Flat flexible wiring—it's great where weight, size and the labor cost of an installation are vital considerations. But how do you specify it? Off-the-shelf cable won't satisfy all requirements; most is custom-made. The data sheets don't help much either. For tips on specifying flexible flat cable and PCs, see page 60.
Dale's way with wire matches your need for precision at a price... and meets your special design needs.

**Shuntsmanship**
Your meter needs Dale's new LVR. Dale has slashed shunt resistor prices as much as 66% and reduced resistance values to as low as .008 ohm.

Circle 181

**Fuse News**
Two Dale styles combine precision resistance with predictable fusing times. Axial lead (CFR) has 1/4 to 21/2 W power. Special disc type for use in socket applications.

Circle 182

**Wirepower in RN50 Size**
Dale's tiny new RS-1/4 dissipates up to 3/4 watt in 155°. Operates to -275°C. Molded body can be automatically inserted. T.C. as low as ±20 PPM.

Circle 183

**Networks with Muscle**
WDP wirewound network handles up to 3.5 watts in standard 14-pin DIP size. Contains up to seven resistors which can have closely-matched tolerance (1%) and T.C. (±5 PPM).

Circle 184

It's all in the family. If the resistance function you need isn't in Dale's Catalog A... don't worry, we have it. No one beats our ability to mix and match resistance parameters.

DEPENDABLE DALE... comes to you with the courtesy of the best representatives and distributors in the business. There's a source of information near you... or call 402-564-3131 today.

DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebr. 68601
A subsidiary of The Lionel Corporation
In Canada: Dale Electronics Canada, Ltd.
Ball Bearings, Not Bushings
Ball bearing shaft assembly is designed to reduce the friction that wears out conventional bushing-design fans before their time has come.

Standard models can handle almost any job be it an industrial, military, or space application. Customized designs take over where the standard line leaves off. We welcome special ventilation problems.

Etri is not new. Etri backed by Amphenol is new. It's one of the first products from our Alliance Marketing Service. Amphenol's AMS selects the best components on a world-wide basis and brings them to you. You get a broader component selection and increased design options. For more information, contact: Alliance Marketing Service, Amphenol Sales Division, 2875 South 25th Avenue, Broadview, Illinois 60153. (312) 345-4260.
Time and desert sands have eroded the ancient pyramids of Egypt, but like massive stone mountains they still stand in mute testimony to man's ingenuity. The TO-5 Transistor Case Relay is a modern-day counterpart. As tiny as the pyramids are mammoth, the TO-5 is no less ingenious or durable. Originally developed to conform to the extraordinary reliability and environmental requirements of defense and aerospace needs, the TO-5 is now available for sophisticated industrial applications. The same pioneering spirit at Teledyne that created the TO-5 Relay is breaking new ground in the field of Solid State switching devices. This advanced family of Solid State relays will also stand the test of time. Send us your requirements.

3155 West El Segundo Boulevard
Hawthorne, California 90250
Telephone (213) 679-2205

TELEDYNE
RELAYS
NEWS
25 News Scope
28 X-ray laser: Real or illusory? The stakes in the outcome are high with the possibility of great impact on semiconductor technology.
30 Fiber optics leaps ahead of optical integrated circuits.
34 New system monitors keeping tabs on computer performance.
36 Building-block computer setups are gaining.
38 Improved movies are simplifying simulation techniques.
53 Technology Abroad
55 Washington Report

TECHNOLOGY
60 Focus on Flexible flat cable and PCs: A special report on tradeoffs between types of flat flexible wiring with some useful specifying tips.
72 Reduce noise in feedback circuits. Usually the best signal-to-noise ratio results from high preamp gain and multiple feedback.
78 Keep front-end noise figures low with a tradeoff of filter bandwidth and loss. Simple low-cost components will do the job.
84 Get a statistical analysis in seconds with this inexpensive Fortran program. It provides tabulations, summaries and variance estimates.
90 Cut the testing time of digital circuits with a straightforward programmable clock that can be built with a few inexpensive ICs.
94 Cultivate a budding manager this year. Management-bound engineers require recognition and guidance to grow; supervisors can help to develop their attitudes and methods.
100 Ideas for Design: Eliminate troublesome common-mode output voltages in IC video amplifiers . . . BASIC program expresses any number as a rational fraction . . . Multiplicity counter uses IC logic.

PRODUCTS
107 Modules & Subassemblies: Tiny 10-bit d/a converter plugs into 16-pin IC socket.
128 Components: Solid-state 40-A relay withstands 500-A inrush.
112 ICs & Semiconductors
116 Instrumentation
122 Packaging & Materials
134 Data Processing
136 Microwaves & Lasers

Departments
59 Editorial: A civilian NASA? It'll take a little push.
7 Across the Desk
138 Evaluation Samples
138 Design Aids
140 Application Notes
142 New Literature
146 Bulletin Board
150 Advertisers' Index
152 Product Index
154 Information Retrieval Card

Cover: Photographed by J. H. Troup, Jr., courtesy of AMP, Inc.
ELIMINATE RESISTOR STOCKPILES
WITH... BOURNS

SELECTABLE FIXED RESISTOR*TM

90 SELECTABLE RESISTANCE VALUES IN 1 TINY UNIT.

* A PRECISION FIXED RESISTOR WITH SELECTABLE RESISTANCE VALUES.
BOURNS NEW...UNIQUE CONCEPT IN RESISTIVE COMPONENTS ALSO OFFERS

* 33 ohm to 1.25 megohm combined resistance range over 15 units
* Selectability within ±1% of required resistance value over the entire range

... IS A STABLE, THICK-FILM, FIXED RESISTOR WITH ADJUSTABILITY OF ±1% OR BETTER

... REPLACES STANDARD FIXED RESISTORS IN APPLICATIONS WHERE FINAL RESISTANCE VALUE REQUIRED CAN'T BE PRECISELY DETERMINED AT THE DESIGN STAGE

... REPLACES "ONE-TIME ADJUST" VARIABLE RESISTORS IN APPLICATIONS REQUIRING LONG-TERM STABILITY

... RESISTANCE VALUE IS SELECTED, THEN PERMANENTLY, RELIABLY SET BY SOLDERING

LOOK AT THE $$ YOU SAVE ON INVENTORY!!

FOR EXAMPLE: Your application requires selection of individual resistance values from 550 ohms to 1000 ohms, or 40 different resistors at 10¢ each. One Model 4002 provides the same resistance selection within ±1% at 76¢.*

Result: 40 different resistor values: 40 x 10¢ = $4.00

One Model 4002: 1 x 76¢ = .76

You save...$3.24!!

*1,000 piece quantity price U.S. dollars, F.O.B., U.S.A.

it's easy to use

After mounting on PCB; probe the COARSE and FINE adjustment taps (Figures 1 and 2) to determine the precise resistance required. Solder the selected taps (Figure 3) and the SFR RESISTOR is permanently set.

FOR COMPLETE DETAILS AND A BROCHURE:
- CALL SFR RESISTOR SALES COLLECT
  (714) 781-0270
- CONTACT YOUR LOCAL BOURNS REPRESENTATIVE.

FOR A FREE SAMPLE...write to the factory answering the following on your company letterhead.

(a) My application for the Bourns SFR Resistor is...
(b) It will replace (number) of fixed resistors in my inventory
(c) Approximate anticipated annual quantity usage: (number)

"SFR" is a trademark of Bourns, Inc. Patents Pending

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507
INFORMATION RETRIEVAL NUMBER
A Smart Way to Beat Your Power Supply Size Problem

yet this converter produces 1000 volts DC, regulated, from a battery input of 28 VDC! It weights less than 15 ounces. This is only one of our wide variety of many small light weight converters, inverters and power supplies – there are over 3000 models listed in our newest catalog, including size, weight and prices. If you have a size problem, why not send for an Abbott catalog?

MIL SPEC ENVIRONMENT — All of the power modules listed in our new catalog have been designed to meet the severe environmental conditions required by modern aerospace systems, including MIL-E-5272C and MIL-E-5400K. They are hermetically sealed and encapsulated in heavy steel containers. New all silicon units will operate at 100°C.

RELIABLE — Highest quality components are used in Abbott power modules to yield the high MTBF (mean time between failure) as calculated in the MIL-HDBK-217 handbook. Typical power modules have over 100,000 hours MTBF — proving that the quality was built in from the beginning.

WIDE RANGE OF OUTPUTS — Any voltage from 5 volts DC to 3,650 VDC is available by selecting the correct model you need from our catalog with any of a variety of inputs including:

Send for our new 68 page FREE catalog.

ABBOTT LABORATORIES, INCORPORATED
5200 W. Jefferson Blvd./Los Angeles 90016
(213) 936-8185
Cable ABTLABS

INFORMATION RETRIEVAL NUMBER 5
ACE for CEEs urged so they can EOMGB

Your recent comments on acronyms deserve more concern than you displayed. Few of us can abide the repetitive use of full-length terms that lend themselves to acronymic substitution. We strongly urge, however, that acronyms be derived in some orderly fashion. We propose that Concerned Electronics Engineers (CEEs) use a systematic Acronymic Code for Electronics (ACE).

Any proper code should start with a Condition of Definition Ethics (CODE). The CODE must take into account the difference between devices that are off, for which we use the prefix X, and devices that are fake or not available, for which we use F. Thus, a de-energized IC becomes XIC (Roman numeral 89) and an uninvited Ranging and Automatic Detection system becomes FRAUD.

The basic rules of ACE can be applied in a Systematic and Comprehensive Fashion (SCF).

1. First-Use Rule. The first time an acronym appears, the expression it replaces shall precede it. Thus, if written, Radar-Assisted Pilot Ejector becomes RPE. If spoken, it becomes ARPEE (with phonetic spelling showing the preferred pronunciation).

2. First-Letter Rule. An acronym shall comprise the first letters of the principal words it replaces. Second letters or first letters of conjunctions can be included if necessary, and it is permissible to omit first letters. Thus CARP is the preferred acronym for Controlling And Regulating Auxiliary Power.

3. General-Usage Rule. Acronyms shall not have been preempted for use in another field. It might prove confusing if the Air Force were required to provide Integrated Logistic Support (ILS) for its Instrumented Landing System (ILS), or if troops were ordered to report to Armored Group Network Equipment Wave-lengths (AGNEW). Avoiding such careless use of pre-empted acronyms would have prevented usurpation of MOS FET (for Metal-Oxide Semiconductor, Field-Effect Transistor), when it properly belonged to Moss On Sides of Far-Eastern Trees, an invaluable guide to self-location in Indo-China (IC).

4. Brevity Rule. Acronyms shall be shorter than their parents. One should prefer SEQS to the more ubiquitous SPEBSQSA for the Society for the Preservation and Encouragement of Barber-Shop Quartet Singing in America—and HIC for its affiliate, the Happy-Hour Improvement Club. Always, one should Exercise Obeisance to the Modern God, Brevity (EOMGB).

We recommend that the White House Office of Telecommunications (WHOT) set up a Committee on Regulation of Acronyms (CORA) to enforce ACE. CORA under WHOT would direct the use of ACE for CEEs. This would provide an SCF for CODE, which would EOMGB and allow the CEE to avoid ILS, SPEBSQSA and AGNEW, while encouraging HIC. Isn't that an improvement?

Jim Rose
Communications Management Co.
Palos Verdes Estates, Calif. 90274.

Tom Stephenson
George Yardley Co.
Westminster, Calif. 92683.

(continued on page 10)
containing electrical energy is a little more complex
How a cable copes with the problems of voltage safety; frequencies; current; attenuation; capacitance; velocity of propagation; inductance; electrostatic and electromagnetic interference, depends heavily on what surrounds the conductors:

The coating, insulation, shielding, jacketing materials. And how they are applied. Belden has the ways and means. Material answers that can help you cope with both the electronic and physical environment your cable works in. The design and production know-how to give you the right combination of quality, reliability and performance your application demands.

Talk to your Belden wire specialist. He has more than 8,000 standard cable items to draw from. Knows what modifications are possible. What the tradeoffs are. The costs involved. He can give you a complete cable package tailored to your needs.

You won't find a better source for know-how, understanding or results.

Write for a copy of the Belden Electronic Wire and Cable Catalog. Belden Electronic Division, P.O. Box 1100, Richmond, Indiana 47374. Phone (317) 966-6681.

INFORMATION RETRIEVAL NUMBER 234

BELDEN

We want your cable business and are out to prove...
Belden covers wire with performance, service and ingenuity
These new low-priced power amplifiers boost the output power and usefulness of laboratory signal sources.

ENI’s highly linear, all solid-state, broadband power amplifiers boost the output power of signal generators, sweep generators and frequency synthesizers—and they do so with a remarkably high performance/price ratio.

Here’s the performance...
These high gain RF amplifiers deliver up to 3 watts while faithfully reproducing complex broadband input signals. Unconditionally stable, the amplifiers will operate without damage or oscillation into severe load conditions (from an open to a short). This makes them ideal for driving electro-optical devices, ultrasonic transducers, broadband antennas—any device with an impedance that’s a function of applied power and/or frequency. This table contains additional performance parameters as well as prices.

<table>
<thead>
<tr>
<th></th>
<th>Model 300L</th>
<th>Model 403L</th>
<th>Model 500L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Coverage</td>
<td>150KHz-140MHz</td>
<td>100KHz-275MHz</td>
<td>1.7MHz-560MHz</td>
</tr>
<tr>
<td>(without tuning)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Power Output</td>
<td>3 watts</td>
<td>2.7 watts</td>
<td>300 milliwatts</td>
</tr>
<tr>
<td>Price</td>
<td>$535</td>
<td>$795</td>
<td>$295</td>
</tr>
</tbody>
</table>

Prices FOB Rochester for delivery in U.S.A.

How do we do it for the price?
We use thin film hybrid and microstrip construction. All of the transistor circuitry, except the wideband impedance transformers, is bonded to an alumina substrate through “heat spreaders” that reduce chip temperatures by up to 30°C. This reduces the number of transistors needed to produce the rated output, while increasing the overall reliability.

It’s your move...
For your complete catalog of power amplifiers and mult couplers circle our reader service number. For immediate action or to arrange a demonstration write to: ENI, 3000 Winton Road South, Rochester, N.Y. 14623. Call 716-473-6900 or TELEX 97-8283.

Further focusing on MOS/LSI testers
“Focus on MOS/LSI Testers” in the Aug. 17 issue (ED 17, p. 60) appears to us to be an excellent piece of work, pulling together the contenders in this marketplace and their various points of view. The only thing that frankly dismays us is that our company, Non-Linear Systems, Inc., is totally unmentioned. I believe that the fault is primarily our own. I found that a questionnaire was indeed sent to us many months ago but evidently was not returned to you.

Non-Linear Systems has been very active for several years in the test-instrumentation and system field. We produce test systems and components, such as clocks, word generators, drivers, comparators, digital displays and test heads. We designed and manufacture an array test system that we call our Series A-2. One of these systems has been in productive use for two years at the NRMEC Div. of North American Rockwell. Most recently we have been doing custom design work and producing computer-controlled MOS/LSI test systems as well as basic acceptance testers.

Charles J. Marsh
Vice President, Marketing
Non-Linear Systems, Inc.
P.O. Box N
Del Mar, Calif. 92014.

Pythagorean squaws
Reader Jack Althouse of Palomar Engineers in Escondido, Calif., quite irrelevantly wrote to remind us of the ancient tale of the three Indian wives who bore sons at about the same time. The first squaw, who slept on a horse’s hide, and the second squaw, who slept on a buffalo’s hide, each bore a son. But the third squaw, who slept on a hippopotamus’ hide, bore twin sons.

This proves, once again, that the squaw of the hippopotamus is equal to the sons of the squaws of the other two hides.
PACK YOUR CARDS TIGHTER . . .
KEEP THEM COOLER . . .
with a System that helps you
beat the system . . .

Low cost. Easily assembled.

Varipak® II. The modular printed circuit card enclosure system. Elco's trick to help you beat problems caused by high density card packaging. Like space limitations. Component overheating. And overall systems design.

Use Varipak II to pack up to 82 cards and connectors in a row. Even with cards this tight, we've made sure you'll get plenty of air flow between them. To keep components cooler, working longer. For convenience, we mount connectors on the back panel. Makes it easy to cross wire and check out. And Varipak's modular construction lets you design around your needs. Not the limitations of your enclosure. So even special packaging adaptations require little or no tooling costs.

The Varipak II system is available in 32 standard models. In an almost infinite variety of configurations. You'll find it useful in large logic storage cabinets, as pull-out computer drawers, and even as the framework for small instrument panels. Construction is rugged aluminum. And the system will take all the hard knocks you can give it. While protecting delicate components inside. Where can you get it? From any authorized Elco distributor. He'll put it together for you. To put you ahead of the system. And keep you there. Another service in keeping with CONNECTRONICS, Elco's Total Connector Capability.

For full details on the Varipak II system from Elco, contact your local Elco representative or distributor, or:

Elco, Willow Grove Division
Willow Grove, Pa. 19090
(215) 659-7000

Elco, Pacific Division
2200 Park Place
El Segundo, Calif. 90245
(213) 675-3311

Operations in USA, Australia, Belgium, Canada, Denmark, England, France, Germany, Israel and Japan. Sales offices throughout the world. In Europe, Elco Buc, 97 Blancheflorisain, Antwerp, Belgium, Tel. 03-190064. In the Far East, Elco International, TBR Building, 2-10-2 Nagata-cho, Chiyoda-ku, Tokyo 100, Japan. Tel. 580-2711/5.

Copyright © 1972 Elco Corp. All rights reserved.
...the universal answer?

We've got more power Darlingtons than anyone else. First to introduce them. First to offer complements. First to do what they said couldn't be done — single-diffused, UniBase® power Darlingtons. Now we're offering high-voltage types in state-of-the-art, triple-diffused, etch-cut technology.

Impressive, you say. "I can use high-voltage power Darlings right now to get a competitive edge in my equipment market."

Hold on. Maybe one of the other high-voltage techniques, in a discrete device, would be a better answer. Double-diffused or triple-diffused Annular. And unless you understand the basics of all three HV technologies you won't get what you really want — an optimum device matched to true design needs, with the best tradeoffs in device characteristics.

Lots of designers are educating themselves before using any process. Questioning and comparing to find out which is best for their needs. Studying. Checking. Challenging.

"Why should structure make a difference?"
"Which is best for high-speed inverters?"
"Are there SOA tradeoffs?"
"Can I get high-voltage and high-current in one?"
"What about complementary designs?"

If you're satisfied with your supplier's answers, your education, your design, fine. If not, listen.

YOUR POWER STRUCTURE . . .

Know it before you use it.

Emitter and base on old-reliable, double-diffused Annular types are diffused into an epitaxial substrate. Devices are characterized by high frequency response, excellent switching efficiencies and complementary capability. The Annular ring retards inversion layer leakage and shapes surface electrical fields eliminating fringing field effects. But inherently narrow base width limits optimum safe operating areas. Result — devices that switch fast at high currents with excellent beta linearity . . . as long as they're not required to operate into overly reactive loads.

More sophistication, and more SOA, can be had with triple diffused. The Annular approach is applicable but base, emitter and collector are separately diffused. Collector layer can be 1/2 or more thicker than double-diffused with emitter and base profiles coming on proportionately deeper. Net effect of all this is allowance for wider depletion regions and better defined fringing fields (i.e. higher voltage), increased SOA and moderate \( f_T \). One pays the price with poorer switching efficiency and lower gain.

Ruggedness with a reverse twist characterizes triple-diffused, etch-cut technology. Mesa structuring is used for ultra-deep base diffusions. But this precludes use of metal overlays to retard fringing field effects. Etch-cutting from the back side at a precise angle to define the junctions solves this problem and provides high operating voltage and SOA potential.

TECHNOLOGY OVERVIEW . . .

If you're at home with high-speed, high-current switching, double-diffused can't be beat. Generally, gain linearity with voltage is better, too, with sat voltage coming in low because of limited epi layer thickness. In a high-speed design where most device heat stems from switch losses, it's a mistake to use super-rugged, slow types. Triple-diffused, however, is your best bet where speed and efficiency take a back seat to operating voltage and ruggedness. But the wider the base, the lower the current — and triple-diffused is basically wide-base.

You can't have everything.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Double Diffused</th>
<th>Triple Diffused</th>
<th>Triple Diffused</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annular</td>
<td>Annular</td>
<td>Etch Cut</td>
</tr>
<tr>
<td>( f_T )</td>
<td>30-80 MHz</td>
<td>10-30 MHz</td>
<td>5-10 MHz</td>
</tr>
<tr>
<td>SOA@100V</td>
<td>7W</td>
<td>15W</td>
<td>30W</td>
</tr>
<tr>
<td>Voltage</td>
<td>20-300V</td>
<td>40-1000V</td>
<td>To 2000V</td>
</tr>
<tr>
<td>Current</td>
<td>100A</td>
<td>20A</td>
<td>20A</td>
</tr>
</tbody>
</table>
**Power Darlingtons**

**THE APPLICATIONS . . .**
High voltage is everywhere and more! Regulators, converters, inverters, TV, line-operated amps, auto ignition, ad infinitum. Where to plug the process? Simple. Follow our recommendations: we’ve factored in trade-offs - gain, fT, ruggedness and breakdown voltage. In pulse mode designs where you’re responsible for fast-changing load conditions and junction heating is minimal, double-diffused is desirable. As you go up the voltage/SOA ladder, triple-diffused tips the scales in its favor. In some cases, such as high voltage switches, all three technologies will fill the bill—and the speed/SOA demands of your application will determine your choice. HV complements can be had too — but there are two processes involved that must be matched and slight variations in fT and SOA have to be considered.

<table>
<thead>
<tr>
<th>Application</th>
<th>Double Diffused</th>
<th>Triple Diffused</th>
<th>Triple Diffused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series Pass. Regulator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV Deflection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Screen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto Ignition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Voltage Amplifier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Voltage Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Speed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**THE PACKAGING . . .**
For your optimized form factor: plastic discretes, metal TO-66 and TO-3 discretes, plastic and TO-3 Darlingtons, plastic and metal discrete complements. For your optimized cost factor: HV prices start at 65¢, 100-up.

**THE DARLINGTONS . . .**
It's been said before — Monolithic power integrated circuits with revolutionary new levels of super-high gain, direct logic-to-Darlington interfacing, simplicity, cost-savings. It bears repeating. Now all the advantages are there in triple-diffused HV Darlingtons. Depending on your conclusions and your needs, your choice will be Darlingtons or discretes, in the technology that fits best.

Draw those conclusions now. Match your design need with an unmatched high voltage power capability. Write us at Box 20912, Phoenix, AZ 85036 — contact your Motorola distributor for prototype or production. Motorola is the source for high-voltage power.

No question about it.

*MOT IOR ALA POWER
—Technology By Design, For Design*

---

*Patented Process of Motorola Inc.
†Trademark of Motorola Inc.
Reliability is a single-sided frame, a ball and a cricket room.
Our Type 45 rotary stepping switch is made to be forgotten. We build them to work hard, fast and long without constant fiddling or adjusting. They’ve got to be able to work in heat or cold, take bumps and grinds and still click-click along with close-spaced consecutive operations.

**We start out really flat** To keep everything on the level we start our assembly with an open-type, one-piece frame. Thick and really flat. Some manufacturers use two thinner frames. But we found that starting with a single thick frame eliminates problems of matching the switch parts. Everything stays in line. And a single-sided frame takes a lot less room—the switch is only as wide as need be.

**A lube job that lasts a lifetime** The entire wiper assembly rotates on a large-diameter stainless steel shaft around a full-length hub bearing. We lubricate this bearing and seal it during assembly. So throw away the oil can.

**Then we supply a pinch that’s just right** Each pair of wipers is tension-adjusted during assembly. As they click around the bank levels on a flat plane, we want each pair to pinch the contact just the right amount. Too hard a pinch and the contacts will wear out quickly. Too soft a pinch will cause a poor connection. We teach our wipers to pinch just right.

**Then comes our big wheel** The entire wiper assembly is turned by the ratchet wheel. It’s big and it’s strong and it has 52 flat case-hardened teeth. Why flat teeth? So when they mesh with the teeth on the ratchet wheel they mesh tight. No banging, wiggling, or scraping. And as the teeth wear, they just mesh deeper in the grooves.

**Ball bearing anchor for good measure** The armature assembly has to be securely fastened to keep it from wiggling up and down, or everything goes out of whack. So we choose a big stainless steel pin and secure it with wide bearings to the armature yoke. To make sure this pin never slips out of the yoke, we drill a hole in both ends. Then we force a steel ball bearing into these holes. This expands the walls of the pin into and against the walls of the armature and the whole assembly is anchored for life. We’re the only ones that do it this way. So we’re the only ones that offer a lifetime fit.

**Then into our cricket room** Every single AE stepping switch goes to the run-in test room. Or, as we call it, the cricket room, because of the chirping noise all the switches we’re testing produce. Here, every switch is tested 50 times a second for 45,000 operations. Then, and only then, are they ready for delivery to our customers.

Now that we’ve explained all the little things we do to make our Type 45 reliable, put it through your own tests. GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.
CUTLER-HAMMER'S BIG NEW LINE OF COMMERCIAL MINIATURES.


Now the same great quality, service and availability you've come to expect from Cutler-Hammer is available in miniature size—at a competitive price!

Make your selection. Standard or watertight. Single or multiple pole. A wide range of decorator caps, buttons, bezels that extend application flexibility. And for their size, hefty electrical/mechanical ratings.

Before you place that next order, check with your new source for commercial miniature switches—your nearest Cutler-Hammer Sales Office or Authorized Stocking Distributor.

CUTLER-HAMMER
SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

More than just switches; prompt availability, field help, innovation, quality assurance, too.

INFORMATION RETRIEVAL NUMBER 17
GENERAL ELECTRIC
OPTOELECTRONIC COUPLER LINEUP

H10 SERIES COUPLERS
- 3 hermetically packaged models offer choice of SSL-Photo-transistor, SSL-Photo-darlington and SSL-light sensitive SCR

H11 SERIES COUPLERS
- 6 models offer interchangeability with popular industry types
- H11A1 and H11B1 offer 50% and 500% min current transfer ratios respectively
- 2,500V isolation

H13 SERIES INTERRUPTER MODULES
- 4 models offer "no contact" switching for use with shaft encoders, counters, position sensing, keyboards and limit switch application

H15 SERIES COUPLERS
- 4000V isolation
- 4 low cost models for pulse transformer replacement, SCR and TRIAC triggering
- Solid State reliability at low cost

OUR NO. 1 GOAL: TO MAKE GENERAL ELECTRIC YOUR BEST BUY

AVAILABLE NOW FROM YOUR AUTHORIZED GENERAL ELECTRIC DISTRIBUTOR

INFORMATION RETRIEVAL NUMBER 141
A positive reaction to negative review

As another reader of a gratis copy of Louis Warner’s book, “Stand Up! But Don’t Get Off,” I was quite interested in your Oct. 12 editorial (“Everything You Always Wanted to Know About Everything,” ED 21, p. 59). My personal reaction to the book was almost identical to yours, and I concur in your observations. Thank you for having the courage to print your negative, but objective, review.

Warner’s book, if taken seriously, could jeopardize public confidence in the engineers’ professional judgment and image. I believe that Warner typifies the immature, highly vocal, shallow-thinking technician whose claims to professional status should be deliberately challenged by his associates, particularly since he claims the distinction of self-appointed spokesman.

Don L. Broderick
Chairman (1971-72)
San Gabriel Valley Section IEEE
519 E. La Sierra Dr.
Arcadia, Calif. 91006.

Help! Widget wanted to drive the mutts nuts

How can a person trying to get some sleep hush up barking dogs? Is there some type of instrument on the market or on the drawing boards that, by mimicry, barks back at the noisy canines—but in a frequency that drives them nuts while leaving humans unaware of what is happening?

I would appreciate information on where to get such an instrument or gadget. Awaiting your reply, because Mexico seems to have a zillion dogs.

David Stry
Director
Villa-V Health Spa
Apdo 1228
Cuernavaca, Morelia, Mexico

Ed. Note: Send replies to ELECTRONIC DESIGN. We have an editor who has the same problem.
Schmitt, the name that made the trigger famous, now makes HiNIL universal.

Schmitt is Teledyne's new HiNIL 367, noise-proof line receiver. It's the new way to go for a universal input-port to logic blocks. In industrial applications, for example, most inputs are either a switch or a relay closure. They usually cause contact bounce. But the most amazing thing about the 367 is that it has a truth table that simply eliminates contact bounce by definition.

And by the way, the noise immunity of the 367 is more than enough to handle any long lines between the logic and input. It has a 5.0 volt worst-case noise immunity and an additional 2.5 volt dead-zone Schmitt Trigger margin.

Because the 367 is a Schmitt Trigger, it holds that 2.5 volt noise immunity even during logic transition. Slow-down capacitors, as you all know, do not provide true noise immunity during switching. But, with the 367 in there, you can use those slow-down capacitors at the rate of 4msec/μF and achieve a high guaranteed noise immunity too.

For fussy people, we put an inhibit pin on the 367 that allows information to be accepted only at times of low noise.

The new Quad Schmitt 367 is available now at $2.98 in 100 up quantities. Order now or get in line.

the challenger
explore Bahamas, West Indies, Virgin Isles, Mexico.

Comfortable cabins...good "Grub 'n Grog".

10 adventurous days from $200

- Great for employee incentive programs
- Ideal for executive meetings and parties
- Wonderful for customer prizes

WRITE CAP’N MIKE FOR FULL INFORMATION AND ADVENTURE BROCHURE
P.O. BOX 120, DEPT. 787A MIAMI BEACH, FLORIDA 33139
If you're trying to create logic functions with your own hardwired circuitry, there's an easier way to go. Don't look now, but minicomputer state-of-the-art (and state-of-the-price) just caught up with your application.

The Naked Mini 8 is a computer that's a component. A powerful, fully-operational, byte-oriented, 8-bit computer. Completely tested and easy to interface. Ready to drop into your system like a simple component.

All you add is the power supply and control panel. Everything else is already there. A 1600 nanosecond cycle time, 4K core memory (expandable to 32K), fully-parallel broad-side I/O, three vectored priority interrupts, two direct memory channels, and an unconditional one-year warranty — the longest in the business.

In 200 unit OEM quantities, you get all of this and more for $1450. For full specs and price lists, write today: Computer Automation, Inc., 18651 Von Karman, Irvine, California 92664. (714) 833-8830. TWX 910-595-1767.

The Naked Mini 8 is a component. A powerful, fully-operational, byte-oriented, 8-bit computer. Completely tested and easy to interface. Ready to drop into your system like a simple component.

In 200 unit OEM quantities, you get all of this and more for $1450. For full specs and price lists, write today: Computer Automation, Inc., 18651 Von Karman, Irvine, California 92664. (714) 833-8830. TWX 910-595-1767.

The computer that's a component.

The NAKED MINI, $1450.
WRITE... or phone sales department at (212) 899-4422 for information on connectors for your flexible cable applications.

For the Sales Representative Nearest You, See Our Listings in EEM and VSMF Directories.

CONTINENTAL CONNECTORS
CONTINENTAL CONNECTOR CORPORATION • WOODSIDE, NEW YORK 11377
INFORMATION RETRIEVAL NUMBER 14
Quality resistor networks now available off-the-shelf.

Pull ups or terminators, in popular values.

If you're really serious about cost, be serious about quality.

Now our most popular thick-film resistor networks are ready and waiting, in quantity, at your A-B electronics distributor. Pull-up networks and terminator networks with tolerances of ±2% in popular values from 68 ohms to 22K ohms. All in compatible 14 lead .300 series DIP's. Or if you need something special we'll quickly custom design any circuit that'll fit into a 14 or 16 lead DIP. And we mean quickly. Overall specs include: absolute tolerances to ±.5%. Tracking ±50 ppm/°C (and lower). TCR to ±100 ppm/°C. Write for free technical publications 5850 and 5851. Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Limited, Galt, Ontario. United Kingdom: Morganite Resistors Limited, Jarrow, Durham.
WOULD YOU LIKE A CAREFREE WEEK FOR TWO IN THE BLUE CARIBBEAN? Relax or lend a hand, swim, scuba dive, or just put your feet on the rail. Visit exotic tropical islands and foreign ports. It's the vacation for thinking people with a spirit of adventure. Sail in air conditioned comfort on big, safe windjammers. Choice of Bahamas, Virgin Islands, Windward or Leeward islands cruises. Pick your own departure dates. It's a trip you'll always remember. AND it's only part of the big first prize offered this year.

PLUS: $1,000 IN CASH!

Everyone can use some extra money—especially on a cruise. Use it for babysitters, tropical clothes, shop the free ports, bank it or spend it. It goes along as an extra bonus to the lucky first prize winner who picks the Top Ten ads in the January 4 issue.

LAST YEAR'S TOP PRIZE WINNERS TELL HOW TO DO IT

Ronald S. Newbower
Bio Engineering Division
Harvard Anesthesia Center
Massachusetts General Hospital

Dr. Newbower looked through the contest issue with particular attention to general interest advertisements. He assumed that those ads with appeal to a large fraction of readers would place in the Top Ten. He also tended to choose ads for products that were (a) new (and of general interest), or (b) had their logos emphasized. The result: Dr. Newbower sailed off with first prize. He and his wife enjoyed their windjammer cruise; sent Electronic Design an enthusiastic note from the Caribbean island of Saint Lucia.

William R. Austin
Senior Engineer
Singer, Simulated Products Division
Binghamton, New York

Mr. Austin selected 37 ads which he considered potential winners. Then he made a chart, assigning points to each ad for esthetic appeal, copy approach, usefulness, etc.—six rating categories in all. The final results were then modified using a purely subjective approach. His system must be a good one. Two or three hours of work paid off with second prize.

Arthur L. Moorcroft
E.E.
Naval Underwater Systems Center
New London, Connecticut

Mr. Moorcroft first selected the 15 to 20 ads that he considered exceptional. Then culled them to pick the Top Ten. He leaned heavily toward new advertisements, new products, or new features in making his choices. The system worked well enough to make him one of the three big reader winners in last year's contest.
AND: FREE JET TRANSPORTATION

This really makes the 1st prize complete. Think about it! The cruise . . . the $1,000 in cash, AND free round-trip tickets for two on regularly scheduled jets to the cruise’s point of departure. It all adds up to the vacation of a lifetime. AND, you can be the lucky winner!

AND: YOU CAN WIN VALUES UP TO $4,500—OR MORE—FOR YOUR COMPANY

Another big feature of the Top Ten Contest is the free advertising you can win for your company. Here’s what your company can win if it has an ad in the January 4 issue:

A FREE RERUN . . . if one of your company’s engineers wins any one of the first 3 prizes—whether or not your ad placed in the top ten.

A FREE RERUN . . . if one of your company’s advertising or marketing people, or your advertising agency, wins any of the first 3 prizes.

Suppose you are one of the first three prize winners. If your company has a full page, 2-color ad in the January 4 issue, your company will receive a free rerun worth $2,165. But suppose it is a 4-color spread. You’ve just racked up space worth $4,500 for your top brass.

Be sure to alert your advertising or marketing manager to these possibilities. Urge him to schedule your company’s ad in the January 4 issue . . . It’s an opportunity no company can afford to miss.

PLUS 99 OTHER VALUABLE PRIZES

There are two separate Top Ten Contests, one for Electronic Design’s engineer-readers, and one for advertisers and their advertising agencies.

PRIZES (Reader Contest)

Windjammer cruise for two.

1st Prize: Jet transportation for two.
$1,000 cash.
Free ad rerun.

2nd Prize: Portable color TV.
Free ad rerun.

3rd, 4th & 5th Prizes:
Bulova timepieces.
Free ad rerun (3rd Prize only).

6th thru Technical books.

100th Prizes: (Title to be announced.)

PRIZES (Advertiser Contest)

Windjammer cruise for two.

1st Prize: Jet transportation for two.
$1,000 cash.
Free ad rerun.

2nd Prize: Portable color TV.
Free ad rerun.

3rd Prize: Bulova timepiece.
Free ad rerun.

NO STRINGS, NO GIMMICKS . . . HERE’S ALL YOU HAVE TO DO TO ENTER

1. Read the January 4th issue of Electronic Design with extra care.
2. Select the ten advertisements that you think will be best remembered by your 78,300 fellow engineer readers.
3. Identify the advertisements by company name and Information Retrieval Number (Reader Service Number) on the entry blanks bound in the issue. Mail before midnight February 15.

MARK JANUARY 4 ON YOUR CALENDAR NOW

Try for the Top Ten Contest judges will compare your selections with “Percent Recall Seen” scores on Reader Recall—Electronic Design’s method of rating readership. Complete information, rules, and entry blanks will appear in the January 4 issue.
MCL cavities
10 to 6000 MHz
all power levels

From milliwatts to megawatts, from HF to C band, MCL cavities deliver state-of-the-art performance in your RF systems. Maximum efficiency and extended tube life are possible through MCL high-reliability approach to cavity design.

MCL can assist you in developing the most advanced microwave systems available today. Our new applications guide covers important system parameters, trade-offs, cooling and power supply requirements.

Relationships between pulse width and duty factor, tube life, and other important factors are included to help you get maximum performance from latest tube developments.

MCL engineers will also work with you directly in evaluating your application. And we will supply a fast quotation for price and delivery of the cavity that meets your needs.

For your copy of our applications guide or for assistance in meeting your requirements, call (312) 354-4350 or write: MCL, Inc., 10 North Beach Avenue, LaGrange, Illinois 60525.
This minicomputer memory dropped 2 bits in 7 days... and failed.

Our final performance test is rugged, and sometimes it takes guts to stick to it. But we have found through experience that it is required to be sure that you get a working disc memory that will keep working.

The test is simple: The disc is run continuously for 7 days; each day during the test repetitive write, read, and check operations are performed to verify error-free performance. If more than one bit is dropped, the unit goes back for rework—it's pass or fail with no compromises.

Every minicomputer disc memory we ship is factory certified to have successfully passed this final test; the memory you put into your system has been through it.

And we have a memory just right for your system—memories with capacities ranging from 32k to 4200k words for Data General, for DEC, for HP, for Varian, and for most other minicomputers.

To find out more about the disc memories with tested reliability, call your Data Disc representative or contact us at 688 West Maude Avenue, Sunnyvale, California 94086; 408/732-7330.

DATA DISC

INFORMATION RETRIEVAL NUMBER 12
OUR ANGLE:
Low Cost D/S and S/D Modules

How does a choice of 14-bit resolution, 60 or 400 Hz data frequency, high accuracy, 11.8V to 90V line-line voltages and all kinds of self-protection circuitry look from your angle?

North Atlantic's Series 780 is available now. Only 5 modules make up a complete S/D or D/S converter, and any set nests in an area less than 21 square inches.

S/D specifications include 3 minutes ± 0.9LSB accuracy, and continuous tracking with low velocity errors. D/S specifications include 4 minute accuracy, 1.25 VA output and 25 µsec settling time.

Key performance specifications for both converters include 14-bit (0.22°) resolution over 360°, 0-70°C operation and 4000°/sec data rates. Both units are DTL and TTL compatible.

To shrink your prototype schedule, we offer an interconnecting PC board. Or, if you plan to integrate a converter directly onto your own PC cards, we can supply proven mylar artwork.

Any set of modules — $650. Order a set today. North Atlantic sales engineering representatives are located throughout the free world.

NORTH ATLANTIC industries, inc.

200 Terminal Drive, Plainview, New York 11803 Phone (516) 681-8600
California District Office: 13418 Wyandotte Street, N. Hollywood, CA 91605; Phone (213) 982-0442
Two more slide rules enter calculator race

Last January the first pocket electronic slide rule was introduced by Hewlett-Packard. Now, almost a year later, at least two other calculator manufacturers are tossing slide rules into the ring: Texas Instruments and the North American Rockwell Microelectronics Co.

Continuing its big push into the calculator market, TI has announced the first of what is expected to be a series of electronic slide rules. Known as the SR-10, the new calculator features scientific-notation, squaring and square-root capabilities.

The display for the SR-10 consists of 12 light-emitting diode digits that provide eight-digit accuracy. There are two digits for the exponent, one for the sign of the exponent and one for a multipurpose symbol. The multipurpose symbol is used to indicate a minus sign, positive or negative overflow and a low battery condition.

The price of TI's electronic slide rule is significantly lower than that of Hewlett-Packard's HP-35—$149.95 vs. $395. But the TI calculator is not as versatile as the HP. A TI spokesman says it never intended to be a direct competitor.

Like the HP-35, the SR-10 has nearly a 200-decade range. It has 23 keys—10 for numbers, one for the decimal point and 12 single-function keys. In addition to performing the standard mathematical operations of addition, subtraction, multiplication and division, the SR-10 also takes reciprocals, changes signs, squares and takes square roots.

The logic is contained in a special version of TI's TMS 0100 calculator on a chip. The slide rule will be sold both by direct mail and in large department stores.

Meanwhile North American's one-chip slide rule is still under development and not expected to be ready for marketing until next March. A North American spokesman says the company has no plans to market the calculator itself but is talking with several companies who are interested in bringing it out under their own labels.

North American's slide rule is expected to be a direct competitor of Hewlett-Packard's with a price of about $100. It will use a liquid-crystal display, and it will be a small-word-length machine with 10-digit accuracy. The readout devices will be liquid crystals, which are chiefly responsible for the low power consumption. It is expected that the calculator will be able to operate for 30 hours before the batteries will need recharging. The HP and TI instruments require recharging after five to seven hours of continuous use.

A 'severe' shortage of engineers feared

Remember when there were "too many" engineers? Well, now there's a shortage—in certain fields at least. And the situation is getting worse. By 1980, according to a U.S. Labor Dept. projection, it will be "severe."

A number of factors have caused this turn of events, according to a study made by the Wall Street Journal. They include these:

- Engineering graduates are not being produced fast enough. A few years ago young people were reluctant to enter a profession that was depositing so many of its member in the street. Now the Labor Dept. estimates that at least 48,000 engineering graduates will be needed each year during the rest of the decade. But only about 43,000 received bachelor's degrees in engineering in 1971 and again in 1972. And this total may drop to 32,000 in 1975, according to the Engineers Joint Council in New York, because of the recent recession and cutbacks in defense and aerospace spending.

- There will be fewer people of college age in the years ahead.

- Engineers are needed to match demands created by the developing economic upturn and to replace engineers who will retire in the early 1980s.

- Engineers are needed to deal with new priorities: the reduction of pollution, noise and hazardous working conditions and an energy crisis in the utility field.

The engineer in demand now, according to the study, is one with specialized skills. Litton Industries is looking for experts in analog and digital circuit design. Harris Intertype in Melbourne, Fla., wants digital-system and radio designers.

The Singer Co. is seeking microelectronics engineers. And Standard Oil of Ohio wants people with a fluidics background.

Acoustical engineers are reported commanding premium pay.

