EDN

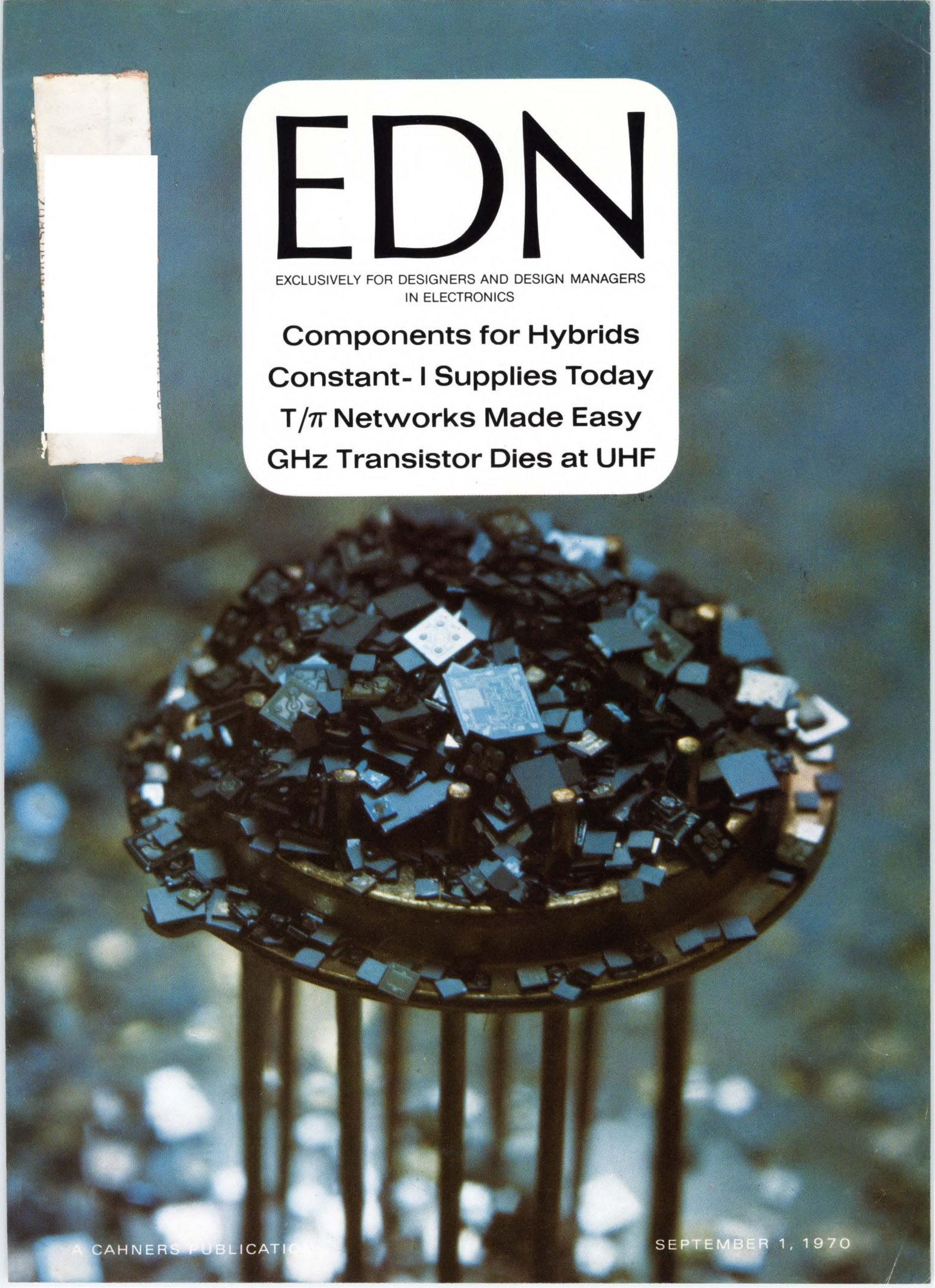
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Components for Hybrids

Constant-I Supplies Today

T/π Networks Made Easy

GHz Transistor Dies at UHF



A CAHNERS PUBLICATION

SEPTEMBER 1, 1970

Bench or System — the HP 3450A gives you maximum performance in a minimum space.

A quick look at the unfolding dodecahedron shows each of the 12 functions the Incredible Dodecameter performs. What it doesn't show is just how well this 5-digit multifunction meter performs each function.

For instance, you not only get true rms capability—you also get value-plus features like true 4-terminal ac ratio testing and 4-terminal ohms measurements.

And, accurate, fast measurements in each of these twelve categories is only the start. You can add digital output and directly control external equipment like a printer. Or, add remote control and get full programmability for system use.

No matter what the application, you get more for your money with the HP 3450A.

This Incredible Dodecameter lets you start with the basic dc meter and add the capability that best fits your requirements. If your needs change, any of the options (except the rear input terminals) can be easily installed in the field.

For more information on this outstanding 12 in 1 bargain, just call your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

Price Basic HP 3450A, $3300; AC Option 001, $1250; Ohms Option 002, $425; Limit Test Option 003 $375; Digital Output Option 004, $190; Remote Control Option 005, $245; Rear Input Terminal Option 006, $70.

090/8A

The Incredible Dodecameter— A 12-in-1 way to better measurements!

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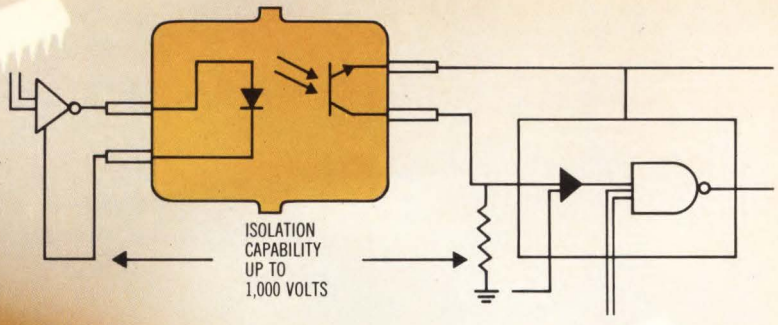
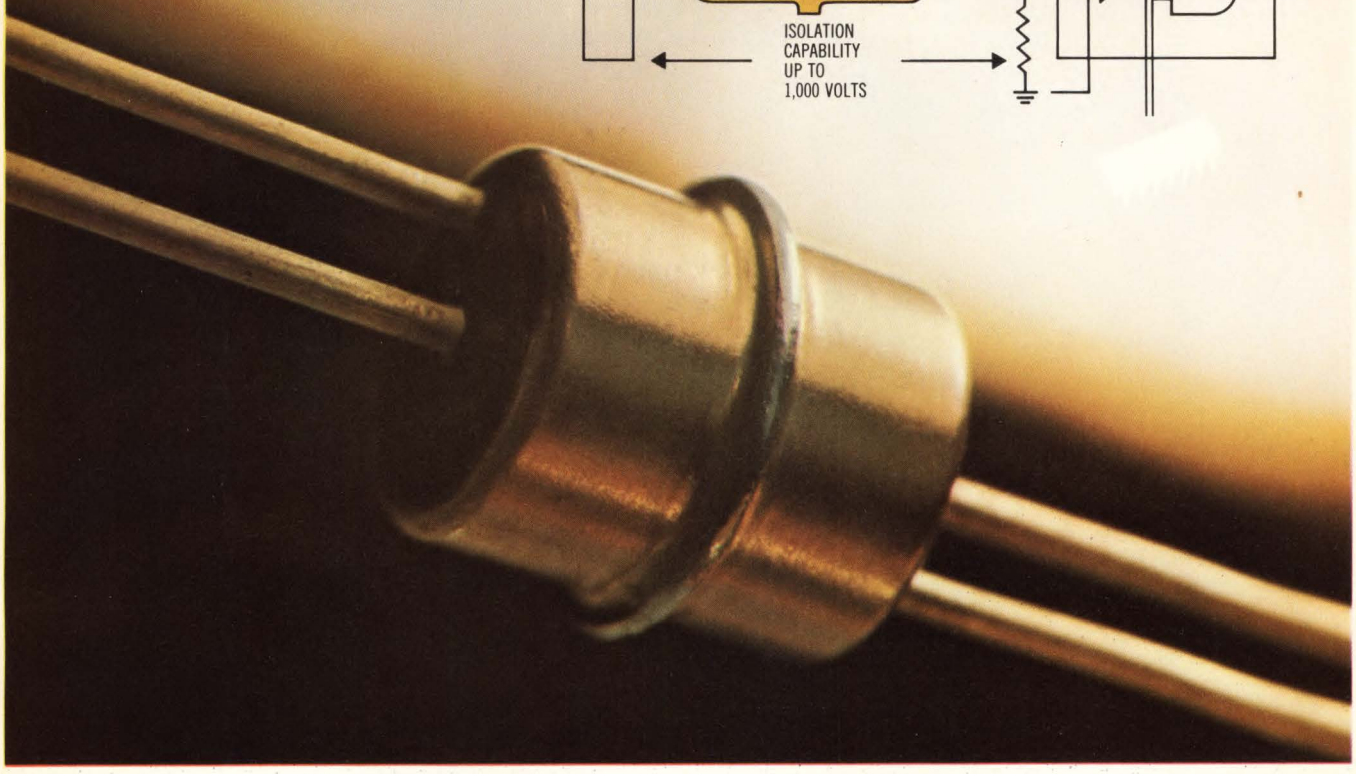
DIGITAL VOLTMETERS

CIRCLE NO. 1

TI's quiet revolution in optoelectronics





Volume is up, prices are down on TI's optically-coupled isolators.

Now get all the advantages of optical interfacing – and economy, too.

Big demand has increased our production... and brought prices down more than 50% on TI optically-coupled isolators (OCIs).

TIL 107 is $2.95; TIL 108 is $3.50 (both 100-999 quantities).

That's how little it takes to gain these new benefits for your interface circuit design.

Isolation to 1000 volts.

Input/output isolation of up to 1000 volts allows for the simple interface of different voltage levels and suppresses troublesome high voltage transients.

Greater noise immunity.

Electrical isolation of the input diode and output transistor eliminates ground loops and noise signal transmission.

Lower design costs.

TI OCIs handle the job alone. You don't need complex circuits to pass noise-free signals between input terminals and computers and along transmission lines.

Plus, you get these advantages over relays and pulse transformers: Response from dc to 100 kHz. High shock and vibration immunity. Bounceless action. Speeds to 5 μ sec. Wide operating temperature range. Longer Life.

Smaller size.

