS BSEE or Physics, experienced in electronics manufacturing test or environmental test. Specific background in low frequency vibration, temperature, humidity and altitude environmental test techniques required.

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DIVISION OF LITTON INDUSTRIES
Black box controls gasoline injection in '68 Volkswagens

West Germany's largest auto maker, Volkswagenwerk AG, will start selling in the U.S. next week the first mass-produced car with a fully electronic fuel-injection control system. The black box is standard equipment on VW's top-of-the-line models for 1968—the 1600 fastback and the 1600 station wagon.

About the size of a cigar-box and mounted in the engine compartment at the rear of the car, the control unit makes use of 25 transistors, 35 diodes, 140 resistors, and 20 capacitors. Sensors on the motor feed in such data as intake-manifold pressure, cylinder temperature, crankcase temperature, throttle-valve position, and engine speed. From this data, the unit develops opening and closing pulses for the fuel-injection valves.

VW developed the electronic control with Robert Bosch GmbH of Germany primarily to meet U.S. standards on exhaust gases. With the electronic control, the 1600 engine exhaust has a carbon monoxide content of 1% or less, much lower than the 2.3% limit set by U.S. antipollution laws. In addition, Bosch claims, the black box cuts fuel consumption.

Russian color tv at bargain price

Soviet officials now claim they'll have a color-television set on the market early next year for about $300—a price that would make the set a loss leader elsewhere in Europe. Y.B. Soloviev, head of the institute that designed the receiver, says the model is put together mainly from components used in black-and-white sets; hence the hard-to-believe low price.

Although the Russians insist they've started producing color sets in quantity, few will be in evidence when colorcasts start on Nov. 7. The first color programs will be seen on only some 100 receivers set up in public places.

German order likely for Phantom jets

The West German Defense Ministry and the McDonnell Douglas Corp. very likely will close a deal around year's end for at least 150 Phantom 2 jet fighters. The planes would cost up to $3.5 million apiece and would go to accident-depleted squadrons now flying F-104G Starfighters.

The deal should be good news for the German electronics industry. Bonn will probably specify that much of the avionics gear in the planes be made domestically. That's what the British did when they placed their large Phantom order [Electronics, Dec. 26, 1966, p. 93].

Britain rejoins Mallard Project

British communications equipment makers now stand to pick up a piece of the action in Project Mallard, a massive tactical communications system that will take almost a decade to build and will cost upwards of $500 million [Electronics, May 15, p. 153].

The British, who initiated the project and then pulled out last spring after a squabble over contract allocations, rejoined the U.S., Canada, and Australia last week. Britain will contribute 30% of the $126 million it will cost to develop the system; the U.S. will handle 62% of the tab, Canada 5%, and Australia 3%.

Originally, Britain insisted that her share of Mallard contracts match her contribution. The Pentagon, however, wanted contracts awarded to low bidders—meaning U.S. companies in most cases. What brought
Britain back in was apparently a compromise that assures British electronics firms of contracts, but not necessarily in strict proportion to the U.K. contribution.

Fujitsu may crack U.S. computer field

Fujitsu Ltd. now has high hopes of breaking into the U.S. computer market. The Japanese company says it's well along in negotiations with the Control Data Corp. for the export of a large number of Facom 230/10 computers.

Control Data most likely will offer the small Fujitsu computers as satellite equipment for its own large machines. The 230/10 has a 4,000-word basic internal store with a cycle time of 2.2 microseconds. To swing the deal, Fujitsu may buy tape and disk memory units from the U.S. firm.

U.K. silicon maker asks tariff boost

British semiconductor-materials makers should get an idea next month of how much to expect in the way of government protection against price-cutting foreign competitors. The reading will come from a Board of Trade ruling on a request for a higher duty on one size of silicon wafer imported from Belgium.

Britain's largest producer of silicon slices, Monsanto Chemicals Ltd., filed for an anti-dumping duty on a wafer produced by Metallurgie Hoboken. The added duty would bring prices of Hoboken's wafers to the same levels as British-made wafers. Monsanto asked that the tariff be raised on a specific wafer (1.283 to 1.287 inches in diameter and 0.0095 to 0.015 thick) but almost certainly will file for action on other sizes. Hoboken says it has the same price scale in Britain as in many other countries.