Private TV networks beginning to form

Since July, 1970, when the Federal Communications Commission authorized the use of the 2150-to-2160-MHz portion of the band for over-the-air transmission of private television signals, there has been a rush for licenses. In fact, it has led to the creation of a new industry that has come to be called Multipoint Distribution Service (MDS).

A leading company in the competition—at least in terms of the number of licenses it has requested—is the Microband Corp. of America of New York City.

The company recently demonstrated a new microwave common-carrier television system for use by business, institutions, government and general entertainment. The system involves the omnidirectional transmission of microwave signals to any number of points within a 25-mile radius. The TV signals are "address encoded" and are picked up only at certain predesignated reception sites.

The receiving locations are equipped with parabolic dish an-
Laser printing system tested by Bell Labs

Printed pages, photographs and even X-rays have been transmitted digitally from distant points and recorded by pulsed laser on microfilm—all in seconds.

Developed by Bell Laboratories in Murray Hill, N.J., the experimental system can transmit an entire newspaper page over a high-capacity transmission channel (0.5-MHz bandwidth) and print it in four seconds. Over an ordinary telephone link, it would take about four minutes.

The data, or documents, are scanned by a helium-neon laser in a facsimile fashion. The light that is scattered back from the data is monitored by a light-sensitive detector, such as a photomultiplier, and then transmitted by a communications link.

Etched on film by the laser light, the image can simply be filed as a permanent record or used to make paper copies.

Eventually, Bell Laboratories says, the system could be used as a high-speed terminal for recording information from computers, for accessing remote files or records and for the low-cost production of instantly usable microfilm records.

The key components in the terminal include a simple, low-power gas laser and a device called an intracavity acousto-optic modulator, which deflects very short, high-power pulses of light from the laser cavity.

In the experimental version, pulses from a 6328-A helium-neon laser hit the recording medium, a bismuth film, at a rate of one million per second. The laser burns millions of tiny holes of varying diameter in the metal coating, creating a transparency instantly without chemical or physical development. The result is an extremely fine pattern of dots similar to the dot patterns that create newspaper and magazine pictures.

The modulator, which is within the laser cavity, deflects light energy out of the cavity for the duration of each acoustic pulse. The short pulses the modulator is able to obtain are of much higher power than the average power the laser would normally produce.

By changing the intensity of the laser pulses, the modulator can vary the area of the holes machined in the bismuth film can be varied. In this way it's possible to achieve a wide range of shades of gray when ordinary light is directed onto the array of holes to project an image onto a screen. The total time required to write each frame is about four seconds.

Russian air spoilers stabilize TV antennas

Using wind tunnels to investigate the potentially destructive effect of strong winds on tall television towers, Soviet engineers have developed two types of air spoilers to deflect the winds.

The spoilers are placed on the outside framework of the antenna.

Venus-Mercury flight to crack two frontiers

Two significant firsts in space science are planned when the first two-planet space flight is launched from Cape Kennedy. Known as the Mariner Venus-Mercury Project, the flight will make use of the gravitational field of Venus to propel the spacecraft toward Mercury, and there will be exploration of Mercury, the nearest planet to the sun.

The spacecraft, which is to be launched in about a year, will carry seven scientific experiments that will return data about both planets. Two television cameras will be used to provide 8000 pictures of the two planets. Signals from the two radio transmitters aboard the spacecraft will provide data on the physical characteristics of the planets and their atmospheres.

The new Mariner spacecraft is expected to fly past Venus in February, 1974, and to reach Mercury in March, 1974.

News Briefs

CMOS is starting to take hold in the automotive industry, according to Robert Mason, sales manager at Solid-State Scientific, Montgomeryville, Pa. He reports that his company—the first to deliver working prototypes to Chrysler—has received commitments for CMOS circuits to be used in electronic digital clocks and seatbelt systems. Philco-Ford is also buying circuits.
8K MOS ROMs: Delivered in four weeks flat!

(Just like every other device in Signetics MOS ROM line.)

No ifs, no buts. No gimmicks. Only Signetics guarantees 8K static MOS ROMs—masked, tested, shipped—in less than 30 days time. A fantastic 3-to-1 improvement over any other supplier in the field. Now extended to include the high-speed, high-density capability you need so frequently today: an 8,192-bit static ROM, the new Signetics 2548.

No shot in the dark: Signetics has already proven this incredible four-week turnaround on all our MOS ROMs—1K, 2K, 4K, and now 8K.

8K of memory in 2048x4 organization. Fully optimized to give you the whole shooting match in design simplication and speed. Power supplies +5V and -12V; 700 ns access time. All 2548 inputs/outputs are totally TTL compatible. With a single TTL level clock. Fully operational to your specs within four weeks, at only 0.2¢ a bit, in 100-999 quantities—no premium for our exclusive fast delivery.

And how in the heck do we do it? We verify your coding format from cards and send confirming print-out to you in 24 hours. Masks and test programs are computer-generated. Wafers are pulled from inventory: processed, packaged, tested and shipped. You get the works—on-line, on time. In just four weeks. Just the way you wanted them.

And what you want, Signetics makes sure you get. Right down the entire MOS ROM line. Maximized user-oriented circuits, in minimized user-oriented time. To push designs into production faster...and pull systems out the door for quicker profits.

Signetics Corporation
811 E. Arques Avenue
Sunnyvale, California 94086

78 MOS ROMs in only 4 weeks? Prove it to me. Please send:
I delivery quotes on parts circled above.
I specs and data on your new 8K ROM, the 2548, plus your
ROM selection guide and cross-reference chart.

Name
Title
Company
Address
City State Zip

Telephone

Signetics Corporation—A subsidiary of Corning Glass Works

INFORMATION RETRIEVAL NUMBER 19

ELECTRONIC DESIGN 25, December 7, 1972
REPORT FROM NEREM

X-ray laser: Real or illusory?
The stakes in outcome are high

Since the invention of the laser about 12 years ago, scientists have been tantalized by the possibility of producing an X-ray laser that would enable them to study the atomic structure of molecules. Such a laser could lead to increases in density in integrated circuits, to X-ray holography and to use in cancer therapy. So when John G. Kepros, a graduate physicist at the University of Utah, announced last August that he had produced the world's first X-ray laser, there was initial jubilation. But then a controversy began to grow.

Is what Kepros has really an X-ray laser?

There are top authorities in the field who say no. One of the skeptics, Prof. Benjamin Lax of the Massachusetts Institute of Technology's Lincoln Laboratory, made his doubts known in a paper at the recent IEEE Northeast Electronics and Engineering Meeting (NEREM) in Boston. Other scientists contacted by ELECTRONIC DESIGN agree with Lax.

But on one thing all experts are agreed: A commercially developed X-ray laser would have tremendous potential.

One application would significantly affect the semiconductor industry; the X-ray laser could be used to increase the density of ICs. A factor currently limiting the increase in density is line width. According to one laser investigator, Michel Duguay, a research scientist at Bell Telephone Laboratories, Murray Hill, N. J., it should be possible to focus an X-ray laser spot down to a diameter of only 10 Å. This would make it possible to draw lines with a width of only 10 Å—two orders of magnitude smaller than those now possible with electron-beam scanning.

Another added advantage, notes Duguay, is that if soft X-rays are used, the laser beam would react only with the surface of the semiconductor material—a feature that Duguay suspects would be of great interest to semiconductor manufacturers.

Aside from semiconductor applications, X-ray lasers are thought to be useful for communications. They should be capable of greater penetration and be less susceptible to weather conditions than optical lasers, and they could carry much more information. Dr. Barry Levine, a research physicist at Bell Telephone Laboratories, has proposed a method of parametric mixing of X-rays and the modulation of X-rays by an optical laser. Experimental work is being done, and the results may lead to the development of a parametric amplifier for X-rays, he reports. Such an amplifier would make possible the construction of tunable X-ray lasers.

Doubt over Kepros' laser

In his NEREM paper on "The Feasibility of X-ray Lasers," Lax cited calculations that he had done showing that the power level of the Kepros laser at 1.5 GW was much too low and could not produce a coherent beam of X-rays. Stating that Kepros' experiment and explanation were not satisfactory, Lax went on to describe a method of producing a "soft" X-ray laser, that is, one with X-rays that are very easily attenuated. He contended this would be possible if a solid target of low atomic number were excited by a laser with a power level of greater than 10^13 W.

Duguay agrees with Lax. He has told ELECTRONIC DESIGN that according to the most optimistic calculations that he has done, at least 300,000 GW of power would be needed to produce a hard X-ray laser.

In an interview after the NEREM meeting, Kepros stood by his original claim. "The calculations that Prof. Lax has done, assume only the main pulse is present," says Kepros. "He does not take into account the spike activity present, which changes the situation significantly."

Dr. Arthur Schawlow, professor of physics at Stanford University and considered by some to be the
Low-cost limit control for OEM's.
With a circuit breaker.

With a circuit breaker?

A Heinemann relay-trip circuit breaker. With this one economical device, you can take a signal from any low-voltage sensor and, at a preselected level, switch off a massive current load. As much as 100 amp, to be precise.

There is no end to the uses you can find for this simple little control device. It will work with pressure sensors, voltmeters, ammeters, tachometers, pH sensors, what have you. For alarm or other purposes, we can include auxiliary switch contacts right inside the breaker. When the circuit changes state, you can turn on a light, ring a bell, or start another operation.

If you want the security of precision fault protection, as well as the relay-trip action, get our Dual-Control breaker (JA or AM Series). It monitors the critical analog signal, or signals, basic to the operation, and keeps tabs on the electrical integrity of your equipment at the same time. Whichever design you choose, you can get a lot of functional value for the price of a circuit breaker.

Like to find out more? Send for our Engineering Guide, and we'll include a copy of Bulletin 3352 on Dual-Control breakers. Free, of course. Heinemann Electric Company, 2618 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.
father of the laser, tends to side with Kepros. Rejecting the arguments of Lax and Duguay, Schawlow has told ELECTRONIC DESIGN:

"I am rather skeptical of theoretical calculations in this field and favor experiments, because things are so complicated . . . . Lax's calculations are probably correct for the assumptions that he made, but there might be some process at very high excitation rates that might be more important than those he considered."

Many people, Schawlow says, have been trying to explain away Kepros' results. Noting that the Naval Research Laboratory in Washington, D.C., had confirmed Kepros' results, the Stanford physicist adds: "I find it easier to believe that he has an X-ray laser than to find an alternate explanation."

**A very simple setup**

The X-ray laser constructed both by Kepros and the Naval Research Laboratory is an infrared Neodymium-doped glass (type) whose output beam is focused onto a thin copper sulfate sandwich. The sandwich consists of a gelatin solution squeezed between two glass microscope covers. When the infrared beam hits the sandwich, X-rays are emitted.

Kepros says these X-rays are in a coherent beam. Skeptics theorize that the materials in the laser are opaque to X-rays and create a narrow channel that acts as a pinhole collimator, thus giving the beam laser-like qualities.

He concedes that his X-ray laser is strictly experimental and that when commercial units become available, they likely will be of completely different construction. However, both Kepros and Schawlow point out that the key advantage of the device is that it will allow scientists to study the basics of X-ray lasers and that this can pave the way for more practical devices.

According to Schawlow, the major problem in constructing X-ray lasers is the short lifetimes of the excited states of the target materials. Excited atoms cannot be stored for long periods of time—a necessary condition for lasing action. Another big problem is that as X-ray frequencies are approached, the power required to produce lasing action increases exponentially.

If Kepros' claim that he has overcome these problems proves correct—and supporting evidence is mounting—it will be one of the most exciting things to happen in lasers for years, Schawlow says.

It would probably involve a new physical phenomenon, Duguay notes. **■ ■ ■**

**Fiber optics leaps ahead of optical ICs**

While optical integrated circuits continue their impressive march from the laboratory to the field with important advances in fabrication and design, fiber-optic development has surged ahead with glass-guide loss cut to a new low. There was general agreement on this point among participants at an integrated optics session of NEREM in Boston.

A major source of excitement was the recent announcement by the Corning Glass Works, Corning, N.Y., of glass-fiber waveguides with attenuation losses reduced to 4 decibels per kilometer. This value is down several times from the previously reported 16 to 20 dB/km. The immediate significance of this development is that expensive repeater stations in laser communication systems can now be placed four or five times farther apart.

The low-loss fiber consists of solid glass with a core material of higher refractive index. It was tested at wavelengths between 0.6 and 1.1 µ, which includes the 0.8- to-0.9-µ wavelength region of gallium-arsenide (GaAs) lasers. The laser can be matched to a minimum attenuation frequency of the fiber over a 0.1-µ range, centered on 0.85 µ, by the addition of aluminum to the GaAs laser.

At around 1.06 µ, another attenuation minimum occurs. This is the region of operation for neodymium-doped yttrium-aluminum-garnet (YAG) lasers. Robert D. Maurer, manager of applied physics research at Corning, identified the source of fiber loss as scattering—as well as absorption—in a paper, "Optical Communication with Glass Fibers," delivered at the NEREM session. Scattering arises from material imperfections and parameter variations.

Maurer sees practical applications of fibers for incoherent sources—like LEDs—involving bundles of many fibers operating in parallel. They offer a large cross section for source-coupling efficiency while retaining flexibility, and they give redundancy to offset broken fibers.

Edward A. Torrero
Associate Editor
Press here to save on lighted pushbutton switches.

Oak's Series 300 gives you good looks and a small price-tag in lighted pushbutton switches. Plenty of switching performance for most jobs, without paying a premium. Even the Series 300 Split-Legend/4 Lamp Switch is less than $1.60 (normal latch, 2P2T, glass alkyd insulation, no engraving, less lamps.)

$1.25 buys all the switch you need.

Built to take it.
Series 300 is built for reliable performance and long life. Applications galore—bank terminals, calculators, and copy equipment.

Three versions with switching up to 4P2T.
Choose from single, dual, or four lamp display as well as non-lighted type. One to twelve station, momentary, interlock, alternate action, or any combination available on the same switch bank. Lockout feature available for all types. Power Module 3A 125VAC. Lighted indicators are identical in size and appearance, but without switching.

Gang them up by the dozen.
Order up to 12 switching stations on a single channel, any switching mix, with convenient panel-mounting studs. Color selection: white, lunar white, yellow, amber, orange, red, green, blue. Choose silk-screened, hot-stamped, or engraved-and-filled legends. Split-legend switches can be specified with any two, three, or four colors on insertable legend plates.

Modular design.
Single-legend/single-lamp, split-legend/4-lamp, and single-legend/redundant lamp switches have snap-on lamp holders. Plus replaceable legend plates, lens caps, and button assemblies. Front-panel relamping, too, without special tools on all types.

Write for our Series 300 Brochure

Oak Industries Inc.
SWITCH DIVISION / CRYSTAL LAKE, ILLINOIS 60014
TELEPHONE: 815 • 459 • 5000 • TWX: 910 • 634-3353 • TELEX: 72 • 2447
INFORMATION RETRIEVAL NUMBER 21
In the developing field of optical integrated circuits, Dr. Elsa Garmire of the California Institute of Technology created a stir with a paper on optical structures fabricated with masking techniques and ion implantation. The paper, "Integrated Optics in Semiconductors," described thin-film semiconductor waveguides prepared by three techniques: the deposition of epitaxial n or n' films in gallium arsenide, the epitaxial preparation of gallium-aluminum-arsenide films, and ion (proton) implantation in gallium-arsenide material.

The presence of a fraction of aluminum in a gallium-arsenide compound changes the refractive index of the material. As a result, a simple waveguide can be fabricated by growing an epitaxial gallium-aluminum-arsenide layer on a substrate containing a larger aluminum concentration.

Density gradient forms waveguide

In a major new development, Dr. Garmire reported the fabrication of a thin-film waveguide having a doped-aluminum density gradient (Fig. 1). Previous efforts had concentrated on producing a uniform distribution. The guide described by Dr. Garmire conducts light in the near infrared region. However, the basic approach can be readily applied to visible light regions, according to Dr. Amon Yariv, professor of engineering at Cal Tech, who was not present at NEREM but who heads a research group on semiconductor optical waveguides. The fabrication approach also represents a simpler means of building such guides.

Another new guiding structure reported at the session was a thin-film periodic guide with center-to-center spacing of only 4100 A (Fig. 2). According to Yariv, it's the most advanced waveguide structure of its type.

This structure could provide the foundation for important devices of the future. A backward-wave oscillator, for example, could be built with a periodic structure that has corrugated elements and an electron beam. The corrugations would trap electron-beam energy, and the interaction with the semiconductor material could result in radiated energy traveling in the direction opposite that of the exciting beam.

New passive waveguides

Passive optical waveguides-containing neither active laser material nor active electro-optic material—were the subject of a paper by W. John Tomlinson of Bell Telephone Laboratories, Holmdel, N.J. He stressed two techniques that use organic materials and take advantage of photochemical reactions.

The first technique uses photoresist—the same material employed in integrated circuits. The lowest loss guides are reported to have less than about 1.5 dB/cm of attenuation. The major loss mechanism appears to be edge roughness, caused by long polymer chains.

A second technique-called embossing—uses a die with a pattern of ridges in the form of the desired waveguide circuit to emboss grooves in a thermoplastic substrate. These grooves are then filled with a transparent dielectric with a refractive index that is higher than that of the substrate.

During a discussion of loss figures, the session participants noted that published waveguide loss figures could sometimes be misleading, since they depend on type of mode and field strength. A single-mode guide with its fields strongest at the center, for example, could have markedly different loss than that of multimode operation for the same configuration.

2. The steps in forming a thin-film optical waveguide (above) lead to a guiding structure that has center-to-center spacing of 4100 A (below).

Yariv envisions obtaining 10-µ waves with this scheme.

There was wide agreement at the session that true optical integrated circuits—including integral lasers, modulators and deflectors on a chip—are years away (see "OICs: When they come, they'll revolutionize communications," ED 12, June 8, 1972, p. 28). Individual optical thin-film devices, however, are much closer, the participants agreed. In either case, further advances depend on how soon some basic problems can be licked.

Some of the problems were discussed by Fritz Zernike, senior research physicist of the Laser Products Dept. at Perkin-Elmer, Wilton, Conn. His paper, "Integrated Optics—an Overview," cited a major difficulty: Most waveguides made today are slabs; the wave is bounded in one direction only. Typical dimensions are 1-µ thick by 1-inch wide. The ideal guide, Zernike says, should have a rectangular cross section that is 1 µ thick by 2 to 3 µ wide. And that's difficult to fabricate.

Moreover the losses in optical semiconductor waveguides—due mostly to scattering—are too high to support true optical integrated circuits, according to Zernike.

In the fabrication of optical waveguides, the usual photolithographic techniques are generally not good enough, he says, since poor edge definition leads to excess scattering. That definition has to be within 1/10 to 1/20 of the optical wavelength.

Zernike sees hope in the emerging electron-beam technology, currently being pushed by manufacturers of LSI chips. In IC work, scanning electron beams are used to make devices small for higher density; for optical ICs, they could be used to keep tolerances tight.

Fully integrated circuits will most likely not be available for another ten years, says Zernike. But he sees waveguide techniques being used within five years on a much smaller scale, for example to make optical scanners.

Passive optical waveguides—containing neither active laser material nor active electro-optic material—were the subject of a paper by W. John Tomlinson of Bell Telephone Laboratories, Holmdel, N.J. He stressed two techniques that use organic materials and take advantage of photochemical reactions.

The first technique uses photoresist—the same material employed in integrated circuits. The lowest loss guides are reported to have less than about 1.5 dB/cm of attenuation. The major loss mechanism appears to be edge roughness, caused by long polymer chains.

A second technique—called embossing—uses a die with a pattern of ridges in the form of the desired waveguide circuit to emboss grooves in a thermoplastic substrate. These grooves are then filled with a transparent dielectric with a refractive index that is higher than that of the substrate.

During a discussion of loss figures, the session participants noted that published waveguide loss figures could sometimes be misleading, since they depend on type of mode and field strength. A single-mode guide with its fields strongest at the center, for example, could have markedly different loss than that of multimode operation for the same configuration. ■ ■
GI is capacitors

The GI catalog tells almost everything you need to know about capacitors. Send for your free copy today. Capacitor Division/General Instrument Corporation, 165 Front St., Chicopee, Mass., 01014. Phone 413/592-7795. In Canada 416/763-4133.

General Instrument
the capacitor company

“Off the shelf” delivery from your GI/MI distributor.

INFORMATION RETRIEVAL NUMBER 22
AT THE FALL JOINT COMPUTER CONFERENCE

New system-monitors keeping tabs on computer performance

Computers are constructed, in one sense, much like humans. There’s no way of looking at the outside and knowing what’s going on inside. So how is it possible to tell when the data are flowing freely and when and where they’re backed up, waiting to be processed? How can the user know just how much of the computer capacity is useful and how much is being wasted?

To answer questions like these, six sessions were presented at the recent Fall Joint Computer Conference (FJCC) at Anaheim, Calif. These sessions, according to the technical program chairman, Donal A. Meier, gave for the first time a comprehensive picture of an emerging technology—computer system measurement.

Computer system measurement, employing monitors, is useful to both designers and users because it can be used to do the following:

- Track down computer flaws.
- Show where the computer is spending its time in the execution of a program.
- Map core memories to determine core activity.
- Determine what data to store in core memory and what to put on discs or drums.
- Decide what action to take if storage capacity is running out.
- Reduce computer rental expenditures by eliminating excessive equipment.

The measurement of computer performance isn’t exactly new. Computer manufacturers like International Business Machines have built their own monitoring equipment for years. But the commercial availability of a range of such equipment is relatively new.

Computer-monitoring equipment keeps track, on a microsecond basis, of when the various computer elements are busy and when they are free. The first such equipment, sold about 3-1/2 years ago, was used only for counting or timing individual events inside the computer. The latest equipment can store sequences of simultaneous events and present the findings on CRT displays—in real time, if desired.

The basic computer monitoring equipment is comprised of these elements (Fig. 1):

- Sensors (probes) that can be attached to key signal points in a computer without disturbing the signals being monitored.
- Control logic that controls the flow of data signals from the probes to appropriate counters or timers.
- Accumulators or registers to store the counted or timed events.
- A magnetic tape deck on which the data from the accumulators is stored over a period of time.

Monitor equipment compared


One panelist—Dr. David Copp, a member of the technical staff at Bell Telephone Laboratories, Murray Hill, N.J.—stressed that monitoring equipment was still in a state of development. Only a few hundred hardware monitors are in use around the world, he noted.

“We’re still learning how to use them most effectively and also how to analyze the data we get from them,” he said.

Sensors in the monitors pick up signals from registers, indicators and activity lines and combine them logically. Register activity can be compared at the control panel and then routed to accumulators for...
Build assembly cost savings into your electronics package with "Scotchflex" flat cable and connectors. These fast, simple systems make simultaneous multiple connections in seconds without stripping or soldering. Equipment investment is minimal; there's no need for special training. The inexpensive assembly press, shown above, crimps connections tightly, operates easily and assures error free wiring.

Reliability is built in, too, with "Scotchflex" interconnects. Inside of connector bodies, unique U-contacts strip through flat cable insulation, grip each conductor for dependable gas-tight connections.

"Scotchflex" offers you design freedom, with a wide choice of cable and connectors. From off-the-shelf stock you can choose: 14 to 50-conductor cables. Connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards. Headers for de-pluggable connection between cable jumpers and PCB. Custom assemblies are also available on request.

For more information, write Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.
The elements of a computer monitor system serve to count and store the number of events or their durations. The data are processed in the computer.

counting or timing events.

Because monitors can keep track of when computer sections are busy or free, they can, by recording the activity of the instruction and execute-address registers, show where in the program the computer is spending its time, Copp said.

In tracking down system flaws, monitors can measure data streaming rates between computers; it's possible to measure burst as well as sustained rates.

From these data, the time the various modules use in execution can be determined. And, on the basis of this and other information gained—such as the percentage of time that the central memory and the peripheral processors are in use—the computer hardware can be modified to correct system flaws.

Nicholas R. Finamore, chief of computer applied studies at Western Electric, New York City, told the panel session of the advantages his company had obtained in using monitoring equipment built by Tesdata Systems.

For example, he pointed out, with the Tesdata equipment, which has a distributor module concept, it's possible to connect up to 96 probes on an instruction register and to sample the instructions being executed. Also, core memory can be mapped to get a measure of core activity.

The highly used data can then be put into the core after a tradeoff involving storage vs access time. Other data may be stored on a disc or drum.

The monitor can also tell what to do if the computer is running out of storage capacity, Finamore noted. For example, it helps answer such questions as: Will an increase in tape drive speeds increase storage capacity? Will changing from an IBM 2314 disc memory to a 3330 solve the problem?

Western Electric has, from computer monitor analysis, been able to reduce rental expenditures.

Building-block computer setups gaining

MSI and LSI are changing the architecture of computer systems. Functions formerly independent are now merging to produce compact efficient and low-cost building blocks.

These points were covered in FJCC Session F-6 on computer architecture.

"LSI has voided the traditional barrier between logic and memories," says Dr. Tien Chi Chen, research staff member at IBM's research laboratory in San Jose, Calif.

Formerly, Chen notes, memories were comprised of cores or some exotic form of storage. Processing logic was comprised of semiconductors. And the distinction between the two has been based traditionally on the differences in technologies.

But today, Chen points out, this distinction has been removed, with storage now being performed by fast semiconductor memories.

These memories can also be used for processing, he says, such as in look-up tables.

With the new technology, Chen says, it's possible to build pieces of hardware that behave as self-sufficient items. And they can be linked together loosely—rather than with tight coupling, as in the past.

Organization like this, he says, looks inefficient, but it allows indefinite growth of the system.

LSI can now provide compact, efficient and inexpensive building blocks with arbitrary degrees of a stored program nature. This arrangement signals a new era of polycentric architecture, based on the loose coupling of autonomous modules.

MOS computer with TTL speed

The architecture of an MOS LSI minicomputer that has the speed of a TTL equivalent depends on several considerations, according to G. W. Schultz, manager of LSI minicomputer design for American Micro-Systems, Inc., Santa Clara, Calif. In a paper in Session B-5, "The MOS LSI Minicomputer Comes of Age," he defined these considerations as follows:

- Microprogramming vs conventional control.
- Instruction decoding.
- Microinstruction formats.
- Input-output interface relationships.
- Stack organization.
- Register design.
- Data bussing format.

In his paper, Schultz applied these considerations to the design of a hypothetical minicomputer capable of addressing directly 65k words or bytes. The machine, he said, would be able to function as an 8 or 16-bit machine. The mem-
This filter contact

Amphenol has met the challenge of placing fragile components—ceramic and ferrite—in the rugged mechanical environment of an electrical connector. And we've done it without disturbing the electrical and mechanical integrity of the individual components.

Our stress-isolated filter contact eliminates the possibility of failure due to vibration, physical abuse and thermo/transient shock.

The proof is in its five-year record on many major military and industrial programs.

We'd like to discuss your specific filter connector requirements and show you how this filter contact can help eliminate electromagnetic pollution.

Send for our new catalog which tells much more. Circle the reader service card. Or call your local Amphenol salesman. Amphenol Sales Division, 2875 S. 25th Avenue, Broadview, Illinois 60153.

Send for this catalog!
ory address would use 16 bits, which must be sent in a single byte transfer, even with an 8-bit oriented machine.

For cost effectiveness, Schultz noted, the TTL requirements external to the LSI unit would be minimized. And for the same reason, the computer would use only LSI techniques now employed in the mass production of these devices.

The microprogramming organization of this computer is a clear choice over conventional control, Schultz insisted, for reasons based on two criteria directly related to the use of LSI: system partitioning and its related pin limitations; and the efficiency of chip-area use.

Placing the entire computer on a single chip would simplify system partitioning, Schultz pointed out. But the limitations imposed by standard pin formats would still remain.

The alternative, he said, is to partition the registers and the arithmetic logic unit (ALU) and place the control on other chips. But signal delays of 150 to 200 ns from chip to chip would reduce computer speed undesirably.

To maximize the speed, Schultz suggested the use of pipelining techniques. With these, the execution of the next instruction must be started before the last is finished. The time spent in communicating the control between chips would thus be minimum, he said. And the registers and ALU sections could be operated independently.

The Pin limitations stem from the present packaging technology and cost considerations, Schultz said. The designer of the MOS/LSI computer is faced with a choice of 16, 24 and 40-pin packages.

The 16 or 24-pin packages are not preferable, Schultz said, because the registers and ALU would have to be partitioned into four-bit slices. As a result, the chip-to-chip transitions between sections of the ALU itself would greatly reduce machine speed. Schultz warned that the remaining pins would be the real limiting factor. All buses would use the dynamic storage inherent in the chip.

The most logical, he said, would be 16-pin packages, which would make the chip-to-chip communication minimum. He pointed out that the TTL requirements exceed the 40-pin limit.

The microprogramming organization of this computer is a clear choice over conventional control, Schultz insisted, for reasons based on two criteria directly related to the use of LSI: system partitioning and its related pin limitations; and the efficiency of chip-area use.

The simplest data-bus scheme (a) provides minimum interconnection but reduces machine speed. Two busses (b) use the dynamic storage inherent in MOS to allow these busses to appear as registers to the computer. The scheme in "c" requires the greatest area on the MOS chip.

2. The simplest data-bus scheme (a) provides minimum interconnection but reduces machine speed. Two busses (b) use the dynamic storage inherent in MOS to allow these busses to appear as registers to the computer. The scheme in "c" requires the greatest area on the MOS chip.

Improved movies simplifying simulation

The output of a computer simulation program can be a mass of data that is almost impossible to wade through with concise understanding. For this reason, computer graphics in the form of motion pictures, composed of individual frames from a computer run, are being developed as a tool for obtaining a clear, visual interpretation of simulated events.

But without sound, these movies still require a significant amount of explanatory material that must be read as well. Sound tracks can be made independently and combined with the film, but this generally requires two or three weeks and is essentially useless to the experimenter. A solution was presented by Edward K. Tucker, information systems specialist at the Los Alamos Scientific Laboratories in New Mexico, in a FJCC paper on the presentation of vehicle dynamics.

The key element in the system is the use of a microfim projector. Many of these are being used to generate the motion pictures that show the results of the simulations.

For example, Tucker said, the Los Alamos laboratory has been using one to represent the output of a code simulating what happens to a structure when it's hit by an earthquake. In digital form this would be impossible to understand, Tucker says.

The objective, he pointed out, was to get the sound track generated at the same time as the picture on one single pass through the computer plotter.

Normally, he noted, you generate a computer tape that drives the plotter. In one pass over that tape, the visual representation is generated.

System saves user time

With the new system, which may require an extra five to 30 minutes of plotter time to plot more lines for the sound track, the turn-around time for the user does not go up significantly.

To plot the sound track—which may be both computer-generated sounds, voices and other complex audio waveforms, the audio signal is periodically sampled, Tucker explains. The digital output was produced on standard half-inch, seven-track magnetic tape in a format compatible with a CDC-6600 computer.

The latest concept Tucker is working on is compiling a soundtrack file keyed to the computer program. On command, a particular sound could be extracted and plotted onto a given frame.

Another technique for making movies of a simulation program—photographing the pictures frame by frame from the face of a CRT—has been used by engineers at the Cornell Aeronautical Laboratory in Buffalo, N.Y., for the presentation of vehicle dynamics.

James P. Lynch, assistant electrical engineer at the laboratory, pointed out in a Session C-4 paper on computer animation that this type of photography—with the camera in front of the CRT—per-
A new standard in AM/FM generators

HP's solid-state successor to the time-proven 608 signal generator.

For more than 20 years, the HP 608 series VHF signal generators have generally been recognized as the standard of the industry. Now, we introduce a solid-state VHF generator series with wider frequency coverage (450 kHz to 550 MHz), increased modulation capability (FM as well as AM), better stability, and impressive spectral purity.

The 8640 generators deliver low-noise signals that, until now, could be attained only with vacuum-tube generators. Non-harmonic and sub-harmonic outputs are down more than 100 dB and noise is less than \(-130 \text{ dB/Hz}\) at 20 kHz offset from the carrier. Extremely clean

(continued on page 4)
New OEM computer discounts reflect lower memory costs

Prices for the HP 2100A computer have been reduced by $2,000 for each 8K of core memory. Likewise, HP has increased its discount rate to original equipment manufacturers.

You save dollars without losing any capability. The expandable 2100A minicomputer holds up to 32K of memory in a 12-inch (30.48 cm) mainframe. Standard equipment includes 80 powerful instructions, hardware multiply/divide, memory protection, automatic restart after a power failure, unlimited levels of indirect addressing, and 14 I/O channels. With HP's proven software and a wide selection of peripherals, OEMs can tailor the 2100A to virtually any configuration.

For details on the 2100A computer and OEM discounts, check B on the HP Reply Card.

Now, distribute frequency without distortion

The 5087A is the first distribution amplifier to accept single 5 MHz input and distribute 0.1, 5 and 10 MHz outputs.

For isolated, undistorted multiple outputs from atomic or crystal frequency standards, try the 12-channel 5087A distribution amplifier. Three input channels accept 10 MHz, 5 MHz, 1 MHz or 100 kHz in any combination. You can select the number of outputs for each channel, up to a total of 12 outputs. Each output level is adjustable from 0 to 3 V rms.

The distribution amplifier boasts of excellent short-circuit isolation (< 0.1% amplitude change); exceptional phase stability (< 0.1 ns/°C for 5 and 10 MHz); low noise; and -60 dB crosstalk. Amplitude stability is ± 0.5 dB, 0° to 50°C. In the event of an ac power failure, the distribution amplifier switches over to standby dc.

Price: $1500 for the standard configuration.

Several options are available. For details, check H on the HP Reply Card.
Choose independent or tracking power outputs

Three new solutions to your network analysis problems

You don't have to run diagnostics; the HP calculator executes network analysis self-calibration programs to maintain system accuracy.

Two versatile lab supplies each house two identical 50W regulated power supplies. A convenient front panel switch lets you select either independent or tracking operation. In the tracking mode, the right supply tracks the left within 0.2% ± 2 mV. Tracking mode is especially useful for powering operational amplifiers, push-pull stages, deflection systems, or any application where plus and minus voltages must track with insignificant error. The independent mode lets you operate the two supplies individually, in auto-parallel or in auto series.

Each side of the dual supply can be operated as a constant voltage or constant current source, and each has its own crowbar for overvoltage protection. In the tracking mode, an overvoltage condition in either supply trips both crowbars.

Output ratings for the 6227B (each side) are 0—25 V at 0—2 A; for the 6228B (each side), 0—50 V at 0—1 A. Price: $495. For specifications, check J on the HP Reply Card.

HP 6227B dual-output power supply.

What happens when you combine a network analyzer with a calculator? You get automatic testing of gain, phase and group delay.

Designed primarily for the production line and R & D lab, HP's new 3040A, 3041A and 3042A network analyzers measure gain with 0.01 dB resolution, phase with 0.01° resolution, and delay with 20 choices of split frequencies (or an unlimited number under calculator control). Point-by-point, swept and differential measurements can be made.

The 3040A is a manual network analyzer with a frequency synthesizer as the source and a two-channel selective tracking detector. With the synthesizer as a stable, accurate frequency standard, all measurements are precise. Use the 3040A to characterize narrowband devices with extremely high Q.

The semi-automatic 3041A is controlled by a marked card programmer via the new ASCII interface bus. The card programmer adds limit testing capability. Simply mark the test on a card, then run it.

The 3042A runs under control of an HP 9820 programmable calculator. An ideal manufacturing and research tool, this automatic network analyzer can be operated manually or programmed by magnetic cards. The ASCII bus simplifies programming and interfacing. The calculator handles simple decision-making and performs high-level statistical manipulation of test data.

Prices range from $6,900 to $22,900.

For network analyzer information, check C on the HP Reply Card.

HEWLETT PACKARD MEASUREMENT NEWS
Electronic measurement: books on why and how

Whether you are an electronics student or highly experienced engineer, two new books by HP authors dispel the haze surrounding electronic instrumentation. Both books are available from McGraw-Hill.

The Basic Electronic Instrument Handbook—edited by HP’s Clyde F. Coombs, Jr.—is the first text to bridge the gap between academic knowledge and a realistic working situation (where you struggle to interpret a complex instruction manual). Content ranges from basic electronic theory to specific measurement problems and solutions. An 832-page general reference for the practicing engineer or technician, it’s also a valuable guide for non-electronic people involved in instrument selection and purchasing.

Price: $28.50

Because “science and technology are so intertwined with measurement as to be totally inseparable from it,” Dr. Bernard M. Oliver, HP R&D Vice-President, and John M. Cage of HP Laboratories co-edited Electronic Measurement and Instrumentation from contributions by 35 authorities. This 720-page book discusses the role of measurement, many measurement techniques, the theories behind them, their inherent limitations, and the preferred instrumentation. This definitive text for graduate EE students, engineers and physicists is part of the McGraw-Hill Inter-University Electronic Series.

Price: $29.50

Check R or S on the HP Reply Card and we’ll have the publisher send you more information.

New pulse generator for ECL circuit tests

ECL (emitter-coupled logic) is the coming high-speed IC logic, particularly in the computer and communications industries. Now, there’s another versatile laboratory pulse generator that handles general IC testing yet is fast enough to test modern ECL chips.

Two output connectors deliver simultaneous, complementary signals—ideal for driving differential inputs. Repetition rate ranges from 10 Hz to 200 MHz, so the 8008A pulse generator satisfies TTL requirements as well as ECL. The maximum 200 MHz rate satisfies the most advanced designs, while the manual and low frequencies are used for stepping through logic states. And you can vary pulse transition times from $1 \leq 1.2$ ns to $2.5$ ns with an optional risetime converter.

Price: $2700.

For more information, check N on the HP Reply Card.

Fast, low-cost plotter for minicomputer

This quiet 11 by 17 in. (28 by 43 cm) graphic plotter draws as fast as a computer thinks.

Need a plotter that can keep up with your computer? The 7210A graphic plotter processes up to 20 coordinate pairs per second and draws symbols at the rate of 5 per second. A high-acceleration mechanism accelerates the pen to 10 in./sec. (25.4 cm/sec) in less than 12 milliseconds. Even at these fast speeds, the plotter is virtually silent.

Our secret is a built-in microprocessor that accepts pen position data in either binary or BCD codes—in other words, directly from the computer or a terminal. There’s no complex software, nor do you tie up any valuable core storage. The finished drawing has smooth arcs and circles. Because of the micro-processor, the computer doesn’t calculate intermediate points. The resulting graph is free of the “stair-step” pattern typically found in most incremental plotters.

Installation is easy. If you own an HP computer, your plotter can start drawing five minutes after it arrives. Price: $3400.

For the complete plotter picture, check M on the HP Reply Card.

(Continued from page 1)
New two-channel recorder sets new standards for sensitivity and trace

Any two-channel oscillographic recorder offers the versatility of plotting two events at once, but HP's new 7402A recorder lets you select and vary the sensitivity according to your requirements. A choice of three preamplifiers plug into the mainframe for sensitivities of: 1µv/div. with differential, floated and guarded input; 1 mv/div. with differential, balanced to ground input; and 20 mv/div. with single-ended input.

Because the 50 mm chart width is 25% wider than other comparably priced recorders, the writing resolution is 25% better. After two months of continuous use, HP's new stainless steel pens with carbide tips had no measurable pen fatigue.

Select chart speeds from 1 to 125 mm/sec. Frequency response is ± 2% of full scale from dc to 40 Hz, and rise time is 7.0 to 7.5 ms. A complete working system starts at $1740.

To learn more about the new two-channel recorder, check L on the HP Reply Card.

Knowing signal power at critical frequencies is essential for communications system operators; for agencies that manage the radio spectrum; and for manufacturers who design, build and maintain RF systems.

Now, HP's 8580B spectrum analyzer performs frequency-selective signal strength measurements automatically, from RF through microwave. This new system measures signal characteristics in a congested environment to aid in spectrum management or in the control of communications systems. The 8580B also characterizes signal sources and frequency translators as well as linear networks—which means you can test mixer, modulators, oscillators and receiver front-ends.

Wide frequency coverage, 10 kHz to 18 GHz, is automatic. Multiple inputs measure signals from several sources. Frequency accuracy is better than 3 parts in 10^7 at 18 GHz. The receiver can tune in increments as small as 5 Hz, with analyzing bandwidths as narrow as 10 Hz. Measurement range is +30 to −130 dBm.

Automatic operation, combined with an easy-to-use keyboard and control panel, means your operator won't require extensive training. Or let the system run unattended, with HP software doing the work. Prices start at $96,400.

To learn more, check O on the HP Reply Card.
New HP automatic system for communication equipment tests

Fast, easy diagnostic testing: simply use a probe to contact internal test points, then follow the instructions on the 9540 system display.

Now, you can test a typical transceiver to EIA standards for land mobile communications equipment in about three minutes—that's 5 to 10 times faster than equivalent manual testing.

The 9540 automatic test system performs many common tests for the production and maintenance of AM and FM mobile transceivers. Capability includes distortion, deviation, power, frequency, stability, SINAD, and sensitivity. Special software routines let you measure FM deviation and distortion without using extra instruments. You can test radio equipment operating on any frequency from 10 MHz to 1000 MHz at transmitter powers up to 100 W (1 KW maximum is optional).

The computer runs tests and analyzes data from a test station located up to 20 feet away. For streamlined, fast troubleshooting, a dual-connector RF test head at the test station interfaces the transceiver and system. The test head contains RF switches, RF mixer and RF detector. Two sets of connectors let one transceiver warm up while the other is being tested, or they may be used for input and output when testing modules. A high-speed DVM and timer/counter are used as A/D and frequency-to-digital converters, respectively.

HP supplies typical test listings to help technicians and engineers write their own tests using the HP ATS BASIC language. Operating instructions appear on the system display; an average operator can run the system merely by pushing a button.

Select the economical 9540B paper tape system or the 9540D disc memory system with files for 2.4 million words. Prices start at about $100K.

For more on computerized transceiver testing, check Q on the HP Reply Card.

New multiprogrammer for automatic test/control

Put your minicomputer to work in automatic test and control systems with HP's 6940A/6941A multiprogrammer. This low-cost system building-block provides a bidirectional data link between a single computer I/O channel and up to 240 individually addressable, plug-in card slots, each with a 12-bit I/O capability.

In automatic test applications, the multiprogrammer can provide stimuli for a device under test and instantly collect responses from that device. A wide range of plug-in cards lets you program analog outputs (V, R and I), output digital words, close contacts, monitor digital lines, and sense status changes.

The modular nature of the multiprogrammer permits flexible system development. You start with a master unit (6940A) and 1 to 15 plug-in I/O cards. As system needs increase, simply add extender mainframes (6941A) and plug-in cards.

The 6940A master unit costs $1500; the 6941A extender, $900. I/O cards cost $75 to $430 each. For more on the multiprogrammer, check K on the HP Reply Card.