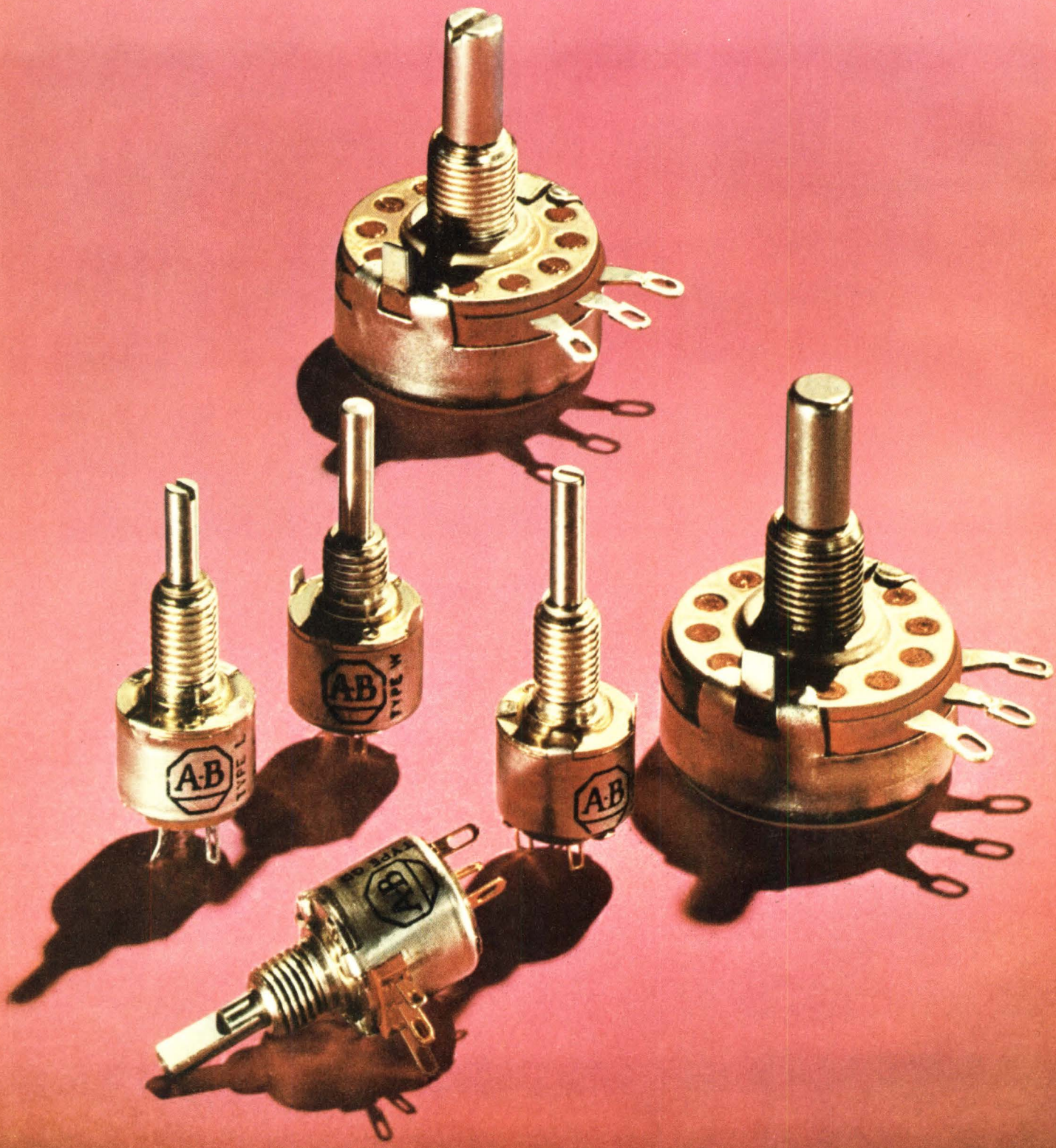
TI OCIs fit into high density situations with ease. The twin TO-18 metal can is just 0.206″ x 0.220″ diameter.

Performance is improved, too. A more efficient emitter guarantees a 1.6 mA output for a 15 mA input. Enough to drive DTL/TTL logic without additional components. You cut space, weight, power and system costs.

Both OCIs are available now. Call your TI sales office or authorized distributor. For a data sheet, write Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

Fight noise pollution



with this quiet family.

Hot Molding with Allen-Bradley's exclusive technique, gives these composition variable resistors an unusually low noise level. And importantly, this low noise level actually decreases in use. Under tremendous heat and pressure the resistance track is molded into place. A solid element with a large cross-section is produced.

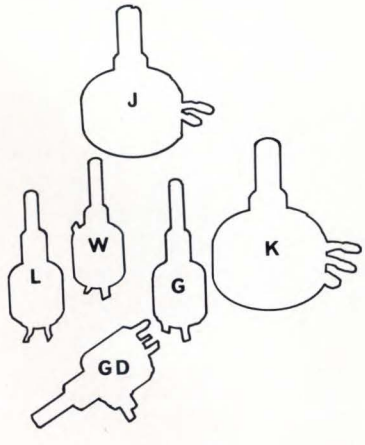
This important Allen-Bradley difference means better short-time overload capacity and a long operating life. Control is smooth, resolution almost infinite. These variable resistors are ideal for high frequency circuits. Why should you trust the performance of your designs or your reputation to anything less than Allen-Bradley quality? Use the most thoroughly "field tested" (over 20 years) variable resistors available today. Quantity stocks of popular types J, G, W and GD available for immediate delivery from your appointed A-B industrial electronics distributor.

For information write: Marketing Department, Electronics Division, Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wisconsin 53204. Export office: 1293 Broad Street, Bloomfield, N. J. 07003, U.S.A. In Canada: Allen-Bradley, Canada Ltd., 135 Dundas Street, Galt, Ontario.

SPECIFICATIONS

	TYPE J— STYLE RV4	TYPE K	TYPE G— STYLE RV6	TYPE L	TYPE W	TYPE GD
CASE DIMENSIONS	5/8" deep x 1-5/32" dia. (single section)	5/8" deep x 1-5/32" dia. (single section)	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	35/64" deep x 1/2" dia.
POWER at + 70°C	2.25 W	3 W	0.5 W	0.8 W	0.5 W	0.5 W
TEMPERATURE RANGE	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +120°C
RESISTANCE RANGE (Tolerances: ±10 and 20%)	50 ohms to 5.0 megs	50 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs
TAPERS	Linear (U), Modified Linear (S), Clockwise Modified Log (A), Counter-Clockwise Modified Log (B), Clockwise Exact Log (DB). (Special tapers available from factory)					
FEATURES (Many electrical and mechanical options available from factory)	Single, dual, and triple versions available. Long rotational life. Ideal for attenuator applications. Snap switches can be attached to single and dual.	Single, dual, and triple versions available. Long rotational life.	Miniature size. Immersion-proof. SPST switch can be attached.	Miniature size. Immersion-proof.	Commercial version of type G. Immersion-proof.	DUAL section version of type G. Ideal for attenuator applications. Immersion-proof.

ALLEN-BRADLEY



NEW DIMENSION ELECTRONICS

CIRCLE NO. 2

The mind easer...

• You never worry about what it's doing to the circuit

• You forget about zero adjusting forever

The Digilin Type 340 Digital Multimeter eliminates the two major causes of multimeter fretting in one low-cost, high-performance meter. First, the exclusive new Digilin Input Amplifier Technique (patent pending) does away with circuit loading *throughout* the test function. Forget about transient noise creeping in when impedance drops during the measurement cycle — a worry that always nags you when such input techniques as dual slope integration and chopper-stabilized amplifiers are used. The 340 never disturbs the circuit ever. And with a 340, you'll never short another lead and adjust for zero again. Before every measurement cycle, the 340 does it for you — automatically, precisely, leaving no doubt about whether it was done right.

Only with Digilin do you get these features, and the 3½-digit, 0.1%-accuracy Digilin 340 gives you lots more: Award winning design (1969 WESCON Industrial Design Competition) • Automatic polarity • Pushbutton ranging • High visibility, no-blink display • only 3 pounds • Assured reliability by Digilin 100-hour burn-in and factory test. $375 complete in single units. Need battery-powered flexibility? Digilin 341 with same features plus battery supply at $445. Digilin Type 340. The mind easer. It's an eye pleaser, too.

Get more information—or no-obligation demonstration. Call or write Digilin today. Digilin Inc., 6533 San Fernando Rd., Glendale, California 91201. Tel. 213-246-8161.

digilin
DIGITAL INSTRUMENTS

CIRCLE NO. 3

SEPTEMBER 1, 1970
VOLUME 15, NUMBER 17

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Cover

With a TO-header as a stage, Intersil, Inc. displays the wide variety of dice they offer hybrid designers. Shown are n- and p-channel junction and MOS FETs, linear devices with thin-film resistors deposited on silicon, as well as C-MOS devices. See article, "Minicomponents—Building Blocks for Hybrids", p. 33.

Design News

Design Predictions

Design Features

Design Ideas

Design Interface

Design Products

Design Departments

EDN's DESIGN ACTIVITY FILING SYSTEM is used to classify all Design Feature and Design Idea articles. The first word indicates the *activity* discussed in the article. The second word denotes the principal product being used in the activity. The third word modifies the second word. Finally, a number is used to specify frequency, where applicable. This number is the $\log_{10}$ of the frequency in hertz.

ABP CP MCB BPA

ibpa International Business Press Associates

DESIGN ELECTRONICS
ELECTRONICS WEEKLY
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INTER ELECTRONIQUE

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We make components for guys who can't stand failures.

Even the coolest and calmest of us somehow comes unglued when there's a "little" electronics systems failure. Because before it's done, that little systems failure often becomes a big, big systems failure. One that takes a long, long time to forget.

But that's where we come in. We make resistors and capacitors for guys who can't stand failures. Guys like your most important customers, guys like you.

We build an extra measure of reliability into all our components to help you build extra reliability into all your systems.

To be specific, we make tin oxide resistors—now including both miniature RLR05's and flame proofs—and glass and Glass-K™ capacitors. They're the best you can get, though they'll cost you no more.

Resistors for guys who can't stand failures—

Take our tin oxide resistors—no other resistors can deliver the same stability and reliability over life. They offer guaranteed moisture resistance across all ohmic values, for reliability that can't be matched by metal film, wirewounds, carbon comps or metal glaze resistors.

This kind of extra performance comes in miniature size, too. Our new RLR05 (commercial style C3), developed for dense packaging applications, competes costwise with carbon comps.

Including Flame Proof Resistors—

And we lead the field with flame proof resistors. Ours will withstand overloads in excess of 100 times rated power without any trace of flame. And because they open rather than short under severe overload, they provide protection for the rest of the system—a vital consideration in critical and expensive EDP, telecommunications, and instrumentation gear.

Capacitors for guys who can't stand failures—

Or take our glass capacitors. The Air Force has confirmed they have much better stability and much higher insulation resistance than the ceramic, mica, and other capacitor types tested. That's why our glass capacitors have been designed into so many major aerospace, EDP and instrument applications.

Or our Glass-K™ capacitors—we developed them to give you the volumetric efficiency and economy of monolithic ceramic capacitors, but with the much improved stability and reliability that only a glass dielectric can add. Our Glass-K™ capacitors are now being used in pacemaker heart units and in several major EDP systems. And these Glass-K™ capacitors can now be used in BX characteristic applications.