Spain restores investment curbs

The Franco government has suddenly tightened its controls on the establishment of consumer-electronics plants. Up to this month, foreign or domestic companies proposing new production facilities in the country were assured of approval if the planned output came to 100,000 receivers or more annually. Now the government has switched to a policy of considering plant investment plans case by case.

Industry ministry officials describe the move as part of an effort to restructure Spain's highly fragmented consumer-electronics industry. With at least 45 receiver makers now competing in the market, the government wants no new small operators. At the same time, it's encouraging mergers by offering tax incentives.

Marconi group gets Eurocontrol award

A consortium headed by Britain's Marconi Co. has won the $2.8 million order for air traffic control equipment for Eurocontrol's experimental control center at Bretigny, France. The contract, which will probably be signed this week by the companies and the seven-nation air-space-control organization, covers software and hardware, plus an experimental data processor.

Marconi's partners are Standard Elektrik Lorenz, a West German ITT affiliate, and SAIT Electronics of Belgium. Among the losing bidders were the Eurosystem consortium [Electronics, Sept. 4, p. 202] and a group that included Philips' Gloeilampenfabrieken.
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Circle 264 on reader service card
Great Britain

Double standard

By and large, broadcast networks have taken the easy way out for intercontinental relays of television programs. Instead of trying for sophisticated electronic conversion from one standard to another, most telecasters have simply aimed a tv-camera onto an image storage tube linked to receiving circuits for the incoming standard.

This electro-optical scheme, however, makes for poor picture quality even for black-and-white. And it won't do at all for color tv. Realizing this, the engineering division of the British Broadcasting Corp. has been working on a fully electronic conversion technique. So has the Japan Broadcasting Co. [Electronics, Feb. 6, p. 108]. But BBC figures to be the first to put electronic conversion into service for colorcasts. At the International Broadcasting Convention in London this week, bbc engineers will tell of an interim system ready for use now and an advanced system that should be in service within a year.

Playing the field. Both systems rely heavily on quartz delay lines to convert from the U.S. standard of 525 lines per frame and 60 fields per second to the European color standard of 625 lines and 50 fields. In both standards, two interlaced fields make up a frame. And in both bbc systems, the basis of the conversion is dropping one out of every six incoming fields.

In the interim system, though, the compensation for the lost field is much the simpler. Where the advanced system stretches the retained fields from 16% milliseconds to 20 ms by adding 50 lines to each field, the interim system simply shortens the line length in a line-store converter to match the shorter field period. This keeps images proportional, but makes them about 17% smaller.

Cascade. Fields are knocked out by running the 525/60 video input through a five-position switch and a cascade of four quartz delay lines. The first incoming field passes directly through the switch to the following stage, the line-store converter. The second field is passed through the first 3 1/3 ms delay line and then is switched onto the line-store unit. The third field passes through two delay lines, the fourth field three delay lines, and the fifth field four delay lines before they are switched. As a result, the fifth field is switched onto the line-store exactly when the sixth field of the raw input appears. This field never reaches the line-store; by the time the switch returns to the first position the first field of the next group of six is at the input.

Lineup. Although the interim system produces a good-quality color image by knocking out fields and shortening line lengths, BBC plans to do considerably better with its follow-on system. It uses 3 1/3 ms delay lines in cascade but couples them with a second cascade where each delay lasts twice as long as the preceding one. A logic circuit switches in the binary delay units so that 50 averaged lines can be inserted into each field, stretching its duration from 16% ms to 20 ms.

West Germany

Hue and cry

It was a premiere worthy of Hollywood in its heyday. The West German post office and broadcasting networks spent $25 million getting ready for the occasion. And when, after weeks of ballyhoo, the great day arrived, droves of stage and screen stars shared the spotlights with government officials. But the glitter and the fanfare that marked the start of color television in West Germany late last month did little to allay the worries of set producers. Their concern is the price war that began early this summer. Gone are the producers’ plans to hold set prices at fairly high levels at the outset and then trim them gradually as the market grew. Gone, too, are retailers’ hopes of high profit margins on color receivers.