Run HP's multiprogrammer under computer control, or operate it manually from the front panel switch register.
The lowest noise yet for HF transistors

The lowest guaranteed noise figure ever offered in a microwave transistor is here—and it's priced below all other low-noise transistors on the market. The new 35870 series small signal NPN device boasts a guaranteed maximum noise figure of 2.3 dB at 2 GHz and 3.3 dB at 4 GHz. Typical noise figures are lower, of course: 2.0 dB at 2 GHz and 3.0 dB at 4 GHz.

The new transistor has plenty of gain, too: typically 14.8 dB at 2 GHz, 9.6 dB at 4 GHz, and 6.4 dB at 6 GHz (f_max is 14 GHz).

Price: only $90 each in 100+ quantities.

For details, check D on the HP Reply Card.

New low-cost beam-lead Schottky diode

High-level detection, switching, gating, A/D conversions, sampling and wave shaping are only a few applications for HP’s new beam-lead equivalent of our 5082-2800 Schottky diode.

With fast switching, this device is ideal for applications that require large numbers of high frequency diodes or as replacements for P-N junction diodes.

Breakdown voltage is 70 V; reverse leakage current, 200 nA; capacitance, 2 pF; and carrier lifetime, 100 pico-seconds. At UHF frequencies, the diode has 95% rectification efficiency. Priced at 99¢ in small quantities.

To learn more, check F on the HP Reply Card.

New packaging protects PIN diodes

Three new 100 MHz to 12 GHz PIN diodes are available in hermetically-sealed stripline packages which pass MIL specs for a variety of environmental tests. The 5082-3140 device is for general applications from VHF through X band. Model 5082-3170 has similar characteristics but is reverse polarity. Both handle 30 W of power; dissipation is 2.5 W.

The fast-switching 5082-3141 device is also useful where low bias current is needed for maximum attenuation. Switching time is 5 ns.

Power handling ability is 13 W; dissipation is 1 W. Isolation is > 20 dB for all three devices.

Prices: $25 each in quantities of 1-9, and $21.50 each for 10-99.

Delivery is from stock.

For hermetic diode details, check G on the HP Reply Card.

New microwave stripline Schottky diodes

These low-noise stripline diodes are only 0.1 inch (2.5 mm) in diameter.

For economically-priced microwave mixer Schottky diodes, consider four new low-noise devices from HP. In the 1-4 GHz range, the 5082-2213 diode has a maximum noise figure of 6.0 dB and a VSWR of 15:1. The lower-priced 5082-2215 model has a typical NF of 6.5 dB and a maximum VSWR of 2:1.

From 4 to 12 GHz, the 5082-2217 diode has a maximum NF of 6.5 dB and a VSWR of 1.5:1. The lower-priced 5082-2219 series has a typical NF of 7.0 dB with a VSWR of 2:1.

Uniformity of RF characteristics is assured so that you can replace these components in the field without circuit adjustment. Typical applications include telecommunications receivers, microwave synthesizers, ECM and radar front ends.

In quantities of 1 to 9, the 5082-2213 costs $8.25 each; 5082-2215, $6.00; 5082-2217, $12.50; and 5082-2219, $9.00.

For more information, check E on the HP Reply Card.
Universal counters offer higher sensitivity and faster time interval measurements

HP universal counters/timers measure frequency, ratio, period, multiple period, time intervals, and totalize with one significant difference—these do it better than any comparably-priced counter. Measure the frequency of CW or burst signals, 50 to 550 MHz with better accuracy and high sensitivity (to 15 mV). As for stability, the aging rate is as low as 5 x 10⁻¹⁰/day. Now, these HP counters have FCC approval.

For time interval measurement, only HP offers averaging down to 150 ps, with resolution to 100 ps—that's 1000 times better than conventional techniques. You can also get a built-in DVM for setting trigger levels digitally. That's far more accurate and faster than using an oscilloscope, and the DVM technique works at high frequencies where the scope markers tend to blur. Because these counters have hysteresis compensation, you don't have to reset levels when switching from positive to negative inputs. Hysteresis compensation simplifies setup and reduces errors.

Be assured that HP counters also have better system capability. All front panel controls can be operated remotely and economically. A built-in three-range integrating DVM and counter can easily be programmed into your system.

Whether you compare accuracy, price, versatility or performance, HP counters stack up better.

With a choice of six models, select the universal counter that fits both your performance needs and your not-so-universal budget. Prices range from $995 to $2195. A new book explains it all. For your copy, check I on the HP Reply Card.

Send for our informative booklet on easier ways to make frequency and time interval measurements.

HEWLETT & PACKARD

Measurement, Analysis, Computation
The 5-volt, N-channel MOS static RAM.

(Much more useful. Much easier to use.)

100% TTL compatibility—without clocks, without refresh. Interfacing's so simple you'll think you're working with bipolar parts. All the performance you've been itching to get your hands on. Backed by the smoothest specs ever put into MOS static RAMs. 1024 bits, 500ns access time. Single +5V supply.

N-channel technology developed by Signetics makes the difference. We designed out the kinks in competing devices, and came up with a new trouble-free line of ion-implanted N-channel MOS static RAMs.

And what a difference N-channel makes on your boards. Three times the circuit speed of P-channel RAMs, 50% lower power dissipation. Absolutely no fudging on bipolar compatibility—no clocks, no refreshing needed. So the parts are much easier to understand and put to use.

First super-RAM off the line: Signetics' new ion-implanted 2602 static RAM. N-channel delivers 1024x1 organization: four times the density of similar products. With extremely fast access time for a static RAM: 500ns. And we threw out the -12V power requirement that made terminal applications so sticky. 2602 operates from only +5 and ground.

In production now in a 16-pin package. For full details, write Signetics, or call your Signetics rep, salesman or distributor.

And ask about our breakthrough N-channel dynamic RAM, the 2601: non-overlapping clocks, 1024x1 in 18-pin packs, with 85ns access time, requiring under 300mW power.

High speed, high density, lower power, optimized convenience. Signetics make it in MOS. Of course.

Signetics-MOS
811 East Arques Avenue
Sunnyvale, California 94086
(408) 730-7700

Please send complete specs and technical data on your new N-channel line of RAMs; including the 2602 5V static RAM and the 2601 dynamic RAM.

Name
Title
Company
Address
City State Zip Telephone

In production now in a 16-pin package. For full details, write Signetics, or call your Signetics rep, salesman or distributor.

Signetics Corporation—A subsidiary of Corning Glass Works.
An advanced version of the successful Intelsat IV satellite has been proposed by a Hughes-led team of international companies under a Comsat study contract. The new satellite will have nearly twice the communications capacity and be operable with Intelsat's present ground-station network. At the present rate of growth, world communications traffic is expected to reach the capacity of the Intelsat satellite network in the Atlantic segment by 1975.

Two U.S. Navy aviators in an F-14A Tomcat became the first military crew in history to attack multiple targets simultaneously with multiple missiles from a single fighter aircraft when they launched two Phoenix missiles against two widely separated drones off Pt. Mugu, Calif., recently. The "double whammy" launch was a test of the multiple launch and guidance capability of the AWG-9 weapon control system. Both the Phoenix and the AWG-9 are built by Hughes. The Navy recently commissioned the first two F-14A squadrons.

Complex electronics systems for today's manned aircraft must withstand high G forces and considerable heat generated in critical units. To help solve these problems, Hughes is developing for the U.S. Air Force temperature-stabilized electronic mounting plates that use variable-conductance heat pipes in conjunction with phase-change heat-sink materials. Designed to improve component reliability, they can cool electronic units for as long as 30 minutes without using the aircraft's primary loop cooling because of a built-in emergency internal heat-sink capability.

Twelve long-range infrared devices that "see" at night are being built by Hughes for service testing under simulated combat conditions by the U.S. Army. Called NODLR (for Night Observation Device, Long Range), the portable, battery-powered device forms a TV-like image from thermal radiation of objects in view. It can be mounted on a ground tripod or installed on vehicles and will enable ground observers to detect people, vehicles, and field fortifications in total darkness.

Hughes has immediate openings for Field Engineers. Qualifications include U.S. citizenship, BSEE or Physics degree, willingness to travel, and experience in any of the following systems: electro-optical, infrared detection, laser ranging and target designation, or low-level-light TV detection. Please write: Professional Staffing, Hughes Aircraft Company, Field Service & Support Division, P.O. Box 90515, Los Angeles, CA 90009. Hughes is an equal opportunity employer.

An experimental laser communications system, developed by Hughes scientists under contract with the U.S. Army Electronics Command, provides a 5-megabit/second communications channel at 10.6 micron wavelength. With 1 watt output, and over the 8-kilometer path for which it was designed, the system is effective in all but the most severe weather. Keys to its high operating capability are the increased reliability and efficiency of the CO₂ laser in the transmitter and the optical heterodyne detection in the receiver. It has a potential in excess of 300-megabit data rate or 10 television channels.
Gunn oscillators that can be tuned by means of YIG spheres to the X band (8-12 GHz) and the C band (4-8 GHz) have been developed by Philips Research Laboratories in conjunction with the National Applied Physics Laboratory at Limeil-Brevannes, France. Output powers of greater than 20 mW have been achieved with temperature stabilities on the order of 0.5 MHz/°C. The research studies were undertaken for S.A. RTC-La Radiotechnique Compelec of France. The development of complete microwave generators is now planned. The group will also study the operating characteristics of Q-band devices.

CIRCLE NO. 391

Any part of a video tape recording can be located within 0.1 second without modifying the recorder when using a new English 'digital information system. The system—called the Tapecord—numbers every frame of a video recording without interfering with the picture content. A solid-state display shows the frame data during both recording and playback. Data added to the tape may be: elapsed time, 24-hour clock time, digital counts up to eight digits, or a binary coded output from a computer or other video tape. Produced by Video Electronics Ltd., Manchester, England, the system cost is about $800.

CIRCLE NO. 392

A computer-controlled spectrophotometer system to improve color matching in textiles will be used by the British wool textile industry. The spectrophotometer, made by Pretema AG of Zurich, measures varying intensities of colors in a sample piece of fabric and transmits this information to the minicomputer. The computer evaluates the data and derives a formula for selecting the dyes that will produce the same color as that on the sample fabric. The result appears on a teleprinter. Whereas a trained operator might take up to five days to produce a perfect match, the complete computer-controlled operation takes only five seconds.

CIRCLE NO. 393

The first commercial long-distance telephone system capable of transmitting up to 10,800 simultaneous conversations over one pair of coaxial cables will be put into service by Sweden next year. Equipment for terminal operation has been developed by the L.M. Ericsson Telephone Co. under contract to the Swedish Telecommunications Administration. The system will connect cities 100-km apart.

CIRCLE NO. 394

Mapping of star radio sources to within a few seconds of arc—a degree of accuracy never before achieved—will be provided by England's latest radio telescope. Using an array of eight 42-foot dishes (four fixed and four steerable) based over a three-mile range, the system will provide a resolution that is equivalent to that of a single steerable dish having a three-mile diameter. The system is operated by a Marconi Myriad II computer that steers the antenna and also controls a complex cable delay-network that equalizes the phase delays of the signals from the different antennas.

CIRCLE NO. 395

A new type photodetector combining a metal-type junction with an MOS capacitor structure has been studied by researchers at the Central Research Laboratories of Thomson-CSF in France. The device, which is a photo-MOS diode, has been tested experimentally using both indium and antimony as photo elements. These photodevices are expected to be fabricated in photomosaic arrays for sensing data in optical memory.
If you've been plagued by costly, time-consuming data bus line loading problems, our new family of Quad-Tri-State* Party Line Transceivers is just what the doctor ordered.

**BUS-GUARD, EXPLAINED** Thanks to an exclusive new active ingredient called Bus-Guard (made possible through the miracle of Tri-State logic), our new LM 132 series transceivers insure that the computer bus line remains active even when one of the terminals sharing the line is down.

**ALL IN THE FAMILY** But that's not all. The new DM7833, 34, 35 and 39 series also comes with a built-in hysteresis of 400 mV. And a receiver input current of just 50µA maximum. (Which is two orders of magnitude better than anything now on the market. Which also means at least 20 driver/receiver pairs can utilize a single bus.)

**MORE INTERFACE CIRCUITS WHERE THESE CAME FROM** For complete data on our new DM7833, 34, 35 and 39 series of Quad-Tri-State Party Line Transceivers (as well as our other great Interface Circuits), just call (408) 732-5000.

Or write National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051.

**JOIN THE NATIONAL LIBRARY** When you call or write, be sure to ask for your official National Library Card and current-selection bibliography. Your passport to a veritable wealth of Digital, Linear, MOS and Transistor/FET product, application and design information from a single-source.

*Bus-Guard and Tri-State are trademarks of National Semiconductor Corporation.*

National
Major shuffles due in Congressional posts

Changes in the chairmanship of the two Congressional space committees are due as a result of this year's elections. The House Science and Astronautics Committee chairman, George P. Miller (D-Calif.), lost a primary election, paving the way for Olin Teague (D-Tex.) to take over the post. Teague, who would have to surrender his leadership of the Veterans Committee to succeed Miller, is—like the Californian—a staunch advocate of a strong space program.

On the Senate side, Stuart Symington (D-Mo.) is in line for the chairmanship of the Aeronautical and Space Sciences Committee because of the retirement of Sen. Clinton P. Anderson (D-N.M.). Symington, a former Air Force Secretary, has generally been a tougher critic of some of the Government's big programs than Sen. Anderson has.

Meanwhile the defeat of the influential Republican Senator from Maine, Margaret Chase Smith, means that Strom Thurmond (R-S.C.) becomes ranking minority member on the Senate Armed Services Committee.

Justice Department vs. IBM

The Justice Dept. is hoping Judge David Edelstein of the U.S. District Court will decide not to grant IBM's request for an early trial to determine what portion of the computer market the great company actually controls. Antitrust division attorneys, already handling several other large antitrust cases, say such an early trial would take manpower away from their efforts to discover specific instances in which the company may have acted in a way to monopolize the market. Meanwhile, Computer Industries Association's Dan McCurk reports that industry executives attending special meetings across the country have agreed to back the Government's suit.

EIA sees rise in Government electronics spending

A rise in electronics content of most major Government programs is predicted for the 1970s by the Electronic Industries Association. The EIA estimates that electronics will account for 16.6% of a $94-billion defense budget by 1980 and 41.3% of a $3-billion NASA research and development budget.

In other Government spending, the trade association sees electronics accounting for $426-million of a $2.4-billion Federal Aviation Administration budget by 1980; $201-million of a $6.6-billion Federal Highway Administration budget; $48-million of an $822-million Urban Mass Trans-
New commerce trade office opens

In line with the Nixon Administration's goal of improving relations with the Soviet Union and mainland China, the Commerce Dept. has opened a new office here to foster increased exports to communist countries. The new East-West Trade Bureau will include Russian, East European and People's Republic of China desks, as will the U.S. Export Control Office and other advisory offices.

Space-shuttle subcontract race shaping up

North American Rockwell plans to start competition for major subcontracts on its space-shuttle project in about six months. Company representatives outlined the plans at three business symposia held late last month in Long Beach, Calif.; Fort Worth, Tex., and Boston. The company expects to let more than $1.3-billion in subcontracts on the $2.6-billion program. It has already released requests for proposals for design definition and fabrication of major structural components, and bidders' conferences for these projects will be held this month or next. Intermetrics, Inc., has been signed to provide an advanced programming language for the shuttle flight computers.

Capital Capsules: President Nixon's former campaign director, Clark MacGregor, is expected in his new job with the United Aircraft Corp. to "tell the business story" to the Government. United Aircraft was named with 19 other companies in an antitrust suit by the Justice Dept. on March 19. . . . NASA and the Dept. of Health, Education and Welfare are looking for the ideal remote community to field-test a new computerized system called the Integrated Medical and Behavioral Laboratory Measurement System. Built by Lockheed, the system is designed to transmit medical information from remote areas on earth and in space. . . . The Pentagon reports that Lockheed, for the fourth time, is the largest defense contractor with $1.7-billion of defense business. This is an increase of 12% over last year, despite problems on several programs. . . . Apollo 17, scheduled to be launched Dec. 6, will repeat an experiment to test the production of crystals in zero gravity. NASA believes this may one day be more economical for the electronics industry than production on earth. . . . The Navy hopes to cure its communications ills, which have been sharply criticized by Congress, with the new fleet satellite-communications system it has contracted TRW Systems, Inc. to build. . . . Sen. William Proxmire (D-Wis.) reportedly is considering a probe of the Defense Dept.'s ship overrun problems. The Senator also called for grounding the F-111 aircraft after recent losses in Southeast Asia. . . . In line with its effort to streamline bureaucracy, the White House is considering merging the Defense Supply Agency with the General Services Administration. DSA buys many standard electronic items used by all three services. . . . NASA is reportedly asking for $3.4-billion for fiscal 1974. Although the space shuttle is the biggest single item on the budget, the agency is trying hard to show the relevance of space research to earth problems. Skylab, scheduled to go into orbit next spring, will carry a number of earth resources projects.
CRT READOUT, unique to the TEKTRONIX 7000-Series Oscilloscope Systems, provides a combined display of waveforms, measurement parameters and symbols on the CRT for direct reading.

Wrong answers because of overlooked control settings are now passé. CRT READOUT tells you the full story. Speed, perception and convenience are available because the scale data is printed right on the display. These values are automatically corrected for both probe attenuation and sweep magnification. There are also special symbols for identifying trace position (IDENTIFY), amplifier polarity (ña) and uncalibration (>,.).

Correct answers are always on your photographs with CRT READOUT. The photos will show the waveforms along with their parameters and symbols — A REAL TIME SAVER.

CRT READOUT is available for 7000-Series plug-ins working in frequency, time, voltage, current, resistance and temperature domains — AND there are MORE coming.

CRT READOUT functions in all 7000-Series mainframes and plug-ins except those having a suffix N (7403N, 7B53N, etc.).

Tektronix, Inc. lease and rental plans are available in the U.S.A. For information, call your local TEKTRONIX Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.
Here's a versatile new IC for portable or battery-powered instrumentation

150 µWatts powers Triple Op Amp

The Siliconix L144 is a low-power monolithic IC with three complete op amps and a common bias network on the same substrate. The circuit operates over a power supply range of ±1.5 to ±15 V, with a supply current set by an external bias resistor. With a ±1.5 V battery, only 50 µA is required for all three op amps!

Other features:
- Internal compensation provides stable operation for any feedback circuit—including capacitive loads >1000 pF
- 80 dB gain with 20KΩ load
- Typical slew rate 0.4 V/µsec
- Military or commercial versions available

Applications? Above are three suggestions.
There are more: Low-drift sample-and-hold, inverting amplifiers, voltage comparators, and so on.
Call us if you have a specific design problem.

write for data
Applications Engineering: (408) 246-8905

Siliconix incorporated
2201 Laurelwood Road, Santa Clara, California 95054

INFORMATION RETRIEVAL NUMBER 30
A civilian NASA?  
It'll take a little push

A coordinated effort is needed to apply this nation's scientific manpower and resources to the solutions of problems in such areas as health care, poverty, public safety, pollution, unemployment, productivity, housing, education, transportation, nutrition, communications and energy resources. This effort is best organized through a single administration with wide-ranging authority to plan and spend. An organization with the same dedication to purpose as NASA is what is required.

Such an organization is close to reality. It is part of a bill before the House of Representatives called the National Science Policy and Priorities Act of 1972, or S.32. The bill declares the following as national policy: (1) Federal funds for science and technology must be raised to an adequate level and then continue to grow in proportion to the growth of the GNP; (2) There must be continuing employment opportunities for scientists, engineers and technicians in positions commensurate with their capabilities; (3) Federal funds for civilian research and engineering must be maintained at least at a level of parity with Federal funds for defense research and engineering; and (4) Federal funds for civilian research and engineering must be focused on meeting human needs in national priority problem areas.

The civilian NASA is to be called the Civil Science Systems Administration. It is to be under the National Science Foundation. The new authority would have broad-ranging power to plan and fund civil systems projects. It would be advised by the National Science Foundation Board. The foundation would be required to develop the basic policies for the use of technology in solving civil problems, and the new authority would work within those guidelines.

Additional parts of S.32 require the study of the transition of manpower to civilian programs and the protection of pension rights of engineers and scientists. The National Science Foundation would assist state and local governments in formulating transition programs and would give placement assistance. Pension-right protection would be through a rewriting of Federal procurement regulations.

The Senate version of the bill was passed on Aug. 17. It provides for spending $1.02-billion over three years, from 1973 to 1975. The House version also provides $1.02-billion, and did not get out of committee in this session of Congress. Why not write your Congressman and push for speedy passage of this bill.

David N. Kaye  
Senior Western Editor
Flat flexible wiring offers so many advantages that you'd think conventional round wiring would be obsolete by now. But it isn't. Why not?

It boils down to this: Flat flexible cable can offer the optimum solution to many wiring problems. But it's tough to specify it, because there are few published specs. Typical data sheets say more about the limits of the manufacturer's capability than about matching his wiring to a specific application.

The designer must be thoroughly familiar with the options and tradeoffs in flat flexible cable because he'll likely end up telling the manufacturer in detail what he wants. Off-the-shelf styles —when they exist—can't satisfy the require-

Richard Lee Goldberg
Associate Editor
ments of all designs. Vendors are reluctant to stock flat flexible cable in a large variety of sizes and styles because of small demand. For this reason, most of the cable being made today is custom-manufactured. Usually, the buyer simply can’t look in a catalog and specify a part number.

But for the designer who persists, flat flexible cable has decided advantages where weight, size and the labor cost of the installation are critical. Consider military and aerospace systems, computers and consumer products. The interconnection task is large, and reliability is essential. Flat flexible cable is commonly used.

It’s a product with a promising future, too. The automotive and construction industries, appliance manufacturers and machine-tool makers—all are considering the replacement of conventional wiring with flat flexible.

Two major types available

In specification, start with the basics. Flat flexible cable consists of parallel insulated conductor lines held together in one plane. There are two major categories: extruded-conductor cable and etched-conductor cable.

Under extruded, three options—describing ways in which the conductors and insulators are held together: bonded, laminated and woven.

Here are some of the leading characteristics of each:

**Bonded cable.** Made in the same way as conventional insulated wire and the cheapest of all styles. It has the appearance of individually insulated wires stuck together in a row by fusing of their insulations. The conductors can be extruded in any shape, but for economic reasons, they are generally round. Round-conductor flat cable is commonly referred to as ribbon cable.

**Laminated cable.** Offers a choice of either round or rectangular conductors, or even both in the same cable. In the lamination process the conductors are laid between two sheets of insulation. The insulating layers are usually pretreated with an adhesive that reacts to heat and pressure. For high-temperature insulations, such as Teflon, fusion-bonding with heat and pressure works without an adhesive. When adhesives are used, their temperature characteristics must be matched to those for the insulation.

**Woven cable.** A version of ribbon cable in which the individual conductors are woven together in a flat configuration. It allows slight movement within the cable, for added flexibility, and the possibility of conductors with different individual insulations.

The second major category of flat flexible cable—etched conductor—is formed on a common,
Laminated three-conductor power lead from ITT Cannon Electric acts as a jumper cable between a PC board and a wrapped-wire termination.

flexible substrate. It can be thought of as a replacement for a rigid printed circuit, a flat flexible cable and appropriate connections, all in one package:

Etched-conductor cable has conductors of rectangular cross-section only. The etching process is similar to that for printed circuits. In fact, if the conductors run in nonparallel patterns, the resulting etched wiring is known as flexible printed circuitry.

Guidelines in specification

Comes now the nitty-gritty in specifying extruded-conductor cable. It's not enough merely to pick a broad category of cable—bonded, laminated or woven. Three other major decisions are involved:

1. The shape of the conductor.
2. The kind of insulation to be used.
3. How to terminate the cable.

Flat vs round conductors

Like conventional round wires, and unlike flat conductors, round-conductor cables are easy to terminate. Conventional-wire connectors are, of course, designed for round conductors. Unfortunately most round-wire connectors don't allow termination of more than a dozen conductors. So it is only for cables with less than a dozen conductors that round conductors are easier to terminate. For larger numbers of conductors, other termination schemes, such as mass bonding and welding, must be used. These work at least as well for flat conductors as round, thus offsetting the advantage of round conductors.

Flat conductors are usually more flexible than round—but not if the round conductors are stranded. Flat conductors tend to be better for continuous-bending applications—but only over a limited range of wire sizes. For conductors smaller than No. 34 AWG (or the equivalent size for flat conductors), the conductor shape has negligible effect on flexibility. For wire sizes larger than No. 26 AWG, both round and flat conductors become so stiff that they tend to break after several flexes (though manufacturers of flat-conductor cable claim that, even in heavier gauges, flat cable still offers superior life. One company cites a six-to-one flex-life advantage for $4 \times 125$-mil flat wire when compared with No. 22 AWG round wire, which has the same cross-sectional area.) It's generally agreed, however, that only for conductors between No. 26 and No. 34 AWG do flat conductors have a useful flexibility advantage.

With their greater surface-to-volume ratio, flat conductors can carry more current than round. Thus, for the same current, a smaller-sized conductor can be used, reducing cable weight and bulk. But though flat conductor cables are thinner, ribbon cables, using round conductors, are narrower. They have about a third the width of flat conductor cables of the same current capacities, because the individual round conductors are narrower than equivalent flat conductors.

Flat conductors dissipate heat better than round ones, because of their greater surface area. But at typical signal frequencies and power levels, heat dissipation usually is not a problem. Also, round conductors offer better electrical characteristics for transmission-line applications. Of course, the electrical characteristics depend on the insulation as well as on the size and shape of the conductors. So let's look at the important characteristics of the more commonly used insulation materials.

Which insulation?

Before specifying an insulation, the designer should consider electrical parameters, flexibility requirements, maximum temperature and other environmental factors. If the insulation meets these requirements, the decision then boils down
Preterminated cable from Ansley Electronics Corp. comes with flat conductors for maximum flexibility, or with mixed round and flat conductors.

250°C, the highest rating of any existing cable insulation. Both FEP and TFE can be bonded without adhesives. But with a tensile strength roughly a tenth that of Mylar, they are susceptible to cold flowing.

Kapton polyimide, though increasingly popular, is the most expensive insulation. It combines the strength of Mylar with the high temperature rating of Teflon TFE, while exhibiting less shrinkage and more stability than any of the other insulations.

Combinations of materials can, in some cases, combine their advantages. For example, vinyl can be added to Kapton to reduce cost without sacrificing strength.

What termination?

The termination choices for flat flexible cable are limited by the number of conductors and their configuration. The connector type and spacing must be compatible with the cable material. To be used with automatic termination systems, for example, the cable must have exact pitch. For cables that have more than a dozen conductors and for large-volume orders, the designer should consider a ready-made and terminated cable system.

Soldering is the most popular termination method. For prototype cable assemblies, hand soldering works satisfactorily with many available types of conventional round-wire connectors. But since hand soldering is sequential and slow, it is not suggested for cables with more than about a dozen conductors. Bar soldering allows all the conductors to be fastened simultaneously, but it is usually restricted to PC board connections and cables with pitch (center-to-center spacing of conductors) of greater than 40 mils.

Mass bonding uses infrared heat to create reflow solder, and thereby simultaneously to attach up to 500 conductors to a connector. In this case, the conductor pitch can be less than 40 mils.

Crimping offers advantages in field servicing, because it requires only hand tools. This method has a lower pitch limit of about 100 mils and can be only partly automated. It requires a precisely pitched cable.

Some specialized connectors have piercing contacts that penetrate the insulation. The technique provides a suitable termination for cables with fewer than two dozen conductors.

In the so-called pressure method of termination, the cable conductors serve directly as contacts. But first they must be separated and spread apart. Each conductor is forced between two cantilever spring members in the socket. Some sockets require tinned conductors.

Welding is the most secure termination method, but it is also the most expensive. Since weld-
Burndy's 51281 laminated cable attaches to a PC right angle by reflow soldering. This termination technique is especially popular among computer manufacturers. soldered joints are the most reliable, they are used in military and aerospace applications, where shock and vibration are major considerations.

**Don't overspecify**

A few words of caution: When specifying flat flexible cable, an engineer should, of course, include tolerances. But if tolerances are overspecified in the hope of getting a better product, you may get only a more costly one instead.

In pursuit of optimum performance, designers may specify flat cable per MIL-C-55543. But this standard lists over 1200 possible cable styles, many of which represent impossible combinations of cable characteristics. Some performance requirements can't be met by existing technology. And no single manufacturer offers all the types listed. Commercial spec IPC-FC-220 (published by the Institute of Printed Circuits) is generally acknowledged by cable manufacturers to be a more realistic spec. Unfortunately, not all users of flat flexible cable are familiar with the IPC spec.

Though flat flexible cable is largely custom-manufactured, the standard products that are stocked demonstrate the range of possible applications.

Burndy mixes round and flat conductors in one type of cable, and a variety of conductor spacing is available. Gore's PSE Multi-Strip, a flat-conductor cable with polyester self-extinguishing insulation, meets all the requirements of IPC-FC-220, Type BS, Tolerance Class IV. It has tolerances designed for commercial applications that use automatic termination systems.

Ansley's Black Magic cable features low crosstalk for signal-transmission lines. 3M and several other companies specialize in round-conductor cable for signal-transmission applications.

Parlex, AMP, 3M, Methode, ITT Cannon Electric, S/Ronics Associates and several other companies manufacture preterminated cable assemblies.

Rogers Corp., Storm Products Co. and Calmont Engineering produce ribbon cable designed for dynamic flexing applications. Calmont's Siliflex and Storm's Flex cable both have silicone rubber insulations. Siliflex comes with up to 500 conductors in sizes from No. 40 AWG to 14 AWG.

Brand-Rex PVCA cable uses a single aluminum conductor large enough for power-distribution applications. Daburn and many other companies also make flat flexible cables with PVC insulation.

Woven cable is manufactured by Woven Electronics, Philadelphia Insulated Wire and several other vendors. The conductors are individually color-coded and can be separated for easy termination without additional apparatus.

**Flexible printed circuitry has great promise**

Flexible printed circuitry offers many of the same advantages over rigid PCs that flexible flat cable does over more rigid cable harnesses. An important advantage is that flexible printed circuitry can be tucked into tight spaces. Its efficiency here surpasses even that of flat flexible cable when the latter links several rigid PCs.

But, like flexible flat cable, flexible printed circuitry is not as widely used as you might expect it to be. The main reason—difficulty in specifying—parallels that for flat flexible cable. But there are other reasons peculiar to flexible PC—
Laminated flat-conductor cable from AMP, Inc., comes preterminated for easy installation.

Ribbon cable from the 3M Co., preterminated to a PC connector, plugs directly into a PC board socket. This allows rapid circuit-board changes.

the circuit's reputation as a high-cost item, used only where weight and space restrictions prevent the use of rigid PC boards, for example. Most engineers think of flexible circuits as an expensive and glamorous commodity. In most cases it is used only when nothing else will work. But flexible PC boards can be even better suited for high-volume, commercial products than rigid boards are.

Whereas there are some off-the-shelf flexible cables, all flexible PCs are custom-made. The vendor is not selling a product but rather a process and a capability. Unfortunately, flexible PCs do not allow for breadboarding; therefore the designer must determine the requirements for his particular application.

Among the things the designer will consider in drawing up his specs are these:

Laminates. In addition to Kapton polyimide, Mylar polyester and Teflon, the more popular glass epoxy is available. It's similar to that used for rigid PC boards, but it's much thinner. Combinations such as a polyester-impregnated glass mat or an epoxy-impregnated woven glass can boost impact strength without greatly increasing the cost.

Density limitations. Many of the design problems with flexible PCs are similar to those for rigid PC boards. For example, if the density is such that very fine lines—say, 10 mils—and tight spacings—25 to 30 mils—are required on a single-sided board, prices and delivery times increase markedly. If the use of both sides of the board allows wider lines with larger spacing, a two-sided board may actually cost less. In any event, fine lines and close spacings should be avoided where possible. A tiny speck of dust that wouldn't bother 25-mil lines on 50-mil centers can cause a defect in a 10-mil line. A speck of dust in a resist coating, for instance, could interrupt a fine line or short out adjacent lines with small spacing. And if that speck of dust appears on a large board, the defect can be really costly. Therefore, it's wise to keep dense boards small.

Line spacings are also dictated by the spacing between holes on a board and by the diameter of pads. A finished hole should have a diameter that is about 10 mils greater than the diameter of a component lead (and perhaps more for automatic insertion). Thus the hole may have a diameter of 30 mils for a 20-mil lead. The pad should have a diameter that is at least 10 mils greater than the hole diameter, which calls for a 40-mil-diameter pad. If 10-mil-wide conductors are on 50-mil centers, it's possible to put a 40-mil pad between them.

Tight tolerances

Avoid specifying them. Flexible circuitry need not be dimensioned as precisely as metal, because its flexibility and elasticity help to compensate for mismatched hole locations caused by loose tolerances or tolerance buildup. But for machine insertion, the hole-position tolerances will need to be tighter. Also, tight tolerances require precision tooling, resulting in higher manufacturing costs and longer delivery times.

Circuit complexity

As wiring on a board becomes more dense and as tolerances get tighter, dimensional stability increases in importance. A material of poor stability can be quite suitable for a single-sided board.
Woven cable from Woven Electronics demonstrates easy conductor identification with color-coded insulations. Simple conductor separation facilitates termination.

Advantages of flat flexible cable are apparent in this complex interconnection task—the wiring of an IBM computer mainframe.

Analogic's Model 2535-1 DPM with LED readouts has all of its circuitry on a single flexible printed circuit. Packaging is thus greatly facilitated.

with rather large line widths and spacings. If, however, conductor widths and spacings must be decreased to less than 1/16 inch, you have to decide whether to use larger single-sided boards, more single-sided boards or double-sided boards.

The number of boards and their sizes may be dictated by the dimensions of the equipment into which the boards will go, as well as the number of components you're willing to mount on a board. The number of boards is also limited by the number of connectors you're planning to use. Small boards are also less susceptible to warping.

To keep both board size and quantity down, try two-sided boards with etched wiring on both surfaces. For the same wiring density on each side, a two-sided board generally costs at least twice as much as a single-sided board, but the two-sided board can save money if it allows wider lines with larger spacing. At the same time the two-sided board increases reliability.

The same consideration—circuit density—that encourages the use of double rather than single-sided boards also favors a transition to multilayer boards.

Most multilayer boards consist of thin layers (perhaps 2 or 4 mils thick) of copper-clad glass epoxy (usually G-10), sandwiched between layers of thin prepeg, perhaps 3.5 mils thick. The prepeg is an epoxy-impregnated glass cloth that's not fully cured. When subjected to heat and pressure, it liquifies, then gels as it flows around the printed wiring before it is fully cured and hardens.

It's possible to use a copper-foil plane for one layer. This can serve as a ground or shield plane for decoupling and reducing noise interference. Or, for greater flexibility, you can use a wire-mesh screen. It's possible to design strip transmission lines with controlled impedances from about 50 to 150 Ω.

Most vendors prefer two-sided copper-clad
Rogers Corp.'s multilayer two-sided flexible PC combines the complexity of a rigid multilayer with the flexibility of an etched flat flexible cable. The resulting sheets to equalize strain on both sides, thereby reducing warping. Others feel they get lower scrap rates and more perfect sheet-to-sheet registration if they use single-sided sheets.

Each layer of copperclad is etched the same way a conventional rigid board would be etched. But the individual sheets must be lined up perfectly before they are pressed together to form a multilayer board.

The method of connecting from layer to layer differs among vendors. Most use plated-through holes. In almost all cases each hole goes through all layers, but the plating makes connection only at layers where a pad surrounds the hole.

Interconnections. With two-sided boards, you have to decide how to connect through the holes from one surface to the other. Through-hole plating is by far the most popular method. When it's used, it's necessary to maintain proper clearance between the hole and the component lead. If the hole is too small, the lead may not fit or solder may be unable to rise into the hole to make a good bond with the lead. If the hole is too large, there may be inadequate capillary action to drive the solder into the hole. This can pose a problem because of the variation in lead diameter.

Eyelets, preferred for many years as more reliable than through-hole plating, are costly. For small-diameter holes, the parts and assembly can cost twice as much as plating through. But they can be very useful in precise control of the position of force-fitted components. Eyelets have an additional advantage in that they can be used in punched glass-epoxy boards.

The clearance-hole, or buildup, method for interconnecting layers is less costly, especially in small quantities, but it requires more space. In this method succeeding layers of laminate have increasingly larger holes. Each hole has a copper pad, and the copper pads are bridged during soldering. One advantage of this method is that it's not necessary to go through all the layers of a board. You can interconnect just the first three or four layers if necessary. But the outermost hole can get to be rather large.

Another method uses pillars of copper or electroformed nickel tubelets. These, too, don't require holes through all the layers, and they don't require successively larger clearance holes toward the surface.

Multilayer tradeoffs. Double-sided boards, too, may need interconnections from one surface to the other. Occasionally several layers are bonded together, and wide copper pads in corresponding positions are actually welded together. Holes can be punched or drilled through the centers of the webs. This structure is strong enough to support small components whose leads can be soldered into the holes. About seven layers, each about 2 mils thick, can be bonded together in this way. The resulting flexible multilayer is not overly flexible, but it can be bent around corners or "glued" to curved surfaces.

Flexible printed circuits come in a variety of types with different degrees of flexibilities, numbers of layers and types of materials. Parlex offers two-sided and multilayer circuits with plated-through holes. Schjeldahl mounts rigid stiffener boards to portions of a flexible circuit. This allows the mounting of components to a rigid structure in more than one plane without the use of jumper cables or the purchase of more than one circuit.

Rogers Corp. has developed a treatment, called MBT, for enhancing the bond strength of rolled copper. This combines its desirable mechanical properties of rolled copper with the good adhesion ability of electro-deposited copper. Buckbee-Mears Co. has narrowed line spacings to 2-mil lines on 5-mil centers. ITT Cannon Electric, AMP and S/
Ronics Associates offer flexible circuitry preterminated to a flat flexible cable. This is perhaps the most versatile form of flat flexible wiring.

Flat flexible cable and flexible circuitry have been around for over 15 years. Yet, manufacturers point out, it took longer than that for many electronic concepts to be widely accepted. As more designers become aware of the advantages of flat flexible wiring, sales will rise and prices should drop. As Wilhelm Angele, an articulate proponent of flat flexible wiring at the Marshall Space Flight Center, has said: "If engineers were more knowledgeable about flat flexible cable and PC, they wouldn’t use anything else."
Ceramag® Beads Do Away with Noise

Stackpole ferrite beads offer a simple, yet effective means of suppressing spurious RF signals to prevent them from entering areas susceptible to such "noise." No other filtering method is as inexpensive as a ferrite bead.

How can you use a bead? Consider it as a frequency-sensitive impedance (Z) element. Beads are available in a variety of Stackpole Ceramag® materials. Depending upon the material selected, beads can provide increasing impedances. From 1 MHz to over 200 MHz. Keep in mind, the higher the permeability, the lower the frequency at which the bead becomes effective.

Should a ferrite bead be small? Not necessarily. The unique, giant bead shown below is used by IBM to eliminate the effect of transient noise.

The impedance of Stackpole ferrite beads can be changed by simply varying the length or the O.D.-I.D. ratio.

Installation of Stackpole beads is easy. And inexpensive. Simply slip one (or several) over the appropriate conductor(s) for the desired noise suppression or high frequency isolation.

Additional savings in production time and labor costs are possible by utilizing automatic insertion equipment to install ferrite beads with leads in printed circuit boards.

CERAMAG® FERRITE BEAD CHARACTERISTICS

<table>
<thead>
<tr>
<th>Material</th>
<th>Initial Permeability</th>
<th>Volume Resistivity @ 25°C</th>
<th>Effective Suppression At:</th>
<th>Curie Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>2500</td>
<td>1.0x10^2</td>
<td>1 MHz 20 MHz 50 MHz 100 MHz</td>
<td>205</td>
</tr>
<tr>
<td>7D</td>
<td>850</td>
<td>1.4x10^5</td>
<td></td>
<td>140</td>
</tr>
<tr>
<td>5N</td>
<td>500</td>
<td>1.0x10^3</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>11</td>
<td>125</td>
<td>2.0x10^7</td>
<td></td>
<td>385</td>
</tr>
</tbody>
</table>

Beads are available in sleeve form in a range of sizes starting at .020 I.D., .038 O.D., and .050 long. For special compact filtering applications, beads can be supplied to tight mechanical tolerances.

Sample quantities of beads and beads with leads are available upon request. Send your requirements to: Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.
Increase life expectancy with Dow Corning silicones.

Silicone materials increase the life, reliability and safety of microcircuitry. They battle adverse environments, especially high temperatures, as no other material can. This module may give you an idea or two about the use of silicones to add efficiency and life to your next consumer, industrial or military design:

**Silicone encapsulated ICs** (1) perform with reliability approaching that of hermetics. Similar performance is obtained with silicone-packaged **resistors** (2) and **power transistors** (3). Flame-retardant thermosetting molding compounds from Dow Corning opened the door to this advance in low-cost, transfer-molded plastic packaging. Years of service, and device life tests in the millions, record the superior moisture and mechanical shock resistance, thermal life and dimensional stability of silicones over all other plastics.

**Silicone heat-sink compound** (4) helps maintain device efficiency, guards against premature device failure. Bridging the gap between devices and the heat sink, this compound ensures high thermal conductivity and high-temperature stability.

**Flame-retardant silicone elastomer** (5), encapsulating the module, adds safety, protects circuitry from moisture, dirty atmospheres, mechanical shock and vibration. This pourable material cures to a tough, flexible rubber without exotherm or corrosive byproducts.

Electrical/electronic materials from DOW CORNING
Reduce noise in feedback circuits
Usually the best signal-to-noise ratio results from high preamp gain and multiple feedback.

A circuit designer frequently needs to minimize the output noise of a linear feedback circuit. However, it isn’t obvious which part of a closed loop affects the output S/N ratio most—that is, where noise-reducing measures should be applied. Analysis shows that the best procedure is to increase the forward gain preceding the point of noise entrance. To do this you may find it necessary to use multiple loops. Let’s see why.

Depending upon the specific situation, unwanted noise may be caused by many factors. These include random perturbations in the conductance of active or passive circuit devices (thermal noise, shot noise, 1/f noise), undesired pickup from stray magnetic fields, ripple injected from the power supply, very low frequency temperature-dependent shifts (drift) and harmonic distortion in a nonlinear amplifying stage.

For the purpose of analysis, the effects of these unwanted signal disturbances within feedback circuits can all be treated in the same way; thus we will not distinguish between different kinds of noise sources. Also, for simplicity, we will assume that there is only one noise source injected into a feedback loop. Since we are dealing with linear circuits, the designer can look at the effects of one noise source at a time and then superimpose the effects of several such sources on the output.

Performance depends on feedback
The basic equation for the gain of a feedback amplifier (Fig. 1) is given by:

\[ E_{os} = \frac{E_A}{1 + AB} \]

Normally \( AB >> 1 \), so this gain is approximately \( 1/B \). This means that the use of feedback shifts the dependence of many essential performance characteristics from the active forward gain elements to the feedback elements. These are usually passive components and therefore less subject to undesired variations. But this deliberate depend-

1. Analysis of noise-free circuit shows that performance depends mostly on the feedback elements.

ence on the feedback elements also means that the circuit is especially vulnerable to noise injection into the feedback path.