As you might expect, both our resistors and capacitors meet Established and High Reliability standards, such as MIL-R-39017, MIL-R-55182, and Minuteman.

And they'll cost you no more—

And even though you might expect to pay a lot more for these features, you don't. Because as the largest manufacturer of these type components, our production volume affords us economies that enable us to be competitive in price.

So the next time you're designing a system, design-in an extra measure of performance. Reach for your CORNING® resistor and capacitor catalogs or look us up in EEM. Or write us at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

Then call your local CORNING authorized distributor for fast off-the-shelf delivery. He not only stocks components for guys who are demanding, but he offers service to match, too.

CORNING
ELECTRONICS

CIRCLE NO. 4

Here's a quick plug for micro-systems.

The A-MP Chevron Shaped Connector plugs in, plugs out and interchanges to give you connection flexibility in your most mini-micro applications.

This connector has contacts on straight centers of .050". Or staggered centers of .025". Because of their special design, the contacts are very tolerant of misalignment and very redundant in their connection.

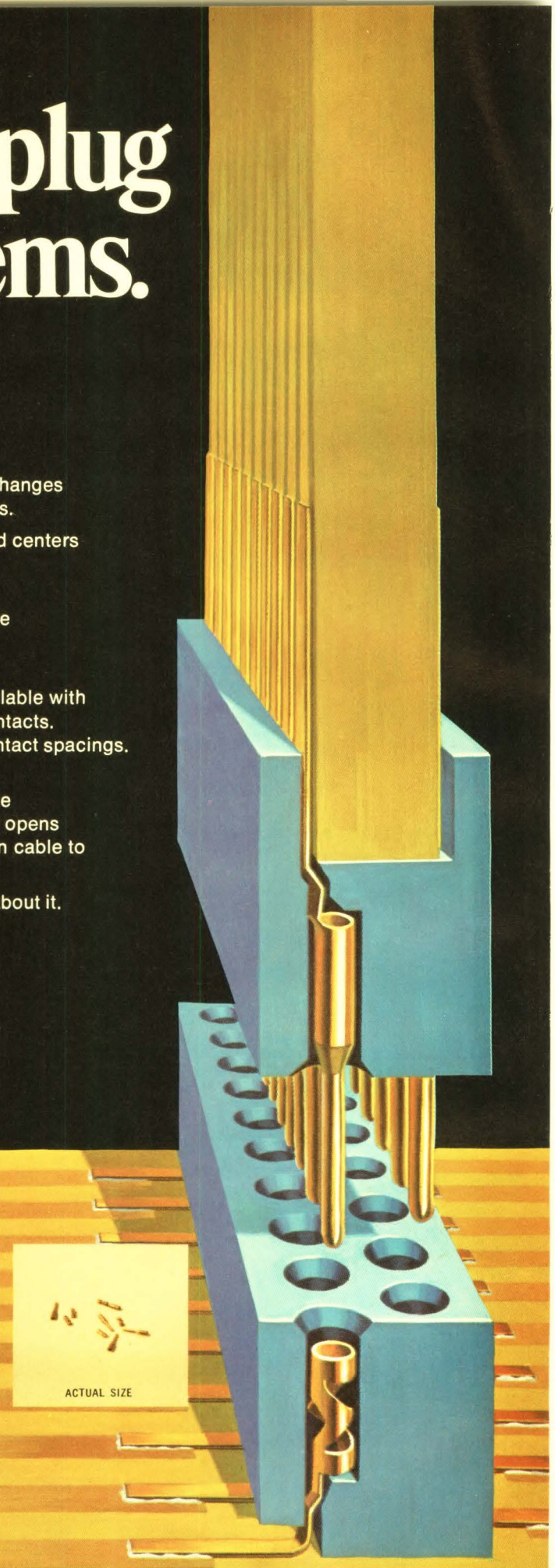
The receptacle contacts have an outside diameter of .030". Inside there are two spiral springs that redundantly grasp every pin.

The connector housings are dimensionally identical for both pin and receptacle contacts. (A foresight for versatility's sake.) They are available with contoured edges that correspond to the staggered pattern of the contacts. Which means you can fit the housings together and maintain even contact spacings.

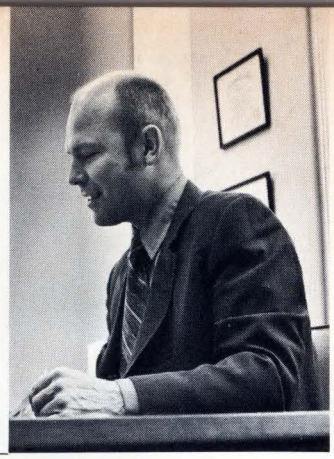
For application versatility, the connectors can be mounted for either perpendicular or parallel card mating in addition to the standard in-line card-to-card applications. There's also a version for ribbon cable that opens many cable-to-card or cable-to-cable possibilities, or for transmission cable to match 75 ohm impedance.

That's our plug for micro-systems. But it's not all you'll need to know about it. For more information on the A-MP Chevron Connector write:
Industrial Division,
AMP Incorporated, Harrisburg, Pa. 17105.

AMP
INCORPORATED



CIRCLE NO. 5



Editorial

The Chips Are Down

No, this is not more rhetoric on the state of the economy. Rather, it is a comment on the state of technology. More people are putting down more chip components on more hybrid substrates than ever before. And the trend appears to be only in its infancy.

Most electronic manufacturers—both component and equipment—have at least pilot hybrid circuit production facilities in operation. Virtually all manufacturers feel that hybrid techniques will be of major importance in the very near future. With many it is a present way of life. For any function that cannot be performed monolithically, we have every reason to believe that hybrids will be the dominant packaging method of the '70s.

As is true of any major shift in technology, there is a learning curve which must be negotiated before economy and reliability can outstrip older technologies. Industry today is distributed randomly over that curve. Many companies are still moving by "fits and starts," while others have whipped the design and production problems and are moving products out the door like clockwork.

A unique aspect of hybrid circuits that makes this learning curve more precarious than some others we've seen is that hybrids require the simultaneous concentration of many disciplines. Circuit designers, metallurgists, chemists, packaging engineers and production people all must contribute their special brands of expertise in a single cooperative effort.

Hybrid circuit design and production—especially thick-film—look deceivingly simple, but there's many a slip 'twixt design and ship. Our suggestion is that if your company plans to grow in this decade, it's time you learned your way around the hybrid world. Get started by reading our cover feature this issue and another on hybrid technology coming in our Oct. 1 issue.

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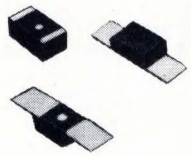
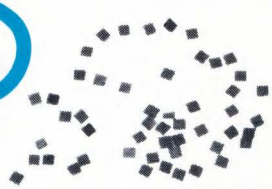
Best for Hybrid Circuits...



PIPS OF CHIPS



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Solid-electrolyte Tantalum Capacitors

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Offer a unique combination of high volumetric efficiency, wide selection of capacitance ranges and body formulations, and moderate cost. Excellent adherence of metallized terminations eliminates problems often encountered with other chip ceramic capacitors. Available in four EIA-preferred chip sizes.

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Simplifying TO-3 Complements!

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- 60, 80 V Sustaining Voltage
- 75 W Power-Handling
- The Pair For $3.20

***5 A Power* — 1,000 Minimum Gain at 3 A**
Now In 5 A,
High-Gain Metal Complements!

- MJ900/1000 Series
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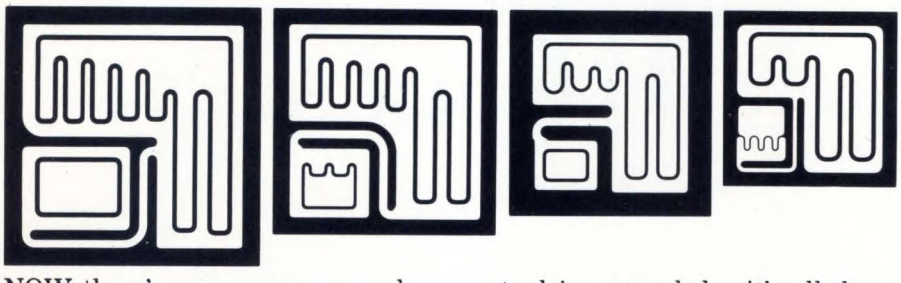
- 3 A-at-30 V Safe Operating Area
- The Pair For $3.85

Power Darlington



NOW there's more new power darlington transistors that promise to forever eliminate conventional, silicon power circuits requiring separate, "one-for-one" driver and output transistors and associated emitter-base resistors... NOW there's five new, first-of-their-kind, series from 5 A to 16 A that let you design revolutionary new levels of efficiency, simplicity and cost-savings into most any of your relay and solenoid drivers, audio amplifiers, power supply regulators, servo amplifiers and series pass regulators!

NOW you can:

Up op amp power – no separate, discrete drivers needed... it's all there on one monolithic, EpiBase* power chip: driver transistor, output device and base-emitter resistors.

Compress your costs – Cut space and heat sinking needs, assembly time and components because the driver is now on the same heat sink as the output unit. Reliability rises, too.

Innovate with IC's – Drive the darlingtons with power levels derived from integrated circuit logic gates. Go from milliamperes to amperes directly, compatibly, easily.

Obtain 1,000 dc gain – Design minimums of 1,000 – and typicals of 2,500 ... into your state-of-the-art commercial/industrial equipment!

Put in either polarity – they're all complementary! You can positive or ground-connect and use them as direct-coupled pairs in audio amps.

Perform with package variety – Metal or plastic... you have your choice of two optimized, standard packages for the exact degree of cost/performance you need.

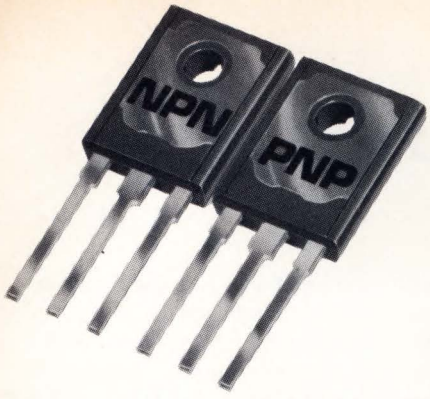
NOW there's every reason to take another look at new and existing designs that demand unequalled power device performance and a minimum of components and costs.

Break with the past – contact your franchised Motorola distributor about evaluating any of these 28 revolutionary new devices or the factory for production quantities.

Tomorrow's new world of silicon power darlingtons is here for you today!

*Trademark Motorola Inc.

All prices shown are 100-up for 60 V, NPN/PNP complementary pairs; individual darlingtons are substantially less in 100-up quantities.



***5 A Power*— 750 Minimum Gain at 3 or 4 A**
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70 W Plastic Complements!