Snowball. The first shot in the price war was fired in June, when Neckermann Versand KGaA, the

Slight delay. Five-position switch and four delay lines in cascade are key to BBC’s television-standard converter.
country’s largest mail-order house shattered the industry’s $600 minimum price level by offering 25-inch color sets for $460 [Electronics, July 10, p. 189]. Since then, all the major set makers, plus retailers, discount houses, and even the federal cartel office have been drawn into the fray.

The set makers first countered by dropping their retail prices by about $50. But when the retailers’ association balked, the set makers restored part of the cut, settling on a level of about $575. But discounters and big department stores broke the new price barrier, selling 25-inch sets for just under $500.

The industry reacted fast to this second assault on its price line. Three producers—Siemens AG, the General Electric Co.’s Kuba-Imperial subsidiary, and Graetz KG, an affiliate of the International Telephone & Telegraph Corp.—took the problem to the federal government’s cartel office, the agency that oversees marketing practices. The department stores fell back into line, but the discounters claimed the sets they were selling weren’t subject to price fixing. To sidestep price-fixing regulations, the discounters set up export-reimport deals so that their receivers would be legally classified as coming from Israel even though they had been made in Germany.

**Falling out.** After a flurry of charges and countercharges, the cartel office ruled that the producers had no case. As a result, the alliance of the producers seems about to collapse. Kuba, for example, is now giving its color-set retailers free rein on prices. Says a Kuba official, “We are not in the business to fight in courts all the time but to produce television sets.”

Kuba’s new stance could well trigger a chain reaction throughout the industry, with each producer going his own way. One likely result is a spate of smaller, lower-cost sets. Some producers are considering 22-inch models that would sell for $35 and 19-inch models with price tags in the neighborhood of $420. Kuba will soon put out an 11-inch portable priced below $375. Neckermann, presumably, will hold to its $460 price for the 25-inch set it supplied to it by Koerting Radio Werke GmbH. When Neckermann started the price war, it planned to bounce its “introductory” price up to just under $500 after colorcasts started in West Germany.

For all the woes it has caused set makers, the price war has helped get West Germany’s infant color-receiver market off to a bounding start. Some 40,000 sets have been sold in the past two and a half months. Optimists predict 100,000 color-set sales by year end, and volume of between 200,000 and 250,000 in 1968.

**Bargain beacon**

By and large, the Sunday pilot is limited to flying on days when he can see where he’s going, when he can use landmarks to determine where he is and how to return home. Not for him are the sophisticated navigational aids such as very high frequency omnidirectional range installations, instrument landing systems essential for commercial aircraft. Such aids require sophisticated electronic gear well beyond the means of small-plane owners. Moreover, the instruments would take up too much space in small aircraft and use too much power.

Now, West Germany’s Rohde & Schwarz has developed a system that brings direction-finding into the cockpits of most small planes at no cost to their owners. From the signals broadcast by the two-way radio sets carried on small planes, the system’s ground equipment determines bearings. When a pilot has lost his bearings, he calls the airport for a reading and the airport control tower radios it back to him. The operation takes about three seconds and the indication is accurate to within 1°.

The ground equipment, called NPS, sells for $11,250 and several small West German airports have it on order.

**Circle.** The antenna system consists of 16 vertically installed monopole elements arranged uniformly around a 10-foot diameter circle. Monopole elements are used because they cut out interference caused by the antenna supporting pole and other equipment that may be under the base of the antenna array. These monopole elements probably also account for an antenna pattern in which the so-called cone of silence (a region directly over the antenna of a transmitter, in which no signal is heard by the pilot), is greatly reduced. Because of these factors, selecting the site for an NPS antenna is less critical than it is for conventional direction-finding equipment such as Adcock systems based on dipole antennas.

**Merry-go-round.** To pick up the signal broadcast by an aircraft radio, the individual monopole elements are electronically scanned in a clockwise direction by a 170-hertz signal fed to each element via diodes.