Assume that a noise signal is somehow coupled into the feedback path between the output and the feedback elements (Fig. 2). Then:

For \( E_s = 0 \):

\[ E_0 = E_{on} = \frac{E_N (-AB)}{1 + AB} \]

Since normally \( AB >> 1 \), \( E_{on} \approx -E_N \). Thus a 1-V noise signal results in nearly 1 V of inverted output noise.

Things can get worse. Suppose the same noise disturbance is injected between the feedback elements and the summing point (Fig. 3).

For \( E_s = 0 \):

\[ E_0 = E_{on} = \frac{E_N (-A)}{(1 + AB)} \]

With \( AB >> 1 \), \( E_{on} \approx -E_N (1/B) \). Since \( B \) is usually less than unity, the noise output \( E_{on} \) is \( 1/B \) times worse. In fact, in comparing equations, we see that the amplifier offers as much gain for \( E_N \) as for \( E_s \) (this is reasonable, since the noise has been added at the input to the amplifier).

So the designer must be careful not to let disturbing signals creep into the feedback path. Noise-free and drift-free components—for example, noninductive wirewound resistors—should be used here and the circuit shielded or spaced to
excludes the effects of stray fields.

The circuit designer has to live with the feedback-path noise constraints. But by careful design he can usually reduce the output noise that would otherwise result from unavoidable noise sources in the forward-gain path.

Preamp gain is important

We can simulate noise injection anywhere along the forward-gain path of a multistage amplifier by breaking apart the forward-gain element, A, into two elements so that $A_1A_2 = A$ (Fig. 4). The equations for the output are:

For $E_N = 0$: 
$$E_{OS} = E_s \frac{A_1A_2}{1 + A_1A_2B}.$$  
(1)

For $E_s = 0$: 
$$E_{ON} = E_N \frac{A_2}{1 + A_1A_2B}.$$  
(2)

To obtain the equations for noise injected at the output of the A path, we would select $A_1 = A$ and $A_2 = 1$ in Fig. 4. Then, from Eq. 2 we obtain the well-known equation:

$$E_{ON} = E_N \frac{1}{1 + AB}.$$  
(3)

Similarly, for noise injected between the summing point and the input to A, select $A_1 = 1$ and $A_2 = A$, and the noise-caused output becomes:

$$E_{ON} = E_N \frac{A}{1 + AB}.$$  
(4)

This is identical in form to the basic gain equation for a feedback loop. Closing a feedback loop around an amplifier, therefore, does not reduce the effects of noise or drift at the input of the first stage.

If we divide Eq. 1 for $E_{OS}$ by Eq. 2 for $E_{ON}$, we get:

$$\frac{E_{OS}}{E_{ON}} = \frac{E_s}{E_N} A_1.$$  
(5)

This is an important relationship—it says that to improve the signal-to-noise ratio of a closed loop, the designer should increase the noise-free gain preceding the point of noise injection. Thus increased gain in early stages can reduce output drift, distortion, power-supply ripple and other noise effects introduced by later stages. The output noise is a factor, $A_1$, less than if the same noise had been injected at the input to the feedback amplifier.

How does this compare with the nonfeedback amplifier? Removing the feedback path from Fig. 4, we get:

$$\frac{E_{OS}}{E_{ON}} = \frac{A_1A_2E_s}{A_3E_N} = \frac{E_s}{E_N} A_1.$$  
(6)

Since this agrees exactly with Eq. 5, it would seem that, with respect to output signal-to-noise...
4. **Noise in the forward path** will be attenuated by preceding gain. But noise at the input cannot be reduced by closing the loop around an amplifier.

ratio, we have gained nothing by using a feedback configuration. However, when a designer is given fixed input and output signal levels and he has an output stage with fixed gain $A_z$ and an associated injected noise source $E_N$, he cannot increase $A_1$ in an open-loop design without overdriving the output. But he can increase $A_1$ in a closed-loop design.

Put another way, the circuit designer is not faced with the alternatives of using the identical building blocks of Fig. 4 in either an open-loop or closed-loop configuration, because two quite different values of over-all gain would result. Instead, the designer is usually faced with a desired output signal level, $E_{os}$, and an available input signal level, $E_s$.

He may choose to use amplifiers $A_1$ and $A_z$ (which presumably have the proper over-all gain to boost $E_s$ to $E_{os}$) in an open-loop configuration, and accept a certain output signal-noise ratio because of an unavoidable noise disturbance, $E_N$.

Alternatively, he may choose to close a feedback loop around the same gain elements, $A_1$ and $A_z$, thus reducing over-all gain by $1 + A_1 A_z B_x$ without affecting the output signal-noise ratio. He can then restore the lost gain and also improve output signal-noise performance by inserting noise-free gain ahead of the noise-injection point.

**Which configuration is best?**

Fig. 5 shows five alternate amplifier configurations. For comparison, all five are assumed to have the same values for $E_s$, $E_{os}$, $E_N$, $A_z$, and $A_x$. Some amplifiers have additional elements in common—for example, the feedback factor $B_x$ and the preamp gain stage $A_z$. Except for the injected noise disturbances, $E_N$, all other elements are assumed inherently noise-free. The designer can proceed by analyzing one noise source at a time and then adding the output effects of all noise sources.

Comparing output equations, we see that the circuit with the preamp outside the loop (Fig. 5b) has less output noise than the open-loop circuit (Fig. 5a) by a factor of $A_x$. Since the two circuits are to have the same over-all gain from input to output, $A_x$ must equal $1 + A_1 A_z B_x$, the factor by which the gain $A_1 A_z$ is reduced when we close the loop with $B_x$. If we move the preamp inside the loop (Fig. 5c), the signal-to-noise ratio is again improved by the preamp factor, $A_y$. Thus compared with the open-loop arrangement, both closed-loop circuits offer an output signal-noise ratio improvement.

Which is the better configuration? If the designer is concerned primarily with output noise reduction, he will most likely choose the circuit with the preamp inside the loop, because it allows higher values of preamp gain. With the preamp outside, and with fixed levels of $E_s$ and $E_{os}$, $A_x$ must equal $1 + A_1 A_z B_x$. With passive elements in the feedback path, $B_x$ is limited to a maximum of unity (in some circuits transformers can permit $B_x$ greater than 1), and $A_x$ is thus limited to a maximum value of $1 + A_1 A_z$.

Even this may not be practical: In high-gain systems unity feedback results in unity voltage
Signal-to-noise ratio is improved by preamp gain factor (5b and 5c). Multiple loops allow higher preamp gain than a single closed loop.

Multiple loops require caution

As more loops are added, or as more gain is used inside the loop, greater demands are placed upon the designer to avoid loop oscillation. Reference 2 contains a useful discussion of design techniques for circuits containing inner (minor) loops.

It is interesting to compare the two-loop configuration with another alternative (Fig. 5e) using the same forward-gain elements, $A_x$, $A_z$, and $A_y$, but with the inner loop closed around input stages preceding the point-of-noise injection. For this circuit, the closed-loop gain of the inner loop is:

$$A'' = \frac{E_{o_x}}{E_{o_t}} = \frac{A_x A_z}{1 + A_x A_z B_u}$$

And the signal-to-noise ratio is:

$$\frac{E_{o_s}}{E_{o_n}} = \frac{E_s A''}{E_N} = \frac{E_s A_x A_z}{E_N 1 + A_x A_z B_u}$$

In comparison, we see that the circuit of Fig. 5e is inferior to that of Fig. 5d with respect to injected noise, $E_N$, by a factor of $(1+A_x A_z B_u)$—usually a large number. The inferior performance results because, in closing the inner loop of Fig. 5e, we have reduced the forward gain preceding the point-of-noise injection.

Probably the single most important feedback noise relation for the designer to remember is

$$\frac{E_{o_s}}{E_{o_n}} = \frac{E_s}{E_N} A_x$$

This equation states that the output signal-to-noise ratio is improved whenever we increase the forward gain preceding the point of noise injection. In interpreting this equation, it is important to recognize that $E_s$, $E_N$, and $A_x$ are, in general, frequency-dependent terms and that the noise improvement at a particular frequency depends upon the values of these terms at that frequency.

Referring to the circuit with the preamp inside the loop (Fig. 5c), we see that if $E_N$ represents a drift or a disturbance caused by temperature effects, then $A_x$ and $A_y$ should have high gain at dc and very low frequencies. If $E_N$ is a wideband noise source or a source of distortion, then it’s important that $A_x$ and $A_y$ have sufficient bandwidth to insure high gain over those frequencies where output noise reduction is desired. For this reason, it is often preferable to place wideband stages ahead of narrowband stages. However, this decision will be influenced by other factors, including the ease with which necessary loop-equalization networks can be inserted at various points in the forward-gain path.

In any case, the designer will do well to check the open-loop signal vs frequency profile at the input to each stage to see if there are frequencies at which the signal level is lower than at the input to the first stage, or low compared with potential noise sources present in each stage. ••

References


NEW ECL
1024-BIT RAM
ISOPLANAR
DID IT AGAIN
The 95415: 1024 x 1 bit ECL.  
45ns access time at 0.5mW per bit.

For designers of very high speed ECL systems, here's a 1024-bit RAM that can operate at speeds compatible with those of their system’s logic. The 95415 features 15ns chip select time, full ECL compatibility, emitter follower outputs for ease of memory expansion, and decreasing power dissipation with rising temperature.

Because the 95415 is static, it’s simple to use and requires no peripheral electronics. And because of its functional density, designers can save significant costs by reducing package count, circuit board number and size, number of connections and by increasing system reliability.

This fastest of all 1K RAMs is available now in limited quantity—in 16-pin hermetic DIP—from your friendly Fairchild distributor. The cost: $109 (1-24) or $100 (25-99).

New Applications
The isoplanar process introduces very high speed operation at near MOS densities, opening up exciting new applications such as:

- Fast writeable control store for microprogramming, adding flexibility and eliminating the need for fixed ROMs.
- Large high-speed scratchpad to make multiprocessing more feasible.
- Simulation of long high-speed shift registers.
- Improvements of buffer or cache memory performance by increasing capacity without any power or size trade-off.
- Building cost-effective high-speed mainframe memories.

The fastest of all 1K RAMs is available now in limited quantity—in 16-pin hermetic DIP—from your friendly Fairchild distributor. The cost: $109 (1-24) or $100 (25-99).

Isoplanar Memory Line-up

<table>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>ORGANIZATION</th>
<th>ACCESS TIME (ns)</th>
<th>SELECT TIME (ns)</th>
<th>POWER (mW/bit)</th>
<th>INPUT LOADING</th>
</tr>
</thead>
<tbody>
<tr>
<td>93410 TTL</td>
<td>256 X 1</td>
<td>45</td>
<td>25</td>
<td>1.8</td>
<td>0.5 U.L.</td>
</tr>
<tr>
<td>93410A TTL</td>
<td>256 X 1</td>
<td>25</td>
<td>20</td>
<td>1.8</td>
<td>0.5 U.L.</td>
</tr>
<tr>
<td>93415 TTL</td>
<td>1024 X 1</td>
<td>60</td>
<td>30</td>
<td>0.5</td>
<td>0.25 U.L.</td>
</tr>
<tr>
<td>95410 ECL</td>
<td>256 X 1</td>
<td>25</td>
<td>7</td>
<td>1.8</td>
<td>50KΩ Typ.</td>
</tr>
<tr>
<td>95415 ECL</td>
<td>1024 X 1</td>
<td>45</td>
<td>15</td>
<td>0.5</td>
<td>60KΩ Typ.</td>
</tr>
</tbody>
</table>

Whatever your memory needs, you could well find the answer among these devices. Call your Fairchild distributor or the factory for prices and availabilities.
Keep front-end noise figures low 
with a tradeoff of filter bandwidth and loss. 
Simple low-cost components will do the job.

One of the major design problems in building microwave receiver front-ends is keeping the noise figure of the front-end elements from degrading the performance of the receiver system. This consideration becomes especially important when a phase-locked loop is used in the receiver system to detect very low-level input signals—as, say, in deep-space probe applications. The phase-locked loop sensitivity advantages can easily be nullified by high noise margins.

A simple way to solve the problem, using easy-to-build inexpensive elements, is to tradeoff bandwidth and insertion loss in the front-end filter elements shown in Fig. 1. In general, filter insertion loss decreases as the filter bandwidth increases. If the filter is placed in front of the preamplifier serving as a preselector, its loss adds directly to the noise figure.

Accordingly, if the preselector bandpass filter is built to have a large bandwidth (and low loss), an image-rejection filter can be used to narrow the bandwidth to meet the receiver specs. The image-rejection filter’s loss will have a minimal effect on noise figure, since this filter follows a preamp stage.

Here’s an example: An S-band phase-locked loop receiving system is required to detect signals in the range -60 to -145 dBm. The noise figure of the front-end subsystem must be held to 6 dB; its power consumption, below 200 mW. Also the image rejection should be greater than 10 dB, while gain is specified at 13 dB.

Gain tradeoff

In order to meet the gain requirement, the filter-amplifier combination should provide 20-dB gain. This allows a reasonable 5.5-dB loss in the mixer stage, leaving an over-all 14.5-dB gain for the front end—or 1.5 dB more than specified. To meet the power requirement, the amplifier—the only element using dc power—can be limited to 120-mW dissipation.

For the individual elements in the front-end receiver, let’s start with the filters.

Microwave filters using a coaxial comb-line structure are selected for our design since they can be tuned over a wide range of frequencies without suffering serious deterioration in performance. An S-band comb-line filter can be tuned over a frequency range of as much as 200% of the design frequency. Moreover, they are relatively inexpensive to build.

An alternative choice could have been a bandpass filter on a high dielectric substrate in a microstrip or stripline configuration. While this approach could provide additional size and weight reduction, it suffers from possible filter detuning due to mechanically and thermally induced stress on the dielectric substrate. The dielectric constant of the substrate can also change with time and temperature. Therefore, a high-grade dielectric substrate material would be necessary.

Furthermore, microstrip and stripline filters are not easily tuned and require very close tolerances in their fabrication. While the microstrip or stripline filter pattern is being etched on the dielectric substrate, any variations in the etching process can seriously degrade the filter bandpass characteristics. When dimensional tolerances and temperature variations significantly affect the performance of highly selective bandpass filters, yield becomes an additional problem.

A five-pole comb-line filter, covering the 1.2-to-3.0 GHz frequency range, serves as the basic filter design for the preselector. A similar three-pole comb-line filter provides additional image rejection. The five-pole filter has a 4 to 6% bandwidth at the 1-dB points and a 10 to 14% bandwidth for the 30-dB points. Tuning screws placed at the comb-line filter input and output ports help compensate for mismatches of up to 3:1.

Select the amplifier

For the preamplifier, a low-noise three-stage microstrip amplifier can readily be built with

George D. O'Clock Jr., Senior Member, Engineering Staff, RCA Advanced Technology Labs, 8500 Balboa Blvd., Van Nuys, Calif. 91409.
high performance transistors and carefully chosen input-output matching and interstage coupling circuits. The resulting microwave amplifiers can yield high gain, excellent stability, and low dc power consumption.

Moreover, microwave transistors with noise figures of 3.0 dB and gains of 10 dB at 2.0 GHz are currently available for as little as one third the price they were two or three years ago.

A basic two-stage low-noise microwave amplifier design, shown in Fig. 2, includes a microstrip quarter-wave input matching network on an alumina substrate. The two-stage amplifier uses Nippon Electric (NEC) 2N5761 transistors with Erie Filtercons serving as bypass and dc-isolation elements.

An exact analysis for precise determination of microstrip dimensions is difficult, and the low unloaded Qs of the transmission-line method of amplifier design cause some difficulty in optimiz-
2. Adding an extra stage to this two-stage microstrip amplifier results in the three-stage low-noise amplifier used in the front-end receiver design. Performance characteristics are fairly insensitive to small changes, due to the effects of temperature and aging, in the substrate dielectric constant.

Branch-line vs rat-race mixer

In the selection of mixers, the choice generally narrows down to either a 90° (branch line) hybrid or a 180° (rat-race) hybrid coupler (Fig. 3). These are two of the most popular mixer configurations for S and C-band applications. The 180° hybrid mixer has the advantage of wider bandwidth, better isolation and lower VSWR compared with the 90° hybrid mixer configuration. While the 90° hybrid is smaller, the 180° hybrid mixer is selected for its electrical advantages.

Another important advantage is the rat-race mixer's reliability and reproducibility—it's almost impossible to make one that doesn't work. The rat-race mixer configuration also exhibits reciprocity: It can be operated as an up-converter with the same loss that it possesses as a down-converter.

Our front-end design uses a stripline configuration for beam-lead hot-carrier diode mixing elements in a 180° hybrid mixer. Due to third-order nonlinearities and gain saturation, the preamplifier and mixer will have intermodulation products (IM) that cannot be filtered.

For a preamplifier input signal of −30 dBm the mixer input signal is approximately −10 dBm. The mixer and preamplifier third-order IMs are almost equal at the i-f amplifier input, and are approximately 50 dB below the carrier.

Image-band noise can be suppressed by the preselector. Additional image-band noise suppression is provided by the image-rejection filter at the mixer input-port.

Design the local oscillator

Finally, with the ideal local-oscillator power to the matched pair of hot-carrier mixer diodes of approximately +7 dBm, several stages of frequency multiplication are generally required in a conventional oscillator-frequency multiplier chain. The various types of available varactor and charge-storage diodes have parametric effects that enhance frequency multiplication. Although conventional transistors offer gain, the efficiency of
3. The most popular microwave mixers are the 180° (rat-race) hybrid coupler (a) and the 90° (branch-line) hybrid coupler (b). The design described uses the rat-race hybrid with beam-lead, hot-carrier, diodes as the mixing elements. The coupler selected provides wider bandwidths, better isolation and lower VSWR.

a conventional transistor amplifier beyond a ×4 frequency multiplier is low compared to a varactor frequency multiplier.

However, some of the “new generation” transistors also exhibit parametric effects that provide very efficient—up to ×10—frequency-multiplication thus limiting the number of stages required in the multiplier chain and reducing the over-all power requirement.

References:


Bibliography:


**ANALOG ENGINEERS — We haven’t forgotten you. Accutronics has not devoted all its engineering talents to digital devices which are compatible with TTL, ECL, MECL and COS/MOS logic. In our standard product line we carry a complete line of SINE WAVE oscillators from 1 Hz to 250 MHz. Take for example our Series 110 which is neatly packaged in a 1.5 x 1.5 x 1.5 hermetically sealed can and available from 10 MHz to 250 MHz with +10dbm out into 50Ω. GREAT for your analog application.

INTERESTING? Call Dennis Griffin (312) 232-2600, and he will be glad to fill you in on all the details and send you our new catalog.**
The Kokomoans now give you Darlington Switching Power.

Use a Darlington in place of an ordinary transistor, and you'll realize an additional magnitude of gain plus increased switching power. Use a Delco silicon power Darlington (DTS-1010 or DTS-1020) and you'll also realize a gain in dependability.

Delco's Darlington are triple diffused mesa units housed in copper TO204MA cases and built for ruggedness. The design gives them high energy capability—the ability to handle surges of current and voltage simultaneously. They are ideal for switching inductive loads in circuits subject to transients or fault conditions.

Design a switching regulator circuit around a Delco Darlington or use it in any 60-100 volt application to reduce circuit size, weight, and cost. In addition, the Darlington space saving feature allows you more design flexibility. Unlike an ordinary transistor, it's only energy-limited, not beta-limited. You can exploit its full energy capability in your circuit.

Call your nearest Delco distributor. He has them in stock and he's got the data on high energy switching for small spaces.

For details on the switching regulator circuit, ask for Application Note 49.

Delco Electronics
DIVISION OF GENERAL MOTORS CORPORATION.
KOKOMO, INDIANA

Now available from these distributors in production quantities.

ALABAMA, BIRMINGHAM • Forbes Distributing Co., Inc. (205)-251-4104
ARIZ., PHOENIX • Sterling Electronics (602)-258-4381
CAL., LOS ANGELES • Kierulf Electronics, Inc. (213)-988-5511 • Radio Products Sales, Inc. (213)-748-1271
CAL., PALO ALTO • Kierulf Electronics, Inc. (415)-988-6203
CAL., REDWOOD CITY • Cramer/San Francisco, (415)-365-4000
CAL., SAN DIEGO • Radio Products Sales, Inc. (714)-292-5611
CAL., SAN DIEGO • Kierulf Electronics, Inc. (714)-278-2112
COLORADO, DENVER • Cramer/Denver (303)-758-2100 • Denver Walker Electronics (303)-985-2401
CONN., NORWALK • Harvey/Connecticut (203)-853-1515
FLA., MIAMI SPRINGS • Powell/Gulf Electronics (305)-886-8761
FLA., ORLANDO • Powell/Gulf Electronics (305)-859-1400
ILL., ROSEMONT (Chicago) • Kierulf Electronics (312)-578-8560
ILL., SROKIE (Chicago) • Menquip Electronics (312)-292-4400
INDIANA, INDIANAPOLIS • Graham Electronics Supply, Inc. (317)-634-8202
INO., BALTIMORE • Radio Electric Service Co. (301)-883-2675
MASS., NEWTON • The Greene-Shaw Co., Inc. (617)-989-8900
MICH., ROMULUS • Harvey-Michigan (313)-723-5000
MINN., MINNEAPOLIS • Stark Electronics Supply Co. (612)-332-1325
MO., KANSAS CITY • Walters Radio Supply, Inc. (816)-531-7015
MO., ST. LOUIS • LCOMP-St. Louis, Inc. (314)-647-5005
N.J., CLIFTON • Eastern Radio Corporation (201)-395-2600, (212)-944-8800
N.Y., BINGHAMTON • Harvey/Federal (607)-748-8211
N.Y., EAST SYRACUSE • Cramer/Eastern (315)-485-6671
N.Y., ROCHESTER • Cramer/Rochester (716)-270-0300
N.Y., WOODBURY • Harvey/New York (516)-921-8700, (212)-582-2590
OHIO, CINCINNATI • United Radio, Inc. (513)-781-4930
OHIO, CLEVELAND • Pettison Supply (216)-441-3000
OHIO, DAYTON • Kierulf Electronics (513)-278-9411
OKLA., TULSA • Radio, Inc. (918)-587-9213
PENN., PHILADELPHIA • Alno Electronics (215)-746-6000
PENN., PITTSBURGH • RPC Electronics (412)-782-3770
S.C., COLUMBIA • Dixie Radio Supply Co., Inc. (803)-253-5330
TEXAS, DALLAS • Adleta Electronics Co. (214)-741-3151
TEXAS, PORT WORTH • Adleta Electronics Co. (817)-256-7444
TEXAS, GARLAND • Kierulf Electronics, Inc. (214)-371-2471
TEXAS, HOUSTON • Harrison Equipment Co., Inc. (713)-224-9131
UTAH, SALT LAKE CITY • Cramer/Utah (801)-877-3881
VA., RICHMOND • Meridian Electronics, Inc. • Sterling Electronics Company (703)-353-6648
WASH., SEATTLE • Kierulf Electronics, Inc (206)-763-1350
WASH., TACOMA • Cramer/Electronics Co. (206)-744-3181
ALL OVERSEAS INQUIRIES:
CANA DA, ONT., SCARBOROUGH • Lake Engineering Co., Ltd. (416)-751-5980
ALL OVERSEAS INQUIRIES:
Delco Electronics
DIVISION OF GENERAL MOTORS CORPORATION.
KOKOMO, INDIANA

INFORMATION RETRIEVAL NUMBER 34

S.C., COLUMBIA • Dixie Radio Supply Co., Inc. (803)-253-5330
TEXAS, DALLAS • Adleta Electronics Co. (214)-741-3151
TEXAS, PORT WORTH • Adleta Electronics Co. (817)-256-7444
TEXAS, GARLAND • Kierulf Electronics, Inc. (214)-371-2471
TEXAS, HOUSTON • Harrison Equipment Co., Inc. (713)-224-9131
UTAH, SALT LAKE CITY • Cramer/Utah (801)-877-3881
VA., RICHMOND • Meridian Electronics, Inc. • Sterling Electronics Company (703)-353-6648
WASH., SEATTLE • Kierulf Electronics, Inc (206)-763-1350
WASH., TACOMA • Cramer/Electronics Co. (206)-744-3181
ALL OVERSEAS INQUIRIES:
CANA DA, ONT., SCARBOROUGH • Lake Engineering Co., Ltd. (416)-751-5980
ALL OVERSEAS INQUIRIES:
Get a statistical analysis in seconds
with this inexpensive Fortran program. It provides
tabulations, summaries and variance estimates.

Whether you are evaluating a batch of resistors or checking a worst-case design, you can have a detailed statistical analysis of a mass of measurement data within seconds with a simple, penny-pinching Fortran program (Fig. 1). It arrays the data in ascending order, then computes the mean, median, range and standard deviation. The data are also summarized by their distribution within class intervals. A glance at the printout suffices to check on the homogeneity, tolerance and precision of the input data.

Preparation and running times vary, of course, with the quantity of data. For the example cited here—200 resistance measurements—15 minutes are required for keypunching the data, and 0.675 seconds for executing the program on a Univac 1108 computer. The cost of the run: about 20 cents.

Key statistical data are extracted

Measurement results are read into the program by means of punch cards. The program sorts the values into ascending order, and the sorted values are used to compute the following data:
- Lower and upper measurement limits.
- Arithmetic mean.
- Median.
- Standard deviation (sigma).
- Percentages of measurements that lie within the one, two and three-sigma limits about the mean.
- Frequency distribution for the measurements.

From these, the user can judge tolerance, see if the mean lies within acceptable bounds, decide whether the variance is excessive, set confidence limits for population tolerance and judge symmetry by comparing the mean and median.

The distribution tabulation is useful in determining the quality of the data. For example, the presence of two peaks may indicate two causative factors or a lack of sample homogeneity.

Finally, and perhaps most important, the convenient summary makes it easier to decide on the sample size needed for future tests. In many cases the reduced expenditures for test effort readily offset the costs incurred in preparing and using the program.

Preparation is straightforward

Before the program of Fig. 1 can be used, the engineer must prepare a source deck. Once it has been punched, the only remaining task is to supply the job-control and data cards containing the measurement values.

Input 10 values per card

To illustrate how the program can be used, a sample of two hundred 1000-Ω 10 percent resistors was measured to four significant figures on a General Radio 650A bridge. Computer statement 0010 (refer to the numbers in the left margin of Fig. 1) is the READ statement, and statement 0011 is its corresponding FORMAT statement. The FORMAT statement indicates that the first data card must contain the numerical value of N, the number of data values.

The remaining data cards must supply the measured (resistor) values, 10 items per card and each in E8.4 format. Fig. 2 shows three of the data cards for this 200-resistor example. The first data card indicates that the value of N, which must be right-justified, equals 200. The second data card gives the values of the first 10 resistor measurements, and the third data card the values of the next 10. The remaining 18 data cards are not shown.

Program operation is easy to follow

Since Fortran algebraic statements are used for arithmetic, readers should be able to follow the operation quite easily.

B. James Ley, Professor, New York University, Bronx, N.Y. 10453.
EVALUATION OF INSTRUMENT MEASUREMENTS.

DIMENSION VALUE(20), DIST(20)

READ INPUT DATA
   N = NUMBER OF DATA VALUES,
   VALUE = AN ARRAY FOR STORING MEASURED VALUES.

READ(5,1)(VALUE(I), I=1,N)

1 FORMAT(15/((10E8,4I1))

DETERMINE SMALLEST VALUE, LARGEST VALUE, AND MEDIAN VALUE.

LIMIT=N/2+1

Do 10 I=1,N

SMALL=VALUE(I)

K=1

Do 20 J=1,N

IF(SMALL=VALUE(J))2Q,2Q,30

J=K+1

SMALL=VALUE(J)

20 CONTINUE

IF(K=LIMIT)4Q

40 VALUE(K)=VALUE(LIMIT)

10 CONTINUE

IF(N-N/2.2150,50,60

50 AMEDJA=VALUE(LIMIT)

60 CONTINUE

DETERMINE AVERAGE OR MEAN VALUE,

SUN=0.

Do 100 I=1,N

100 SUM=SUM+VALUE(I)

AVE=SUM/N

DETERMINE STANDARD DEVIATION.

SQR01F=0.

Do 100 I=1,N

100 SQR01F=SQR01F+VALUE(I)-AVE*

SQR01F

DETERMINE PERCENTAGE OF MEASUREMENTS WITHIN ONE,

TWO, AND THREE STANDARD DEVIATIONS.

STD1=0.

STD2=0.

STD3=0.

Do 120 I=1,N

120 CONTINUE

IF(ABS(VALUE(I)-AVE)-SIGMA=130,130,140

130 ST01=ST01+1.0

140 IF(ABS(VALUE(I)-AVE)-2.*SIGMA=150,150,160

150 ST02=ST02+1.0

160 IF(ABS(VALUE(I)-AVE)-3.*SIGMA=170,170,180

170 ST03=ST03+1.0

180 CONTINUE

PER1SD=ST01/N

PER2SD=ST02/N

PER3SD=ST03/N

PRINT ORDERED INPUT DATA.

WRITE(6,2)N(VALUES(I), I=1,N)

2 FORMAT(1'EVALUATION OF INSTRUMENT MEASUREMENTS',///,'NUMBER OF

MEASUREMENTS = ',5X,' MEASURED VALUES:',///,'5F10.4')

PRINT LOWEST VALUE, HIGHEST VALUE, MEDIAN VALUE, MEAN VALUE,

STANDARD DEVIATION, AND PERCENTAGE OF MEASUREMENTS WITHIN ONE,

TWO, AND THREE STANDARD DEVIATIONS.

WRITE(6,3)VALUE(I), N(VALUES(I), I=1,N), AMEDIA, AVE, SIGMA, PER1SD, PER2SD, PER3SD

3 FORMAT(1'I1','X','LOWEST VALUE = ',E19.5,' HIGHEST VALUE = ',E19.5,

12X,' MEDIAN VALUE = ',E19.5,' MEAN VALUE = ',E19.5,' STANDARD

20 DEVATION = ',E19.5,' PERCENTAGE OF MEASUREMENTS WITHIN ONE SIG

3 MA = ',F5.1,' PERCENTAGE OF MEASUREMENTS WITHIN TWO SIGMA = ',F5.

41,' PERCENTAGE OF MEASUREMENTS WITHIN THREE SIGMA = ',F5.1)

COMPUTE DISTRIBUTION OF MEASURED VALUES.

NUMA=20.

SMALL9990.

STEP=5.0.

Do 180 I=1,NUMA

180 DISTRIBUTION(I)=0.

Do 190 J=1,NUMA

190 DISTRIBUTION(I)=DISTRIBUTION(I)+1.0

WRITE(6,4) DISTRIBUTION(I), I=1,NUMA

4 FORMAT(1'EVALUATION OF INSTRUMENT MEASUREMENTS','///,'NUMBER OF

MEASUREMENTS BETWEEN ',5X,' AND ',5X)

A(0)

Do 200 I=1,NUMA

200 A(I)=A(I)+STEP

WRITE(6,5) A(I), I=1,NUMA

5 FORMAT(1'I1','X',' A',I10.0)

STOP

END

1. Fortran program sorts the input data into ascending order and then computes the range, mean, variance and frequency distribution.
Computer statements 0015 through 0032 rearrange the input values so they are in ascending order. The lowest, highest and median value can then be determined.

The median value is defined as the middle datum after the measured values are arranged in ascending order. If N is even, this definition does not work. Computer statement 0028 is therefore used to determine if N is even or odd. In those cases where N is found to be even, the median value is set equal to the average of the two measured midvalues (see computer statement 0029).

Computer statements 0036 through 0039 determine the average or mean measured value, 0043 through 0047 the standard deviation, 0052 through 0065 the percentage of measurements within one, two, and three standard deviations, and 0086 through 0093 the distribution of the measured values.

Computer statements 0069 through 0071 print measured values in IS format. This sample deck shows the values punched for the first 10 measurements.

Use the normal distribution as a guide

The printout in Fig. 3 indicates that this particular set of 1000-Ω 10% resistors had actual values ranging from 992 to 1088 Ω rather than the expected 900 to 1100 Ω.

In the purchase of any component the user will rarely find that the measured values range from the nominal value minus the tolerance...
3. The first printout shows the input data rearranged in ascending order.

\[ (1000 - 100 = 900) \] to the nominal value plus the tolerance \( (1000 + 100 = 1100) \). Note also that the mean value of 1035.6 \( \Omega \) and the median value of 1035.5 \( \Omega \) (Fig. 4) differ from the nominal value of 1000 \( \Omega \). Since in this example the mean and median values are essentially the same, this shows very little skew in the input data.

The standard deviation, \( \sigma \), is given by

\[
\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (\text{Value}(i) - \text{AVE})^2},
\]

where \( N \) is the number of measurements and AVE is the mean (average) value. Variance, \( \sigma^2 \), is a measure of the dispersion of the measured values and is defined as the average of the square of all off-averages. For a very large number of measurements, a Normal distribution should be expected. The Normal distribution is given by the expression

4. Continuation of printout summarizes the statistical characteristics and lists the frequency distribution. The intervals for the distribution are set by the user.

5. Normal (Gaussian) distribution, defined by this curve forms an estimate of the population percentages that fall within one, two or three standard deviations from the mean. At least 30 data points are necessary.
Two Top Choices

Frequency Synthesizer

- 1 kHz to 80 MHz in 1 kHz Steps
- 1 Hz Resolution Optional
- Fully Programmable

PRD 7828 is offered with 1 kHz phase-locked steps. An optional vernier provides 1 Hz resolution. The RF-828 is fully programmable with contact closures, RTL, DTL or TTL logic.

Or

Synthesized Signal Generator

- AM/FM/Pulse Modulation
- Manual and Automatic Sweep
- 160 db Output Level Range

PRD 7808 is three instruments in one: signal generator and frequency synthesizer and sweeper. Frequency range is 0.05 to 80 MHz in 1 kHz phase-locked steps with a vernier for 1 Hz resolution. Frequency, modulation and attenuation are programmable.

Applications
Automated Test Systems • General Lab Use • Computer-Controlled Signal Sources • Semi-Automatic Test Systems • Receiver and Transmitter Systems • Nuclear Magnetic Resonance • Crystal Calibration and Resonance

Where $\overline{X}$ is the mean value, $\sigma$ is the standard deviation and $\sigma^2$ is the variance. Thus, for a large number of measurements, most of them will cluster about the mean value $\overline{X}$, and the probability distribution of the measured value $X$ will approach the Normal distribution shown in Fig. 5. Note, from an examination of Fig. 5, that if a measurement being made is Normally distributed, 68.26% of the sample values will fall between $±\sigma$ of the mean, 95.46% between $±2\sigma$ of the mean value and 99.74% between $±3\sigma$ of the mean value. For the $\sigma$ of 16.60 (Fig. 4), the percentages of resistors computed within one, two and three standard deviations of the average value show that the input data in this example had an essentially Normal distribution.

Choose SMALL, STEP and NUMB

Values for SMALL, STEP and NUMB are fixed in statements 0086 through 0088 as 20, 990 and 5.0 respectively. The value of NUMB represents the number of incremental steps in the distribution and according to Sturgess' rule should be at least equal to

$$\text{NUMB} = 1 + 3.322 \log_{10} N.$$  

SMALL represents the value of the lowest measured value, and STEP represents the numerical value of the incremental step. In initially running the program, SMALL was set equal to 900—the smallest value expected. The first run showed that the values ranged from 992 to 1088 $\Omega$ rather than 900 to 1100 $\Omega$, as originally expected. Resolution was improved by setting SMALL to 990 and STEP to 5.0—that is, the user chooses the final values of STEP and SMALL after at least one trial run. The rule used is:

largest value $= \text{SMALL} + (\text{NUMB} \times \text{STEP})$.

Extend your options

Many other types of parameter measurements—for example, inductance, slew rate, $h_{fe}$, capacitance or computer-job throughput—can be evaluated by this program. Supplying the appropriate data is all that is necessary. The array, VALUE, must be redimensioned to the largest number of points used, if that number exceeds 200. It is also a simple matter to use the program as a subroutine, so long as NUMB, SMALL and STEP are supplied as argument values along with measured data values. When small numbers of points, say less than 30, are being inputted, it is advisable to add corrections to the standard deviation computation (statements 0042 to 0047).
INTRODUCING
THE EA 1502 BIPOLAR
COMPATIBLE 1024-BIT RAM

The EA 1502 is another new addition to the growing line of N-Channel silicon gate products from EA. The EA 1502 accepts TTL inputs without external level shifting and sinks 1.6 mA on the output. It has an access time of typically 130 nanoseconds and dissipates only 115 mW (typical). In fact, in a systems configuration the EA 1502 outperforms the so-called high performance versions of the 1103, with lower power, bipolar compatibility, automatic refresh and low cost to boot! Oh yes, there’s no address cycling requirements either. A single write pulse refreshes all data independent of the state of the address and chip enable inputs. Place your order early, everyone else is. $27.50 in 100 quantities.

To make it easier for you to evaluate our EA 1500 series RAM’s, we have an evaluation P.C. board available which contains all of the necessary interconnections for building a 2K by 4 memory. Ask about it!

MORE FROM THE
VERY SAME FOLKS
WHO BROUGHT YOU
N-CHANNEL
SILICON GATE.
Cut the testing time of digital circuits
with a straightforward programmable clock that
can be built with a few inexpensive ICs.

When testing digital circuitry, the engineer
often finds it convenient to be able to run the
system clock either continuously or in single
pulses. If the circuit doesn’t function properly
with the normal running clock, he can usually un­
cover the trouble by single-stepping the clock
with a pushbutton. But this can pose problems.

The engineer’s finger may get pretty tired
pushing the button, say, 1024 times. This could
occur when he’s single-stepping through a 1024­
bit shift register (to insure that the data in are
the same as data out, or to check what is happen­
ing at a certain point in time, such as 4096 clock
pulses after initialization).

To relieve finger fatigue, and to cut testing
time, try building a simple programmable clock
with readily available components.

How the clock works

The programmable clock (“clock” in the dia­
gram) operates in two modes—automatic or
manual. In the automatic mode, it runs continu­
ously. In the manual mode, the operator selects
the number of pulses and pushes the button. The
selected number of pulses are then generated.

The clock uses a binary down counter (Fig.
1a). While TTL is used here, the same basic ap­
proach can be used with any type of logic. The
manual clock can be a pushbutton, with a latch
to prevent jitter due to contact bounce (Fig. 1b).
Assuming a positive pulse from the manual clock,
and with the mode switch in the AUTO position
(thus clearing FF1, the clock should produce
continuous clock pulses at the output.

When the mode switch is flipped from AUTO
to MANUAL, FF1 will still be cleared and will
allow the clock to pass through G1 until the count
reaches zero. At this point the ripple output of
the counter presets FF1 (Fig. 2), inhibiting G1.

The desired binary number is inserted with the
toggle switches (Fig. 1a). Logical ONE is repre­
sented by +5 V. Logical ZEROs are represented
by 0 V (ground), because this is the simplest
and most straightforward method. The manual
clock loads the selected number into the counter.
FF1 synchronizes the manual clock with the
clock. The output of FF1, clears FF2, to allow the
clock to pass through G1, until the count again
reaches zero. Note that the inverted clock passes
through G1 (Fig. 1a). If the clock were sent to
G1 in the same phase as that used to clock FF2,
the delay due to FF1 and FF2 would allow only
part of the first clock pulse to pass through G1.

Use an up counter instead of a down counter

Figure 3a depicts a schematic of a program­
mable clock built with an up, rather than a down,
counter. Actually this scheme is very similar to
that of Fig. 1a, using the same number of ICs.

The idea behind this approach is to load the
counter with the complement of the necessary
binary number. Then the maximum count of the
counter will be reached with the desired number
of pulses. If the full capacity of the counter is
not being used, the MSB+1 can be employed to
inhibit any further clock pulses to the output,
since this bit changes state after the maximum
count is reached. If the full capacity of the
counter is used, the terminal count on the “most
significant” IC can be used.

Here is why the number to be loaded into the
counter should now be the complement of the
desired binary number minus one:

Suppose the maximum count available is 511
and the number of desired clock pulses is 3. The
complement of 3 is (511 - 3) = 508, and this is
the number to be loaded into the counter with
the toggle switches.

Since the counter counts up, the count of 511
will be reached with three clock pulses. But it
will take an extra clock pulse to bring the
MSB+1 (at Q1 in Fig. 3a), high to inhibit fur­
ther clock pulses. Thus four clock pulses would
pass through G1 in this case, not three.

Flip-flop FF1 not only synchronizes the manual
clock with the clock, but because of the loading
procedure of the 9316 counters (the leading edge
of C, must occur while PE is high and the falling
edge must occur while PE is low), FF1 and G1
provide the necessary delay and inversion for Cp.
FF2 synchronizes the clock with MSB+1. 

James S. Burrill, Electrical Engineer, Sanders Associates,
1. Clock-pulse counts up to 512 can be obtained with this circuit (a). Larger pulse counts can be obtained by adding more SN-74191s. A simple circuit (b) eliminates switch-contact bounce.

2. Four clock pulses are obtained from the programmable clock of Fig. 1a by presetting it to 4 with the toggle switches. The continuous clock can be derived either from the system clock or from an external source.

3. A different version of the programmable clock is built with up, rather than down, counters. Note that it uses the same number of ICs as the circuit of Fig. 1a but that now, instead of presetting the actual desired number of clock pulses, its complement is preset. Thus presetting this counter to 508 (the complement of 3) produces four clock pulses (b).
You name it—we have the exact cermet resistor network size and characteristics you need. Here's the choice you get right now: our 750 line includes: .100" centers with 4, 6 & 8 pins; .125" centers with 2, 4, 6 & 8 pins; and .150" centers with 4 through 13 pins. And we're working on new designs right now!

All compact, extremely stable and highly reliable. Recently we packed even more circuitry into our 760 series, giving you a choice of four popular space-saver packages: 8, 14, 16 and 18 flat lead styles. Packed with up to 17 resistors per module with flat leads standard (round leads on request).
Our broad line provides an infinite number of circuit combinations, all with excellent TC, load and temperature characteristics supported by millions of hours of reliability testing. Ask your CTS sales engineer for data. Or write CTS of Berne, Inc., Berne, Indiana 46711. Phone (219) 589-3111.

A world leader in cermet and variable resistor technology.
Cultivate a budding manager this year.
Management-bound engineers require recognition and guidance to grow; supervisors can help to develop their attitudes and methods.

How do you recognize and cultivate a budding manager? For us it starts when we recruit people. We put them before a technical committee that shoots them questions. Although we haven't yet learned to adequately assess each person's management ability at this stage, we do get an idea of their behavior and confidence under pressure.