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- 60, 80 V Sustaining Voltage
- 2 A-at-30 V Safe Operating Area
- The Pair For $3.45

***10 A Power* — 1,000 Minimum Gain at 5 A**
Now In Time-Saving,
Medium-Power Complements!

- MJ2500/3000 Series
- 60, 80 V Sustaining Voltage
- 5 A-at-30 V Safe Operating Area
- The Pair For $6.70

***16 A Power* — 1,000 Minimum Gain at 10 A**
Now In High-Performing,
100 V Complements!

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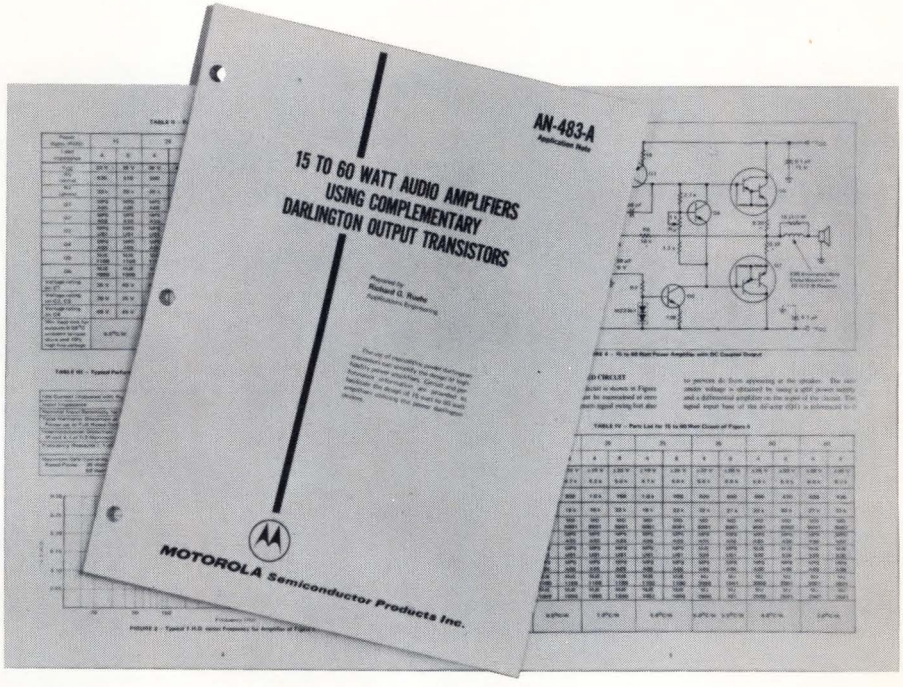
- 60, 80 & 100 V Sustaining Voltage
- 150 W Power-Handling
- The Pair For $8.50

Revolution Goes On



How To Revolutionize With Complementary Power... Circuit and performance information are provided in a fresh new application note to help you on the way to designing 15 to 60 W amplifiers using the power darlington devices. Write Motorola Semiconductor Products, Inc., Box 20912, Phoenix 85036 for your copy of AN483A and data sheets on these state-of-the-art silicon power innovations today!

MOTOROLA POWER
—where the priceless ingredient is care!

CIRCLE NO. 8

New Techniques
Wire Backplanes and Boards

WR (Wire-Wrap) - W = Infobond

BOSTON, MASS. – Eliminate the wrapping operation from wire-wrap systems, substitute solder bonds, and you have a simplified explanation of the Infobond process. At the 1970 Eastern Electronics Packaging Conference, Inforex described how its Infobond process wires a backplane like a wire-wrap process does, except that it uses no sockets, achieves higher density on a universal 2-sided PC card, wires four boards simultaneously, tests each joint mechanically and electrically, and continuously tests for wire continuity and insulation breakdown. One of these connections costs at least an order of magnitude less than a wire-wrap connection.

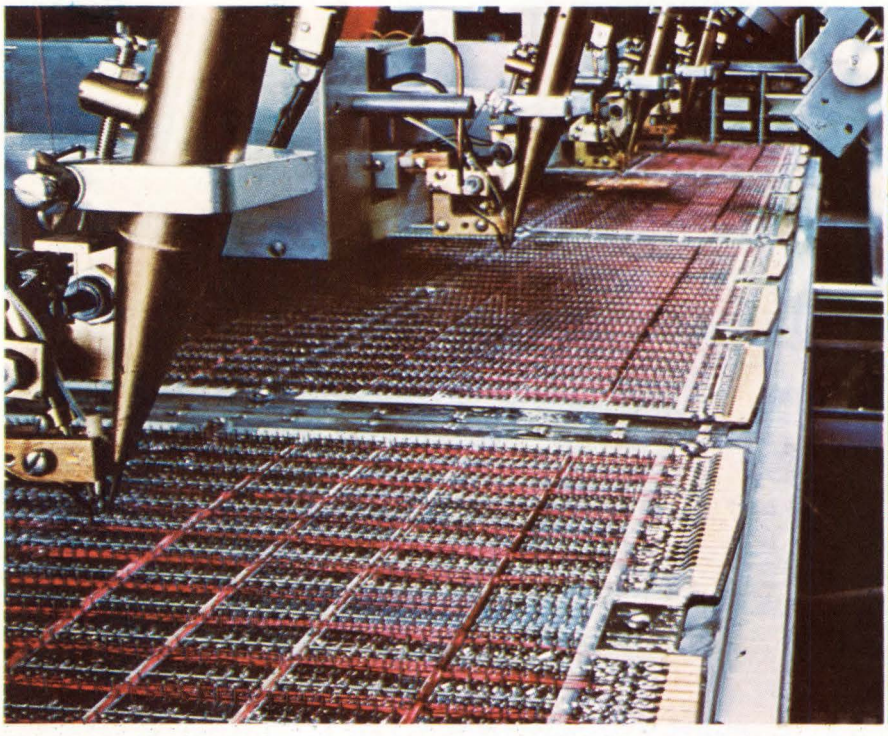
Infobond also aims at competing with multilayer approaches, citing response times of days vs months (ML requires artwork masters vs a new punched paper tape), tooling costs (Infobond uses the same PC board for all circuits), and changeability (wire changes are made manually in 1/2h, as fast or faster than wire-wrap).

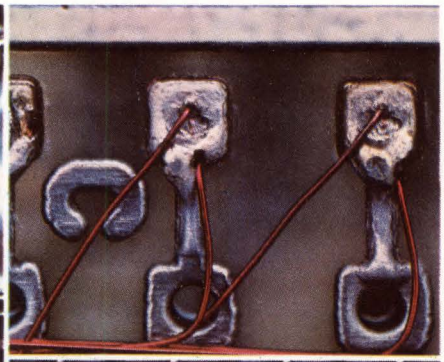
Capacity is by no means limited to the present 1700 wires/h. Production yields from the 4-head machines indicate that 6-head machines are feasible and that servo speeds can be increased at least 50%.

Basic vehicle is a universal 2-sided PC board with the wiring run on one side and DIPs soldered to the other. Circuit design and layout are controlled by punched paper tape. Polyurethane-insulated 38 AWG wire is fed through a thermal compression bonding tip and is wired from bonding pad to bonding pad until a wiring net is complete. There the wire is cut and a new net started.

Essentially, system operation is as follows: The tip is lowered to the bonding pad and power is applied to sublimate wire insulation and solder the wire to the pre-tinned pad. After the heat cycle, an air blast cools the joint and tip, the tip is raised, and the joint is mechanically stressed by pulling with a pre-set force. A probe then contacts the bonding pad checking for electrical continuity between pad and wire. If no continuity is sensed, the bonding cycle is repeated, and if discontinuity still exists, the machine stops for operator intervention. An optical sighter is always aimed at the joint so that faults are quickly analyzed. As the wire runs through the machine to a new pad, it is continually tested for insulation stripping occurrence of which will again shut the machine down. At the end of a wiring net, a cutter descends, cuts the wire at the board, and the tip returns to the last pad to verify that the cut was successful (no continuity). A switch allows each head to be taken off-line without interfering with operation of the other heads, in case of mechanical problems.

The system has been making production boards for over 6 months and an error rate that appears to run less than 1% verifies reliability.





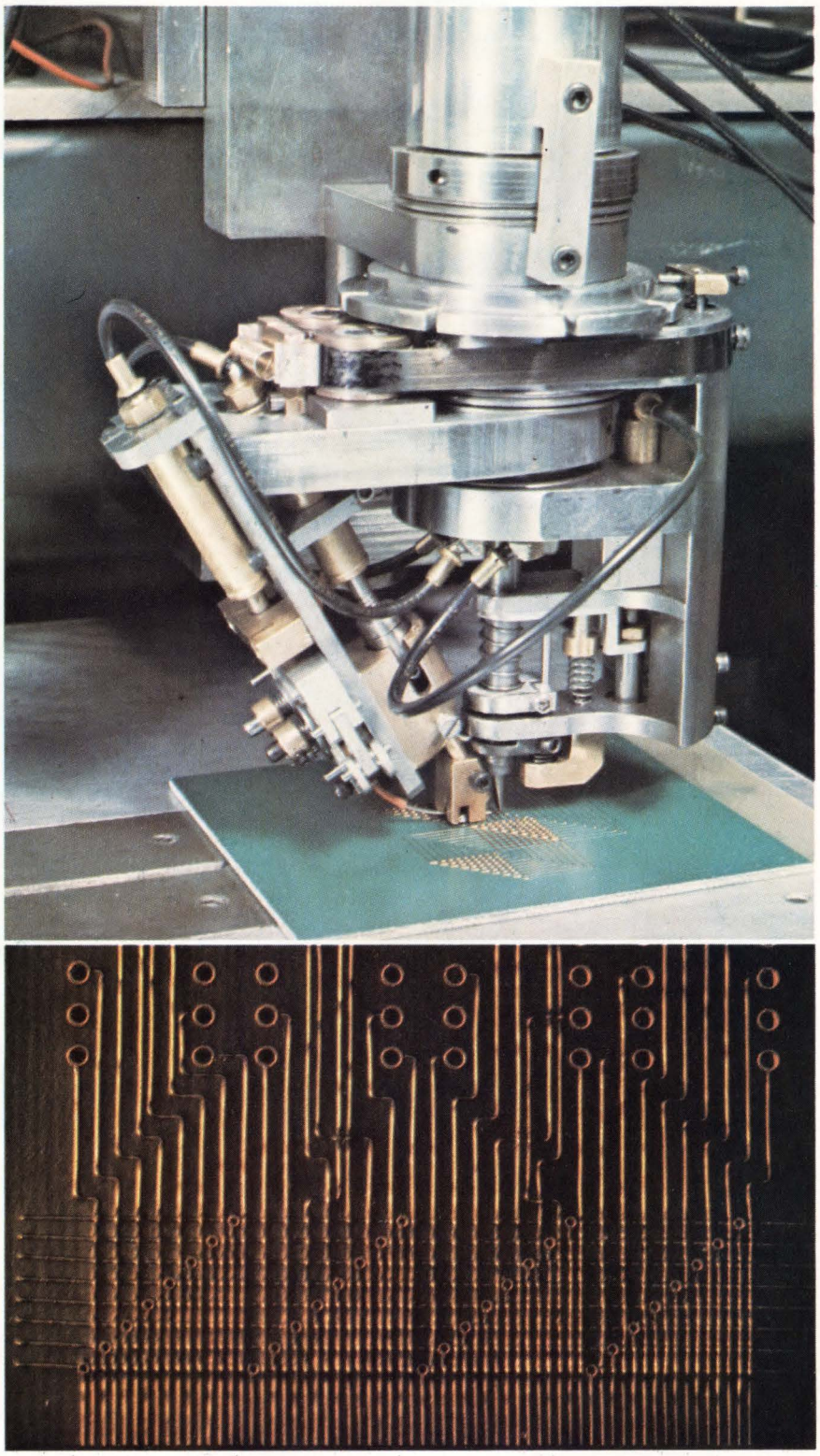
Infobond machine (left) completes four boards at once. Bonding tips are to the left and optical sighter at upper right. **Close-up of solder joint** (upper right). Independent lab tests have not only verified physics of joint reliability, but also successfully completed MIL tests for wire-wrap joints. **Wire-routing channels** (lower right) on portion of completed board.