To stabilize the bearing indication, the phase differences obtained during 180 simulated rotations are averaged out in 1.05 seconds. For plus or minus 1 degree bearing determination, the carrier frequency has to be present at the antenna for at least 1.2 seconds. Depending on altitude of the aircraft and transmitting power of its equipment, the range of the direction finder is between 30 and several hundred miles. Modular construction techniques allow separate
installation of the direction-finding transmitter and the indicator.
The system has a 1-megahertz bandwidth and operates in a 117.5-
to 136.5-megahertz frequency range.

**Hands-off.** Once the operating frequency has been set, the system is fully automatic. Three digital indicator tubes indicate the true bearing and the direction is shown by one of 36 glow lamps arranged around the indicator field. A built-in loudspeaker permits monitoring the tuned-in airborne transmitter.

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**Japan**

**Self-booster**

Long strong in high-capacity microwave links, the Nippon Electric Co. seems ready to make its mark with equipment designed for relatively few channels.

Last week, the concern shipped to Morocco $200,000 worth of hardware for a 60-channel, three-hop, 2-gigahertz system. Later this year, a 4-Ghz system will go to Mexico. And Nippon Electric has on its order books low-capacity, 6-Ghz links for Mexico and Brazil.

More than anything else, the combination of a low price and telephone-system reliability has brought this business to Nippon. Large because of a simplified transmitter designed for baseband operation. Nippon's microwave repeater units cost considerably less—half in some cases—than comparable heterodyne types, according to the company.

**Kingpin.** The paramount component in the transmitter is a high-frequency transistor developed by Nippon for microwave use. The transistor (2SC652) has a maximum frequency of about 1.6 Ghz, but the circuit is arranged so that the nonlinear collector-to-base capacitance boosts the frequency to 2 Ghz at the output, eliminating the need for a varactor multiplier. A low-power varactor, (SV87A), however is used to frequency-modulate the self-multiplying transistor oscillator.

The circuit is essentially a variation on an old standby, the Colpitts oscillator. A series resonant circuit \((L_1, C_1)\) sets the oscillation frequency. The input signal is applied to the varactor \((X_1)\) in parallel with \(C_1\) and its variation in capacitance modulates the oscillator. The transistor's emitter-to-base and base-to-collector capacitances take care of the voltage division needed for feedback.

**Efficient.** Input to the oscillator is normally 900 milliwatts and output at the fundamental frequency of the transistor is 400 mw, for a conversion efficiency of 44%. With the circuit tuned for 2-Ghz operation, the maximum oscillator output is 160 mw. Because the transmitter works in a baseband system with the modulation recovered at each repeater, the oscillator is set for optimum modulation characteristics rather than maximum power output. This slightly cuts the modulated power fed to the antenna to 100 mw for 2-Ghz operation, for example. For 4- and 6-Ghz systems, varactor doublers or triplers are added on to the basic 2-Ghz oscillator, lowering the power fed to the antenna even further.

**Colorful.** Repeaters using the simplified transmitter are intended mainly for telephone links. With 4-foot antenna dishes, the repeaters can be spaced at 30-mile intervals and still easily meet CCIR international standards for 120-channel operation. For 300-channel operation, the output power is a little low for 4-foot antennas and 30-mile spacing, but it suffices for larger antennas or shorter hops between repeaters.

Nippon says the modulation characteristic of the simplified transmitter is highly linear over a wide frequency band, good enough for one color-television channel. One potential customer, in fact, may buy the microwave system as a backup for a telephone-cable link and use the standby equipment for TV transmission.

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**Soviet Union**

**People's patents**

There was a time when Soviet officialdom could turn up a "Comrade Inventor" for just about any important technological advance anyone cared to name.

But since the Soviet Union joined the Paris Union—the international patent agreement—two years ago, it's become clear that the Soviets are piling up a serious deficit in their "balance of patents." In a move aimed at wiping out the deficit, the all-powerful Soviet Council of Ministers last month put into force some sweeping revisions in the country's patent policy.