To help bring out some of the interviewee's qualities, we conduct a two-way interview. We figure that if the engineer is willing to be tested, the man doing the testing should be willing, too. Aside from the usual questions about the company's training program, educational benefits, and facilities, we expect a really sharp candidate to ask us direct questions like:

- What can I learn from you as a manager?
- You guys haven't capitalized much in the past two years; are you serious about being in this business?
- You talked about acquisition strategies; what other businesses might you get into that could enhance my career?

After we hire a man, we look for him to make an individual technical contribution. We challenge him immediately to use his school course work to design whatever product the company is engaged in. Of most interest to us concerning an engineer who shows managerial ability is how he handles his aides; how he accepts responsibility for the work of others; and how flexible he is.

Human relations the first benchmark

The first benchmark in an engineer's career is the way he handles the aide or two who assist him. Some technicians are engineers in their own right; they're sort of the mustangs of the industry. A prospective future manager can learn quite a lot from these guys if he keeps his mind open to suggestions.

But he also has some decisions to make at this point. When the time comes for merit review, the engineer will have to say whether his aides have performed well or performed poorly. This is the first time management ability, manifests itself. It's very easy in that situation to become friends instead of a supervisor. It's very easy to call in Charlie and say, "Well, you've done well the past six months, so I'm giving you a ten percent raise." If management buys that, then Charlie's going to be happy. But if Charlie's a thinking guy, he might say to himself: "This guy's a pushover. I sat on my duff half the time and still got a raise. I think I'll try it three-quarters of the time and see if I can get away with it." Very often engineers strike out as managers at this level because they can't separate friendship from business.

That's one aspect of the management of technicians. Another is, can our prospective manager plan an efficient work load for his aide(s)? What does he do? Does he sit in his office and not worry about what Charlie is doing? Does he pass his designs out in well-documented form and tell Charlie to construct this bread board or perform these tests or take this data and return it to him so they can talk about it. Or does he go out and sit at the oscilloscope and do the work himself?

Don Sorchych, Vice President, General Manager, Harris Semiconductor, Melbourne, Fla. 32901
while Charlie is watching over his shoulder, forcing the company to pay two salaries for one man's work? Perhaps engineers shouldn't try to use the argument that they're teaching Charlie when at this stage in their development, Charlie is the one who could probably do the teaching.

The supervisor at the next level of management must be very sensitive to the fact that his subordinate is developing management attitudes and methods. If the engineer is left to his own devices, he might pick the wrong ones.

**Learning how to take the blame**

The next position in the evolution of this prospective manager is project leader or project engineer. At this point he will have a small group of technicians and engineers and various equipment and resources under his control to carry out a well-defined mission to develop a product.

Now his decisions become tougher because he has professional engineers to supervise in addition to other employees. He has to learn to evaluate these people, judge them, develop them, and be responsible for their work.

Accepting blame is another crucial step in the making of the engineering manager because it's very difficult for him to accept responsibility for work that's not his. It just doesn't seem to be just. But he learns that the buck has to stop somewhere and if he assigns responsibility to a man for a project, he gets both the credit and the blame. In management, that's justice.

The man's supervisor should be very close to what's going on and help him develop his management skills through constructive criticism. I think that project engineering is a critical test of a man's management ability because there are many disparate parts to pull together. The project is an important function to any company, and if a fellow is an outstanding project manager, you can usually recognize that he is going to be a good manager well up into the management ranks, perhaps even up to corporate management.

**Overcoming the overlay**

As there are different kinds of projects, so are there different kinds of management methods to control them. The most complicated of these management methods is called "functional with overlay." In this case, the project engineer has to answer two bosses: the functional manager, who operates the project, and the overlay manager who protects the customer interest and integrates the whole program. Overlay management integrates the resources of a common goal. The project engineer's responsibility may be one specialized element of a total project; he's one key on the schedule path, and he has to perform to that time and dollar limit and so on.

His flexibility will be given a tough test because he, like most people, has been used to answering to only one boss.

An overlay management situation is frequently a source of conflict, particularly with new engineers; they don't understand the concept and they find it difficult to accept. So here, too, is another fork in the road to management. Which direction the project engineer takes depends on his ability or determination to overcome the situation.

Higher management requires the ability to judge scheduling, what's possible with the resources available, and a thorough knowledge of the technological hurdles to overcome. The higher a manager goes the more likely he is to deal with the customer. So, he'll need to develop some marketing knowhow. He should also avail himself of specialized tools such as legal counsel or contract management. He'll need these people to make sure he's staying within the law, within the terms of the contract.

As a supervisor who has been responsible for the development of many up and coming management-bound engineers, I think it's important to know that every engineer has different needs, biases, knowledge, education, fixations, neuroses and everything else. You have to find a different key to open up each individual. Sometimes you
find the key, and sometimes you don't. Usually when you don't, it's a failure of both parties. Any time you have to terminate an employee, it's a failure of management.

**Give subordinates “political immunity”**

As a company policy we've tried many ways to improve the methods we use to reach our management objectives. No company can really afford to lose its feedback mechanism because the most healthy type of organization is one where there's a lot of give and take. Management should be able to say what it doesn't like about what's happening or what performance is bad; if there are reasons, other than alibis, for those negative things happening, then subordinate management should be able to say what it is with immunity.

We tried sensitivity training (“T” group) over a four year period. We processed about twelve men each time with a trainer. Although these sessions would get out of control occasionally (I don't think you want to put everyone into a T group), the experience does teach people that hostilities are a normal sort of thing and that conflict can clear the air and lead the way to the healing of wounds and a goal-oriented team effort. I found, among management personnel, the people that go into a T group in a very open way, learn something from it. It takes a very small attitudinal change to make a difference in relationships.

We don't use T groups any more because everyone has little things to hide and they don't want to get that interpersonal. Also, we had guys who tried to beat the game. What they do is develop a mental list of rules to live by, i.e., “That guy complained in there because I put my foot on his desk. I'm not going to do that anymore. I'm going to change that behavior”. That reaction is sort of positive because this guy has a thing about people scratching up the top of his desk. But that's not really what you hope to get from a T group. You are, in fact, trying to accomplish a behavior change. So, why play games?

Another thing that we are doing now which is an experiment and is yet to be measured is an assessment center approach. We train a group of assessors from the highest level of management. The training is accomplished by industrial psychologists. The assessors learn the games and the methods of measurements. And then the assessors put a group of middle management people through these games and observe their performance. Some people don't like the games because they're very competitive. It is a pretty good simulation of what industry is really like.

In our limited experience with it we have yet to decide whether this is the tool we want to use in going forward. Assessors do give participants direct feedback, i.e., here is how you scored, and why; we think you have these strengths and we think you have these weaknesses, and we suggest this development method to help strengthen you.

We try to arrange it so that all assessors assess each individual through these exercises to get a composite picture. All the assessors and the trainer trade information, argue it out and decide what is the best judgment and that is what is written down and reported to the man.

Regardless of what training methods a company may use, it's very paternalistic to think that there's anything as powerful as self-development. How does an individual who decides he wants to become a professional manager go about it?

There's an enormous body of literature on this but he should read with skepticism. The manager-to-be should be encouraged to continue the self-study habit, partly on company time, and partly on his own time. Maintain it and use it.

Also, observation of methods employed by bosses, peers and subordinates should constantly be evaluated for addition to a manager's own methods. And finally, constant and objective critique of past management methods, particularly with respect to failures, is essential. It's all too true in the management microcosm that a man who fails to learn from past mistakes is likely to repeat those same mistakes. • •
The Uncomputers.
An unabashed attempt to uncomplicate mathematics.

Until today, everybody who needed a computer to help with his job was faced with a far greater decision than a simple choice of hardware. He literally had to go back to school to learn a whole new language. Indeed a science. Just to be able to translate his job (which he knew well in the first place) into something computers and programmers could understand.

This is utter nonsense. So we decided to bring out a kind of computer that works from the job up instead of from computerese down. What follows is a glossary of the terms that guided us and can help you understand what the Uncomputers are all about.

**Unlearn.**
This is what you do with Fortran and Cobol and all the other ungainly languages you need for ordinary computers.

**Uncomputerese.**
This is the language we use. It's made up of algebra, trigonometry, basic arithmetic and common sense.

**Unbudgeted.**
When you bring out a computer everybody can use, you have to be sure everybody can afford it. Uncomputers are for sale for around $3,000 and lease rates start at under $20 a week.

**Unlimited.**
We didn't forget anything. With the Uncomputers over 4,000 steps of programming and up to 522 complete arithmetic registers, symbolic logic, sub-routines, and capability for up to 22 simultaneous equations fit into a space no bigger than the corner of a desktop.

**Unessential.**
With the Uncomputers you don't need a lot of extra-cost extras either. The basic unit creates, debugs, and updates its own magnetic program cards. You will however be able to get a lot of pretty advanced peripherals if you really need them.

**Uninformed.**
If you have a computer everybody can use and everybody can afford, the next thing is to be sure everybody can get to see it at least. And try it at most. We went for most. Just call your local man from Monroe, and we'll let you try one in your office for a week free of charge and obligation.

**Monroe.**
The Calculator Company.
PLESSEY BEATS THE MHZ'S OUT OF EVERYONE ELSE.

The SP 616 bi-polar digital divider operates at frequencies in excess of 1000 MHz. One top IC supplier declares a 500 MHz; the next best only guarantees 220—and both only at room temperature. And so it goes—straight down the line.

The SP 600 series of DC to 1GHz frequency dividers (with guaranteed operating temperature ranges of -55 to +125 degrees centigrade) is absolutely the fastest by far.

And it includes dozens of prescalers and variable ratio counters which deliver Plessey’s superior performance.

Whether you’re putting together complex communications, or military systems or specialized high frequency test instruments, it pays to specify Plessey.

PLESSEY SEMICONDUCTORS
1674 McGaw Avenue, Santa Ana
California 92705 (714) 540-9945

Please send me a complete literature packet. Now.
☐ I would like information only at this time.
☐ I would like to talk to your representative personally.

Name ____________________________
Title ____________________________
Firm ____________________________
Address ____________________________
City __________ State ______ Zip ______
Phone No. ____________________________

Minneapolis, Minnesota
(612) 835-2717

Framingham, Massachusetts
(617) 879-7920
San Diego, California
(714) 295-2900
Farmingdale, New York
(516) 694-7377

Los Altos, California
(415) 941-4080
Houston, Texas
(713) 462-4077

INFORMATION RETRIEVAL NUMBER 39
Eliminate troublesome common-mode output voltages in IC video amplifiers

There are problems when the dc common mode output voltage is removed from a video amplifier. They include temperature drift and frequency-response degradation. The circuit shown in Fig. 1 avoids these problems. A series string of diodes shifts the voltage and the output voltage can be made independent of temperature.

Other approaches that the designer might be tempted to take—such as the circuits shown in Figs. 2a and 2b—do not compensate for the temperature dependence of the diode voltage drops, while the use of a current source (Fig. 2c) degrades the high-frequency response.

In the circuit of Fig. 1 the output of the IC amplifier is fed to emitter follower \( Q_1 \), which provides isolation. A resistive divider, \( R_1 \) and \( R_2 \), in the \( Q_1 \) emitter circuit shifts the output level. Emitter follower \( Q_2 \) isolates the load from the level-shifting network. If we assume that \( V_{BE}(Q_1) \), \( V_{BE}(Q_2) \) and \( V_D \) (the voltage drop per diode) are equal, then \( N \), the number of diodes, can be calculated so that the output voltage is independent of temperature. (Diode strings, such as the CA 3039, or a transistor array, such as the CA 3046, satisfy these requirements.)

A design example will illustrate the technique. Assume that \( V_{BE} \) and \( V_D \) are both equal to 0.7 V while \( V_{EE} \) equals 6 V. Also let \( V_1 = 3.0 \) V and \( N \) equal 5. Then \( V_A \) equals 2.3 V and \( V_B \) equals -2.4 V. If \( I_1 \) is set at 1 mA, \( R_1 \) and \( R_2 \) are computed to be 1.6 k\( \Omega \) and 3.2 k\( \Omega \), respectively. Thus \( V_c \) is 0.7 V and \( V_{OUT} \) is zero.

Next, assume a negative 2 mV/°C temperature coefficient for the diode and transistor junctions. And let the temperature rise from 25 C to 75 C. Then, at 75 C, \( V_A = 2.4 \) V, \( V_B = -3.0 \) V and \( V_c = 6 \) V. Hence \( V_{OUT} \) is still zero.

This circuit removes common-mode output voltages from 2.4 to 3.4 V, which are found in commercially available video amplifiers. One should apply appropriate bias at the input of the IC to make its dc output voltage correspond to an integral number of diodes.

S. Sareen, Design Engineer, Aertech Industries, 325 Steward Dr., Sunnyvale, Calif. 94086.

CIRCLE No. 311
The Programmable Unijunction Transistor (PUT) has superseded conventional Unijunctions. It has become the preferred device for low-cost timing circuits, oscillators, sensing circuits, and many other variable voltage level threshold applications. Now with the addition of 4 new plastic PUTs, Unitrode has the broadest line available—15 standard types including hermetically sealed. And we will select to meet your specific needs. Unitrode also offers the highest voltage PUTs and the first with better than 1% oscillator timing accuracy guaranteed from -55°C to +125°C. ©-Line plastic PUTs are available off-the-shelf for as low as 24¢ ea. in quantity, and they come complete with the services of a strong applications engineering staff. For fast action and the name of your nearest Unitrode distributor, call Sales Engineering collect at (617) 926-0404. Unitrode Corporation, Dept. 12 X
580 Pleasant Street, Watertown, Mass. 02172

UNITRODE quality takes the worry out of paying less.
BASIC program expresses any number as a rational fraction

Designers often find a need to express a number as a rational fraction. An engineer designing a frequency synthesizer, for instance, or one designing gear-train drives, can work only with rational fractions. The BASIC program in Fig. 1 takes any number (rational or irrational) and produces successively finer rational-fraction approximations. The number to be rationalized is requested as an input in line 10 as the variable S. Any number can be defined by changing line 10.

The printout consists of the coarsest approximation (the integer part of the number), followed by finer and finer approximations. Pi, for instance, is approximated as $\frac{3}{1}$, $\frac{22}{7}$, $\frac{355}{113}$, etc., continuing until internal accuracy is exhausted. The input of a rational value causes printout of a finite number of successive approximations followed by the word EXACT. The program is then terminated.

Computer roundoff limits the accuracy of the result; the algorithm is exact.


CIRCLE No. 312

Multiplicity counter uses IC logic

Suppose you want to count active photomultiplier channels. MSI logic doesn't exist in a convenient form for determining an event count and converting it to an equivalent binary number. One economical solution is to implement the early stages of addition directly with logic gates (Fig. 1). The circuit provides a four-bit binary number for every set of eight lines. These four-bit numbers can then be combined by adders to provide a binary sum over any number of channels.

The logic solution is fairly simple. Four sets of two lines each are converted to four sets of 1, 2 sums. These are paired and converted to two 1, 2, 4 sums. These are combined in the last stage to form the final 1, 2, 4, 8 sum. Equations for three stages are:

1. $I$ ("1") = $A \oplus B$ (same for $K, L; M, N; O, P$) (1)
2. $J$ ("2") = $AB$
3. $Q$ ("1") = $I \oplus K$
4. $R$ ("2") = $I \cdot K + J \oplus L$ (same for $T, U, V$) (2)
5. $S$ ("4") = $J \cdot L$
6. $W$ ("1") = $Q \oplus T$
7. $X$ ("2") = $(QT) \oplus (R \oplus U)$
8. $Y$ ("4") = $(QT) \cdot (R \oplus U) + R \cdot U + S \oplus V$
9. $Z$ ("8") = $S \cdot V$

It is clear from Eq. 1 that a ("2") J output occurs when both A and B are true. When either A or B (EXCLUSIVE OR) is true, only the ("1") output occurs. Similarly, in the second level Q ("1") = $A \oplus B \oplus C \oplus D$ will be true if only one input is true or if three inputs are true. For example, let's say that A, B, C are true and D false, then $I = A \oplus B = "O", K = C \oplus D = "1", \text{ then } Q = I \oplus K = "1", \text{ and } R ("2") \text{ will be true when two or three inputs are true. Then either } J ("2") \text{ or } L ("2") \text{ can be true (EXCLUSIVE OR) OR both } I ("1") \text{ AND } K ("1") \text{ will be true. The same approach is used for the next stage.}$

It does not pay, however, to continue the procedure beyond the level selected (eight inputs) as the function becomes increasingly complex.

102 ELECTRONIC DESIGN 25, December 7, 1972
MMI breaks the character density barrier—128 characters, 9x9 resolution, in one 24-pin DIP. Bipolar!

Who but the memory industry leader could bring you this kind of character generator selection?

Look what you get with MMI character generators:

- Lower power dissipation—450 mW per package. What's more, no clocks are required and the whole family is made to meet MIL specs. Cost is low; interfacing is simple as TTL.

Somewhere in the MMI family are just the characters you want for your CRT or LED displays. They're standard ASCII definition. Format is 5 x 7 or 7 x 9 in either column or row scan.

Custom characters use 35 ns MMI ROMs for strike writing techniques or MMI high density (128-character) ROMs for foreign language characters or special symbols. Get all the custom info from—ready?

Customer Service.

Meet the whole family:

<table>
<thead>
<tr>
<th>MMI Part No.</th>
<th>DESCRIPTION</th>
<th>SCAN</th>
<th>ACCESS</th>
<th>Pkg. Pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM6051</td>
<td>5x7</td>
<td>Row</td>
<td>60</td>
<td>16 DIP</td>
</tr>
<tr>
<td>MM6052</td>
<td>5x7</td>
<td>Row</td>
<td>60</td>
<td>16 DIP</td>
</tr>
<tr>
<td>MM6053</td>
<td>5x7</td>
<td>Row</td>
<td>90</td>
<td>18 DIP</td>
</tr>
<tr>
<td>MM6054</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6055</td>
<td>5x7</td>
<td>Row</td>
<td>60</td>
<td>16 DIP</td>
</tr>
<tr>
<td>MM6056</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6057</td>
<td>7x9</td>
<td>Row</td>
<td>75</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6058</td>
<td>7x9</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6059</td>
<td>7x9</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6060</td>
<td>7x9</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6061</td>
<td>5x7</td>
<td>Row</td>
<td>60</td>
<td>16 DIP</td>
</tr>
<tr>
<td>MM6062</td>
<td>5x7</td>
<td>Row</td>
<td>90</td>
<td>18 DIP</td>
</tr>
<tr>
<td>MM6063</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6064</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6065</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6066</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6067</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6068</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6069</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6070</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6071</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6072</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6073</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
<tr>
<td>MM6074</td>
<td>5x7</td>
<td>Column</td>
<td>175</td>
<td>24 DIP</td>
</tr>
</tbody>
</table>

Call, write, TWX or Telex us today.

Monolithic Memories, Inc.

165 East Arques Avenue, Sunnyvale, CA 94086 • (408) 730-3235 • TWX: 910-339-2229 • TLX: 346301

Representing your best buy in memories: ALABAMA, Huntsville (205) 539-1771; ARIZONA, Phoenix (602) 264-7771; CALIFORNIA, Los Angeles (213) 945-2341; San Diego (714) 747-3015; Palo Alto (415) 369-4671; COLORADO, Denver (303) 623-8713; CONNECTICUT, North Haven (203) 239-8762; FLORIDA, Orlando (305) 423-7613; ILLINOIS, Chicago (312) 455-5100; INDIANA, Ft. Wayne (219) 744-4331; INDIANAPOLIS, IN (317) 844-3241; IOWA, Cedar Rapids (319) 362-8155; KENTUCKY, Louisville (502) 893-7303; MASSACHUSETTS, Boston (617) 653-3158; New York (212) 684-2525; MIAMI, Miami (305) 438-2345; MILWAUKEE, Milwaukee (414) 726-5050; MINNESOTA, Minneapolis (612) 929-8721; NEW JERSEY, Turnpike (201) 692-0200; NEW YORK, N.Y.C., (212) 632-8155; OHIO, Cleveland (216) 228-7525; OREGON, Portland (503) 292-6565; PENNSYLVANIA, Willow Grove (215) 614-3850; Pittsburgh (412) 242-0100; TEXAS, Dallas (214) 233-4499; Houston (713) 835-1872; WASHINGTON, Bellevue (206) 455-2778.

INFORMATION RETRIEVAL NUMBER 41
1. Three levels of logic convert inputs to a binary equivalent count.

For a greater number of input lines, multiple groups of eight-line encoders can be combined, as shown in Fig. 2.

If high-speed operation is not required, TTL ICs, such as these can be used in place of the ECL units:

- EXCLUSIVE OR: MC1030, MC3021, 7486
- AND: MC1047, MC3001, 7408
- OR: MC3003, 7432
- Full Adder: MC1019, MC4026
- Dual Full Adder: MC8304, 74H183

With TTL, be sure to use an OR gate instead of the wired OR shown in Fig. 1.

Boris Bertolucci, Stanford Linear Accelerator Center, Electronics Instrumentation, P.O. Box 4349, Stanford, Calif. 94305.

CIRCLE NO. 313

IFD Winner of August 3, 1972
R.J. Battes, P.O. Box 11604, Palo Alto, Calif. 94306. His idea, "Build a quartz-crystal-controlled digital clock with only six ICs," has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Information Retrieval Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

ELECTRONIC DESIGN cannot assume responsibility for circuits shown nor represent freedom from patent infringement.
START YOUR OWN BUG COLLECTION...

WITH A FREE LADY BUG FROM ADC!

If you've been thinking that most commercial transformers are pretty much alike, these new ADC Lady Bugs will change your mind.

We've engineered Lady Bugs to provide the kind of reliability you've come to associate only with transformers meeting military specifications. More than that, we've made sure these ADC Transformers offer something you haven't seen in a while: economy. So, beginning now, you can have the transformer performance you've always wanted, and still keep costs in line.

ADC Lady Bugs come in 46 different electrical configurations with power ratings from 50 mw to 2 watts. There are four different case sizes, with the smallest being approximately one-third cubic inch.

We don't want to bug you, but if you have a real need for miniature transformers, we will send you an evaluation sample free — no strings attached. Just tell us what your requirements are on the coupon and send it back to us. Or, if you just want more information, please circle the number on the Reader Service card.

ADC PRODUCTS

4900 West 78th Street
Minneapolis, Minnesota 55435

Yes, I would like an evaluation sample of the new Lady Bug transformer. Here's my application:

We anticipate using _______ units/year.
My needs are for _______ 30 days
________ 60-120 days _______ Future

Division of Magnetic Controls Company
4900 West 78th Street
Minneapolis, Minnesota 55435
TEL: (612) 835-6800 TWX: 910-576-2832 TELEX: 29-0321

NAME ___________________________
COMPANY _______________________
ADDRESS _______________________
CITY ___________________ STATE _______ ZIP _______
TELEPHONE ____________________

INFORMATION RETRIEVAL NUMBER 42

ELECTRONIC DESIGN 25, December 7, 1972
Now you can buy as few or as many

**WJ-5118 SERIES YIG SPHERES**

<table>
<thead>
<tr>
<th>Diameter - Inches</th>
<th>Linewidth, maximum (Oe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.037</td>
<td>1.5</td>
</tr>
<tr>
<td>.034</td>
<td>1.5</td>
</tr>
<tr>
<td>.032</td>
<td>1.5</td>
</tr>
<tr>
<td>.029</td>
<td>1.1</td>
</tr>
<tr>
<td>.026</td>
<td>1.1</td>
</tr>
<tr>
<td>.022</td>
<td>1.1</td>
</tr>
<tr>
<td>.019</td>
<td>1.1</td>
</tr>
<tr>
<td>.015</td>
<td>1.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diameter - Inches</th>
<th>Linewidth, maximum (Oe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.029</td>
<td>1.1</td>
</tr>
<tr>
<td>.031</td>
<td>0.9</td>
</tr>
<tr>
<td>.032</td>
<td>0.9</td>
</tr>
<tr>
<td>.033</td>
<td>0.9</td>
</tr>
<tr>
<td>.034</td>
<td>0.9</td>
</tr>
<tr>
<td>.035</td>
<td>0.9</td>
</tr>
<tr>
<td>.036</td>
<td>0.9</td>
</tr>
<tr>
<td>.037</td>
<td>0.9</td>
</tr>
<tr>
<td>.038</td>
<td>0.9</td>
</tr>
<tr>
<td>.039</td>
<td>0.9</td>
</tr>
<tr>
<td>.040</td>
<td>0.9</td>
</tr>
<tr>
<td>.041</td>
<td>0.9</td>
</tr>
<tr>
<td>.042</td>
<td>0.9</td>
</tr>
<tr>
<td>.043</td>
<td>0.9</td>
</tr>
<tr>
<td>.044</td>
<td>0.9</td>
</tr>
<tr>
<td>.045</td>
<td>0.9</td>
</tr>
<tr>
<td>.046</td>
<td>0.9</td>
</tr>
<tr>
<td>.047</td>
<td>0.9</td>
</tr>
<tr>
<td>.048</td>
<td>0.9</td>
</tr>
<tr>
<td>.049</td>
<td>0.9</td>
</tr>
<tr>
<td>.050</td>
<td>0.9</td>
</tr>
<tr>
<td>.051</td>
<td>0.9</td>
</tr>
<tr>
<td>.052</td>
<td>0.9</td>
</tr>
<tr>
<td>.053</td>
<td>0.9</td>
</tr>
<tr>
<td>.054</td>
<td>0.9</td>
</tr>
<tr>
<td>.055</td>
<td>0.9</td>
</tr>
<tr>
<td>.056</td>
<td>0.9</td>
</tr>
<tr>
<td>.057</td>
<td>0.9</td>
</tr>
<tr>
<td>.058</td>
<td>0.9</td>
</tr>
<tr>
<td>.059</td>
<td>0.9</td>
</tr>
<tr>
<td>.060</td>
<td>0.9</td>
</tr>
<tr>
<td>.061</td>
<td>0.9</td>
</tr>
<tr>
<td>.062</td>
<td>0.9</td>
</tr>
<tr>
<td>.063</td>
<td>0.9</td>
</tr>
<tr>
<td>.064</td>
<td>0.9</td>
</tr>
<tr>
<td>.065</td>
<td>0.9</td>
</tr>
<tr>
<td>.066</td>
<td>0.9</td>
</tr>
<tr>
<td>.067</td>
<td>0.9</td>
</tr>
<tr>
<td>.068</td>
<td>0.9</td>
</tr>
<tr>
<td>.069</td>
<td>0.9</td>
</tr>
<tr>
<td>.070</td>
<td>0.9</td>
</tr>
<tr>
<td>.071</td>
<td>0.9</td>
</tr>
<tr>
<td>.072</td>
<td>0.9</td>
</tr>
<tr>
<td>.073</td>
<td>0.9</td>
</tr>
<tr>
<td>.074</td>
<td>0.9</td>
</tr>
<tr>
<td>.075</td>
<td>0.9</td>
</tr>
<tr>
<td>.076</td>
<td>0.9</td>
</tr>
<tr>
<td>.077</td>
<td>0.9</td>
</tr>
<tr>
<td>.078</td>
<td>0.9</td>
</tr>
<tr>
<td>.079</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Quantity**

<table>
<thead>
<tr>
<th>Unit Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 9</td>
</tr>
<tr>
<td>10 to 19</td>
</tr>
<tr>
<td>20 to 29</td>
</tr>
<tr>
<td>30 to 49</td>
</tr>
<tr>
<td>50 to 99</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

Watkins-Johnson YIG spheres are guaranteed to be free of dirt, wax and other surface contamination at time of purchase. Sphericity is guaranteed to 0.0001, finish is typically 0.15 microns and diameter is accurate within ±0.0005. Variations of the spheres listed are available upon request.

**TO ORDER YOUR YIG SPHERES,** simply select the combination of diameter, 4πMγ range and linewidth that meets your requirements. Then contact our Representative in your area or call Watkins-Johnson Applications Engineering at (415) 493-4141, Extension 252. It's as simple as that!
Tiny 10-bit d/a converter plugs into 16-pin IC socket

Hybrid Systems Corp., 87 Second Ave., Northwest Park, Burlington, Mass. 01803. (617) 272-1522. $19.00 (1-9); stock to 2 wks.

Hybrid Systems has pulled out all the stops in packaging to produce a discrete-component, 10-bit d/a converter that occupies only 0.4 cubic inch. Called the DAC 3711-10, the 1.4 x 0.6 x 0.48-inch module plugs into a 16-pin DIP socket and includes current-steering switches, the ladder network and the reference circuit.

The module is an offspring of the company's small eight-bit converter, the DAC 371-8. But the new unit, which accommodates two extra bits, is only 0.1 inch longer.

Though small in size, the DAC 3711-10 delivers a fairly large full-scale output current of 4 mA. This is sufficient to drive a coaxial cable directly. And with an output impedance of greater than 1 MΩ, the unit behaves as a current source.

Output current may be converted to a voltage by terminating the output pin with a resistor to ground. When this is done, up to +1.25 V (compliance) can be obtained. An op amp may be used to boost the voltage further. The settling time of the output is a maximum of 1 µs to 0.1%, for a full-scale input step from all ZEROs to all ONEs.

As for performance, no sacrifices appear to have been made to obtain the miniature size. The new unit has been designed to be monotonic over its full operating temperature range of 0 to +70 C. Discrete thin-film resistors, used in the internal weighting network, contribute to the overall accuracy tempco of 100 ppm/°C and provide extra stability. And the internal reference source has a power-supply sensitivity of only ±0.05%/%

The digital inputs of the DAC 3711-10 are DTL/TTL compatible, and no buffering is required. Coding is straight binary. To insure reliability, all active components are hermetically sealed in metal cans. No plastic or silicone packages are used for the transistors or ICs. At a cost of only $19 each, the DAC 3711-10 should provide tough competition for monolithic and hybrid types, which are typically more expensive.

Intronics Inc., 57 Chapel St., Newton, Mass. 02158. (617) 332-7350.
M610: $85; M611: $125.

The M610 and M611 modules can multiply, divide, square and take square roots. No external trimming is required. Specs include 300-kHz minimum bw, 0.25% accuracy (M611), 100 µV/°C offset drift, and 0.1%/°C scale factor drift (M611). These units are encapsulated in a 1.5 x 1.5 x 0.62-in. case, with gold plated pins for PC-board mounting.

Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. (212) 497-7600. $1.50 (1000); 2-3 wks.

For the OEM who must electrically isolate low-voltage logic circuits from high-voltage outputs, Dialight announces their new 551 series opto-isolators. Both Models 551-0002 and 551-0003 consist of a gallium-arsenide LED and an n-p-n silicon phototransistor mounted on a six-lead frame. The units are encapsulated within an electrically nonconductive plastic compound. Specs include: input-output isolation of ±1.5 kV; 250 mW total dissipation; and input diode current of 60 mA.
## Modules & Subassemblies

Power supply gives multiple outputs

_Burroughs Corp., Electronic Components Div., P.O. Box 1226, Plainfield, N.J. 07061. (201) 757-5000. $211 (100s)._*

The BDS4083-PS1 power supply, which will find applications in terminal and display systems, develops the following dc outputs:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5.0 V</td>
<td>8.0 A</td>
<td>±2.5 %</td>
</tr>
<tr>
<td>-250 V</td>
<td>0.08 A</td>
<td>±6.0 %</td>
</tr>
<tr>
<td>±250 V</td>
<td>0.04 A</td>
<td>±6.0 %</td>
</tr>
<tr>
<td>+30 V</td>
<td>0.04 A</td>
<td>±6.0 %</td>
</tr>
<tr>
<td>±12 V</td>
<td>0.175 A</td>
<td>±7 %</td>
</tr>
<tr>
<td>±12 V</td>
<td>1.0 A</td>
<td>±5 %</td>
</tr>
</tbody>
</table>

The supply can operate at 50/60 Hz, and input taps are provided for operation at 115/220 V input. Input is three-wire including separate earth ground. From 3/4 to full load, the regulation includes variations for 10% line fluctuation, ripple, component accuracy, and temperature effects. Stability is ±1% for eight hours after four hours of warm up with a constant full load. The +5 V section of the supply has overvoltage protection.

### Small Power Supplies Deliver up to 1.5 A

_Acopian Corp., 131 Loomis St., Easton, Pa. 18042. (215) 258-5441. $49 to $105; 3 days._

Miniaturized power supplies with significantly increased output currents are now available from Acopian Corp. Representative models are the 5E150, with an output of 5 V at 1.5 A, and the D15-35, which provides tracking +30 V at 0.04 A, +6.0%, -5%. Most models have regulation of ±0.05% and ripple of 1-mV rms. Standard input is 105-125 V ac, 47-420 Hz. Designed for mounting directly on PC boards, the units are housed in cases measuring 3.5 x 2.5 x 1.25 inches.

### Sample & Hold Module Has 20-ns Aperture

_Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. 85706. (602) 624-8358. 5020: $109; 5021: $101; stock._

Model 5020 sample and hold module is characterized by 20-ns aperture time and 2-ns aperture uncertainty time. Model 5021 features 3-ns total aperture time and 300-ps aperture uncertainty time. Both models are packaged in a 1.8 x 1.2 by 0.6-inch high module and feature: 300 V /µs tracking mode slew rate (Model 5020), 100-MHz minimum tracking mode bw (Model 5021), 1 µV/µs memory decay rate (Model 5020) and 100-ns max. settling time to 0.1% (Model 5020).

### 16-Bit A/D Converter Has Adjustable Linearity

_Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706. (602) 294-1431. $225; 2 wks. ARO._

The ADC100 integrating a/d converter is designed for use in industrial process control, data logging, and high-accuracy instrumentation. The unit features maximum linearity error of 0.005%, a maximum accuracy drift of 5 ppm/°C and is available with BCD or binary coding and unipolar or bipolar inputs. The binary units have user-selectable resolutions of 12, 14 or 16 bits, while the BCD units are available with four digit or four digit plus sign coding. Linearity error of the ADC100 can be adjusted to less than 0.002%. The ADC100 is housed in a 2 x 4 x 0.4-in. module with dual-in-line pin spacing.

### Trigger Module Delivers 2-ns, 100-mA Pulse

_Mullett Associates, 349 Culver Blvd., Playa Del Rey, Calif. 90291. (213) 823-6757. $175 (single qty); stock._

Current pulses of 2 ns width and 100 mA amplitude are produced by this self-contained trigger generator. Model 2906 has no external power requirements and no controls to adjust. Power is consumed only when a pulse is generated. Life of the internal 9-V battery is 2 x 10¹¹ pulses. Output waveshape is virtually independent of input drive pulse.
WHEN you need concise measurement data on antennas or rf cables, you'll see the value of polar (Smith-chart) displays of impedance versus frequency.

WHEN you want accurate measurements of structural return loss, you'll appreciate the ability to switch quickly from a rectilinear to a polar display.

WHEN you have to characterize active devices, you'll find invaluable the large 360-degree display with a full 100-dB dynamic range.

WHEN you must compare two unknowns or compare two ports of multiport unknowns such as power splitters or phase shifters, you'll want the speed and simplicity of polar displays of the vector difference.

WHEN you want all this from 400 kHz to 500 MHz with 0.005-dB resolution, you'll want the 7145-dollar 1710 RF Network Analyzer with polar display from General Radio — the GR 1710...

WHEN you need a lot.

For High-Frequency Measurements

General Radio

NEW YORK (N.Y.) 312-946-3722, N.J. 201-791-8990 • BOSTON 617-646-0550 • CHICAGO 312-992-0800 • WASHINGTON D.C. 202-940-7021 • LOS ANGELES 714-540-9830 • TORONTO 416-252-3395 • ZURICH 01/55 24 20

GR COMPANIES • GRASON-STAHLER • TIME/DATA • TECHWARE COMPUTING CORP. • GR ASSOCIATE • MICRONETIC SYSTEMS INC.
The dynamic digital duo -

$690 buys a lot of resistance measurement:
- 1 milliohm to 1 gigaohm
- 3½ digits, 0.1% accuracy
- fast, automatic bridge balance
- true 4-wire input
- guarded input for high resistance

$690 also buys a lot of capacitance measurement:
- 1 picofarad to 10 millifarads
- 3½ digits, 0.1% accuracy
- use of NBS-recommended charge transfer technique
- no polarizing voltage needed
- low voltage to device under test

And for $995, you can have both. Hickok's plug-in design lets you pay for only what you need.

DP170 Resistance Plug-in  $305
DP200 Capacitance Plug-in  $305
3202 Main Frame  $385
3202P Main Frame with buffered display and printer output  $475

HICKOK
the value innovator

INSTRUMENTATION & CONTROLS DIVISION
THE HICKOK ELECTRICAL INSTRUMENT CO.
10514 Dupont Avenue • Cleveland, OH 44108
(216) 541-8060 • TWX: 810-421-8286
INFORMATION RETRIEVAL NUMBER 46

AMPLIFIER PRODUCTS

Sample/hold settles to 0.01% in 1 μs

Zeltex’s sample/hold module, ZD452, settles to 0.01% in 1 μs. The FET-input buffer amplifier provides 10 MΩ input impedance, and less than 50 pA of input bias (either input). The analog inputs are fully differential, making the ZD452 a sample/hold op amp. Gains may be selected by changing input/feedback resistances. Other specs include a 40 V/μs slew rate and a 5-ns aperture time. A complementary current-mode switching gate (Schottky diode) virtually eliminates ground line switching transients. The hold decay rate is 100 μV/ms, and may be further reduced. Logic and bias circuits are zener regulated to provide optimum performance over a power supply range of ±12 to ±18 V.

CIRCLE NO. 259

Power supply modules give triple outputs

The GPS Corp. announces its new line of triple output power supplies. Each of the PS 170s and PS 180s features output voltages of +15 V dc, −15 V dc and 5 V dc. There are six models to choose from stock in O.E.M. quantities. All supplies are short-circuit protected for any combination of pins. The PS 170s and PS 180s are miniature, encapsulated, plug in modules that are both rugged and lightweight.

CIRCLE NO. 260

D/a converter offers three current ranges

Cycon’s new CY2247 12-bit digital-to-process current converter features a choice of three output current ranges (1 to 5 mA, 4 to 20 mA, 10 to 50 mA) through simple pin-strapping. The 2 x 4-in. module is intended for industrial process control applications and is guaranteed monotonic and linear to ±1/2 LSB over a temperature range of 0 to 70 C. Offset drift is less than 0.001%/°C, and scale factor drift is less than 0.002%/°C. The circuit’s inputs are directly compatible with TTL/DTL levels. Vcc can range from +12 to +30 V. A 10-bit version, CY2147, and an eight-bit version, CY2047, is available, as is a companion series of process current-to-digital converters.

CIRCLE NO. 262

Amplifier delivers 16 dBm to 500 MHz

Avantek, Inc., has broadened its line of popular unit amplifiers. The UA-141 offers 14-dB min gain, +13 dBm output power and a maximum noise figure of 5.5 dB from 2 to 100 MHz. The UA-144 is a push-pull module featuring 85-dB spurious-free dynamic range for a 1-MHz bw between 30 and 500 MHz, and 16 dBm output. Guaranteed specs include: flatness (max) of ±1 dB and VSWR (max) of 1.5. Input power is +15 V at 80 mA for the UA-141 and +12 V at 80 mA for the UA-144.

CIRCLE NO. 261

ELECTRONIC DESIGN 25, December 7, 1972
The only digital ohmmeter that gives you the accurate lowdown.

From 200 ohms down to 10 microhms, that is. Automatic measurements with a basic accuracy of ±0.02% plus 1 digit. Plus 0.01% linearity, 10 microhm resolution, automatic cancellation of thermal emf's, and ac rejection of better than 80 db at 60 Hz. Test leads can have up to 10 ohms resistance with no effect on accuracy.

We call it our SP 3789 Low Resistance Digital Ohmmeter, and it is the ideal instrument for use in design and production work where small resistance value need to be measured. Compact, fully solid state, with a highly visible 4½-digit LED readout, it may be operated in a single measurement or continuous measurement mode.

The SP 3789 Low Resistance DOM consists of the SP 3780 Digital Converter and the SP 3790 Low-Ohm preamp plug-in. The converter is available separately for those who want to make their own plug-ins.

Electro Scientific Industries
13900 N.W. Science Park Drive
Portland, Oregon 97229
Telephone: (503) 646-4141
Telex: 36-0273

Electro Design 25, December 7, 1972

INFORMATION RETRIEVAL NUMBER 47
Strip Chart Recorder
for use when two values are measured simultaneously

In analytical applications such as physiological monitoring or gas chromatography when two inputs are recorded simultaneously (and often on two separate strip chart recorders), the model 2-3300 is the ideal, economical recording tool. You can record two values, in separate colors if desired, at one time with the accuracy and reliability for which Houston Instrument recorders are known.

Paper size: 10" (25cm) x 100'

9 Pushbutton speeds: .05 to 20 In/min.
Plug-in modules: a dozen different signal conditioning modules are interchangeable between Y1 and Y2 axes
Electric Pen Lift: standard on all units
Event marker: standard on all units
Pens: Fibre tip disposable
Price: Base price $1205 + Y axes plug-in modules

Dual TTL-to-MOS driver priced from $2.05

Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. P: See below; 3 wks. (production qty.)

A low-cost dual bipolar to MOS level shifter driver and interface IC, termed the SN75361, accepts standard TTL/DTL input signals and creates high current, high voltage output levels suitable for driving both clock and address inputs for the TMS4062 (AMS6002) and the TMS1103 MOS RAMs. Price in 100-pieces is $2.25 for the 14-lead version and $2.05 for the eight-pin package. The SN75361 operates from the TTL 5-V power supply and the MOS VSS power supply. The IC is designed for nominal 16 to 20 V VSS operation but can be used over a wide VSS power-supply range. The driver in the standby mode features a nominal 10 mW of power dissipation.

Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. 85036. (602) 273-3466. $3.10 (100 up).

A driver IC transmits data at high speeds over long distances. Termed the MC75113, it can be used in systems where numerous drivers and receivers share a common twisted-pair line. All drivers connected to the line appear as an open circuit unless they are in the ON state. The MC75113 features a TTL-compatible four-input OR gate, outputs currents of nominally ±20 mA; output current mismatch of 3 mA maximum and propagation delay of 25 ns.

Npn power transistors in low-cost package


Six power transistors in the plastic molded versawatt package are priced from $0.72 to $0.88 (100-999). Three types 2N6098 (BDX70), 2N6100 (BDX72), and 2N6102 (BDX74) have leads formed for direct TO-66 socket plug-in; the 2N6099 (BDX71), 2N6101 (BDX73), and 2N6103 (BDX75) are straight lead versions. All six types offer low saturation voltage, high current capability and a 75-W power dissipation at their maximum specified voltage. The SGS-ATES plastic devices are guaranteed against damage due to thermal fatigue. In addition, the homotaxial process guarantees that devices are completely free from secondary breakdown.
Etched or stamped parts?
Buckbee-Mears offers both to help you save money.