PC-P=MULTIWIRE

BOSTON, MASS. Take away the **P**rinting from **PC** boards and you come up with a new experimental process called "Multiwire" by Photocircuits Corp., Glen Cove, N.Y. In this technique, a machine "writes" on a circuit board with wire drawing out the circuit pattern. This new approach is intended to combine the high packing density features of multilayer PC boards with short turnaround and lower tooling costs of wire-wrap systems.

The base board can be any material able to withstand chemical processes necessary to metallize termination holes. It is coated with a layer of catalytic thermosetting adhesive, precured to an intermediate stage. The desired wire pattern is formed on the board by the Multiwire machine, an X-Y positioning table and the wiring head. In one method for writing with wire, the writing head dispenses wire thru a stylus, a pressure foot presses on the wire and heats the adhesive via ultrasonic energy imbedding the wire to about half its diameter, and the movement of the X-Y table draws the wire across the board at speed between 2 and 5 in/s. A cutter placed between the pressure foot and wire stylus will cut the wire when required. Wire patterns are determined by a punched paper tape controlling movements of the wiring head and X-Y table. When wiring is completed, the board is heated in a press for about 3 min at 325°F to imbed the entire matrix firmly in the adhesive, then baked for an hour in a 325°F oven. Termination points are holes drilled through wire paths and metallized. The same holes are used for component insertion and can be soldered conventionally. Wire patterns may also be written onto boards carrying prefabricated P-C conductors used as standard features.

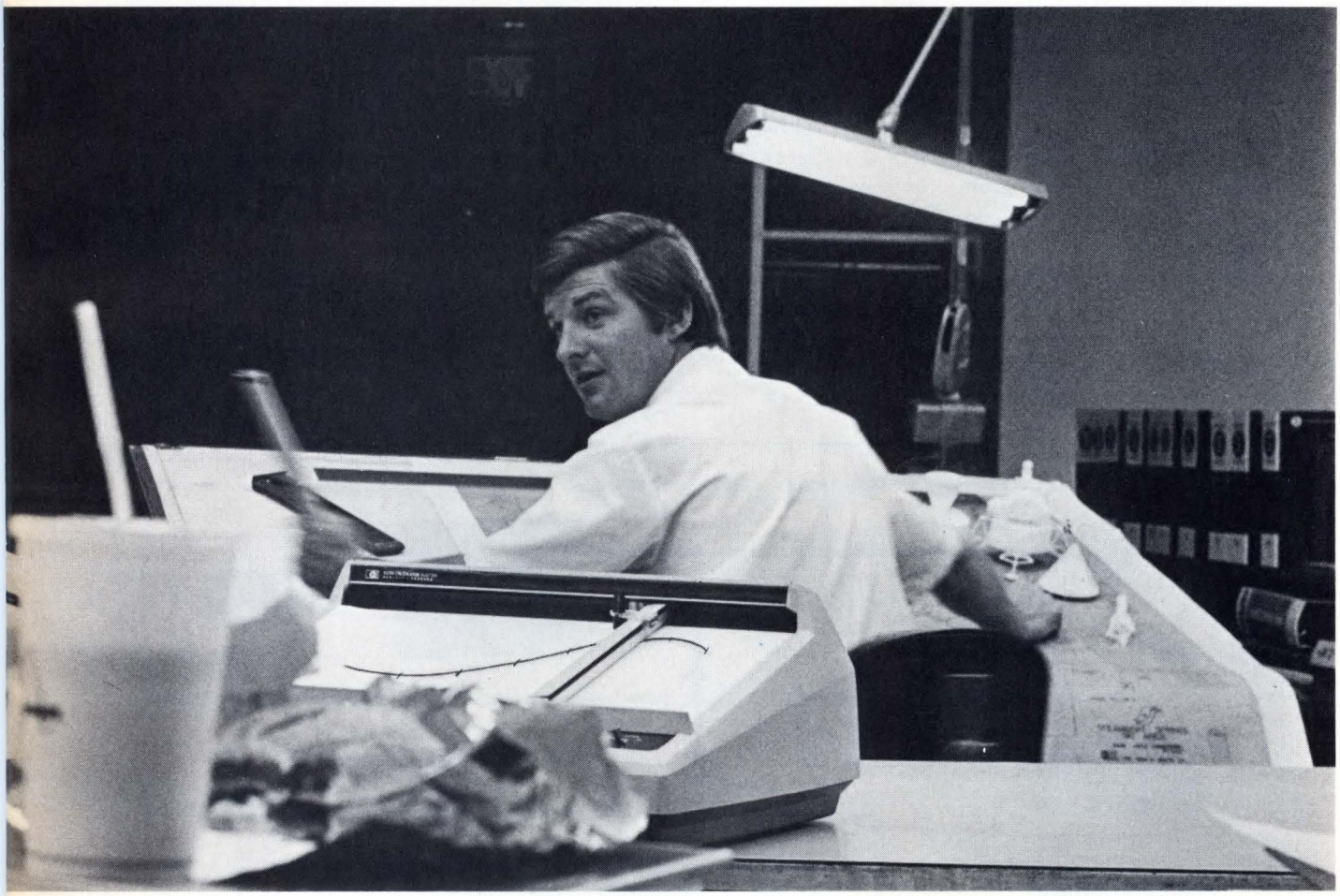
Production capability is about 6 months away, says Photocircuits officials, and costs should compare with dense 2-sided PC boards.



Writing head's dispensing stylus is seen in red to the right in top photo. Cutter piston assumes a 30 deg angle toward the center, and the pressure foot is vertical at left. Magnified area of finished board section (lower photo). Closest wires are on 25-mil centers; component holes are 42-mils diam and interconnect holes are 17 mils diam.

Emancipate your time

When You Are Faced With A Tough Design Problem
The System 9100 Allows You
To Pick It Apart, Analyze It, Modify It,
And Solve It
Right At Your Desk.



You are an engineer on the move—you see a problem and a host of possible solutions fill your mind. Complex combinations of components and parameters—any one of which may be a major breakthrough—demand careful analysis. You write up four or five of your better ideas and take them to the programmer to run on the computer. "Tomorrow if you're lucky," he says, "the next day if you're not." Back to your desk. Pencil, paper, slide rule—if you stay a little late tonight you might be able to work through one possibility yourself.

There is a better way. The HP System 9100. We call it the Emancipator because it frees your time for innovative engineering. No need to wait for a programmer or wait in line at a time-share terminal. The System 9100 will compute your problems, build your models, and plot your graphs—at your desk—instantaneously. With full programming capabilities, including looping and branching and sub-routines—and the most extensive program library available anywhere, the System 9100 starts solving your problems as soon as you open the box.

Arrange a "hands-on" demonstration at your desk. Lease, rental and purchase options available, write: Hewlett-Packard, P.O. Box 301, Loveland, Colorado 80537.

090/31

HEWLETT hp PACKARD

HP CALCULATOR SYSTEM 9100

CIRCLE NO. 9

Interactive Graphic System Speeds IC Mask Making

BOSTON—The system called "Design Assistant", introduced by Applicon Inc. recently, is just that. It increases the efficiency of artwork design and layout and eliminates all laborious tasks associated with conventional pencil and paper layouts. When the design is completed, data is automatically produced for each individual mask level to be drawn on an automatic artwork generator.

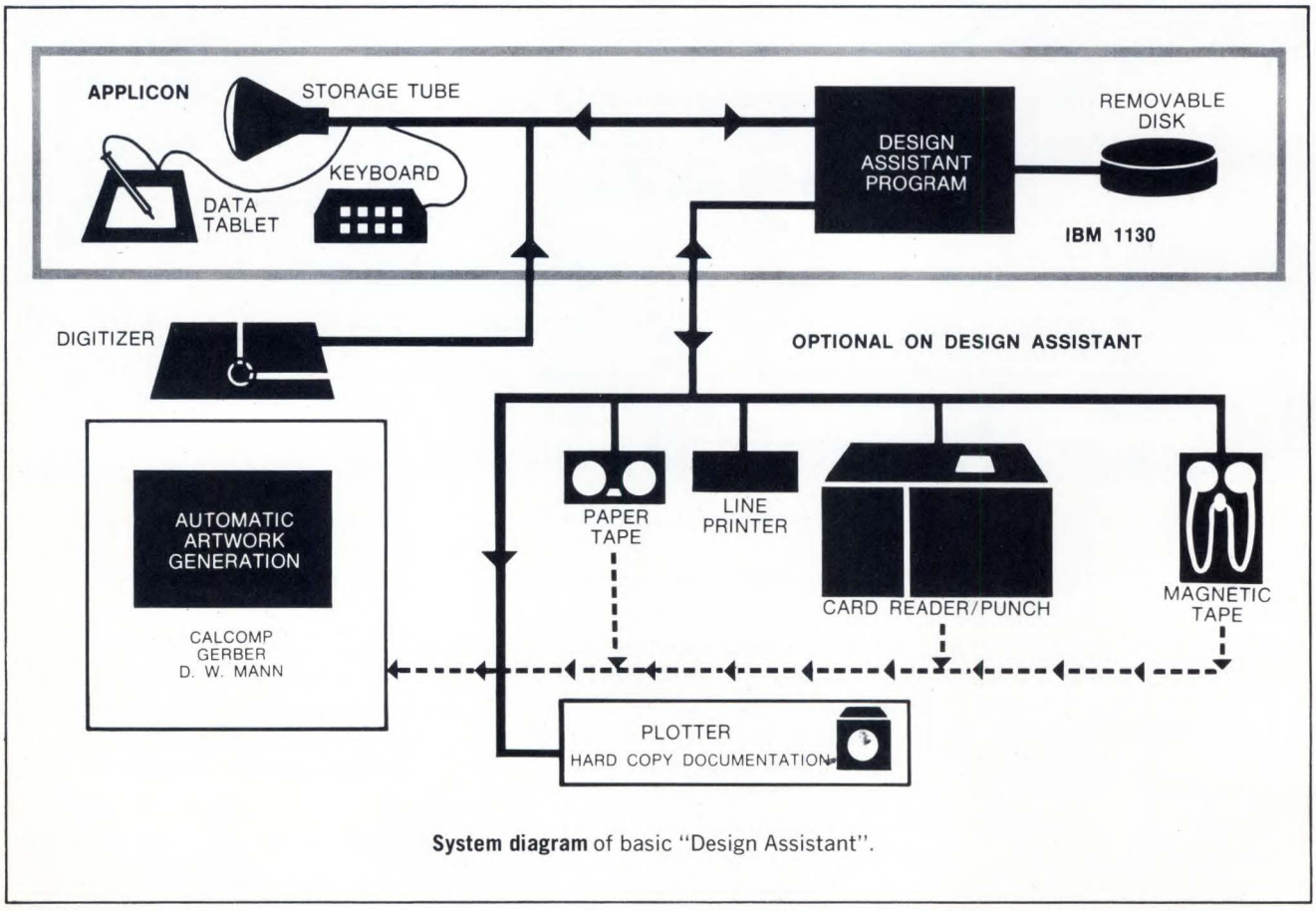
"Design Assistant", as conceived by Applicon, is a complete hardware/software package. The hardware consists of a graphics terminal made up of a Computek storage tube display, keyboard and data table, and an IBM 1130 computer.