High on the list is a new patent service that will be run by the State Committee on Inventions and Discoveries. The committee also has been ordered to set up a special panel to oversee filing of patents abroad and selling licenses outside the Soviet bloc. All government agencies involved in research and development have been ordered to
send on to the committee detailed reports on inventions that look like candidates for licensing abroad.

Factories with strong design staffs, too, have been instructed to set up patent bureaus. And a network of patent libraries will cover the country starting next year. All will have access to a master file of patent information in Moscow.

**Incentives.** To spur patent production, the Soviet Council from now on will channel half the foreign currency earned from sales of licenses or patented machinery to the government of the republic where the invention originated. The research institute that developed the innovation, in turn, will get 30% of the republic's share.

Also from here on out, technological institutes will be judged partly on the number of licenses they sell. Other important criteria will be the number of patents received and the benefits to the economy from an institute's new machines or techniques.

Individual inventors, however, will reap the same rewards as before. Rather than file for patents, Soviet citizens apply for inventor certificates that name them as innovators but make the inventions the property of the state. Based on the invention's value to the national economy, an inventor can get a cash award as high as 20,000 rubles —$22,200 at the official, but inflated, exchange rate.

Although the revisions are primarily intended to foster Russian invention, they also figure to step up the inflow of technology from the West. One of the new regulations stipulates that before an agency assigns a development project to an institute it must "examine the technical and economic expediency of buying licenses for similar machines or processes."

**Backsliders.** On paper, at least, the Soviet Union has had a formidable patent organization ever since it joined the international patent union. Theoretically, 5,000 patent agencies are operating at plants, research institutes, and design offices. But two-thirds of them have never applied for a patent.

"Many design offices do not know the road to the Invention and Discovery Institute," complains Yuri Maksarev, chairman of the institute's governing committee. "To put up any longer with such a situation," he says, "would mean great losses for us both at home and in foreign markets."

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**The Netherlands**

**A first of sorts**

News of yet another radio with integrated circuits no longer creates much excitement—as long as the set maker is American or Japanese.

But NV Philips' Gloeilampenfabrieken figures to cause a considerable stir with an upcoming pocketable portable that will be Europe's first ic-equipped production set. The Dutch company will market the radio this fall at a price of about $30.

Philips has packed much of the set's circuitry onto two ic's. One includes the entire intermediate-frequency strip—13 transistors, 13 resistors and a diode capacitor. The other, part of the audio circuit, has 3 transistors and 3 resistors.

Because the loudspeaker is by far the largest working component in the set, Philips has packaged the radio in a round case roughly 3 inches in diameter and 1 3/16 inches thick. The circuit elements, mounted around the perimeter of the back plate, are tucked around the loudspeaker's magnet when the plate is in place. The set operates off rechargeable cells instead of dry cells.

**Australia**

**Out of step**

The Australian electronics industry, which thought it was advancing toward a larger share of military orders, was told by its government this month that it's tripping over its own feet.

According to the Auditor-General's annual report, only 20% of a wide variety of electronic parts and components made locally during the year ending June 30 met Australian military specs. The report squelched the industry's hopes that the government was sympathetic to demands that more defense electronics be purchased Down Under [Electronics, Aug. 7, p. 180].

**Who, us?** Reaction was quick, angry, and mostly predictable. It ranged from refusal to comment—the usual thing in an industry known for its secrecy and suspicion of competitors—to a statement from Bert Leckie, managing director of Sonic Electronics of Melbourne, that "an increasingly higher proportion of qualification approval certificates is being issued." And M.H. Hicks, president of the National Electrical Manufacturers Association, called on the industry to share production statistics as a step towards higher standards.

In the most pessimistic reaction to the Auditor-General's report, one manufacturer maintained that the government leaked stories about the high rejection rate to support continued buying of components abroad.

**Budget woes.** The cloud has a silver lining—the fiscal 1968 budget message calls for a 9.5% increase in over-all expenditures, and
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Circle,304 on reader service card

Electronics Abroad

an 18% boost in defense outlays to $1.2 billion, a good part of which could go toward made-in-Australia electronics. But the budget would require an increase in postal rates, and the opposition party, joined by independents, is preparing to fight the measure. If the bill were defeated by the legislators, Prime Minister Henry E. Holt might dissolve the House of Representatives and schedule elections for November, delaying budget passage and possibly even resulting in sharply reduced defense expenditures.