Many precision parts can be made by either photo etching or stamping. BMC offers both, which means you can be sure we will recommend the most economical method to produce your part. That's mighty important if you're concerned about costs.

There are other advantages. With our ability to etch parts in large volume, we have built-in second source protection for stamping. That means no expense for a second set of tools. We can get you in production fast by etching your prototypes. Then, when volume is sufficient, you can switch to stamping.

All with one supplier, Buckbee-Mears.
Most component manufacturers must take suppliers into their confidence. Since we are completely independent, you can be sure your proprietary designs are safe with us.

If you need precision parts, call or write our marketing department. Better still, see your regional BMC sales consultant. He's a real pro, specially trained to solve your production problems. And he can make an expert cost analysis on etching versus stamping for you.

Buckbee-Mears is the world's largest volume producer of precision etched, stamped and electroformed parts. You can expect us to deliver, on time, what we say we can deliver. You'll save money with BMC, too, because we can choose from a wide range of capabilities to solve your particular needs. We have a large variety of etchable metals on inventory for fast prototype production.

Fast delivery, reasonable prices, in-depth capability, well trained sales force. Shouldn't you talk to us first?
**ICs & SEMICONDUCTORS**

**MOS clock line drivers** list 1 A, 30 V output

Cermtek, Inc., 660 National Ave., Mountain View, Calif. 94040. (415) 969-9433. CH0009C: $10.40; CH0013C: $9.75 (100 up); stock.

Hybrid MOS clock line drivers offer peak output currents of 1.0 A and output voltage swings of up to 30 V. Typical rise and fall times are under 50 ns when driving 1000-pF loads. The CH0009 series may be direct-coupled to the driving source, or it may be used in capacitor-coupled use. The CH0013 series is designed for capacitor-coupled use. Both are packaged in a 12-lead TO-8 configuration. The lower-cost CH0009C and the CH0013C are rated for a range of -25 to +85 C.

CIRCLE NO. 267

**Line driver eases data-bus operation**

Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN75113N: $3.10 (100 up).

The SN55/75113, a dual tri-state line driver, has a high output impedance inhibit state that makes it possible to connect many drivers together on the same transmission line for data bus operation. The device has individual inhibit control inputs for each output pair and a common inhibit control input for both output pairs. The output stages are similar to TTL totem-pole outputs, but the sink outputs and the corresponding active pull-up outputs are available on adjacent package pins.

CIRCLE NO. 268

**SCRs, diodes handle up to 1500 A**


A family of high-power SCRs and diodes—designated Westcode type D1200—incorporate a 2-1/2-inch (50-mm) diameter silicon slice and come in a capsule package or in a flat-base package for single-ended cooling. The SCRs have current ratings of up to 1500 A, transient voltages to 3.5 kV and surge ratings up to 16,000 A. The diodes have corresponding values of 1500 A, 3 kW and 33,000 A, respectively.

CIRCLE NO. 269

---

**time is on our side.**

**CMOS...**

FROM SOLID STATE SCIENTIFIC

Behind us, four years of absolute dedication to this complex, sophisticated technology. Before you, a leader in CMOS technology, either metal or silicon gate.

We foresaw the time keeping revolution almost two years ago. We were in early. Advancing. Solid State is the only source that delivers in production quantities both CMOS liquid crystal decoder/drivers (5424) and CMOS silicon gate time base circuits (5423).

If you have a time keeping system — for wrists, walls, or waking up — GET UP ON OUR SIDE!

SOLID STATE SCIENTIFIC, INC.
Montgomeryville, Pa. 18936 • (215) 855-8400 • TWX 510-561-7269

INFORMATION RETRIEVAL NUMBER 51
With the Xerox MD40 you get a bit more.

For starters, when you buy the MD40, you get 13-bit resolution for the price of 12. But that's not all.

You also get an instrument you can use as an A-to-D converter, as a high level multiplexer-digitizer with up to 256 channels, as a digitizer-controller for up to 1024 low-level channels, or as a combination high-and-low level digitizer. All without changing wiring or documentation, simply by plugging in different modules.

And you get the MD40 in standard 19" rack mounting, with your choice of two types of digital I/O connections, and any of six different output formats: 1's complement, serial or parallel; or BCD, parallel. Input can be single-ended or differential, gain programmable. And a list of other options.

And even though the MD40 is a 13-bit instrument, with double the resolution of comparably priced units, you can also get it with 8, 9, 10, 11, or 12-bit resolution, to get the perfect match for your application.

Finally, you get compatibility with our full line of 15-bit instruments.

To sum it up, with the MD40 you get not only one more bit, but quite a bit more.

To get more information call (213) 679-4511, ext. 2208 or 1210, or write to Xerox, A3-73, 701 South Aviation Blvd., El Segundo, California 90245.

XEROX® is a trademark of XEROX CORPORATION.
Line-powered DPM is industry's smallest

Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 826-6395. $246; stock.

With a total size of 3 x 1.75 x 2.25-in. and an over-all weight (including the I/O connector) of 6 oz, the Model DM-1000 appears to be the smallest line-operated DPM on the market today. Two input voltage ranges are available, ±199.9 mV or ±1.999 V. Input impedance is specified up to 1000 MΩ with an input bias current as low as 1 nA. Both high and low analog inputs can sustain up to 300 V cm. Other input characteristics include true floating differential input plus a CMR of 70 dB at 60 Hz and a NMR of 40 dB at 60 Hz. Model DM-1000 has an accuracy of ±0.05% and can resolve to 100 µV. Input settling time is 50 µs and up to 200 readings can be made asynchronously or synchronously. Operating temperature range is 0 to +60°C with a tc of ±50 ppm/°C.

4-1/2-digit voltmeter measures to 30 nV


A new autoranging digital nanovoltmeter features a 4-1/2-digit display in which the last digit shows tens of nanovolts on the lowest range. The Model 180 measures from below 30 nV to 2 V. It permits fast measurements with 0.01% resolution and an accuracy of ±0.03% of reading ±0.02% of full scale. Input/output isolation of greater than 10⁶ Ω enables floating measurement up to 500 V, yet the output can be near ground potential. The Model 180 input is protected to overloads of 50 V instantaneous or 30 V rms. Normal mode rejection is greater than 90 dB and common-mode rejection ratio is better than 120 dB. Zero stability is better than 30 nV/°C.

3-1/2-digit DPM is systems oriented

Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. $93 (100s); stock.

The AD2003 is a systems-oriented 3-1/2-digit DPM featuring differential amplifier input and fully latched BCD outputs. The 5 V-powered unit provides common mode rejection of 80 dB min, normal mode rejection of 40 dB and minimum common mode voltage of ±2.5 V. This DPM accepts readings of bipolar, differential input signals over a full scale range of 0 to ±199.9 mV with a maximum error of 0.05% ±1 digit. Polarity and overload indications are provided. BCD outputs are DTL/TTL compatible. The AD2003 can be externally triggered to make up to 16 readings per second, or be programmed to hold readings indefinitely. Size is 1.8 x 3 x 2-in.
If TRW can produce precision attenuator switches in volume

...think what TRW can do for you in fixed and variable resistors, low cross-talk cable and film capacitors.

TRW/Cinch ceramic substrate attenuator assemblies illustrate Cinch's abilities to control the contact spring forces precisely during fabrication, and to weld tiny gold dots to the spring materials. Advanced manufacturing techniques such as these have helped make Cinch a leading world producer of connectors, sockets, and other electromechanical devices. (For further information, circle 000 on the reader service card.)

TRW/IRC resistive products cover the spectrum—from 20-year life Metal Glaze™ resistors with superior stability and reliability to Circuitrim® potentiometers in every conceivable size and style. TRW/IRC is your complete source for all types of fixed resistors (carbon composition, thick or thin film, and wirewound), variable resistors and resistive networks. (For further information, circle 000 on the reader service card.)

TRW/Holyoke wire, cable, and cable assemblies are produced in unlimited variety to meet critical requirements. These include such demands as lowest cross-talk for telecommunications, minimum impedance discontinuities for RF, and enhanced flame retardancy for home entertainment wiring. Shown is a 52-pair telephone cable, an example of a long-life, high-reliability requirement. (For further information, circle 000 on the reader service card.)

TRW metallized film capacitors are available to fit almost any design requirement. Typical are the tape-wrapped X663 (ideal for telecommunications use) and the precision-dimensional X440 for high-density circuits. TRW makes by far the broadest range of film capacitors—both metallized and foil—in terms of dielectrics, case styles, shapes, capacitances, and voltages. (For further information, circle 000 on the reader service card.)

What else do we make? Just about every type of electronic component in the books from actuators to zeners. Plus amplifiers, chokes, connectors, diodes, filters, inductors, miniature motors, oscillators, printed circuits, rectifiers, RF modules, transformers, transistors, tuners, color convergence yokes—and more.

One source—your local TRW representative—offers you all of these product lines and can supply almost all of your needs. With a direct pipeline to all of our plants, he can assure you fast delivery, applications assistance, custom designs, and special engineering help whenever you want it.

Think what TRW can do for you. Then call or write TRW Electronic Components, 10880 Wilshire Blvd., Suite 1700, Los Angeles, CA 90024. Phone (213) 475-6777.
NOW
10 Bits

D/A Converter plugs into a single IC socket!

$19.00 in singles

For the first time ... a miniature 10-bit DAC at low cost. The remarkable ultra-compact DAC 371-10 is a complete current output converter, ready to use — packaged in a 1.4" x 0.6" x 0.48" module. Built-in reference, DTL and TTL compatibility ... plus all active components are hermetically sealed for extra reliability. Contact us for full details.

HYBRID SYSTEMS CORPORATION
67 Second Avenue, Northwest Industrial Park, Burlington, Mass. 01803
Telephone: 617-272-1522 TXW: 710-332-7994

INFORMATION RETRIEVAL NUMBER 56

VACTEC
Portable Photometer only $29500 includes probe

• High sensitivity, wide range .001 to 16,000 fc.
• Accuracy 5% full scale, linearity 3%.
• AC or battery operation.
• Recorder output (1 v. to 1 ma. output).
• Probes available with cosine correction and increased sensitivity to .0002 fc.
• Use a densitometer, reflectometer, edge sensor, counter.

New Vactec photometer performs functions normally found only in $1,000 to $5,000 research instruments. Calibrates illumination or brightness for inspection of photocells, phototransistors, etc. Not only measures illumination precisely for offices, factories, schools, or stadiums, but its low cost, versatility, high sensitivity, and recorder output also make it practical for use as a process control instrument for a variety of photometric operations. Call or write for new technical Bulletin P2700.

VACTEC, INC.
2423 Northline Ind. Blvd., Maryland Heights, Mo. 63043, Phone (314) 872-6300

INFORMATION RETRIEVAL NUMBER 57

NOW
10 Bits

D/A Converter plugs into a single IC socket!

$19.00 in singles

For the first time ... a miniature 10-bit DAC at low cost. The remarkable ultra-compact DAC 371-10 is a complete current output converter, ready to use — packaged in a 1.4" x 0.6" x 0.48" module. Built-in reference, DTL and TTL compatibility ... plus all active components are hermetically sealed for extra reliability. Contact us for full details.

HYBRID SYSTEMS CORPORATION
67 Second Avenue, Northwest Industrial Park, Burlington, Mass. 01803
Telephone: 617-272-1522 TXW: 710-332-7994

INFORMATION RETRIEVAL NUMBER 56

VACTEC
Portable Photometer only $29500 includes probe

• High sensitivity, wide range .001 to 16,000 fc.
• Accuracy 5% full scale, linearity 3%.
• AC or battery operation.
• Recorder output (1 v. to 1 ma. output).
• Probes available with cosine correction and increased sensitivity to .0002 fc.
• Use a densitometer, reflectometer, edge sensor, counter.

New Vactec photometer performs functions normally found only in $1,000 to $5,000 research instruments. Calibrates illumination or brightness for inspection of photocells, phototransistors, etc. Not only measures illumination precisely for offices, factories, schools, or stadiums, but its low cost, versatility, high sensitivity, and recorder output also make it practical for use as a process control instrument for a variety of photometric operations. Call or write for new technical Bulletin P2700.

VACTEC, INC.
2423 Northline Ind. Blvd., Maryland Heights, Mo. 63043, Phone (314) 872-6300

INFORMATION RETRIEVAL NUMBER 57

$500 buys dual-trace triggered-sweep scope

Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, Ill. 60613. (312) 327-7270. $499.95.

The 1470 is a dual-trace, triggered-sweep scope that offers dc to 10-MHz bw, 10 mV/cm sensitivity and maximum sweep of 0.2 µs/cm. It permits dual display of waveforms in six modes: Channel 1, Channel 2, Chopped (for low-frequency waveforms), Alternate, Add and Channel 2 Invert. The 1470 requires two probes, which are available separately. B & K offers two models: The PR-20, a combination 10:1/DIRECT probe complete with convenient spring-loaded clip-on tip. The PR-16 is similar to the PR-20, but does not have the clip-on feature.

INFORMATION RETRIEVAL NUMBER 57

500-MHz freq. counter is portable, has 5 digits

Analog Digital Research Inc., 1051 Clinton St., Buffalo, N.Y. 14206. $729.

The CM20R is a portable digital frequency counter. The unit operates from standard line voltage, a snap-on rechargeable battery pack or any external 12 V dc source. Features include: 5-digit LED display; automatically-placed decimal point; overflow indicator; 1-MΩ input covering the range from 5 Hz to 15 MHz; and a 50 Ω input covering 10 to 500 MHz. A slide switch selects the input, and automatically repositions the decimal point. Input sensitivity is 30 mV rms from 5 Hz to 15 MHz; 50 mV rms up to 300 MHz, increasing to 100 mV rms at 500 MHz.

CIRCLE NO. 273

CIRCLE NO. 274

ELECTRONIC DESIGN 25, December 7, 1972
Electronic Design’s Nov. 23 issue commemorating The age of the transistor

Order your copy now!

A collector’s item celebrating the 20th anniversary of Electronic Design with the 25th anniversary of the transistor. This issue is a compendium of major milestones in design—a quarter century of design activity in such areas as consumer electronics, packaging and materials, computers, communications, components and instrumentation. This special issue is must reading for every designer. No engineer should be without it. Order extra copies now, for yourself and your associates, by filling in the order blank below.

The complete issue for only $2.00

William H. Smith, Electronic Design Magazine,
50 Essex Street, Rochelle Park, N. J. 07662

Please send me_________ copies of Electronic Design's anniversary issue.

I enclose $2.00 for each copy, including handling and postage.

☐ check
☐ money order

Checks or money orders only, please.

Name__________________________
Firm__________________________
Street_________________________
City__________________________
State/Zip______________________
Augat enclosures. You can do a lot with 3½ inches.

Example: Augat’s 3½-inch-high drawer assembly will package up to 720 DIP’s. That’s a lot. What’s more DIP’s are always in easy reach. Panel frames have unique two-way hinges for accessibility or removal.

Augat rack assemblies also give you plenty of packaging density. Plus flip-up access to panels for fast repairs or design changes.

Smallest of all, our new mini-rack assembly— with small racks and plug-in panels—lets you subdivide logic more flexibly than before.

Whichever way you want to go, you can count on Augat for all your enclosure needs. And probably pay less money than you’re paying now, thanks to our off-the-shelf supply.

Augat. The ones who pioneered the plug-in panel. Call us for panels (with automatic wire wrapping available), enclosures, sockets, accessories. Or write for our catalog.

Augat Inc., 30 Perry Avenue, Attleboro, Mass. 02703. (617) 222-2202. Our representation and distribution is nationwide and international.

Now you need only ONE reader for 150/300/600 CPS

Decitek’s New
UNIVERSAL READER

cuts inventory costs
saves on spare parts
speeds servicing
simplifies your designs
reduces documentation,
software and training

Think of the money, time and trouble you can save by standardizing on one, proven-reliable punched-tape reader for all your applications. Decitek’s evolutionary new “Universal Reader” reads to 300 CPS step-at-a-time truly asynchronously . . . to 600 CPS stop-on-character.

Combines refined electromechanical design and improved electronics with all original Decitek advantages that avoid edge guides, capstans, pinch rolls, brakes, lenses . . . stepping motor/dual sprocket bi-directional drive . . . interchangeable reading of 5, 6, 7 or 8-level paper, metallized polyester or paper-polyester tapes having up to 70% transmissivity. Basic reader with or without electronics, fanfold or spooler. Call or write DECITEK, 16 Sagamore Rd., Worcester, Mass. 01605. Tel. (617) 757-4577.

DECITEK A DIVISION OF JAMESBURY CORP.
INFORMATION RETRIEVAL NUMBER 60
ELECTRONIC DESIGN 25, December 7, 1972
Tektronix, Inc. announces the 577 curve tracer, a measurement system for ICs as well as transistors and other components. The system is divided into three parts: display module, mainframe and test fixture. Modular construction permits a range of options. The system displays parameters of linear ICs such as op amps, comparators and regulators; displays parameters of transistors, FETs, tunnel diodes, SCRs, zener diodes; plots and displays IC characteristics for a whole range of operating conditions, not just single points; and provides storage display.

CIRCLE NO. 277

Distortion analyzer is programmable


Model 334A-H25 distortion analyzer has all the capabilities of the standard Model 334A plus complete programmability of all functions, ranges and settings. Remote control is by parallel BCD TTL logic. A dc output and an interrogation circuit have been added so that an external controller can determine the status of the instrument during measurements. The unit can be manually controlled with back-lighted front-panel push-buttons. As a distortion analyzer, the instrument measures total harmonic distortion from 0.1 to 100% FS in seven ranges. The fundamental frequency range is 10 Hz to 100 kHz; harmonics are indicated up to 1 MHz. Frequency resolution is three digits over the full frequency range.

CIRCLE NO. 278

Simpson Model 2745 offers all this—and more:

- Makes X-Y Recordings with independent selection of X and Y axis sensitivity
- Makes Y-T Recordings with a built-in selectable time sweep
- Has Fast Servo-Drive Response of 0.7 second on X axis and 0.5 second on Y axis for a full scale change
- Makes Bi-Polar Recordings and segmental scale recordings
- Records on Chart Rolls OR Sheets using ink OR inkless writing systems

BATTERY POWERED... NO LINE RESTRICTIONS.

Operates 75 hours or more on a single set of "D" cells with dependable ±1.0% accuracy. All solid state circuitry with high input impedance—FET chopper for long term stability.

Only $750... ready to operate.

Supplied with 2 Y-T chart rolls, 2 X-Y chart pads, inkless stylus pen, fiber tip ink pen, 6 test leads, dust cover, batteries and instruction manual.

ASK YOUR SIMPSON REPRESENTATIVE FOR A DEMONSTRATION... OR WRITE FOR BULLETIN L-1012.

SIMPSON ELECTRIC COMPANY
5200 W. Kinzie St., Chicago, Ill. 60644, (312) 378-1121
Export Dept.: 5200 W. Kinzie St., Chicago, Ill. 60644, Cable SIMELCO
IN INDIA: Ruttansha-Simpson Private Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

INFORMATION RETRIEVAL NUMBER 61
Here's the rechargeable battery for your tough, high-temperature design applications. General Electric's new Goldtop nickel-cadmium batteries have a maximum sustained temperature capability of 65°C — permitting their use in spots previously too hot for nickel-cadmium batteries. And, at 65°C cell temperature, Goldtop batteries have a longer life expectancy than conventional units at 50°C cell temperature. Goldtop batteries are also available in a quick-charge version that can be recharged in 3V2 to 4 hours using a standard charger.

These cylindrical cell batteries are available in a wide variety of sizes and ratings. For more information, write Section 452-02, General Electric Co., Schenectady, New York 12345, or circle reader service card.

**Connector terminates 50 wires simultaneously**


With a single stroke of a special tool, 50 wires are simultaneously cut to length and terminated to the Champ 25-pair cable connector. Designed specifically for the 25-pair cables commonly used in the communications industries, the Champ connector is intermateable and interchangeable with similar connectors currently in use. The all-plastic connectors are molded from an SE-1 rated thermoplastic and can be furnished with or without an integral 90° cover and strain relief made of the same material. Located on 85-mil centers, the replaceable, preloaded contacts are gold-over-nickel plated high conductivity beryllium copper with a unique dual-slot termination. In the actual termination process, an unstripped wire is pressed into both contact slots by the specially designed tooling. The front slot of the contact completely displaces the insulation and extrudes the wire with a wiping action to assure electrical contact, while the rear slot provides a lesser degree of extrusion providing insulation support and strain relief. Excess wire is automatically cut off during the terminating process by the tool. Wiring changes can be readily made in the field with a one-wire-at-a-time hand tool or with a portable hand-operated tool that simultaneously terminates and cuts to length all 50 wires. A semi-automatic power tool is available for production use.

**Leadless IC receptacle uses tin contacts**

Burndy Corp., Richards Ave., Norwalk, Conn. 06852. (203) 838-4444.

Hypoint, a leadless IC receptacle, uses tin contacts to accept an IC package with solder pads. Each Hypoint tin contact has a chisel point which penetrates the IC solder pads to form a highly reliable, gas-tight connection which performs as well as gold-plated contacts. The receptacles come in 24, 28 and 40 contact positions.

**DIP strip connectors span 24, 28, 40 leads**

Standard Applied Engineering Inc., 2165 S. Grand Ave., Santa Ana, Calif. 92705, (714) 540-9256. $0.35 to $0.45 (1000 up); stock.

A line of DIP strip connectors, designed to be used in pairs, accommodates 24, 28 and 40-lead MSI/LSI packages. Contact spacings are on 100-mil centers while strip pairs are positioned according to package width. The 2300 series and 3000 series strip sockets have wire-wrap and dip solder leads respectively. A chamfered closed-entry cap aids insertion of delicate leads.
Everything you always wanted to know about Drive Motors.

Into these five booklets we've crammed 156 pages of the latest information on Kearfott's line of Drive Motors.

Kearfott, as you probably already know, is a primary supplier of drive motors. And has a reputation for quality, service and on-time delivery.

We can furnish you with drive motors in individual units or in packages to fit any of your aerospace or industrial applications. From counters to computers. From business machines to printers and tape readers.

Let's take a look at the type and range of motors we're talking about.

DC TACHOMETERS

Kearfott Tachometers are designed specifically for precision speed sensing and as rate generators to help velocity servos achieve fast response.

Features include: outputs to 100V dc/1000rpm; minimum ripple at high commutation frequency; high linearity; low friction torque.

These are ideal for computer tape transports where efficient data retrieval is a must. And for business machine and numerical control machine tools.

DC TORQUERS

You can get sizes 12 through 42, uncased for gimbal mount applications and cased for direct drive torque motor positioning.

Kearfott can also supply them with a variety of integral feedback elements such as potentiometers, synchros and tachometers—in a single housing.

You've a choice of standard design, inverted construction (inner member is magnetic and transfers power to an outer armature) and brushless Limited Rotation design.

DC MOTORS

These are Moving Coil Motors used for high-response DC servos such as High-Speed Printer and Capatan drives.

One of their unique features is that they need less cooling than equivalent competitive units. The reason: low internal impedance which allows a high cooling flow rate at low developed pressures.

Permanent magnet and wound-field types are available for standard aerospace and industrial applications, including high acceleration motors with integral tachometers for terminal printers.

AC MOTORS

Kearfott induction or synchronous motors of the hysteresis or reluctance type come in a broad range of frame sizes. And from sub-fractional power to 15 HP.

We can furnish motors that run on up to 440 volts ac, single, 2 or 3 phase. Induction motors that operate on 2, 4, 6, 8 or 12 pole design. And dual speed motors such as needed for driving memory discs in large computers.

You can also get: high-slip motors for aircraft requirements at 400 cps; synchronous motors for constant rotating speeds with varying loads; gear motors for extremely low speeds or speeds incompatible with the power supply frequency.

STEPPER MOTORS

If you want precision control—for example for small peripheral devices, small line printers and tape readers—Kearfott Steppers provide it via discreet steps and high slew rates. And in a wide choice of stepping rates and torque levels.

Typical Kearfott units have 15° stepping angles, compatible with all 24-tooth sprockets. They give high holding torque, high stepping speed and fast response.

Units with other step angles, such as 1.8°, 7.5°, 10°, 30°, 45° and 90° are readily available in frame sizes through 50.

But why not get all the details? Mail the coupon for our new booklets now. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, N.J. 07424.
Thermostatic DELAY RELAYS
Offer true hermetic sealing...
Assure maximum stability and life.

Delays: 2 to 180 seconds*
Actuated by a heater, they operate on A.C., D.C., or Pulsating Current... Being hermetically sealed, they are not affected by altitude, moisture, or climate changes... SPST only — normally open or normally closed... Compensated for ambient temperature changes from -55°C to +80°C. Heaters consume approximately 2 W. and may be operated continuously. The units are rugged, explosion-proof, long-lived, and inexpensive!

TYPES: Standard Radio Octal and 9 Pin Miniature.
List Price, $4.00

Cable connector stresses miniaturization, density


Outside diameters of 110, 120 and 140 mils, respectively, for a line of 4, 7 and 12-pin cable connectors demonstrate their small size. The connectors use 1/4-28, 5/16-24 and 3/8-24 threads for the 4, 7 and 12-contact connectors respectively. All bodies, pins and sockets are gold plated brass, the dielectric inserts are TFE teflon and the washers are silicone rubber.

CIRCLE NO. 301
Flat cable connectors remove without strain

Two versions of Scotchflex flat cable connector, designed to permit strain-free pull removal without disturbing the integrity of connections, are Scotchflex 3399-3000, a 26-contact connector, and Scotchflex 3417-3000, a 40-contact connector. Both connectors will transition from Scotchflex round conductor flat cable to standard 25-mil wrap or solder posts on 100-mil grid. They feature a two-part cover that allows the cable to be doubled back over itself and locked in place with a plastic keeper. Pull tests have been performed in excess of the connector removal force without disturbing the integrity of the connection either electrically or physically.

CIRCLE NO. 302

Substrate DIP has area 270 x 270 mils

A 24-lead DIP for MOS and microcircuit packaging, the SP-2298, has a specially processed alumina body molded with a F15-61T lead frame to provide a strong, thermally conductive, hermetic unit for reliable packaging. The over-all dimensions of the package are 1/2 x 1-1/4 in., with the largest reported die-mount area available in a 24-lead package of its size, 270 x 270 mils. The chip cavity, 10 mils deep, has an F15-61T (Kovar) seal ring.

CIRCLE NO. 303
Tung-Sol® Modular Bridge Rectifiers Have Highest Surge Ratings

Junction sizes enable Tung-Sol modular bridge rectifiers to withstand single cycle surges of 300 to 400 amperes. These exceptionally high ratings provide circuit designers with maximum protection against overloads. Check all of the high-performance characteristics of Tung-Sol bridge rectifiers.

Single Phase Bridges

<table>
<thead>
<tr>
<th>Series</th>
<th>DC rating</th>
<th>Forward surge rating</th>
<th>PRV per leg</th>
<th>Case</th>
<th>Epoxy case construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-50</td>
<td>10A @ 75°C</td>
<td>300A @ rated load</td>
<td>50 to 600</td>
<td>Epoxy case construction</td>
<td></td>
</tr>
<tr>
<td>B-40</td>
<td>15A @ 75°C</td>
<td>300A @ rated load</td>
<td>50 to 1,000</td>
<td>Epoxy case construction</td>
<td></td>
</tr>
<tr>
<td>B-10</td>
<td>30A @ 75°C</td>
<td>400A @ rated load</td>
<td>50 to 1,000</td>
<td>Aluminum case construction</td>
<td></td>
</tr>
</tbody>
</table>

Three Phase Bridges

<table>
<thead>
<tr>
<th>Series</th>
<th>DC rating</th>
<th>Forward surge rating</th>
<th>PRV per leg</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-20</td>
<td>35A @ 75°C</td>
<td>400A @ rated load</td>
<td>50 to 1,000</td>
<td>Aluminum case construction</td>
</tr>
</tbody>
</table>

Write for complete information.

SILICON PRODUCTS SECTION
WAGNER ELECTRIC CORPORATION
630 West Mt. Pleasant Ave., Livingston, N.J. 07039
TWX 710-994-4687 PHONE (201) 992-1100
Trademark TUNG-SOL Reg. U.S. Pat. Off., and Marcas Registradas

INFORMATION RETRIEVAL NUMBER 66

Wrapped-wire panels boast high gripping


Wrapped-wire pluggable printed circuit boards offer a spring clip of beryllium-copper alloy and high gripping power even after repeated plug-ins. Entry apertures are funnel-shaped for easy insertion of ICs.

CIRCLE NO. 307

Connector uses lanyard release disconnect


A lanyard-release quick disconnect coupling is an integral part of MS connectors MIL-C-26482, MIL-C-26500 and MIL-C-38999. The special coupling device is available in a swivel or rigid lanyard mount with a choice of bayonet twist-on or straight push-on action. Either style disengages instantly by a straight pull of the lanyard.

CIRCLE NO. 308

Acid dip cleans solder and tin-lead alloys

Enthone Inc., Box 1900, New Haven, Conn. 06508. (203) 934-8611.

An acid dip for immersion cleaning is designed to clean and brighten solder plate on PC boards that have become darkened or tarnished due to etching operations or after long periods of storage. Enplate AD-483 is supplied as a ready-to-use liquid that is operated at room temperature to 120 F for 30 to 60 seconds depending on the processing rate desired.

CIRCLE NO. 309
All-in-one-card RAM. Very fast access time: 125 ns. Very fast delivery: right off the shelf. Contains memory address register, decoding, storage sense amplifiers, write amplifiers, output buffers—everything needed for complete memory function. Up to 18K on a single card. For more words by more bits, just wire the cards together. Power consumption is less than one milliwatt per bit. Price is lower than any other card memory in this speed range. Give us a call. We'll quote price on the phone and ship one to you on a memorandum receipt that gives you a Free Thirty Day Trial Period.

All this from the people who know memories. Electronic Memories & Magnetics Corp. Phoenix Semiconductor Facility, 3883 North 28th Avenue, Phoenix, Arizona 85017. Phone: (602) 263-0202.

INFORMATION RETRIEVAL NUMBER 67

QUICKIE CONNECTOR... FOR THE RAPID, RELIABLE TERMINATION OF FLAT FLEXIBLE CABLE.

The Berg QUICKIE, a female connector, simultaneously terminates multi-lead flexible round cable without pre-stripping. The askedew tines of the contact effect a stripping action which terminates virtually any brand of cable, regardless of insulation material, in about 10 seconds. Design assures redundant electrical contact, and allows for visual inspection before assembly. QUICKIE can be used to interface cable on .050" centers to .025" square wire-wrapping posts on .100" sq. grid. Write for Catalog 125 or call:

BERG ELECTRONICS, INC.
New Cumberland, Pa. 17070
Phone: (717) 936-6711

INFORMATION RETRIEVAL NUMBER 68

Electronics Design 25. December 7, 1972

Rotron Power Conversion Devices

Custom-built to match your own voltage/frequency requirements.

What you need is what you get from Rotron. Because Rotron® will build a solid state converter to meet your most specific requirements—of size, weight, configuration, environmental conditions, and, of course, output. And, with many years experience in matching solid state converters to specific loads, Rotron will do it at reasonable cost.

For computer, aerospace, medicine, marine, instrument, tele-communications, and avionic equipment. AC to AC frequency converters, AC to DC converters (regulated or unregulated) with single or multiple voltage outputs. DC to AC inverters, with optional reverse polarity protection, high voltage protection and RF suppression to MIL specifications.

Before you compromise your system power requirements, learn how the power conditioning pros at Rotron can give you exactly what you do need, at a price you can afford. Contact Wes Riley at Rotron today.

ROTTRON INC., Woodstock, N. Y. 12498
914-679-2401 TWX 510-247-9033
Berg Div., Burbank, Cal. 91506 213-849-7871
Breda, Netherlands, Tel: 49550, Telex: 844-54074

INFORMATION RETRIEVAL NUMBER 69
Keystone
Thermistors
under

glass

You can count on very fast response time and improved reliability even in hostile environments with Keystone's rugged glass beads, probes and assemblies. Select from a large range of resistance values (1 K to 1 meg at 25°C) and temperature levels from -50°C to 260°C. Easy to handle and assemble, these thermistors are ideal for temperature measurement and liquid level detection. Send now for data bulletin. Keystone Carbon Company, Thermistor Division, St. Marys, Pa. 15857.

INFORMATION RETRIEVAL NUMBER 70

Components

Solid-state 40-A relay withstands 500-A inrush

Crydom Controls Div., International Rectifier Corp., 1521 Grand Ave., El Segundo, Calif. 90245. (213) 322-4987. Mod. D1240; $24 (100 up); stock.

Crydom claims that its new 40-A solid-state relay (SSR) has a higher load-current rating than any other SSR. Others on the market are limited to about 25 A when used with equivalent-sized heat sinks. Crydom's 40-A units can switch 120-V (Model D1240) or 240-V (Model D2440) ac loads and operate with 3 to 32-V dc control-signal inputs. Ac-input versions are designated A1240 and A2240, respectively. Units with lower load ratings are also available. The new SSR design achieves the 40-A nominal rating when operating with a 1°C/W heat sink (supplied by the user) in a 30°C ambient temperature. In fact the relay will safely carry as much as 60 A continuously when operated with a larger heat sink that can hold the case below 50°C maximum. The surge rating is 500-A rms for one cycle and 110 A for 0.5 s. Package size is 2.25 x 1.75 x 0.9 in. The device is particularly well suited for high inrush surge applications such as with motors, lamp loads or transformers. Internal design features include photo-isolation and zero-voltage switching. Since there are no contacts to arc the SSR can be used in explosion-prone environments. In addition, the device is compatible with IC or transistor logic levels and can be operated directly from computer outputs.

CIRCLE NO. 250

PSC Low Cost Tape Transports

User Engineered
THROUGHOUT

Interface Industry Standard
7", 8½" or 10½" Reel Size
6.25, 12.5, 25, 37.5 or 45 IPS
Phase Encoding or NRZI
200, 556, 800 or 1600 CPI
Single or Dual Gap Heads
Write, Read, Read Write or Read after Write
Power Fail Safe
Solid State IC Logic

Give us your requirements we'll custom assemble to your specification with off the shelf components.

Call: Chuck Quillen, Director of Marketing for more information.
(213) 245-8424

Producers Service Corp.
Computer Peripheral Div.
1200 Grand Central Ave.
Glendale, Calif. 91201

INFORMATION RETRIEVAL NUMBER 71

ELECTRONIC DESIGN 25, December 7, 1972
Tristimulus detector matches human eye

Photon Products, P. O. Box 1230, Cupertino, Calif. 95014. (408) 296-5226.

The Model T100 tristimulus detector set consists of three detectors—sensitive to blue, green and red—that precisely simulate the human eye's color perception according to the standard C. I. E. observer within 1%. The T100 uses silicon sensors that are spectrally corrected with computer-designed glass-absorption filters. The detectors have better than 1% linearity over a light-level range of six decades. Repeatability remains better than 0.5% of any reading per month or 2% per year.

CIRCLE NO. 320

Rechargeable battery uses gelled electrolyte

Elpower Corp., Div. of Eldon Industries, 2117 S. Anne St., Santa Ana, Calif. 92704 (714) 540-6155.

These gelled-electrolyte units are rechargeable batteries that can replace dry-cell batteries at considerably less cost than nickel-cadmium batteries. They can be connected in series or parallel and they can operate in any position. Standard sizes deliver 6 or 12 V with capacities from 3 to 8 A-hr. Because of the batteries' leakproof construction, the U. S. Postal Service allows them to be shipped by mail without special handling.

CIRCLE NO. 321

Your card reader and interface problems end here.

Hickok designs static card readers with the user in mind. Starting with two rugged, reliable, economical models, we tailor the reader you need for use in programming system control and data collection.

You also receive the help you need. You select among a variety of electronic packages to interface the reader to your system. Packages like TTL-compatible scanners with two operating modes, sequential scanning and addressable by column number.

Reliability is built into Hickok readers with the multistrand continuous brush design. This technique eliminates errors caused by contaminants on the card and allows reading even of cards punched out of tolerance.

This design also saves you money, because it's easier to make. Even in single lots, the 264A Badge Reader is only $175, and the 960A Card Reader, $495.

When you're considering static card readers, call Hickok. We have the right unit at the right price for you.

HICKOK
the value innovator

INFORMATION RETRIEVAL NUMBER 72
The Elegant Custom Coils

Inductor coils made with a jeweler’s touch. At mass-production prices. Elegant answers to applications that demand exacting performance. Like solenoid control valves. And coils for computer disc drives. With custom bobbins, windings and transfer-mold encapsulation executed under a single roof. So turnaround is fast — even when you want sample or pilot quantities.

At U.S. Electronics, you’ll find all the precision and finesse you expect from an EAI component company. Look to EAI also for transformer kits. For thick-film an EAi component company. Look to EAi growing list of other elegantly crafted components, and the economic rationale for thick film hybrids.

The Elegant
Custom Coils

COMPONENTS
Thermister measures fluid flow
Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701. (617) 872-8841.

The Fenwall G-series thermistors have been used successfully in medical applications for respiratory and blood flow-measurement and in industrial applications for fluid pressures and air velocity measurement. These voltage-current (E-I), matched-pair thermistors operate in the self-heat mode. Typical units such as the G112, G126 and G128 have resistance values of 8000, 2000 and 100,000 Ω at 25 °C, respectively.

CIRCLE NO. 322
Synchronous motor reverses electrically

The 86600-Series synchronous motors provide 5.5-oz-in. rotor torque at a rotor speed of 600 rpm. Hardened-steel gear trains provide a selection of shaft speeds down to 10 rpm with proportionate increases in torque. Maximum gear-train capacity is 200 oz-in. The design of the motor insures fast-start and stop operation, eliminating the need for prestart or clutching mechanisms. The motor is built to NEMA type 2-11 configuration and is electrically reversible. Although the standard is 120 V ac at 60 Hz, models can be furnished for 24 or 230 V ac.

CIRCLE NO. 323
Air flow actuates miniature switch
Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. 60085. (312) 639-7600.

A breath of air is said to activate the Series E22-85HX miniature snap-action switch, which is rated 3 A, 125 V ac. The aluminum actuator is purposely long (2-3/8 in.) to allow switch operation on a low force (less than 2 g). The switch can be used to detect air flow from exhaust fans and blowers.

CIRCLE NO. 324
WILEY-INTERSCIENCE
1. Fundamentals of Nuclear Hardening of Electronic Equipment
By L. W. Ricketts, Magnavox Corporation

It is essential that the design engineer be able to analyze, test, and evaluate the radiation effects on his electrical equipment, and design nuclear-hardened components which are resistant to radiation. This book covers every phase of nuclear hardening, from the design and construction of hardened equipment to evaluating the effects of radiation on electronic components.
1972 576 pages $29.95

2. Thick Film Hybrid Microcircuit Technology
By Donald W. Hamer, State of the Art, Inc., and James V. Biggers, Pennsylvania State University

Examining the thick film hybrid circuit from a materials and processing standpoint, this text provides an introduction to thick film microelectronics. Among the topics treated are thick film technology, properties of thick film components, and the economic rationale for thick film hybrids.
1972 424 pages $19.95

3. IEEE Standard Dictionary of Electrical and Electronics Terms
Approved by the Standards Committee of The Institute of Electrical and Electronics Engineers, Inc.

Comprehensive and current, this outstanding dictionary embraces the total language of electrical and electronics engineering. Its special features include 13,000 technical definitions, hundreds of new terms never before found in dictionary form, deprecated terms, and cross-indexing of related terms.
1972 716 pages $19.95

Available from your bookstore or from Dept. 092-A-3070-WI

U.S. Electronics Corporation
Orient Way and New Jersey Avenue
Lyndhurst, New Jersey 07071
Tel. (201) 438-2400
A Subsidiary of Electronic Associates, Inc.

INFORMATION RETRIEVAL NUMBER 73
Chip capacitors serve gigahertz frequencies

GHZ Devices, 16 Maple Rd.,
Chelmsford, Mass. 01824. (617) 256-8101.

A series of high-Q, MOS chip capacitors though designed for operation to only 18 GHz are virtually lossless to 22 GHz. The GC-80000 Series capacitors are used for fixed-capacitive tuning, as filter elements, for capacitive coupling and for dc blocking and rf bypassing. They are available in 48 values, from 1 to 300 pF. A temperature stability of 190 ppm/C max, a tolerance of 10% and their low inductance contribute to the performance at microwave frequencies. Sizes are said to be smaller than other types. Dimensions of the smallest unit are 0.020 W × 0.020 L × 0.005 D in.

CIRCLE NO. 325

Thermistor flakes solder directly to substrate

Thermometrics Inc., 15 Jean Pl.,
Edison, N.J. 08817. (201) 548-2299. $300 (lot of 100); stock to 3 wks.

Claimed to be a first, Thermometrics thermistor flakes provide a flat configuration with directly solderable electrodes for ease in production handling by the microcircuit manufacturer. The Series F20, F40, F80 and F120 Thermoflakes are thick-film thermistors without substrate backings. They are designed for direct mounting to sensing surfaces and substrates. When mounted on substrates, the units tolerate reflow soldering. Thermal time constants range from 38 to 76 ms based on pulsed measurements in still air at 25 C. Resistance coefficients range from -1.5%/C to -5.5%/C. Units with -4%/C are generally available from stock. Resistances at 25 C range from 250 Ω to 3 MΩ and are available in standard tolerances of ±35%. Mid-range resistances from 25 kΩ to 2 MΩ are stocked. Dissipation constants vary with the size of the Thermoflake. A 0.040 × 0.040 × 0.002 in. unit mounted on an aluminum oxide substrate has a dissipation constant of 0.8 mW/C.

CIRCLE NO. 326

A lot of module for your money.

TRIAD’S slot power supplies in B package for OEM systems.

Designed for computers, peripheral equipment and similar applications, Triad’s NCB Series in 5 voltage ranges delivers from 25 to 45 precisely regulated watts of DC power at extremely low ripple. They feature built-in overvoltage protection, automatic fold back current limitation, 10-year life computer grade capacitors, and reverse polarity protection. Lower in cost, the NCB’s retrofit many models on the market today. In stock and available now from Triad distributors.

Wide range, adjustable 40-watt regulated power supplies.

The low cost WR Series features open top construction, integral heat sink housing, 10-year life computer grade capacitors, all silicon semiconductors, FR glass epoxy pc boards, and electrostatically shielded transformers. In stock and available now from Triad distributors.

TRIAD-UTRAD DISTRIBUTOR

Litton
305 North Briant Street, Huntington, Indiana 46750
INFORMATION RETRIEVAL NUMBER 75
MIIDA MODEL 6354

3½ DMM with 0.1% DC ACCURACY.
- Automatic ranging
- 0.1% (DC) and 0.5% (AC) voltage accuracy
- Measures to 200 megohms resistance
- 45Hz to 20 kHz frequency response
- Range and display hold mode
- Automatic polarity display
- Automatic over-range indicator
- Weight under 5 lbs.