The designer interacts with the "Design Assistant" by drawing free-hand symbols with an electronic stylus on the data tablet. Resulting designs are displayed on a flicker-free CRT display tube. These free-hand symbols, taught to the Assistant by the designer, are used for such things as calling up devices from his library, rotating them, zooming in on a certain area, shrinking, moving devices, and so on.

A library on a disc file holds over 1000 components (if dealing with IC circuits). Library components added to a layout are automatically updated on the display and on all appropriate individual levels. The same holds when a component is deleted; all portions, including contacts and contact cuts are deleted from all levels.

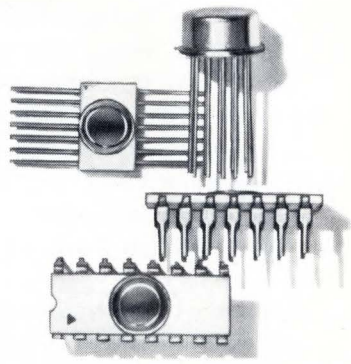
Since the component library is on an easily removed disc, the designer can construct a family of libraries for different uses: one for bipolar circuits, one for MOS circuits, and one for PC board layouts. When making up his library, the designer has complete flexibility in choosing SC or passive device sizes in order to fit his own design rules.

"Design Assistant" is easy to learn and use, and, with its capability to include as many as 32,000 components in a layout, quite complete. The advancement in the art of CAD lies in the "Design Assistant's" ability to allow a designer to come up with a complete layout electronically, and in its ability to take the design when completed and automatically generate data for each individual mask level for plotting on a variety of automatic artwork generators.



System diagram of basic "Design Assistant".

New low prices for RCA's COS/MOS IC's



Once again, as production volume follows market demand, RCA has substantially reduced COS/MOS IC prices. Result: more engineers can take advantage of the unique performance features of the COS/MOS technology in their new and existing logic-circuit designs. Before you begin a new design, evaluate the exceptionally high performance and outstanding reliability of COS/MOS IC's: check cost, check power requirements, check cooling requirements, check noise sensitivity. You'll find many reasons for incorporating RCA's COS/MOS IC's in today logic-circuit designs for tomorrow's production savings.

COS/MOS FEATURES— Typical Values at V_{DD}=10 V

- ☐ Extremely low quiescent-power dissipation
  Gates—P_T = 10 nW/pkg
  MSI circuits—P_T = 5 μW
- ☐ Speed
  Gates—propagation delay (t_{pd}) = 50 ns @ C_L = 15 pF
  MSI circuits—clock pulse frequency (f_{CL}) = 2.5 MH_z
- ☐ Excellent dc and dynamic noise immunity, 4.5 V over full operating-temperature range
- ☐ High dc fanout > 50
- ☐ Simple circuit and subsystem design
- ☐ Compatible gate-level and MSI functions
- ☐ Operation from one unregulated power supply 6 to 15 V
- ☐ Full military operating-temperature range −55°C to +125°C
- ☐ Stable performance over wide ranges of supply voltage and temperature

For further information on COS/MOS integrated circuits, see your local RCA Representative or RCA Distributor. Ask for the following COS/MOS application information: "Noise Immunity", ICAN 6176; "Astable and Monostable Oscillator Designs", ICAN 6267; "COS/MOS IC Reliability Data", RIC 101. Or write: RCA, Commercial Engineering, Section 50I-1 /CD46, Harrison, N. J. 07029. International: RCA. 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

Flat Pack Type No.	DIC Type No.	Description	Flat Pack Price-Each (1000 or more quantities)	DIC Price-Each (1000 or more quantities)
Gates				
CD4000	CD4000D	Dual 3-input NOR plus inverter	$ 3.90	$ 3.25
CD4001	CD4001D	Quad 2-input NOR	4.10	3.45
CD4002	CD4002D	Dual 4-input NOR	4.25	3.60
CD4007	CD4007D	Dual complementary pair plus inverter	3.40	2.75
CD4011	CD4011D	Quad 2-input NAND	4.10	3.45
CD4012	CD4012D	Dual 4-input NAND	4.25	3.60
—	**CD4019D**	**AND-OR select gate**	—	**5.25**
Flip-Flops				
CD4013	CD4013D	Dual-D with set/reset capability	5.60	4.95
Hex Buffers/Logic-Level converters				
—	CD4009D	Inverting	—	5.50
—	CD4010D	Non-inverting	—	5.50
Multiplexers				
CD4016	**CD4016D**	**Quad bilateral switch**	**6.00**	**5.40**
Memories—MSI				
CD4005	CD4005D	16-bit NDRO	10.00	9.45
Static-Shift Registers—MSI				
CD4006	CD4006D	18-stage register	10.00	9.50
—	CD4014D	8-stage synchronous parallel or serial input/serial output	—	10.55
—	CD4015D	Dual 4-stage serial-input/parallel-output	—	10.55
Counters—MSI				
CD4004 *CD4004T	—	7-stage ripple counter/ freq. divider	8.20 7.50	—
—	**CD4017D**	**Decade counter/divider with 10 decoded outputs**	—	**11.00**
—	**CD4018D**	**Presettable divide by "N" counter**	—	**9.65**
—	**CD4020D**	**14-stage ripple-carry binary counter/divider**	—	**12.50**
Adders—MSI				
—	CD4008D	4-bit full adder with parallel carry out	—	10.60

*TO-5 package
(COS/MOS IC's listed in bold-face type are recent additions to the line.)

RCA Integrated Circuits

CIRCLE NO. 10

Custom MOS LSI Library Now Ready

MESA, ARIZ.—Touting fast turnaround (10-14 weeks) and low cost ($5000-$20,000) for custom MOS LSI designs, Motorola Semiconductor now makes available to customers its Custom Circuit Design Center using the Polycell LSI design system. (See "I Am an IC Design Engineer", EDN June 1, 1969).

This computer aided design (CAD) system with a library of proven cells is not only more certain to result in a design that works the first time, but the designer also has fewer details to handle, which greatly reduces design time. The present library of cells contains 30 circuits that include a variety of gates, expanders and flip-flops designed with high threshold p-channel MOS. These will be complemented with silicon gate devices as well as bipolar arrays in the future.

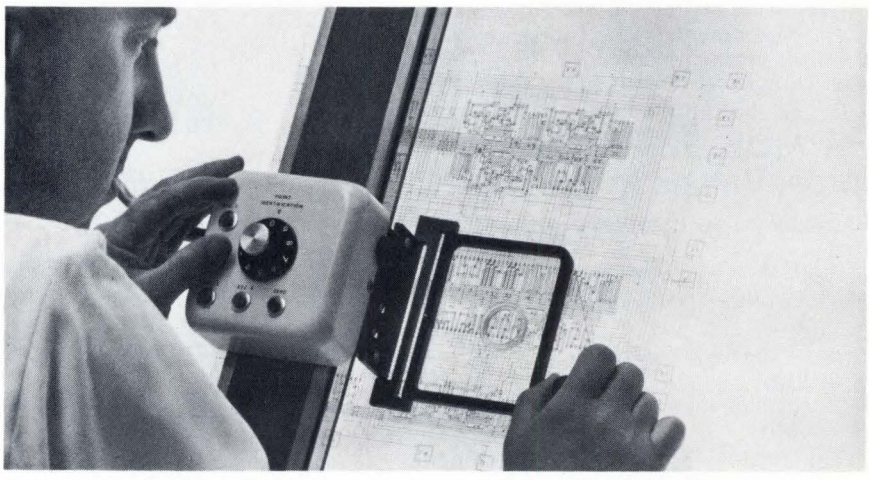
To handle customer needs, a custom LSI design group has been formed that brings together experience in LSI design, logic design and the use of CAD.

After initial negotiations on needs and prices, the design phase begins. This includes partitioning of the logic required, cell selection, data card preparation (describes required logic to CAD system), logic simulation layout, artwork generation and functional sequence test generation. From these steps, nonrecurring design charges can be directly calculated, based on steps to be performed by Motorola and the complexity of each chip. Compared to hand optimized design, the MOS Polycell LSI system can cut nonrecurring design costs in half.

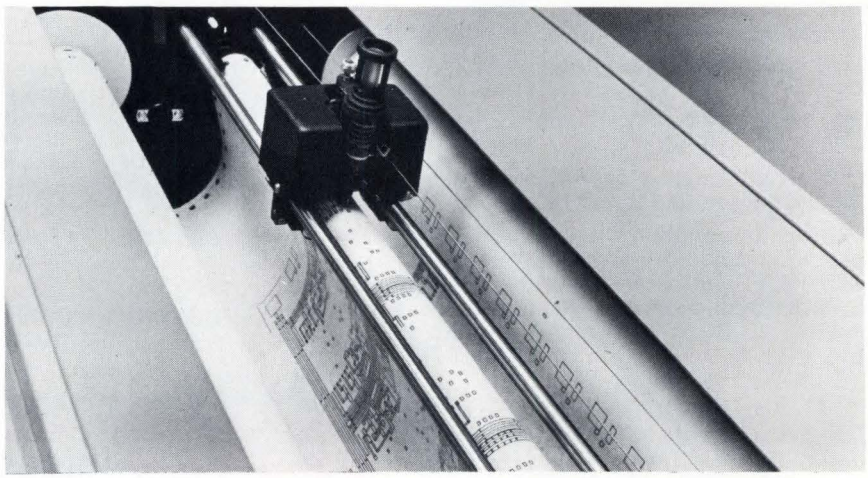
After cell selection is completed, signal interconnections are performed by any of several methods: automatic, CRT interactive or digitizer graphic capabilities (see photos).