Around the world

Pakistan. A satellite link between East and West Pakistan, separated by 1,000 miles of unfriendly Indian territory, now seems certain. The U.S. Import-Export Bank has agreed to loan the divided country $10 million to cover the cost of designing the system and building two ground stations. The Communications Satellite Corp. has received a letter of intent for the design and preparation of bid specifications. The Pakistanis hope to have the system operating by 1969, most likely using an Intelsat-3 satellite with ground stations.

Japan. Tokyo Shibaura Electric Co. has developed an electric auto with a cruising range of about 50 miles and a top speed of 62 miles an hour. The car is powered by a 27-horsepower, 20,000 rpm motor that has a six-thyrister bridge rather than the conventional segment-and-brush commutator.

Switzerland. The Federal Council has cleared the way for the start of color television in Switzerland by adopting Telefunken's phase-alternation-line (PAL) system as the country's standard. Broadcast officials plan to begin televising special events and color movies next year. First studio programs, however, won't be aired until 1970 or 1971. Sets equipped to pick up both Swiss colorcasts and the Secam transmission from neighboring France will be on the market by mid-1968.
When $2.00* can buy solid-state reliability with zero offset voltage...

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RCA's new 3N138 insulated-gate MOS transistor features extremely low feedthrough capacitance (0.25 pF max.)...works equally well with either positive or negative incoming signals!

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  \[ V_{ds} = +35 \text{ volts max.} \]
- **GATE-TO-SOURCE VOLTAGE:** 
  \[ V_{gs} = \pm 10 \text{ Vdc max.} \]
- **GATE LEAKAGE CURRENT:** 
  \[ I_{gs} = 10 \text{ pA max.} @ 25^\circ \text{C} \]
- **DRAIN-TO-SOURCE "OFF" RESISTANCE:** 
  \[ R_{ds} (\text{off}) = 2 \times 10^7 \text{ ohms min.} \]
- **DRAIN-TO-SOURCE "ON" RESISTANCE:** 
  \[ R_{ds} (\text{on}) = 300 \text{ ohms max.} @ V_{ds} = 0, V_{gs} = 0, f = 1\text{KHz} \]
- **FEEDTHROUGH CAPACITANCE:** 
  \[ C_{m} = 0.25 \text{pF max.} \]

*Price in 1,000 up quantities

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RCA Electronic Components and Devices

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Electronics | September 18, 1967
Measuring only 0.23" x 0.5" x 0.4" the TRIMPOT Model 3111 relay fills the need for higher reliability and greater miniaturization. This rugged DPDT unit is hermetically sealed in a 1/6 crystal can size with convenient 0.1" pin spacing.

Model 3111 has a operating temperature range of -65°C to +125°C. The contact rating is 1.0 ampere resistive at 28 VDC, 150,000 operations minimum, and the pick-up sensitivity is 130MW maximum. Operate and release time is 4 milliseconds maximum. The relay features a self damping return spring and balanced armature design assuring excellent shock (50G) and vibration (20G) performance. Matter of fact, all performance requirement of MIL-R-5757 are met or exceeded by the Model 3111 TRIMPOT relay!

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Circle 272 on reader service card

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Tube illustrated above, the Victoreen 6842 pentode with plate voltages to 4 kV, is shown in a typical shunt regulator circuit with two Victoreen Corotron corona type voltage regulators. Other tubes in the Victoreen line include—

7683 — Triode or pentode with plate voltages to 1 kV

VX-80 — Triode with plate voltages to 4 kV

VX-76 — Pentode with plate voltages to 5 kV

7235 — Triode with plate voltages to 10 kV

7234 — Pentode with plate voltages to 10 kV

VX-107 — Beam pentode with plate voltages to 15 kV

VX-68 — Vacuum high-voltage rectifier with 28,000 PIV; application as rectifier or clipper
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