$319.95
Other Miida multimeters in full 4 and 4½ digits
Distributors available

MIIDA ELECTRONICS, a division of Marubeni America Corp.,
2 Hammarskjold Plaza, N.Y., N.Y. 10017
(212) 973-7152

INFORMATION RETRIEVAL NUMBER 76

OTHER MIIDA MULTIMETERS
IN FULL 4 AND 4½ DIGITS
DISTRIBUTORS AVAILABLE

Thermocouple unit can transmit long distances

Model 35701 is an electrically isolated transmitter for long-distance transfer of thermocouple signals using ordinary copper wires. Wiring from the thermocouple to transmitter is short, since the unit mounts directly to a standard industrial thermocouple. The transmitter converts the thermocouple's voltage to a directly proportional 4 to 20-mA dc current. Thus, an ordinary milliamperereading instrument can act as a temperature display. Accuracy is 0.2% in accordance with standard (ISA-J, K, T) calibration. Automatic reference-junction compensation is built-in.

CIRCLE NO. 327

Display
16, 32 or 64 Messages.

Three Random Access Rear Projection Readouts (Major 16, 32 or 64), operating like mini-slide projector, display anything that can be put on film... black & white or color... image sizes from 1.10" to 5" high.
Features include: simple, long-life single lamp projection system... 70 m sec access time... 6-bit self-decoding... 150° viewing angles... last message memory... 5 year / 20,000,000 operation life expectancy.
Send for complete data.

MAJOR DATA CORP.
1798 Monrovia Ave.
Costa Mesa, Calif. 92627
Phone: (714) 546-2455

CIRCLE NO. 328

Solid-tantalum capacitor features small size

Subminiature solid-tantalum capacitors, designated 182D (cylindrical) and 188D (rectangular) are no larger than standard bare-chip, uncased units. They are available with axial and single-ended lead configurations and are packaged in polyester-film sleeving with epoxy-resin end seals. Capacitance values range from 0.010 μF at 50 V dc to 220 μF at 3 V with standard tolerances to ±5%. Full rated-voltage operation is permitted from -55 to +85 C, and up to +125 C at two-thirds of the rated voltage.

CIRCLE NO. 328

THERMO ELECTRIC, 109 FIFTH ST., SADDLE BROOK, N.J., 07662. (201) 843-5800.

Thermocouple unit can transmit long distances

Model 35701 is an electrically isolated transmitter for long-distance transfer of thermocouple signals using ordinary copper wires. Wiring from the thermocouple to transmitter is short, since the unit mounts directly to a standard industrial thermocouple. The transmitter converts the thermocouple's voltage to a directly proportional 4 to 20-mA dc current. Thus, an ordinary milliamperereading instrument can act as a temperature display. Accuracy is 0.2% in accordance with standard (ISA-J, K, T) calibration. Automatic reference-junction compensation is built-in.

CIRCLE NO. 327

TECHMAR
OMNICLOSURE
stocks prefab modular chassis, card cages and cabinets for quick delivery.

This is just one of the 4.5 x 10⁷ configurations that assemble from a wide selection of our precision kits and parts. All on hand. Ready to go. Write or call for free full-line catalog and prices: Techmar Corp., 2232 So. Cotner Ave., Los Angeles, CA 90064. Phone (213) 478-0046.

CIRCLE NO. 327

DISPLAY
16, 32 OR 64 MESSAGES.

THERMO ELECTRIC, 109 FIFTH ST., SADDLE BROOK, N.J., 07662. (201) 843-5800.

Thermocouple unit can transmit long distances

Model 35701 is an electrically isolated transmitter for long-distance transfer of thermocouple signals using ordinary copper wires. Wiring from the thermocouple to transmitter is short, since the unit mounts directly to a standard industrial thermocouple. The transmitter converts the thermocouple's voltage to a directly proportional 4 to 20-mA dc current. Thus, an ordinary milliamperereading instrument can act as a temperature display. Accuracy is 0.2% in accordance with standard (ISA-J, K, T) calibration. Automatic reference-junction compensation is built-in.

CIRCLE NO. 327

Solid-tantalum capacitor features small size

Subminiature solid-tantalum capacitors, designated 182D (cylindrical) and 188D (rectangular) are no larger than standard bare-chip, uncased units. They are available with axial and single-ended lead configurations and are packaged in polyester-film sleeving with epoxy-resin end seals. Capacitance values range from 0.010 μF at 50 V dc to 220 μF at 3 V with standard tolerances to ±5%. Full rated-voltage operation is permitted from -55 to +85 C, and up to +125 C at two-thirds of the rated voltage.

CIRCLE NO. 328

INFORMATION RETRIEVAL NUMBER 76

CIRCLE NO. 328

INFORMATION RETRIEVAL NUMBER 77
Double oven stabilizes crystal oscillator

Vectron Laboratories, Inc., 121 Water St., Norwalk, Conn. 06854. (203) 853-4433. 6-10 wks.

With a double proportional oven control the CO-244V crystal oscillator provides an aging rate of less than $1 \times 10^{-9}$ per day while short-term stability is better than $1 \times 10^{-10}$ per second from 0 to 50 C. Sine-wave or logic-type outputs are standard at 1, 5 or 10 MHz. A wide range of other frequencies are also available. Voltage frequency control is featured to permit locking to an external reference or for remote fine-frequency control. Options include $-55$ to $+75$ C operation and supply voltages as low as 5 V dc.

CIRCLE NO. 329

Fork motor modulates optical beams

Philamon, Inc., 90 Hopper St., Westbury, N.Y. 11590. (516) 333-1700. 6 wks.

Iso-Fork, Series FOM 100, is an optical chopper that uses a vibrating fork to drive the device. The main features of the "motor" are that it requires no lubrication and has a life expectancy of over 100,000 hr. A frequency range of 400 to 800 Hz is standard. Frequency accuracies are better than 1%. Power consumption is typically less than 500 mW. These optical fork motors can operate from sea level to space vacuum over a temperature range of $-55$ to $+85$ C. Available shutter variations can produce square, pulsed, sine, scan or several other types of light modulation waves. The tine ends may also be fitted with lenses or mirrors.

CIRCLE NO. 330

Which of these General Electric lamps can help you most?

New Green Glow Lamp!

Finally, a broad spectrum bright green glow lamp from General Electric, that gives you greater design flexibility than ever before. It emits green and blue light with suitable color filters. It is called G2B.

What's more, the G2B is directly interchangeable electrically and physically with our high-brightness C2A red/orange/yellow glow lamp.

So you can use the G2B alone for 120 volt green indicator service. Or together with the C2A to emphasize multiple functions with color. For example: for safe/unsafe functions, dual state indications and to show multiple operations in up to 5 colors. And remember. Both the G2B and C2A save you money because of their low cost, small size and rugged construction.

New Sub-Miniature Wedge Base Lamp.

If space for indicator lights is your problem, this new GE T-1¾ size all-glass wedge-base lamp is your solution. It measures less than ¾" in diameter.

The filament is always positioned in the same relation to the base. It won't freeze in the socket, which virtually ends corrosion problems. And like its big brother — the T-3Y wedgew base lamp — it features a simplified socket design.

Three Potent Infrared Solid State Lamps (LEDS).

Get more than twice the useful output of other GE solid state lamps with GE SSL-54, SSL-55B and SSL-55C.

The increased energy concentrated in a narrow 20° cone allows you to use less sensitive detectors. Or to operate the lamps at lower current. Or to space lamps and detectors farther apart.

All are excellent matches for GE photodetectors and can be used in many photoelectric applications. They're also particularly useful in applications demanding an infrared source capable of withstanding severe shock and vibration.

To get free technical information on any or all of these lamps, just write: General Electric Company, Miniature Lamp Products Department, Inquiry Bureau, Nela Park, Cleveland, Ohio 44112.
Double duty
Double metals

H. A. Wilson Thermometals® are thermostatic bimetals that (1) change shape with temperature and (2) build up force with change of temperature when constrained.

They can be used for Temperature Indication, Temperature Control, Temperature Compensation or Sequence Control.

The many varieties of Thermometal available offer a choice of properties for an unlimited number of applications.

Thermometals can be rolled to any thickness, formed into almost any shape... plated, brazed or welded.

We have more engineering know-how and manufacturing facilities than anyone in this field.

For information and/or technical assistance, call or write the H. A. Wilson Application Engineering Department (201) 464-7000.

CIRCLE NO. 331

Front loading disc drive holds 48 Mbits

Wangco Inc., 2400 Broadway, Santa Monica, Calif. 90404. (213) 828-5565. $3200.

The Series-F front-loading disc drive uses an IBM 2315-type single-disc cartridge and an integral fixed disc. A linear voice-coil type positioner is said to provide a track-to-track access time of 8 ms. A 24-Mbit version of this unit is also available. Disc rotation speeds provided are 1500 or 2400-rev/min.

The track format affords interchangeability with comparable IBM disc-storage units.

CIRCLE NO. 332

Small tape transport rivals larger units

Kennedy Co., 540 W. Woodbury Rd., Altadena, Calif. 91001. (213) 798-0953. $2500 (large qty.); 30 days.

Sophisticated features of large high-speed tape transports are offered in the modestly priced Kennedy Model 9000. The unit provides crystal-controlled timing, marginal-skew check, overwrite editing, checkout controls and selectable addressing. Tape speeds are from 12-1/2 to 37-1/2 in/s. Recording density for nine tracks is 800 bit/in. Dual density is available for 7-track recording.

CIRCLE NO. 333

Unit punches cards from source data

Varifab, Inc., 1700 E. Putnam Ave., Old Greenwich, Conn. 06870. (203) 637-1434. $1095.

Model 404 automatically punches and prints numeric data on standard tab cards or multiple copy tab-card sets, from external cable signals. Typical signal sources include badge/card readers, time clocks, voltmeters and medical instrumentation. Output signals generated from the keyboard can control other devices such as adding machines. Alphabetic and numeric data are punched at 12 char/s.

CIRCLE NO. 334

Cassette unit includes an RS-232 interface

Cipher Data Products, 765 Convoy Ct., San Diego, Calif. 92111. (714) 277-8070. $2450; 30-60 days.

Featuring an RS-232 bit-serial interface for synchronous systems, the Min-cette 2200 is a tape-cassette recorder with bidirectional read/write capability. It has a packing density of 800 bit/in. and a read/write speed of 600 eight-bit char/s. Among the commands to direct the unit, some important ones are read-a-record forward, write-a-record forward and space-a-record reverse.
LSI modem card lowers communications cost

Novation, Inc., 1864 Oxnard St., Tarzana, Calif. 91356. (213) 344-7191. $256; 30 days.

Model 202 plug-in card modem has a quartz-crystal clock, custom MOS/LSI circuitry and active filtering. The single card 1200/1800 baud unit is end-for-end Bell compatible. Standard features include automatic answer, line test, and equalization. Frequency shift keying is used—1200-Hz mark and 2200-Hz space. Data are accepted as asynchronous serial bits. A reverse channel option operating at five or 150 baud is available for terminal applications.

CIRCLE NO. 335

Device joins Varian Mini with CDC 7000


The Varian 620 minicomputer and Control Data Series 3000, 6000 or 7000 computer I/O channels can be joined by Models 2300 and 2300A interconnectors. Model 2300 joins the 620/f with the CDC series for transfer rates up to 274,000 words/sec. Model 2300 uses the Varian priority memory access. 16-bit Varian words are truncated to 12-bit bytes; 12-bit CDC words become the least significant 12 bits of a Varian word. The 6000 and 7000 series must be equipped with CDC channel converters 6681 and 7681, respectively. The couplers are mounted on two Varian DM-135 boards which are installed at the customer site. Documentation consists of detailed specifications schematics and wire lists. Programs are furnished for troubleshooting and performance verification.

CIRCLE NO. 336

PDP-11 operating system uses less core


TAG-11, available with Basic or Fortran, is claimed to be superior in many ways to DEC’s DOS-11 operating system. It uses 8-k of core instead of DEC’s 12-k minimum and can run from two to five times faster. IBM compatible format can be written on both disc and tape for media interchangeability. One mass-storage device such as a disc memory or a tape unit is required in addition to the core.

CIRCLE NO. 337

Video scan converter digitizes camera signal

Colorado Video, Inc., Box 928, Boulder, Colo. 80302. (303) 444-3972. $2500; 90 days.

CVI Model 260 accepts a standard 525-line composite video signal. A stationary image represented by the signal is sliced into vertical lines of 256 dots each. The brightness of each dot is converted to a 6-bit word. Thirty seconds are required to convert a matrix of 256 X 200 dots or one minute for a 256 X 400 matrix. The digital output can be passed to a computer (for image recognition) or sent over telephone lines by means of the 1-kHz analog output that is provided.

CIRCLE NO. 338

1750 ways to keep in touch

At H. A. Wilson we have over 1750 precious and sintered metals and alloys available for electrical contact applications. Yes! Even more than any other company. This wide variety enables us to produce every conceivable form of contact in sizes ranging from the micro-miniature forms used on Apollo spacecraft to up to 11/4 in. square (NEMA #6 and #7) motor starters. Combine this wide selection of materials with our engineering and production capabilities, and it’s obvious there are few, if any, contact problems we can’t solve. Even yours.

For information and/or technical assistance, call or write the H. A. Wilson Application Engineering Department (201) 464-7000.
For us, the truth comes easy.

When we recommend a contact material for your switch, thermostat, relay, elevator control, or any other contact application, it's because it's the proper material for you to use. Not because it happens to be the one we manufacture.

When you produce the broadest line of contact materials you can afford to be objective. No one else can.

While this objectivity is good for our business, it's even better for yours because we'll only recommend a metal because it's best suited for your application...not to make a sale.

Our engineering background, manufacturing facilities and broad experience in applications surpass those of any one in the field. So does our product line of contact metals. For information and/or technical assistance, call or write the H. A. Wilson Application Engineering Department (201) 464-7000.

Engelmann Microwave, Skyline Dr., Montville, N.J. 07045. (201) 334-5700. $85 (without drivers); 4-6 weeks.

The Series 2013 i-f stripline diode switches are said to be the first such series offered as a stock product line. Switches are available in multiple-throw configurations from SPST to SP16T. Each type covers the full frequency range of 20-to-130 MHz. All units display greater than 60 dB isolation and typical VSWR of 1.5:1. Insertion loss is less than 0.5 dB, with switching speed less than 20 ns.

CIRCLE NO. 339

High performing mixer priced at $19.95

Mini-Circuits Laboratory, 2913 Quentin Rd., Brooklyn, N.Y. 11229. (212) 253-5252. P: See below.

The SRA-6 doubly balanced mixer has these key features: broad bandwidth of 3 kHz-to-100 MHz; low conversion loss of 6 dB; and high isolation of 60 dB at low end of band, while greater than 50 dB at 10 MHz. The unit cost is $19.95 (1-24). Applications include up/down frequency converter, frequency doubler, phase detector and electronic attenuator.

CIRCLE NO. 340

Gain equalizers compensate TWT amps

Frequency Contours, Inc., 3140 Alfred St., Santa Clara, Calif. 95050. (408) 984-7820.

A line of low-loss, low VSWR gain-equalizers, termed the FC-1000 series, offer gain compensation or shaping for TWT amps and similar devices. The half-sine periodic response equalizers provide several modes of tuning to allow compensation for minor variations in production of TWTs. Rf power handling capability is 5 W cw (minimum).

CIRCLE NO. 341

Sweep generators cover 32-to-90 GHz range


A line of sweepers, each using an IMPATT diode as the solid state source, operates over the entire frequency range from 32 to 90 GHz. The power supply (Model 44017H) can be used with each of the five different solid state sources in the line. In the 32 to 40 GHz range, two solid state source models are offered: Model 44056H with a 5-GHz bandwidth and Model 44056H-001 with an 8 GHz bandwidth. Both put out 5 mW of power. From 40 to 90 GHz, three models are offered. Each provides 10 GHz bandwidth and 5 mW power or 12 GHz bandwidth at the 3 mW power level. Model 44066H covers 40 to 60 GHz; Model 44016H covers 50 to 75 GHz; and Model 44076H covers 60 to 90 GHz.

CIRCLE NO. 342
Frequency doubler outputs up to 9 GHz


The Z-Match Model WD-102A frequency multiplier accepts input frequencies from 0.02 to 4.5 GHz and produces high-level outputs from 0.04 to 9.0 GHz. Input power is 10 to 20 dBm with fundamental and third harmonic suppression greater than 30 dB over the entire band. With impedances 50 Ω (nominal), typical input VSWR is less than 2:1 over the band and typical output VSWR is less than 2.5:1.

CIRCLE NO. 343

Uhf/vhf hybrid amps offer gains to 26 dB


Four hybrid amps feature high gain and low distortion between 40 and 890 MHz. The low cost ATF415 and ATF419 deliver 16 dB gain (±1 dB) with an intermodulation distortion of -60 dB. The ATF417 has a gain of 26 dB (±1 dB) with a noise figure of 4 dB. And the AFT414 offers a flat gain characteristic of 15 dB ±0.5 dB. Maximum VSWR for all devices is 2.0:1.

CIRCLE NO. 345

Rfi meter fully portable

Singer Instrumentation, 3211 S. La Cienega Blvd., Los Angeles, Calif. 90016. (213) 870-2761.

Weighing 54 pounds and operating from a rechargeable battery or regular ac power line, the Model NM-65T radio interference meter offers full hand portability. It covers the 1-to-10 GHz range and can function for 10 hours without recharging. The instrument measures field intensity, direct peak and slideback peak, and provides an i-f and four video outputs.

CIRCLE NO. 344

CO₂ laser boasts 50 W variable output power

Hadron Inc., 800 Shames Dr., Westbury, N.Y. 11590. (516) 384-4022. $4500; 30 days.

The Model 1050 laser, a flowing gas, air-cooled carbon dioxide type has a variable output up to 50 W multimode. The unit consists of a laser module—this includes a laser tube, air cooling system and gas fittings—and a support module that consists of the power supply and vacuum pump. The support module features variable control of the laser power from 10 to 50 W. The power supply can be pulsed at 120 Hz for perforating or for more efficient cutting.

CIRCLE NO. 346

Mini contacts, maxi line.

The smaller the contact material you need, the greater the chance is that you'll need H. A. Wilson to supply it. Our wide capability, engineering expertise and vast manufacturing facilities combine to let us recommend what is best for you . . . not just what we can supply.

When you have an application that calls for microminiature contact materials, such as Mil spec relays, telemetering equipment, conventional relays, potentiometers, telephone communications equipment, flashers, contact Engelhard.

Chances are it's not new to us.

Our engineering background, manufacturing facilities and broad experience in applications surpass those of any one in the field. For information and/or technical assistance, call or write the H. A. Wilson Application Engineering Department (201) 464-7000.

CIRCLE NO. 347

INFORMATION RETRIEVAL NUMBER 83
**SOLID STATE? GUARDIAN wrote the book**

And it's yours for the asking.

---

**Design aids**

**Display guide**

A display eye chart and display equipment buyer’s guide compares the appearance of the company’s displays, LEDs and Nixie tubes. It outlines factors which should be considered in the selection of equipment using displays. Sperry Information Displays.

*CIRCLE NO. 347*

**CRT console wall chart**

An actual size poster of the FOX 1 CRT console—communications center of the FOX 1 process management and control systems—features the CRT display and keyboard portions of the console. It is printed on a 35 x 35-inch heavy stock suitable for wall mounting. Available with the poster is a brochure describing the console’s display capabilities. Using photographs of 15 actual displays, the brochure depicts the console’s applicability to various industries and to various plant control needs. Foxboro Co.

*CIRCLE NO. 348*

**Image intensifiers**

Two new image-intensifier-tube wall chart/brochures contain data previously restricted by the U.S. Government. The six-page PIT-712 contains concise data on a selection of the company’s special-purpose and magnetically-focused image intensifiers including gated “zoom” types, light shutter types, image stabilization types, large area types and single, double and triple-stage 40 and 90-mm magnetically focused types. The companion eight-page PIT-83 describes selected first, second and third generation electrostatically focused image intensifiers. Third generation types are characterized by the use of III-V photocathode materials, and second generation types by the use of microchannel plates. RCA Electronic Components.

*CIRCLE NO. 349*

---

**Evaluation samples**

**Flat cable**

A range of flat cable includes 14, 16 and 24-conductors and is suitable for interconnecting DIL plugs, test clips and PC boards. The cables consist of 14, 16 and 24-PVC insulated cores laid in parallel in flat formation bonded together with nonmigratory gell PVC paste. The corea are color-coded and are easily separated and stripped for solder or crimp termination. Conductors are 0.4-mm diameter tinned copper wire and insulation is PVC 0.15 radial thickness. Insulation resistance between adjacent conductors is $10^4$ MΩ. Jermyn.

*CIRCLE NO. 350*

**Headed pin fasteners**

A headed spring pin fastener combines the advantages of conventional straight Spiro! pins with those of traditional headed fasteners. The headed pin performs the same function as rivets, drive pins, drive screws, conventional screws, clevis pins or special headed parts and can be used as a hinge, stop, conventional fastener, spring retainer, dowel or other device. C.E.M. Co., Inc.

*CIRCLE NO. 351*

**Test jack**

A nylon-insulated test jack for 0.080 in. diameter probes is ideal for instrument, meter, test or plug-in equipment and components. The jacks are available in colors, with beryllium copper pretinned contacts. Electronic Molding Corp.

*CIRCLE NO. 352*

**Nylon wire tie**

A one-piece, nylon twist-type fastener, initially designed for tying bundles of wires or other stranded materials, provides an unlimited variety of fastening applications. Fastex, Div. Illinois Tool Works Inc.

*CIRCLE NO. 353*
go portable

Introducing THE Digital Panel Meter for Portable Instruments

- Operates over 600 hours on 4 D-cells
- Only 100 mw total power required
- Eliminates battery recharging

NOW, make your portable instruments smaller, lighter, less expensive and more reliable. With the Datascan Model 820 battery powered DPM, you also get a bright, reliable and readable 3½ digit LED display, 0.1% (of reading) accuracy, battery input voltage from 4.8 to 8.0 volts and an attractive miniaturized metal case that's only 3.5" deep x 2.5" wide x 1.3" high.

To get complete specs or to arrange for a demonstration, call or write. We're anxious to help you GO PORTABLE.

*other ranges available.

Datascan
Electronic Products
P.O. Box 785
1111 Paulison Ave.
Clifton, N.J. 07013
Telephone: (201) 478-2800

THE WORLD'S MOST VERSATILE PUNCH

- High speed - 150 cps
- 5-8 track standard, 6 track TTS optional
- "Tape Low" and "Tape Out" sensor included
- Punches paper, mylar, etc.
- Includes supply and take-up spools
- Drive electronics optional
- Immediate delivery from stock

Facit Odnner Inc.
501 Winsor Drive
Secaucus, N.J.

Gentlemen:
I am interested in receiving detailed data on your Tape Punch

Name
Title
Phone
Company
Address
City State Zip

New NL-8051 from NATIONAL ELECTRONICS

- Segmented Phosphor Display
- Low Cost
- Low Power
- Direct Drive from MOS

NATIONAL ELECTRONICS
a varian division
geneva, illinois 60134 (312) 232-4300

INFORMATION RETRIEVAL NUMBER 85
INFORMATION RETRIEVAL NUMBER 86
INFORMATION RETRIEVAL NUMBER 87
Now get a firm grip on your lead-mounted semi's and heat problems, too

IERC retainers/heat sinks hold lead-mounted semi's while controlling heat to improve reliability or let you operate at higher power levels. Our TXB's for Mil-spec environments are excellent retainers on p-c boards or serve as efficient thermal links between case and heat sink. BeO washers are available for electrically-hot-case applications. Use our staggered-finger LP Series for power increases of 7 to 12 in still and 10 to 15 in forced air with no increase in junction temperature. And, if your semi's are already mounted, slip on a Fan Top and get higher wattages for just pennies. Send for catalog.

IERC, 135 W. Magnolia Blvd., Burbank, Calif. 91502, a subsidiary of Dynamics Corporation of America.

**FREE WITH OUR ENCAPSULATED POWER SUPPLIES**

... we will send you a mating socket. That's right. Computer Products, the leading manufacturer of encapsulated power supplies, will send you a free mating socket with your order (Offer expires January 1, 1973 ... limit one per customer). It's Computer Products' way of introducing you to the most reliable power supply for your applications. Reference this ad when ordering.

Contact us for our catalog describing the complete line and illustrating PIN-FOR-PIN compatibility with major OP-AMP and POWER SUPPLY manufacturers' units.

<table>
<thead>
<tr>
<th>PM505 ±15VDC @ 100mA</th>
<th>LIST</th>
<th>10-24</th>
<th>100-249</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 0.02% Regulation .5mV Ripple</td>
<td>$45.00</td>
<td>$36.00</td>
<td>$24.75</td>
</tr>
<tr>
<td>PM565 ±15VDC @ 200mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>± 0.02% Regulation .5mV Ripple</td>
<td>$65.00</td>
<td>$52.00</td>
<td>$35.75</td>
</tr>
<tr>
<td>PM534 5VDC @ 500mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>± 0.04% Regulation 1.0mV Ripple</td>
<td>$45.00</td>
<td>$36.00</td>
<td>$24.75</td>
</tr>
<tr>
<td>PM542 5VDC @ 1000mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>± 0.04% Regulation 1.0mV Ripple</td>
<td>$65.00</td>
<td>$52.00</td>
<td>$35.75</td>
</tr>
</tbody>
</table>


**APPLICATION NOTES**

**Liquid crystals**

"Liquid Crystals," Publication No. JJ-14, describes liquid crystal compounds and their classifications — nematic, smectic and cholesteric. For application in the measurement of surface temperatures, as well as in the detection of surface temperature variations, the publication lists more than 100 liquid crystal mixtures. Eastman Kodak Co., Rochester, N.Y.

CIRCLE NO. 354

**Three-phase motor guide**

Ideafile No. 4 presents a discussion of problems inherent in the operation of three-phase part-winding-start motors as commonly applied in air-conditioning, refrigeration, heating, data-processing, and other equipment. One of the common problems discussed is the need for closer-tolerance overload protection in new, small motors whose normal running current is nearer to locked-rotor current than was true of earlier, more heavily insulated motors. Heinemann Electric Co., Trenton, N.J.

CIRCLE NO. 355

**File management system**

The MARK IV Technical System Description, a 44-page document, is adapted from "A Survey of Generalized Data Base Management Systems," which was prepared by the CODASYL Systems Committee for the Conference on Data Systems Languages. Part 1 of the publication is a complete, succinct technical description of the MARK IV File Management System. All of the changes and improvements made to the system since its introduction are discussed in this document. Part 2 is entitled "Feature List for the Survey of Generalized Data Base Management Systems," which is the format for the CODASYL report. Informatics Inc., Software Products Co., Canoga Park, Calif.

CIRCLE NO. 356
Thin film materials

The latest "Thin Film Materials Selector" lists, with prices, all the high purity metals and nonmetallic materials that MRC produces for sputtering and vapor deposition techniques. Included are MRC's MARZ grade metals, alloys and compounds; VP grade metals and alloys, most of which meet a 99.99% or better purity specification and IC grade nonmetallic compounds, which the company claims are the highest grade nonmetals available, except for MRC's MARZ grade materials. New listings are: gallium arsenide and gallium phosphide single crystals for the growing LED market; coated COVAP filament evaporation sources with thick, uniform coatings of most every standard MRC metal or nonmetallic material; SUPER-STRATES, MRC's ultra-fine grained 99.6% alumina substrate for thin-film hybrid and microwave integrated circuits. Materials Research Corp., Orangeburg, N.Y.

CIRCLE NO. 357

SCR bias

Tech Tips 3-2 explains in basic terms what happens when the gate cathode of an SCR remains positive while the anode cathode is negative (in a reverse blocking state). The result is a drastic increase in leakage current. The illustrated four-page note points out that the condition can exist in typical thyristor applications, such as a three-phase bridge circuit with a common dc gate cathode supply. It recommends against such designs, citing the reverse power losses which must be taken into account as well as possible effects on device reliability. Written by application engineer J. D. Balenovich, "Positive Gate Bias While an SCR is in a Reverse Blocking Mode" is the latest in the popular "Tech Tip" series of short articles on the selection, application, use and maintenance of discrete power semiconductors and subsystems. Westinghouse Electric Corp., Semiconductor Div., Youngwood, Pa.

CIRCLE NO. 358
Magnetic shielding

A 16-page, two-color catalog constitutes a comprehensive state-of-the-art manual on magnetic shielding. Detailed technical data is given on fabricating and shielding, using AD-MU ductile foils, sheet stock, tape data protectors, various components and custom fabricated shields. Physical characteristics of the four types of AD-MU alloys are tabulated to serve as guidelines in specifying the correct shielding. Other listings include 14 types of tape data protectors and 312 types of shields for photomultiplier tubes. Eight dimensional drawings of typical CRT magnetic shields are shown. Sixteen shields are illustrated. Ad-Vance Magnetics, Inc., Rochester, Ind.

CIRCLE NO. 359

PC laminates

A complete listing of high-quality copper-clad circuit laminates is given in a 12-page brochure. A table of application requirements vs. uses, a grade selection table, technical specifications, Underwriters' Laboratories recognitions and ordering information is found in the illustrated publication. Also listed are the special features of the Micarta materials and sales locations in the U.S. and abroad. Westinghouse Electric Corp., Pittsburgh, Pa.

CIRCLE NO. 361

Aviation products

A new series of literature on the company's aviation equipment product line includes STAN, STAN II and AccuMAC integral weight and balance systems, cockpit voice and flight data recorders and music announcement reproducers. Fairchild Industrial Products, Commack, N.Y.

CIRCLE NO. 362

Digital voltmeter

A four-page bulletin details the Model D-2400 two-range or two-function digital voltage or temperature measurement and display unit. Described is the device's interchangeable plug-in modules, unique cold junction reference and 40,000 count resolution. Esterline Angus, Indianapolis, Ind.

CIRCLE NO. 363

Cooling systems

A complete family of compact, lightweight, modular cooling packages especially designed for cooling systems using power semiconductor devices is described in a catalog. A technical applications section in the catalog reviews the applicable cooling formulae to demonstrate the Cool-Pax's increased cooling effectiveness; and also provides the engineer with a simple guide to analyzing Cool-Pax applications and predicting thermal performance in his own systems. Thermalloy, Dallas, Tex.

CIRCLE NO. 364

Breadboarding system

Bulletin 101, a four-page folder, describes the Mini-Mount Breadboarding System. A variety of Mini-Mount patterns are available, including mounts for DIP IC packages, multilead ICs, transistors, trimmer potentiometers, capacitors, diodes and resistors. Christiansen Radio Co., Laguna Beach, Calif.

CIRCLE NO. 365

Solderless terminals

A 12-page, short-form catalog lists more than 1000 solderless terminals and connectors as well as crimping tools. The four-color, easy-to-read catalog includes illustrations and dimensions of each unit. Hoffman Industrial Products, Farmingdale, N.Y.

CIRCLE NO. 366

Power instrumentation

The Power Instrumentation Catalog, a 24-page, color-coded publication, includes information, specifications, dimensions and connection diagrams for the company's watt, var, power factor, current, voltage, frequency and phase angle transducers. In addition, specifications and other pertinent information on the company's demand computer, temperature transducer, power test console, digit wattmeters and transducer calibrators are shown. Scientific Columbus, a unit of Esterline Corp., Columbus, Ohio.

CIRCLE NO. 367

Industrial transformers

The Industrial/Commercial Transformer and Inductor catalog details the company's line of components for industrial and commercial applications. The short-form catalog previews two lines of miniature plug-in power and audio transformers for PC board applications. Bourns Pacific Magnetics Corp., Romoland, Calif.

CIRCLE NO. 368

Thumbwheel switch data


CIRCLE NO. 369
Your choice package for easier, less expensive circuit design

CORDIP™ COMPONENT NETWORKS

CORNING Electronics offers combinations of resistors, capacitors and diodes in standard dual in-line packages. With these CORDIP networks you can design circuit combinations of up to 20 components in a 14-pin DIP and up to 23 in a 16-pin DIP. They offer higher component densities, less complex circuit boards, reduced inventory of discretes, and significant savings in handling costs. Prototypes available in three weeks, production quantities in approximately eight weeks.


SWITCH/INDICATORS

THE FIRST TRULY SUBMINIATURE LED SWITCH/INDICATOR

Extremely compact TEC-LITE SSBL Series combines LED and SPST–NO–DB switch in a low cost, highly reliable unit for a variety of display and control functions... especially where space is limited. The .360 diameter, anodized aluminum body protrudes just 3/32" behind panel, including terminals. Mounts in 1/8" hole on 3/16" centers.

Red LED is mounted high in lens for maximum visibility. Replaces incandescent or neon lamps for low current, solid state applications. Internal resistor adapts unit for 5 or 6.3 VDC operation. Switch life is one million operations at 20 mA. In 3 lens colors. $4.10 each in quantities of 100.

Matching Indicator. SSIL Series LED with resistor for 5-28 VDC operation. $3.10 ea., 100 quantities.

Write: TEC Incorporated, 9800 N. Oracle Road, Tucson, Arizona 85704. — call (602) 297-1111.
Thin-Trim® variable capacitors are designed to replace fixed tuning techniques. Applications include crystal oscillators, CATV amplifiers, communication and test equipment. Series 9410 has high Q's with five capacitance ranges from 1.0 - 4.5 pf to 10.0 - 50.0 pf. Johnanson Manufacturing Corporation, Boon­ton, N. J. (201) 223-2676

INFORMATION RETRIEVAL NUMBER 161

Control Meter Relay Speed Indicating System for use in process & control machinery. Adjustable single/dbl set pt systems, accuracy ±2% full scale, repeatability 0.5%, speed ranges 10rpm to 12,000rpm. Dbl set pts adjust to 0° ea other. Servo-Tek Products Company, 1086 Goffle Road, Hawthorne, NJ 07506 (201) 427-3100.

INFORMATION RETRIEVAL NUMBER 162

COS/MOS Pulse Generator—Features Squarewaves 1Hz-1MHz/Pulse-widths 1μ - 1 sec/“D” FF with S & R/Non-Capacitive Differentiator/Level Detector/“De-bounced” Push button. Q & Q outputs and complementary inputs available all functions. 3 - 15V circuit supply. Ideal as bench and built-in test equip. $125. American Laser Systems. (805) 687-1212

INFORMATION RETRIEVAL NUMBER 163

IC testing

An applications booklet on the techniques of linear IC testing includes the analysis of transfer functions. The 12-page publication describes the Model 1420 tester and an optional unit that allows instant display of transfer function characteristics. The booklet details how the tester checks performance of linear ICs over the complete operating range of the device, providing inspection and evaluation to the exact specifications of the manufacturer or user. Sitek, Inc., Sunnyvale, Calif.

CIRCLE NO. 370

Digital printer

A technical data sheet describes the company's Series 7726 accumulating digital printer used to produce printed records for inventory control and cut-to-length applications. Standard features are listed for this printer/totalizer. Options include aperture card printout. Veeder-Root. Hartford, Conn.

CIRCLE NO. 371

Connectors

Cylindrical, subminiature rectangular, crimp-removable cylindrical and filtered contact connectors are presented in a catalog. Appropriately sectioned by product groupings for convenient reference, the manual also includes information on the company's specialized connector lines for audio applications, military communications equipment, power and control interconnections. General Connector Corp., Newton, Mass.

CIRCLE NO. 372

Handbook of flat cable

A revised Handbook of Flat Cable prepared by the Institute of Printed Circuits contains 40 pages divided into eight chapters with 40 illustrations, 20 of which are photographs. The eight chapters cover distinguishing features, termination, connectors, wiring change possibilities, cable assemblies, installation and support, technical data, and signal transmission lines, plus a flat cable glossary. Price per copy is $5.00. Institute of Printed Circuits, 1717 Howard St., Evanston, Ill. 60202.

Flexible sound barriers

A brochure provides sound attenuation data, specification and application information on flexible sound barrier material. Duracote Corp., Ravenna, Ohio.

CIRCLE NO. 373

Precision potentiometers

Ten-turn, high-performance precision potentiometers for industrial and commercial applications are described in a bulletin. The bulletin outlines electrical characteristics of the company's 7/8-inch diameter MF 78 Series "pots." Other electrical, mechanical and environmental characteristics, specifications, line drawings, product features and a photo of the precision potentiometer are included. Amphenol Connector Div., Controls Operations, Broadview, Ill.

CIRCLE NO. 374

Wattmeters

An eight-page supplement to the General Catalog lists over thirty new Thru-line rf directional wattmeters, Termaline rf load resistors and an attenuator. Prices are included with equipment photos and performance specifications. Bird Electronic Corp., Cleveland (Solon), Ohio.

CIRCLE NO. 375

LSI computer

The Space Ultrareliable Modular Computer (SUMC) LSI Computer Systems are described in a 12-page bulletin. RCA, Advanced Technology, Camden, N.J.

CIRCLE NO. 376
The Hathaway Form C, FCC miniature dimmer switch has taken off. It should! It covers a multitude of high density packaging applications where moderate voltage and current are faced, and the price is right. Give it a try.

Send for the Hathaway Drireed Switches catalog to get the specs, and ask for samples.

---

**ELECTRICAL COMPAC**

**E2B**

**Life Tests:**

Electrical impulse E2B counters, running at 600 counts per minute under laboratory conditions, have achieved the following:

- 50,000,000 counts—DC units
- 15,000,000 counts—AC units

**Accuracy:** Complete reliability under variable test conditions.

**Figures:** 6 digits, black on white.

**Voltages:**

- 115 V. AC
- 230 V. AC
- 24 V. AC
- 24 V. DC (4 watts)

**Drive:** New patented reciprocating Delrin verge.

**Mounting:** Base or panel mount.

**Face Size:** 1.72" W x 1.19" H x 2.34" D. (Net wt. 5 oz.)

**Recognition:** Meets U.L. and C.S.A. standards.

**Delivery:** Most voltages available from stock.

**FREE**

**The World's Largest Consumer Electronics Catalog**

- Stereo/Hi-Fi Components
- Musical Instruments and Amplifiers
- CB & Ham Equipment
- Tools and Test Equipment
- Police and Fire Monitor Receivers
- Public Address Systems
- Photography Equipment
- Semiconductors, Books, Parts
- Plus Much More!

**Send For Your Free Lafayette Catalog Today!**

Lafayette Radio Electronics, Dept. 45122
P.O. Box 10, Syosset, L.I., N.Y. 11791

**Send Me the Free Lafayette Catalog**

**INFORMATION RETRIEVAL NUMBER 96**

---

**HOT ITEM!**

**Hathaway Form C**

**FCC Drireed Switch**

The Hathaway Form C, FCC miniature dimmer switch has taken off. It should! It covers a multitude of high density packaging applications where moderate voltage and current are faced, and the price is right. Give it a try.

Send for the Hathaway Drireed Switches catalog to get the specs, and ask for samples.

---

**ENM COMPANY**

5340 Northwest Highway, Chicago, Ill. 60630
PHONE: (312) 775-8400 TELEX: 25-4068

---

**INFORMATION RETRIEVAL NUMBER 97**

---
Instant lead exposure! No trouble. No damage. Just snip the cut line or pull the binding thread. Another emphatic advantage of woven cable and one of the biggest time-money savers ever to hit a production line.

Write for our free folder "Fast Lead Exposure."

WOVEN ELECTRONICS
A DIVISION OF SOUTHERN WEAVING COMPANY
P.O. Box 189, Mauldin, S.C. 29662. (803) 288-4411

INFORMATION RETRIEVAL NUMBER 98

Attention Advertisers:

Could you use copies of your ad exactly as it appeared in ELECTRONIC DESIGN? Then order your reprints directly from us; the minimum unit order is 500 copies.

Please specify if you would like the reprint line omitted on your copies and mail your written order to ELECTRONIC DESIGN, Production Dept., 50 Essex Street, Rochelle Park, New Jersey 07662.

500 1,000 Add’l M
8x10 or smaller
1 color, 1 side $74.70 82.95 18.15
2 color, 1 side 95.47 108.00 25.28
4 color, 1 side 311.03 342.00 44.33

Spreads
1 color 113.66 126.65 25.98
2 color 191.19 205.98 29.58
4 color 354.17 380.76 53.19

Prices FOB Waseca, Minn.

Attention Advertisers:

Could you use copies of your ad exactly as it appeared in ELECTRONIC DESIGN? Then order your reprints directly from us; the minimum unit order is 500 copies.

Please specify if you would like the reprint line omitted on your copies and mail your written order to ELECTRONIC DESIGN, Production Dept., 50 Essex Street, Rochelle Park, New Jersey 07662.

500 1,000 Add’l M
8x10 or smaller
1 color, 1 side $74.70 82.95 18.15
2 color, 1 side 95.47 108.00 25.28
4 color, 1 side 311.03 342.00 44.33

Spreads
1 color 113.66 126.65 25.98
2 color 191.19 205.98 29.58
4 color 354.17 380.76 53.19

Prices FOB Waseca, Minn.
NCR will provide maintenance service for Quantor equipment. Service will extend to the total line of COM (Computer Output Microfilm) and microfiche equipment.

CIRCLE NO. 383

The Mallory Capacitor Co., a div. of P. R. Mallory & Co. Inc., has announced price increases of 8% for its lines of FP, CG, CGS, TC, TCW and TCG electrolytic aluminum capacitors and ac motor start capacitors. The price increases are within the applicable guidelines of the Price Commission.

CIRCLE NO. 384

Price reductions

Sperry Information Displays Div. has announced a price cut on its seven-segment planar gas discharge display and decoder/driver lines. Display prices are reduced to $3.80 from $5.50 (1-99); $2.96 from $3.30 (100-499); $2.50 from $3.30 (500-999); $2 from $2.52 (1000-4999). Decoder/driver prices are reduced to $3.25 from $5.40 (1-99); $2.50 from $2.70 (100-499); $2 from $2.70 (500-999); $1.50 from $1.55 (1000-4999).

CIRCLE NO. 385

Materials Research Corp. has reduced prices 25% on its 1 x 1 x 0.025-in. Superstrates sputter-coated with 200 Å of chromium and 150 micro-inches of gold.

CIRCLE NO. 386

Zeltex, Inc., has announced a price reduction for its fast settling, ultra-high speed inverting amplifier, Model ZA910M1. In quantities of 1 to 24, the price has been reduced to $89 from $99.

CIRCLE NO. 387

Digital Computer Controls Inc., has reduced prices 25% on its ME-1 core memory expansion unit. The initial 4-k increment of add-on memory has been reduced to $2700 from $3500. Additional 4-k increments have been cut from $2375 to $1900.

CIRCLE NO. 388

The Chomerics EF Keyboard
(It's the keyboard of tomorrow.)

And most of the key parts are missing. All the moving parts, and most of the expensive ones. Instead, the EF switches with a single piece of highly conductive rubber. It's fail-proof, less than 3/16" thick, and comes in any configuration you want to dream up. For a price you won't believe.