When the designer accepts the layout in ink plot form, an automatic drafting machine takes over and prepares photographic artwork masters of the LSI design.

CRT console provides custom circuit designer with an extremely powerful interactive graphics capability. Through the CRT, designer "takes over" the layout at any stage in order to optimize the design.



Coordinate digitizer is convenient, efficient method for converting designer's signal routing plan into computer-compatible format.



Close up of high speed plotter creating layout documentation. Plotter can draw in several colors, facilitating checking.

Here's important news for every cost-conscious designer—RCA's COS/MOS line in dual-in-line plastic packages, at prices you can't afford to overlook.

This new COS/MOS line, RCA's CD4000E series, offers a broad range of gate-level and MSI devices with the low-power, high-noise-immunity features of hermetically packaged COS/MOS devices. And this plastic package gives you a broad operating temperature range and built-in reliability for industrial, commercial, and consumer applications. Look into RCA's CD4000E series for automotive systems, appliances, avionics applications, alarm systems, communications equipment, computers, industrial controls, and instrumentation.

This new low-cost, high-performance COS/MOS line offers you wide design flexibility in 19 application-oriented devices in 14- or 16-lead dual-in-line plastic packages. Check them now...and check our reliability report (listed below). Here are some important CD4000E series highlights:

☐ Wide operating-temperature range: −40°C to +85°C (−65°C to +150°C storage)

☐ Ultra-low quiescent-power dissipation—
Gates—P_T = 50 nW/pkg. (typ) @ V_{DD} = 10 V
MSI circuits—P_T = 10 μW/pkg. (typ) @ V_{DD} = 10 V

☐ Operation from single unregulated voltage supply: 5 to 15 V range

☐ Excellent dc and dynamic noise immunity—gate level and MSI circuits—
4.5 V (typ) @ V_{DD} = 10 V over full operating-temperature range

☐ Speed
Gates—propagation delay (t_{pd}) = 50 ns (typ) @ V_{DD} = 10 V, C_L = 15 pF
MSI circuits—clock pulse frequency (f_{CL}) = 2.5 MHz (typ) @ V_{DD} = 10 V

☐ Single phase clock

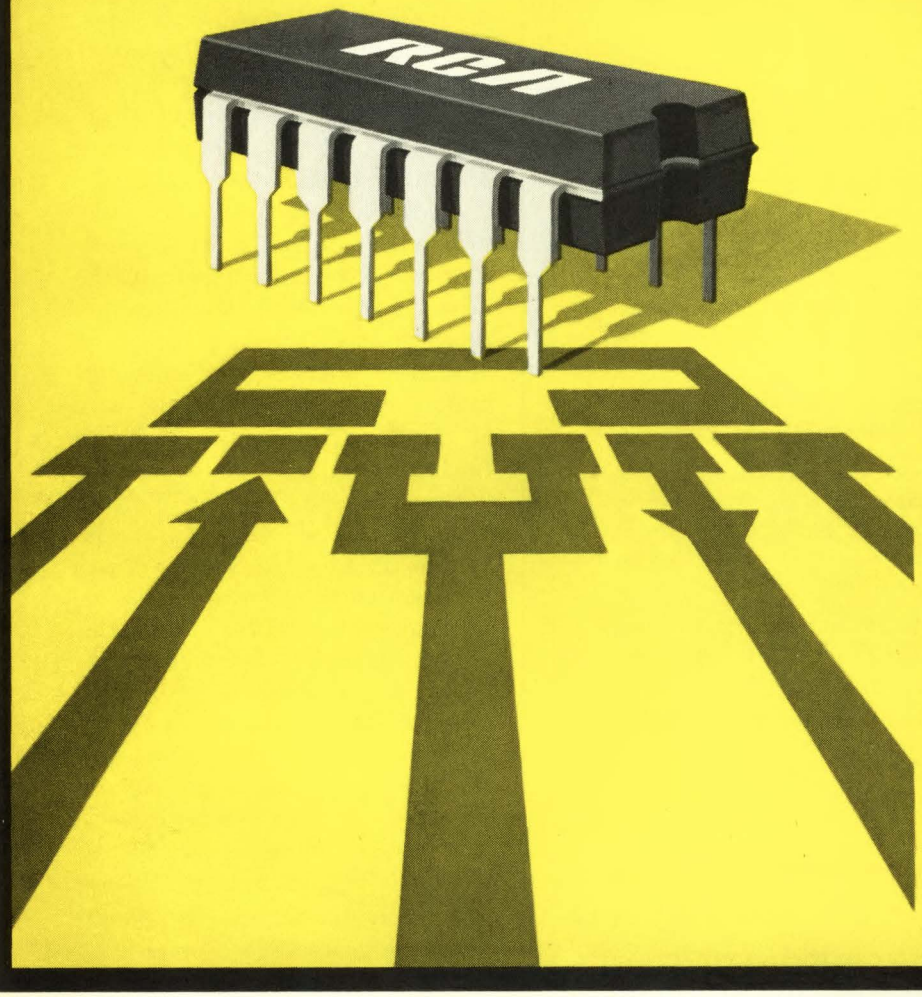
☐ Clock voltage equal to supply voltage

☐ Compatible gate level and MSI functions

☐ Protected inputs and outputs

For further information, see your local RCA Representative or RCA Distributor. Ask for technical bulletin File No. 445, and the following publications: "RCA CD4000E Series COS/MOS IC Reliability Data," RIC 103; "Counters and Registers," ST-4166; "Noise Immunity," ICAN-6176; "Astable and Monostable Oscillator Designs," ICAN-6267. Or write: RCA, Commercial Engineering, Section 50I-1/CD47, Harrison, New Jersey 07029. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

Now! COS/MOS Goes Plastic for a Brand New Approach to Logic Circuits at Low Cost.



TYPE	DESCRIPTION	PRICE (1000 Unit level)
Gates		
CD4000E	Dual 3-input NOR plus inverter	$2.20
CD4001E	Quad 2-input NOR	2.30
CD4002E	Dual 4-input NOR	2.50
CD4007E	Dual complementary pair plus inverter	2.30
CD4011E	Quad 2-input NAND	2.30
CD4012E	Dual 4-input NAND	2.50
CD4019E	Quad AND-OR select gate	3.70
Flip-Flops		
CD4013E	Dual "D" with set/reset capability	3.30
Hex Buffers/Logic-Level Converters		
CD4009E	Inverting	3.60
CD4010E	Non-inverting	3.60
Multiplexer		
CD4016E	Quad bilateral switch	3.30
Static-Shift Registers—MSI		
CD4006E	18-stage register	7.75
CD4014E	8-stage synchronous parallel or serial-input/serial-output	7.75
CD4015E	Dual 4-stage serial-input/parallel-output	7.75
Counters—MSI		
CD4004E	7-stage ripple counter/frequency divider	5.60
CD4017E	Decade counter/divider with 10 decoded outputs	8.00
CD4018E	Presettable divide-by "N" counter	7.00
CD4020E	14-stage ripple-carry binary counter/divider	9.50
Adder—MSI		
CD4008E	4-bit binary full-adder with parallel carry-out	7.50

RCA
Integrated Circuits

CIRCLE NO. 11

Rate Sensor Uses

A new rate sensor that can do anything a rotating-mass gyroscope can has a usable lifetime, without repair, equal to that of aircraft, spacecraft or missiles on which it may be installed.

Honeywell Aerospace Div., Minneapolis, the developer of the new vibrating-wire rate sensor (VWRS) states that it "eliminates the need for frequent replacement and repair common to conventional spinning mass gyroscopes by the application of a new approach to accurately determining the rate of turn."

The thumb-sized device produces a usable output through interaction of a vibrating wire and a pair of magnets. A 2-in beryllium-copper wire is strung taut within two magnetic fields – one to provide drive impetus, and the other to generate the output signal. A second wire, strung at a right angle at the midpoint of the first, is grounded to separate the drive and output signals electrically.

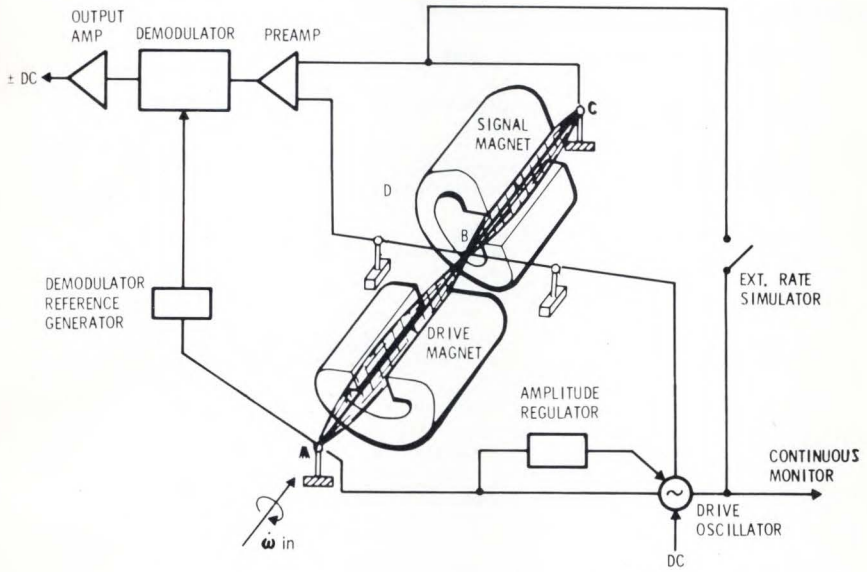
An oscillator feeds alternating current to the main portion of the beryllium-copper wire strung through the drive magnet's field. Magnetic flux causes the main portion of the wire to vibrate and induces sympathetic vibration along the half of the wire strung through the signal magnet's field.