Pretty soon everybody will be trying to make keyboards like the EF. Meanwhile you'll have to come to us.

CIRCLE NO. 389

Erie Frequency Control

The Need:
A 1.22880 MHz CRYSTAL TO MEET
100 G SHOCK AND +50 G VIBRATION

PROBLEM-SOLUTION
#14

PROBLEM
The military demanded a miniature 1.22880 MHz crystal be designed to resist a shock of 100 G and 50 G vibration guaranteed through continuous monitoring during test, while maintaining all frequency and resistance tolerances.

ERIE'S SOLUTION
Erie designed a special welded mount which clamped the crystal without restricting the free vibration of the piezoelectric plate, enabling it to meet this rugged performance criteria.

CRYSTALS . . . CRYSTAL FILTERS . . . OSCILLATORS

Write for our fully illustrated catalog and send us your Frequency Control problem for solution.

ERIE FREQUENCY CONTROL
453 LINCOLN ST., CARLISLE, PA. 17013 (717) 249-2232
DIVISION OF ERIE TECHNOLOGICAL PRODUCTS, INC.

INFORMATION RETRIEVAL NUMBER 101
Electronic Design's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

Want a subscription? ELECTRONIC DESIGN is sent free to qualified engineers and engineering managers doing design work, supervising design or setting standards in the United States and Western Europe. For a free subscription, use the application form bound in the magazine. If none is included, write to us directly for an application form.

If you do not qualify, you may take out a paid subscription for $30 a year in the U.S.A., $40 a year elsewhere. Single copies are $1.50 each.

If you change your address, send us an old mailing label and your new address, there is generally a postcard for this bound in the magazine. You will have to requalify to continue receiving ELECTRONIC DESIGN free.

The accuracy policy of ELECTRONIC DESIGN is:

- To make diligent efforts to ensure the accuracy of editorial matter.
- To publish prompt corrections whenever inaccuracies are brought to our attention. Corrections appear in "Across the Desk."
- To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.
- To refuse any advertisement deemed to be misleading or fraudulent.

Microfilm copies are available of complete volumes of ELECTRONIC DESIGN at $19.00 per volume, beginning with Volume 9, 1961. Work is now in process to complete the microfilm edition of Volumes 1-8. Reprints of individual articles may be obtained for $2.00 each, prepaid ($5.00 for each additional copy of the same article) no matter how long the article. For further details and to place orders, contact the Customer Services Department, University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106 telephone (313) 761-4700.

Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor
ELECTRONIC DESIGN
50 Essex Street
Rochelle Park, N.J. 07662

Design Data from

New Monograph on Real-Time Data Processing Techniques

A new publication by Federal Scientific, originators of the Ubiquitous® Spectrum Analyzer, covers general and specific signal processing techniques and theoretical constraints.

- Random data processing and statistical certainty of Power Spectral Density Estimates
- Constraints in frequency analysis due to bandwidth, sampling and signal length
- Time domain weighting, with charts of theoretical performance using different weighting functions
- Theory of operation of time-compression analyzers
- Cross-property analysis and application in determining transmission and transfer functions by correlation and cross-power spectral density
- Processing of Transient data

Federal Scientific Corporation
615 West 131st Street, New York, N.Y. 10027

EXTRUDED HEAT SINKS WALL CHART

Now available is a short form catalog that opens into a convenient wall chart featuring 107 popular standard models of TOR™ aluminum heat sink extrusions. Accompanying a drawing of each model is the size of the dissipating surface, thermal resistance and weight. Also included are the various standard hole patterns, stud clearance hole options and extrusion tolerances. The introduction of Models 1722A and 1722B Forced Convection Heat Sinks is featured in the catalog. Incorporating new ideas in heat sink design, units are half the size and weight of conventional units at a 20% to 40% cost reduction.

Heat Sink Division
PRECISION DIPBRAZE TOR, INC.
14715 Arminta Street
Van Nuys, California 91402
(213) 786-6524

Practical Instrumentation Transducers

A thorough, authoritative information source on transducer selection and use. This well-planned guide by Frank J. Oliver covers virtually every known device for industrial or aerospace application. Stressing topics neglected elsewhere, it clarifies such areas as interference problems in hard-wire telemetry systems, and transducers as feedback devices in servo systems. Hundreds of diagrams, charts, and tables included.

Hayden Book Company, Inc.
116 West 14th Street
New York, N.Y. 10011
Giant Free Catalog! 4,000 Unusual Bargains

New 164-page catalog! Packed with 1,000's of hard-to-find buys in Optics, Science, Electronics. Loaded with optical, scientific, electronic equipment available from stock. Rare surplus buys. Many "one-of-a-kinds". Ingenious scientific tools. Components galore: lenses, prisms, wedges, mirrors, mounts, accessories. 100's of instruments: pollution test equipment, lasers, comparators, magnifiers, microscopes, projectors, telescopes, binoculars, photo attachments, unique lighting. Shop, save by mail! Request free Catalog "DA".

Edmund Scientific Co.
America's Largest Science-Optics-Electronics Mart
300 Edscorp Bldg., Barrington, New Jersey 08007 (609) 547-3488

1973 Electronic Components Drafting Aids Catalog

Free Catalog! Free Samples! Exciting innovations in pressure-sensitive electronic component drafting aids and methods are detailed in the new 1973 edition of the combined Bishop Technical Manual and Catalog 105. 84 illustrated pages of over 15,000 multi-pad configurations, symbols, tapes, sequential reference designations plus hundreds of time-and-money saving hints in making artwork for PC boards. Includes instructions for using the industry's only red and blue tape system for making two-sided boards in perfect registration. Send now for free Catalog 105 and free samples.

Bishop Graphics, Inc.
7300 Radford Avenue, North Hollywood, California 91605
(213) 982-2000 Telex: 674672

Low-Noise High-Gain Preamplification

Complete specifications of a variable-bandwidth high-gain preamplifier are contained in the P.A.R. data sheet, T-224. Included are typical noise figure contours illustrating the amplifier’s exceptionally low noise, which is as low as .05 dB at mid frequencies with a 1 megohm source. Other illustrations include typical plots of the equivalent input noise and common mode rejection, which exceeds 100 dB at 60 Hz at all gain settings. The data contained in the specification sheet will be of interest to all engineers and researchers looking for a preamplifier with calibrated gain and rolloffs from dc to 300 kHz.

Princeton Applied Research Corporation
Box 2565, Princeton, New Jersey 08540 - (609) 452-2111
When the washer or spacer you want is non-standard, check out...

**BOKER’S ‘Bastard’ WASHERS & SPACERS**

Send for this FREE list of dies on hand.

**OVER 1600 SIZES**
- O.D., .086" to 1.935”
- I.D., .027" to 1.637”
- Thickness, .005" to .125”

Material, ANY stampable. Select the size that fits your need and we will make any quantity without die charge.

All BOKER’S ‘Bastard’ washers and spacers are produced to order. Use of available dies assures PROMPT delivery with certified quality. For a size not listed contact BOKER’S.

BOKER’S Complete Stamping Service includes tooling, stamping, forming, drawing, welding, secondary operations and thorough inspection including metallurgical lab.

Send print for prompt quote or PHONE, 612, 729-9365.

---

**CONDUCTIVE WINDOWS**

- Highly conductive, transparent-coated optical display windows
- Optimum EMI/RFI shielding
- 14 ohms/sq. resistivity
- 75% visible light transmission
- Glass or plastic substrates
- Adherent, inert stable coating
- Silver buss terminations
- Selection of EMI/RFI gaskets
- Reticles available
- Write for data #711.

**TECKNIT®**

Technical Wire Products, Inc.

Eastern Division • 129 Dermody St., Cranford, NJ 07016 (201) 272-5500
Western Division • 427 Olive St., Santa Barbara, CA 93101 (805) 963-1867

---

**MINI/Bus**

The low-cost, noise attenuating, high packaging density, power distribution system for PC boards. Ask for data.

Rogers Corporation / Chandler, Arizona 85224
West: (602) 963-4584
East: (203) 774-9605

---

**Zero Manufacturing Co.**

Zero-West (213) 846-4191 • 1121 Chestnut St. • Burbank, Ca. 91503
Zero-East (413) 267-5561 • 288 Main St. • Monson, Mass. 01057
Zero-South (813) 531-8991 • Int’l Airport • St. Petersburg, Fla. 33732

---

**V-1**

6-WAY versatile instrument package

Multiple function
+ contemporary styling
+ affordable prices.

(1) Vertical Nestable; (2) Vertical Interlockable; (3) Horizontal Interlockable; (4) Rack Mountable; (5) Briefcase Portable; (6) Tiltable... in 14 standard sizes.

Call or write for free VIP Design Guide and Prices.
<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC Products, Inc.</td>
<td>105</td>
</tr>
<tr>
<td>AMP, Incorporated</td>
<td>39</td>
</tr>
<tr>
<td>Abbott Transformer Laboratories, Incorporated</td>
<td>6</td>
</tr>
<tr>
<td>Acutronics, Inc.</td>
<td>81</td>
</tr>
<tr>
<td>Acopian Corp.</td>
<td>153</td>
</tr>
<tr>
<td>Allen-Bradley Co.</td>
<td>19</td>
</tr>
<tr>
<td>American Laser Systems</td>
<td>144</td>
</tr>
<tr>
<td>Amperite</td>
<td></td>
</tr>
<tr>
<td>Amphenol, Bunker-Ramo</td>
<td>37</td>
</tr>
<tr>
<td>Augat, Inc.</td>
<td>120</td>
</tr>
<tr>
<td>Belden Corporation</td>
<td>8, 9</td>
</tr>
<tr>
<td>Berg Electronics, Inc.</td>
<td>127</td>
</tr>
<tr>
<td>Bishop Graphics, Inc.</td>
<td>149</td>
</tr>
<tr>
<td>Boker's Inc.</td>
<td>150</td>
</tr>
<tr>
<td>Bourns, Inc., Trimplot</td>
<td></td>
</tr>
<tr>
<td>Products Division</td>
<td>4, 5</td>
</tr>
<tr>
<td>Buckbee Mears Company</td>
<td>113</td>
</tr>
<tr>
<td>CTS Corporation</td>
<td>92, 93</td>
</tr>
<tr>
<td>Chomerics</td>
<td></td>
</tr>
<tr>
<td>Computer Automation, Inc.</td>
<td>17</td>
</tr>
<tr>
<td>Computer Products</td>
<td>140</td>
</tr>
<tr>
<td>Continental Connector Corporation</td>
<td>18</td>
</tr>
<tr>
<td>Corning Glass Works, Electronic Products Division</td>
<td>143</td>
</tr>
<tr>
<td>Cutler-Hammer</td>
<td>16</td>
</tr>
<tr>
<td>Dale Electronics, Inc.</td>
<td>Cover II</td>
</tr>
<tr>
<td>Data Disc, Inc.</td>
<td>23</td>
</tr>
<tr>
<td>Data Link Corporation</td>
<td>146</td>
</tr>
<tr>
<td>Datak Corporation</td>
<td>153</td>
</tr>
<tr>
<td>Datascan Electronic Products</td>
<td>139</td>
</tr>
<tr>
<td>Decitak, Division of Jamesbury Corp.</td>
<td>120</td>
</tr>
<tr>
<td>Delco Electronics Division of General Motors Corporation</td>
<td>82, 83</td>
</tr>
<tr>
<td>Digital Company, The</td>
<td>152</td>
</tr>
<tr>
<td>Dow Corning Corporation</td>
<td>70, 71</td>
</tr>
<tr>
<td>ECC Corporation</td>
<td>7</td>
</tr>
<tr>
<td>ENM Company</td>
<td>145</td>
</tr>
<tr>
<td>Edmund Scientific Co.</td>
<td>148</td>
</tr>
<tr>
<td>Elco Corporation</td>
<td>11</td>
</tr>
<tr>
<td>Electro Scientific Industries</td>
<td>111</td>
</tr>
<tr>
<td>Electronic Arrays, Inc.</td>
<td>89</td>
</tr>
<tr>
<td>Electronic Design</td>
<td>20, 21,119</td>
</tr>
<tr>
<td>Electronic Memories &amp; Magnetics Corp.</td>
<td>127</td>
</tr>
<tr>
<td>Electronic Navigation Industries</td>
<td>10</td>
</tr>
<tr>
<td>Engelhard Industries Division, Engelhard Minerals &amp; Chemicals Corp.</td>
<td>134, 135, 136, 137</td>
</tr>
<tr>
<td>Erie Frequency Control</td>
<td>147</td>
</tr>
<tr>
<td>Exact Electronics, Inc.</td>
<td>103</td>
</tr>
<tr>
<td>Facit-Odchner, Inc.</td>
<td>139</td>
</tr>
<tr>
<td>Fairchild Semiconductor, A Division</td>
<td></td>
</tr>
<tr>
<td>Fairchild Camera and Instrument Corporation</td>
<td>76, 77</td>
</tr>
<tr>
<td>Federal Scientific Corporation</td>
<td>149</td>
</tr>
<tr>
<td>GTE Automatic Electric</td>
<td>12, 13</td>
</tr>
<tr>
<td>General Electric Co.</td>
<td>16A, 122</td>
</tr>
<tr>
<td>General Electric Company, Miniature Lamp Products Department</td>
<td>133</td>
</tr>
<tr>
<td>General Instrument Corporation</td>
<td>33</td>
</tr>
<tr>
<td>General Radio Company</td>
<td>109</td>
</tr>
<tr>
<td>Guardian Electric Manufacturing Company</td>
<td>138</td>
</tr>
<tr>
<td>Harshaw Chemical Company, The</td>
<td>151</td>
</tr>
<tr>
<td>Hathaway Instruments, Inc.</td>
<td>145</td>
</tr>
<tr>
<td>Hayden Camera, Inc.</td>
<td>148</td>
</tr>
<tr>
<td>Heath Company</td>
<td>153</td>
</tr>
<tr>
<td>Heinemann Electric Company</td>
<td>29</td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>41, 42, 43, 44, 45, 46, 47, 48, 49, 50</td>
</tr>
<tr>
<td>Hickok Instrument and Controls Division</td>
<td>110, 129</td>
</tr>
<tr>
<td>Houston Instrument, A Division of Bausch &amp; Lomb</td>
<td>112</td>
</tr>
<tr>
<td>Hughes Aircraft Company</td>
<td>52, 53</td>
</tr>
<tr>
<td>Hybrid Systems Corp.</td>
<td>118</td>
</tr>
<tr>
<td>Intech, Incorporated</td>
<td>108</td>
</tr>
<tr>
<td>International Electronic Research Corporation</td>
<td>140</td>
</tr>
<tr>
<td>Johnanson Manufacturing Corp.</td>
<td>144</td>
</tr>
<tr>
<td>Keystone Carbon Company</td>
<td>128</td>
</tr>
<tr>
<td>Lafayette Radio Electronics</td>
<td>145</td>
</tr>
<tr>
<td>Lambda Electronics Corp.</td>
<td>Cover III</td>
</tr>
<tr>
<td>Litton Triad-Utrad Distributor</td>
<td>131</td>
</tr>
<tr>
<td>3M Company</td>
<td>35</td>
</tr>
<tr>
<td>MCI, Inc.</td>
<td>22</td>
</tr>
<tr>
<td>Magneclraft Electric Company</td>
<td>154</td>
</tr>
<tr>
<td>Major Data Corp.</td>
<td>132</td>
</tr>
<tr>
<td>Miida Electronics, A Division of Marubeni America Corp.</td>
<td>132</td>
</tr>
<tr>
<td>Monolithic Dielectrics, Inc.</td>
<td>153</td>
</tr>
<tr>
<td>Monolithic Memories, Inc.</td>
<td>16D</td>
</tr>
<tr>
<td>Monroe, The Calculator Company</td>
<td>98</td>
</tr>
<tr>
<td>Motorola Semiconductor Products, Inc.</td>
<td>12, 13, 16E-P</td>
</tr>
<tr>
<td>National Electronics, Inc.</td>
<td>139</td>
</tr>
<tr>
<td>National Semiconductor Corporation</td>
<td>54</td>
</tr>
<tr>
<td>North Atlantic Industries, Inc.</td>
<td>24</td>
</tr>
<tr>
<td>Oak Industries, Inc.</td>
<td>31</td>
</tr>
<tr>
<td>PRD Electronics, Inc.</td>
<td>88</td>
</tr>
<tr>
<td>Plessey, Semiconductors</td>
<td>99</td>
</tr>
<tr>
<td>Power/Mate Corp.</td>
<td>116</td>
</tr>
<tr>
<td>Precision Diprobe Tor, Inc.</td>
<td>148</td>
</tr>
<tr>
<td>Premier Metal Products Co., Inc.</td>
<td>143</td>
</tr>
<tr>
<td>Princeton Applied Research Corp.</td>
<td>149</td>
</tr>
<tr>
<td>Producers Service Corp.</td>
<td>128</td>
</tr>
<tr>
<td>Pulse Engineering, Inc.</td>
<td>124</td>
</tr>
<tr>
<td>RCA Solid State Division</td>
<td>Cover IV</td>
</tr>
<tr>
<td>RFL Industries, Inc.</td>
<td>125</td>
</tr>
<tr>
<td>Rotron, Inc.</td>
<td>27</td>
</tr>
<tr>
<td>Rogers Corporation</td>
<td>150</td>
</tr>
<tr>
<td>Servo-Tek Products Company</td>
<td>144</td>
</tr>
<tr>
<td>Shigoto Industries, Ltd.</td>
<td>145</td>
</tr>
<tr>
<td>Signetics Corporation</td>
<td>27, 51</td>
</tr>
<tr>
<td>Siliconix Incorporated</td>
<td>58</td>
</tr>
<tr>
<td>Simpson Electric Company</td>
<td>121</td>
</tr>
<tr>
<td>Singer Company, The</td>
<td>123</td>
</tr>
<tr>
<td>Kearfott Division</td>
<td></td>
</tr>
<tr>
<td>Solid State Scientific, Inc.</td>
<td>114</td>
</tr>
<tr>
<td>Stackpole Carbon Company</td>
<td>69</td>
</tr>
<tr>
<td>TEC, Incorporated</td>
<td>143</td>
</tr>
<tr>
<td>TRW Electronic Components</td>
<td>117</td>
</tr>
<tr>
<td>Techmar Corp.</td>
<td>132</td>
</tr>
<tr>
<td>Technical Wire Products, Inc.</td>
<td>130</td>
</tr>
<tr>
<td>Tektronix, Inc.</td>
<td>57</td>
</tr>
<tr>
<td>Teledyne Kinetics</td>
<td>141</td>
</tr>
<tr>
<td>Teledyne Relays, A Teledyne Company</td>
<td>2</td>
</tr>
<tr>
<td>Teledyne Semiconductor</td>
<td>16B-C</td>
</tr>
<tr>
<td>U.S. Electronics Corp.</td>
<td>130</td>
</tr>
<tr>
<td>Unitrode Corporation</td>
<td>101</td>
</tr>
<tr>
<td>Vactec, Inc.</td>
<td>118</td>
</tr>
<tr>
<td>Vernitron Corporation</td>
<td>116</td>
</tr>
<tr>
<td>Wagner Electric Corporation</td>
<td>126</td>
</tr>
<tr>
<td>Wagner Johnson</td>
<td>106</td>
</tr>
<tr>
<td>Wiley—Interscience</td>
<td>130</td>
</tr>
<tr>
<td>Woven Electronics</td>
<td>141, 146</td>
</tr>
<tr>
<td>Xerox Corporation</td>
<td>115</td>
</tr>
<tr>
<td>Zero Manufacturing Co.</td>
<td>150</td>
</tr>
</tbody>
</table>

---

**Advertiser's Index**

<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC Products, Inc.</td>
<td>105</td>
</tr>
<tr>
<td>AMP, Incorporated</td>
<td>39</td>
</tr>
<tr>
<td>Abbott Transformer Laboratories, Incorporated</td>
<td>6</td>
</tr>
<tr>
<td>Acutronics, Inc.</td>
<td>81</td>
</tr>
<tr>
<td>Acopian Corp.</td>
<td>153</td>
</tr>
<tr>
<td>Allen-Bradley Co.</td>
<td>19</td>
</tr>
<tr>
<td>American Laser Systems</td>
<td>144</td>
</tr>
<tr>
<td>Amperite</td>
<td></td>
</tr>
<tr>
<td>Amphenol, Bunker-Ramo</td>
<td>37</td>
</tr>
<tr>
<td>Augat, Inc.</td>
<td>120</td>
</tr>
<tr>
<td>Belden Corporation</td>
<td>8, 9</td>
</tr>
<tr>
<td>Berg Electronics, Inc.</td>
<td>127</td>
</tr>
<tr>
<td>Bishop Graphics, Inc.</td>
<td>149</td>
</tr>
<tr>
<td>Boker's Inc.</td>
<td>150</td>
</tr>
<tr>
<td>Bourns, Inc., Trimplot</td>
<td></td>
</tr>
<tr>
<td>Products Division</td>
<td>4, 5</td>
</tr>
<tr>
<td>Buckbee Mears Company</td>
<td>113</td>
</tr>
<tr>
<td>CTS Corporation</td>
<td>92, 93</td>
</tr>
<tr>
<td>Chomerics</td>
<td></td>
</tr>
<tr>
<td>Computer Automation, Inc.</td>
<td>17</td>
</tr>
<tr>
<td>Computer Products</td>
<td>140</td>
</tr>
<tr>
<td>Continental Connector Corporation</td>
<td>18</td>
</tr>
<tr>
<td>Corning Glass Works, Electronic Products Division</td>
<td>143</td>
</tr>
<tr>
<td>Cutler-Hammer</td>
<td>16</td>
</tr>
<tr>
<td>Dale Electronics, Inc.</td>
<td>Cover II</td>
</tr>
<tr>
<td>Data Disc, Inc.</td>
<td>23</td>
</tr>
<tr>
<td>Data Link Corporation</td>
<td>146</td>
</tr>
<tr>
<td>Datask Corporation, The</td>
<td>153</td>
</tr>
<tr>
<td>Datascan Electronic Products</td>
<td>139</td>
</tr>
<tr>
<td>Decitak, Division of Jamesbury Corp.</td>
<td>120</td>
</tr>
<tr>
<td>Delco Electronics Division of General Motors Corporation</td>
<td>82, 83</td>
</tr>
<tr>
<td>Digital Company, The</td>
<td>152</td>
</tr>
<tr>
<td>Dow Corning Corporation</td>
<td>70, 71</td>
</tr>
<tr>
<td>ECC Corporation</td>
<td>7</td>
</tr>
<tr>
<td>ENM Company</td>
<td>145</td>
</tr>
<tr>
<td>Edmund Scientific Co.</td>
<td>148</td>
</tr>
<tr>
<td>Elco Corporation</td>
<td>11</td>
</tr>
<tr>
<td>Electro Scientific Industries</td>
<td>111</td>
</tr>
<tr>
<td>Electronic Arrays, Inc.</td>
<td>89</td>
</tr>
<tr>
<td>Electronic Design</td>
<td>20, 21,119</td>
</tr>
<tr>
<td>Electronic Memories &amp; Magnetics Corp.</td>
<td>127</td>
</tr>
<tr>
<td>Electronic Navigation Industries</td>
<td>10</td>
</tr>
<tr>
<td>Engelhard Industries Division, Engelhard Minerals &amp; Chemicals Corp.</td>
<td>134, 135, 136, 137</td>
</tr>
<tr>
<td>Erie Frequency Control</td>
<td>147</td>
</tr>
<tr>
<td>Exact Electronics, Inc.</td>
<td>103</td>
</tr>
<tr>
<td>Facit-Odchner, Inc.</td>
<td>139</td>
</tr>
<tr>
<td>Fairchild Semiconductor, A Division</td>
<td></td>
</tr>
<tr>
<td>Fairchild Camera and Instrument Corporation</td>
<td>76, 77</td>
</tr>
<tr>
<td>Federal Scientific Corporation</td>
<td>149</td>
</tr>
<tr>
<td>GTE Automatic Electric</td>
<td>12, 13</td>
</tr>
<tr>
<td>General Electric Co.</td>
<td>16A, 122</td>
</tr>
<tr>
<td>General Electric Company, Miniature Lamp Products Department</td>
<td>133</td>
</tr>
<tr>
<td>General Instrument Corporation</td>
<td>33</td>
</tr>
<tr>
<td>General Radio Company</td>
<td>109</td>
</tr>
<tr>
<td>Guardian Electric Manufacturing Company</td>
<td>138</td>
</tr>
<tr>
<td>Harshaw Chemical Company, The</td>
<td>151</td>
</tr>
<tr>
<td>Hathaway Instruments, Inc.</td>
<td>145</td>
</tr>
<tr>
<td>Hayden Camera, Inc.</td>
<td>148</td>
</tr>
<tr>
<td>Heath Company</td>
<td>153</td>
</tr>
<tr>
<td>Heinemann Electric Company</td>
<td>29</td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>41, 42, 43, 44, 45, 46, 47, 48, 49, 50</td>
</tr>
</tbody>
</table>
### Innovation Yesterday

Jacob H. Edison's Horseless Carriage

### Innovation Today

The Digitran Company

#### Fast Setting Bi-Directional Toggle Switch Series 24000

While it may be controversial as to whether the horseless carriage was really a great idea, it was innovative. The modern horseless carriage is certainly faster. And it beats having three million horses on big city expressways. Our new "Toggle" or "Paddle" switch speeds up switching. You can "click" digits quickly in either direction. And for those people who must wear gloves, the accuracy and efficiency is excellent. So, ask us about our Series 24000 or write for our catalog sheet. We think that's a great idea too.

---

### Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

#### Category: Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>battery, rechargeable</td>
<td>129</td>
<td>321</td>
</tr>
<tr>
<td>capacitors, chip</td>
<td>131</td>
<td>325</td>
</tr>
<tr>
<td>capacitors, tantalum</td>
<td>132</td>
<td>328</td>
</tr>
<tr>
<td>crystal oscillator</td>
<td>133</td>
<td>329</td>
</tr>
<tr>
<td>light chopper</td>
<td>133</td>
<td>330</td>
</tr>
<tr>
<td>motor, synch gear</td>
<td>130</td>
<td>323</td>
</tr>
<tr>
<td>optical detector</td>
<td>129</td>
<td>320</td>
</tr>
<tr>
<td>relay, solid-state</td>
<td>128</td>
<td>250</td>
</tr>
<tr>
<td>switch, snap action</td>
<td>130</td>
<td>324</td>
</tr>
<tr>
<td>thermistors</td>
<td>130</td>
<td>322</td>
</tr>
<tr>
<td>thermistors, flakes</td>
<td>131</td>
<td>326</td>
</tr>
<tr>
<td>thermocouple, transmitter</td>
<td>132</td>
<td>327</td>
</tr>
</tbody>
</table>

#### Category: Data Processing

<table>
<thead>
<tr>
<th>Data Processing</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>cassette drive</td>
<td>134</td>
<td>333</td>
</tr>
<tr>
<td>disc drive, OEM</td>
<td>134</td>
<td>331</td>
</tr>
<tr>
<td>interface, computer</td>
<td>135</td>
<td>336</td>
</tr>
<tr>
<td>key punch, tab-card</td>
<td>134</td>
<td>334</td>
</tr>
<tr>
<td>modem, LSI</td>
<td>135</td>
<td>335</td>
</tr>
<tr>
<td>program, minicomputer</td>
<td>135</td>
<td>337</td>
</tr>
<tr>
<td>scan converter, digital</td>
<td>135</td>
<td>338</td>
</tr>
<tr>
<td>tape transport</td>
<td>134</td>
<td>332</td>
</tr>
</tbody>
</table>

#### Category: ICs & Semiconductors

<table>
<thead>
<tr>
<th>ICs &amp; Semiconductors</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>driver</td>
<td>112</td>
<td>263</td>
</tr>
<tr>
<td>driver/receiver</td>
<td>112</td>
<td>264</td>
</tr>
<tr>
<td>line drivers</td>
<td>114</td>
<td>267</td>
</tr>
<tr>
<td>line drivers</td>
<td>114</td>
<td>268</td>
</tr>
<tr>
<td>power transistors</td>
<td>112</td>
<td>266</td>
</tr>
<tr>
<td>SORs, diodes</td>
<td>114</td>
<td>269</td>
</tr>
</tbody>
</table>

#### Category: Instrumentation

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPM</td>
<td>116</td>
<td>272</td>
</tr>
<tr>
<td>DPM</td>
<td>120</td>
<td>276</td>
</tr>
<tr>
<td>distortion analyzer</td>
<td>121</td>
<td>278</td>
</tr>
<tr>
<td>frequency counter</td>
<td>118</td>
<td>274</td>
</tr>
<tr>
<td>IC tester</td>
<td>121</td>
<td>277</td>
</tr>
<tr>
<td>oscilloscope</td>
<td>118</td>
<td>273</td>
</tr>
<tr>
<td>resistance, bridge</td>
<td>120</td>
<td>275</td>
</tr>
<tr>
<td>voltmeter</td>
<td>116</td>
<td>271</td>
</tr>
</tbody>
</table>

#### Category: Microwaves & Lasers

<table>
<thead>
<tr>
<th>Microwaves &amp; Lasers</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>amplifiers</td>
<td>137</td>
<td>345</td>
</tr>
<tr>
<td>gain equalizers</td>
<td>136</td>
<td>341</td>
</tr>
<tr>
<td>laser, CO</td>
<td>137</td>
<td>346</td>
</tr>
<tr>
<td>mixer, doubly balanced</td>
<td>136</td>
<td>340</td>
</tr>
<tr>
<td>multiplier, frequency</td>
<td>137</td>
<td>343</td>
</tr>
<tr>
<td>rfi meter</td>
<td>137</td>
<td>344</td>
</tr>
<tr>
<td>sweeper</td>
<td>136</td>
<td>342</td>
</tr>
<tr>
<td>switches, i-f diode</td>
<td>136</td>
<td>339</td>
</tr>
</tbody>
</table>

#### Category: Modules & Subassemblies

<table>
<thead>
<tr>
<th>Modules &amp; Subassemblies</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>amplifiers</td>
<td>110</td>
<td>261</td>
</tr>
<tr>
<td>a/d converter</td>
<td>108</td>
<td>257</td>
</tr>
<tr>
<td>d/a converter</td>
<td>107</td>
<td>251</td>
</tr>
<tr>
<td>d/a converter</td>
<td>110</td>
<td>262</td>
</tr>
<tr>
<td>isolators</td>
<td>107</td>
<td>253</td>
</tr>
<tr>
<td>multiplier</td>
<td>107</td>
<td>252</td>
</tr>
<tr>
<td>power supplies</td>
<td>108</td>
<td>255</td>
</tr>
<tr>
<td>power supplies</td>
<td>110</td>
<td>260</td>
</tr>
<tr>
<td>sample &amp; hold</td>
<td>108</td>
<td>256</td>
</tr>
<tr>
<td>sample &amp; hold</td>
<td>110</td>
<td>259</td>
</tr>
<tr>
<td>trigger</td>
<td>108</td>
<td>258</td>
</tr>
</tbody>
</table>

#### Category: Packaging & Materials

<table>
<thead>
<tr>
<th>Packaging &amp; Materials</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>acid cleaner</td>
<td>126</td>
<td>309</td>
</tr>
<tr>
<td>connectors, cable</td>
<td>122</td>
<td>279</td>
</tr>
<tr>
<td>connectors, cable</td>
<td>124</td>
<td>301</td>
</tr>
<tr>
<td>connectors, circular</td>
<td>125</td>
<td>302</td>
</tr>
<tr>
<td>connectors, circular</td>
<td>126</td>
<td>308</td>
</tr>
<tr>
<td>connectors, DIP</td>
<td>122</td>
<td>281</td>
</tr>
<tr>
<td>connectors, substrate</td>
<td>122</td>
<td>280</td>
</tr>
<tr>
<td>DIP, substrate</td>
<td>126</td>
<td>305</td>
</tr>
<tr>
<td>heat sink</td>
<td>125</td>
<td>303</td>
</tr>
<tr>
<td>panel, wrapped wire</td>
<td>126</td>
<td>306</td>
</tr>
<tr>
<td>sockets</td>
<td>126</td>
<td>304</td>
</tr>
</tbody>
</table>

#### Category: Application Notes

<table>
<thead>
<tr>
<th>Application Notes</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>aviation products</td>
<td>142</td>
<td>362</td>
</tr>
<tr>
<td>breadboarding system</td>
<td>144</td>
<td>379</td>
</tr>
<tr>
<td>connectors</td>
<td>144</td>
<td>372</td>
</tr>
<tr>
<td>cooling systems</td>
<td>142</td>
<td>364</td>
</tr>
<tr>
<td>counting dials</td>
<td>142</td>
<td>360</td>
</tr>
<tr>
<td>digital voltmeter</td>
<td>142</td>
<td>363</td>
</tr>
<tr>
<td>disc-type thyristors</td>
<td>144</td>
<td>378</td>
</tr>
<tr>
<td>IC testing</td>
<td>144</td>
<td>370</td>
</tr>
<tr>
<td>LSI computer</td>
<td>144</td>
<td>376</td>
</tr>
<tr>
<td>magnetic shielding</td>
<td>142</td>
<td>359</td>
</tr>
<tr>
<td>PC laminates</td>
<td>142</td>
<td>361</td>
</tr>
<tr>
<td>potentiometers</td>
<td>144</td>
<td>374</td>
</tr>
<tr>
<td>power instrumentation</td>
<td>142</td>
<td>367</td>
</tr>
<tr>
<td>printer, digital</td>
<td>144</td>
<td>371</td>
</tr>
<tr>
<td>solderless terminals</td>
<td>142</td>
<td>366</td>
</tr>
<tr>
<td>sound barriers</td>
<td>144</td>
<td>373</td>
</tr>
<tr>
<td>switches, thumbwheel</td>
<td>142</td>
<td>369</td>
</tr>
<tr>
<td>terminal blocks</td>
<td>144</td>
<td>377</td>
</tr>
<tr>
<td>transformers</td>
<td>142</td>
<td>368</td>
</tr>
<tr>
<td>wattmeters</td>
<td>144</td>
<td>375</td>
</tr>
</tbody>
</table>

#### Category: CRT Console

<table>
<thead>
<tr>
<th>CRT console</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>displays</td>
<td>138</td>
<td>348</td>
</tr>
<tr>
<td>image intensifiers</td>
<td>138</td>
<td>349</td>
</tr>
</tbody>
</table>

#### Category: File Management

<table>
<thead>
<tr>
<th>File Management</th>
<th>Page</th>
<th>IRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>flat cable</td>
<td>138</td>
<td>350</td>
</tr>
<tr>
<td>headed pin fasteners</td>
<td>138</td>
<td>351</td>
</tr>
<tr>
<td>test jack</td>
<td>138</td>
<td>352</td>
</tr>
<tr>
<td>wire tie</td>
<td>138</td>
<td>353</td>
</tr>
</tbody>
</table>

---

THE DIGITRAN COMPANY
A Division of Becton, Dickinson and Co.

855 So. Arroyo Parkway, Pasadena, Ca. 91105
Tel. (213) 449-3110 • TWX 910-588-3794

INFORMATION RETRIEVAL NUMBER 111

Electronic Design 25, December 7, 1972
**World's smallest power supply for op amps...$14**

This 2.3 x 1.8 x 1-inch module has tracking outputs of ± 15 V @ 25 ma with regulation of ±0.1% and ripple of 1 mv. It costs $14.00 in 1,000 lots and only $24.00 for one. Requisition Model D15-03. (For ± 12 V @ 25 ma, order Model D12-03.) Three-day shipment guaranteed.

Acopian Corp., Easton, Pa. 18042
Telephone: (215) 258-5441

---

**FIXED CAPACITORS... Hermetically Sealed ...in Glass!**

**FOR MAXIMUM RELIABILITY AND LONGER LIFE!**

Now you can design circuit capabilities never before possible! "Glass-To-Metal" hermetic seal guarantees long-term reliability and greater strength! All potential problems are ruled out because they are sealed out... with glass! High to low temperature excursions (-100°C to +500°C or vice versa) will not affect the thermally matched components! Contact surfaces are non-oxidizing even under the most extreme conditions! Available in 4 sizes from .160 x .065 to .400 x .155 with capacitance ranges of 1 pf to .22 mfd. Write for catalog sheet.

Monolithic Dielectrics Inc.
P.O. Box 647 • Burbank, Ca. 91503
Phone (213) 848-4465

---

**NEW Heathkit 2½ Digit DMM**

**only 79.95**

A compact, solid-state multimeter with digital readout - at a fantastic kit-form price. The new Heathkit IM-1202 has four overlapping ranges to measure voltages from 10 mV to 1000 V on DC (either polarity), 10 mV to 700 V rms on AC, 10 uA to 2.5A on AC or DC current. Five resistance ranges measure from 1 ohm to 2.5 megohms. Front panel polarity switch reverses inputs without changing leads. 6 lbs.

HEATH COMPANY, Dept. 60-12
Benton Harbor, Michigan 49022

---

**NEW Heathkit 30 MHz Counter**

**only 169.95**

The Heathkit IB-1100 gives 1 Hz to over 30 MHz counting on a full 5-digit readout with 8-digit capability. The lighted overrange indicator makes misreading virtually impossible. Stable time-base circuitry assures accuracy better than ±3 ppm from 22° to 37° C. Diode protected J-FET gives improved triggering over 100 mV to 150 V input range. Solid-state circuitry mounts on one large board for easy assembly. 6 lbs.

Send for FREE '73 Catalog

---

**RUB...IT'S TRANSFERRED**

PERFECT REGISTRATION because you position patterns first, then rub them down.

CORRECTIONS ARE EASY because you can lift patterns with a knife and reuse them.

TOUGHER THAN STICK-ONS because the ink is underneath a hard plastic overcoat.

Try the JotDraft Sampler and convince yourself. It's an assortment of 746 patterns and pads (2X scale) for $4.50. Or write for a free sample and catalog. You'll be glad you did!

The DATAK Corporation
85 Highland Avenue • Passaic, New Jersey 07055
WHERE SEALED CONTACT PROTECTION IS REQUIRED FOR EXPLOSIVE, CORROSIVE, DIRTY OR MOIST AMBIENT CONDITIONS; WHERE THE USE OF CONTACTORS DOES NOT PERMIT CONTACT MAINTENANCE; WHERE NOISELESS OPERATION IS REQUIRED; WHERE WEIGHT, SIZE, AND COST MUST BE A MINIMUM FOR CONTACT RATINGS UP TO 100 AMPS, MERCURY DISPLACEMENT RELAYS ARE UNSURPASSED.

This unique design, which incorporates broad cross-sections of liquid mercury for switching, is what makes the Mercury Displacement relay a high current, high voltage, high power device. Whereas conventional relays, which use hard contacts are destroyed by pitting and sticking under high load conditions, the perpetually self-renewing, mercury-to-mercury contacts insure maximum contact life and in-rush capabilities up to 15 times rated loads.

In a highly competitive business, delivery can be a deciding factor. If delivery is important to you, be aware that Magnecraft ships better than 90% of all incoming orders for stock relays, received before noon, THE SAME DAY (substantiated by an independent auditing firm). In addition to our shipping record, most stock items are available off-the-shelf from our local distributor.

The purpose of this 16-page catalog is to assist the design engineer in specifying the proper relay for a given application. The book completely describes 20, 35, 60, and 100 amp versions with one, two, or three poles as well as Time Delay models of Mercury Displacement Power Relays.

MERCURY DISPLACEMENT POWER RELAYS

FREE!

MERCURY Displacement Power Relays

CATALOG

The purpose of this 16-page catalog is to assist the design engineer in specifying the proper relay for a given application. The book completely describes 20, 35, 60, and 100 amp versions with one, two, or three poles as well as Time Delay models of Mercury Displacement Power Relays.

Magnectraft® ELECTRIC COMPANY
5575 NORTH LYNCH AVENUE • CHICAGO, ILLINOIS 60630 • 312 • 282-5500 • TWX 910-221-5221

INFORMATION RETRIEVAL NUMBER 112

ELECTRONIC DESIGN 25, December 7, 1972
Do you face a make or buy decision on power supplies?

BUY
THE NEW LAMBDA
LY SERIES

>50% efficient, 20KHz switching,
50mV P-P ripple, 0.1% line or load regulation

<table>
<thead>
<tr>
<th>SINGLE OUTPUT</th>
<th>DUAL OUTPUT</th>
<th>TRIPLE OUTPUT</th>
<th>QUADRUPLE OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$300</td>
<td>$380</td>
<td>$395</td>
<td>$450</td>
</tr>
<tr>
<td>5 VOLTS 30 AMPS</td>
<td>5 VOLTS 18 AMPS</td>
<td>5 VOLTS 16 AMPS</td>
<td>5 VOLTS 16 AMPS</td>
</tr>
<tr>
<td>WITH OVERVOLTAGE PROTECTION BUILT-IN</td>
<td>15 TO 12 VOLTS</td>
<td>15 TO 12 VOLTS</td>
<td>DUAL 15 TO 12 VOLTS</td>
</tr>
<tr>
<td></td>
<td>8.5 AMPS EACH OUTPUT</td>
<td>1.5 TO 12 VOLTS</td>
<td>1.5 AMPS EACH OUTPUT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 AMPS EACH OUTPUT</td>
<td>24 TO 28 VOLTS 1.0 AMPS</td>
</tr>
</tbody>
</table>

AC input: 105-132 VAC, 47-440 Hz
DC input: 145 VDC ±10%

11 standard models in single, dual, triple or quadruple outputs in new "5" package. Triple and quadruple output models incorporate Lambda Power Hybrid Voltage Regulator.

ALL CARRY LAMBDA'S 5-YEAR GUARANTEE.
ALL IN STOCK FOR 1-DAY DELIVERY.
RCA put 1,238 devices on a 150 mil COS/MOS chip. What are your LSI requirements?

The move is toward LSI. And RCA is ready now to develop custom COS/MOS circuits to your most demanding requirements.

For example, the 149 x 150 mil timing circuit above was integrated from a breadboard containing 1,238 discrete devices. Just one of many custom chips designed with RCA’s unique silicon interconnect process to provide high packaging density.

RCA maintains a staff of systems engineers who are experienced in the development of complex micropower arrays. They are backed by extensive facilities to speed the process of IC design and development.

These facilities consist of computers for logic simulation, artwork digitizer-plotter systems that can cut turnaround time by 33% in typical circuits, Mann Pattern Generator facilities to speed mask preparation, and Teradyne Model J-283 digital IC systems which functionally evaluate complex arrays.

Put RCA’s COS/MOS team to work to help reduce package count, cut assembly costs, and achieve excellent cost effectiveness in your systems.

When it comes to COS/MOS LSI, come to RCA.

Contact your local RCA Representative or RCA Distributor, or write RCA Solid State Division, Section 57L-7, Box 3200, Somerville, New Jersey 08876.