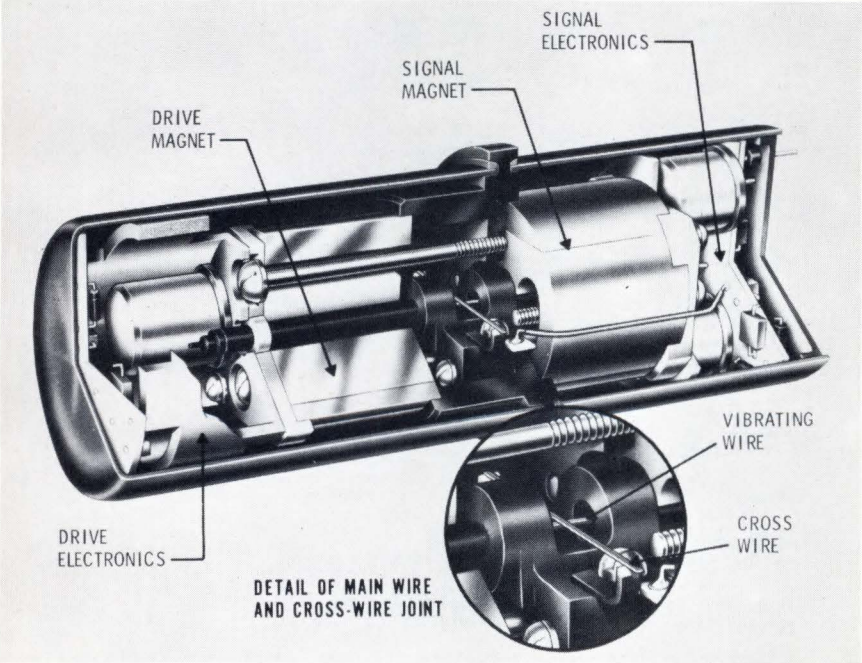
The input axis of the VWRS is along the longitudinal axis of the device. Rotation on the input axis causes Coriolis deflection forces on the vibrating wire to produce an output signal proportional to the input rate.

Some of the other features which make the device unusual are electrical isolation of the output signal; control of wire vibration to prevent signal error; relative insensitivity to temperature and aging; use of latest microcircuitry; ready time of 100 ms; and constant wire frequency vibration.

Coriolis Effect

The device has been in development at Honeywell about 5 years. The firm has built 36 for test purposes.





Cutaway drawing shows the component parts of Honeywell's newly-developed rate-of-turn sensor, which has a total volume of 3 in³. The vibrating wire which is the heart of the device runs for 2 in down the middle of the device. Aerospace Div. engineers say it can replace spinning mass gyroscopes in nearly all conventional applications and will last 10 times longer.

EDN CARAVAN ROUTING

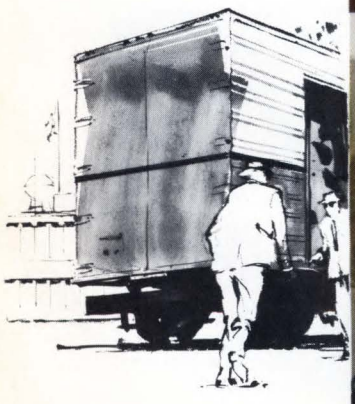
September 1 - October 2, 1970

DATE / DAY / TIME	AREA	SITE
Tuesday, September 1		
9:00 - 12:00 noon	Loveland, Colorado	Hewlett-Packard
1:30 - 4:00 p.m.	Boulder, Colorado	IBM
Wednesday, September 2		
9:00 - 11:30 a.m.	Denver, Colorado	Honeywell
2:30 - 4:30 p.m.	Colorado Springs, Colo.	Hewlett-Packard
Friday, September 4		
9:30 - 12:00 noon	Wichita, Kansas	Boeing
1:30 - 4:00 p.m.	Wichita, Kansas	Beech Aircraft
Tuesday, September 8		
9:00 - 12:00 noon	Kansas City, Mo.	Bendix
Wednesday, September 9		
9:00 - 12:00 noon	St. Louis, Mo.	McDonnell-Douglas (Bldg. 33)
1:30 - 4:30 p.m.	St. Louis, Mo.	McDonnell-Douglas (Bldg. 106-7)
Thursday, September 10		
9:00 - 12:00 noon	St. Louis, Mo.	Conductron
Friday, September 11		
1:30 - 4:30 p.m.	Cedar Rapids, Iowa	Collins Radio
Monday, September 14		
9:00 - 12:00 noon	Hopkins, Minn.	Honeywell
1:30 - 4:30 p.m.	Normandale, Minn.	Control Data
Tuesday, September 15		
9:00 - 12:00 noon	Minneapolis, Minn.	Control Data (Space & Def. Syst.)
1:30 - 4:30 p.m.	St. Paul, Minn.	3M Research Center
Wednesday, September 16		
9:00 - 11:00 a.m.	Roseville, Minn.	Univac
12:00 - 2:00 p.m.	St. Paul, Minn.	Univac—Plant 1
3:00 - 4:30 p.m.	St. Paul, Minn.	Univac—Plant 5
Thursday, September 17		
9:00 - 12:00 noon	Arden Hills, Minn.	Control Data
Friday, September 18		
9:00 - 12:00 noon	Milwaukee, Wisc.	AC Electronics
1:30 - 4:00 p.m.	Milwaukee, Wisc.	G.E. Medical Systems
Monday, September 21		
9:00 - 12:00 noon	Schaumburg, Ill.	Motorola
1:30 - 4:30 p.m.	Skokie, Ill.	Teletype
Tuesday, September 22		
9:00 - 12:00 noon	Chicago, Ill.	Zenith
Wednesday, September 23		
9:00 - 12:00 noon	Ann Arbor, Mich.	Bendix
1:30 - 4:30 p.m.	Plymouth, Mich.	Burroughs
Thursday, September 24		
9:00 - 12:00 noon	Southfield, Mich.	Bendix
Friday, September 25		
9:00 - 11:00 a.m.	Ft. Wayne, Ind.	Magnavox (Corp. Hq.)
12:00 - 2:30 p.m.	Ft. Wayne, Ind.	Magnavox (Bueter Rd.)
3:30 - 4:30 p.m.	Ft. Wayne, Ind.	Magnavox (Industrial Park)
Monday, September 28		
9:00 - 12:00 noon	Indianapolis, Ind.	RCA
Tuesday, September 29		
9:00 - 12:00 noon	Dayton, Ohio	NCR
2:00 - 4:30 p.m.	Columbus, Ohio	Western Electric
Wednesday, September 30		
9:00 - 12:00 noon	Galion, Ohio	North Electric
3:00 - 4:30 p.m.	Cleveland, Ohio	Picker X-Ray
Thursday, October 1		
9:00 - 11:00 a.m.	Cleveland, Ohio	Addressograph-Multigraph
Friday, October 2		
9:00 - 12:00 noon	Webster, New York	Xerox
1:30 - 4:30 p.m.	Rochester, New York	Eastman Kodak

Watch for EDN's fourth annual Caravan tour, September-December 1970. A traveling exposition of products and ideas visiting over 100 leading electronic manufacturers throughout the U.S.A.

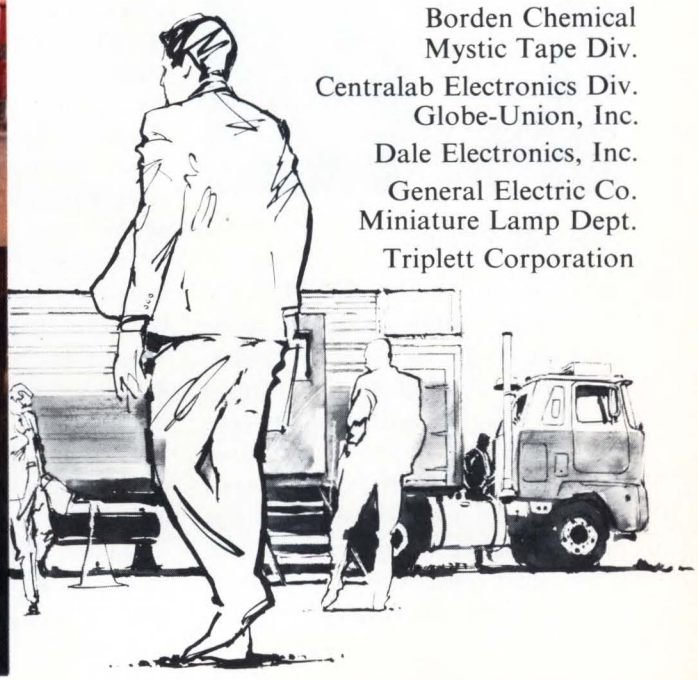
EDN MAGAZINE PRESENTS...

Caravan '70



Featuring new products, ideas and application assistance from:

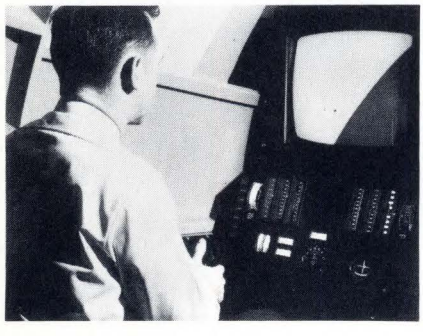
Allen-Bradley Company
Bodine Electric Co.
Borden Chemical
Mystic Tape Div.
Centralab Electronics Div.
Globe-Union, Inc.
Dale Electronics, Inc.
General Electric Co.
Miniature Lamp Dept.
Triplett Corporation



Fake It

Architects may walk the streets of a city that exists only in their minds. Highway engineers may cruise along planned superhighways, and supersonic jet pilots may practice collision-avoidance techniques at Mach 3. Such is the promise of the Visual Environment Simulation System (VESS) located at GE's avionic controls laboratory in Binghamton, N.Y. The system operator watches his environment change on a color TV screen while a computer changes the scene in response to the operator's control movements.

VESS operates in two modes, real-time and non-real-time. In real-time mode, the view is updated 30 times/s, while nonreal-time update takes 4s but permits much more complex environment display. No TV cameras, videotape or films are used; the computer-driven display operates from descriptions of numbers of "edges" or intersections of planes stored in the computer program. The resulting scene can be viewed from any angle or position.



Get LEDs Out

Bell Labs. in Murray Hill, N. J. are developing gallium phosphide light-emitting diodes to replace incandescent lamps in telephones and display boards. With an estimated life over 100,000h of continuous use, compared to 10,000h for incandescent lamps, their largest potential application is in business-type telephone sets with illuminated push buttons on millions of desks across the country.

That's a "Gotcha"

Forward-looking infrared (FLIR) system provides "24-hour eyes" for the U.S. Army. Gimbal mounted on the front of the Army helicopters, the passive infrared systems are currently being produced by Aerojet's Electronics Div., Azuza, Calif., under contract with the Army.

Large-scale TTL Coming

Fairchild Semiconductor plans to add several standard LSI devices to their TTL family before the end of this year. The new additions to the 9300 Series should satisfy the greater complexity/higher speed appetite of many minicomputer manufacturers.

Robert Wickham, Fairchild Product Marketing Mgr., told EDN, "Within the basic TTL technology, there's a lot of room to move—both in terms of technology and complexity." He went on to say that Fairchild was placing their major TTL effort on developing new functions for LSI. To create the new line of TTL/LSI devices, Fairchild will use their "Micromosaic" technology. Until now, the "Micromosaic" approach was used primarily for making custom circuits. Under the present plan, Fairchild will become its own customer—in that it will use "Micromosaic" to make a standard line of TTL/LSI devices.

Wickham would not comment on what devices would be offered or exactly when they would be available. He hinted that they would have 200-gate complexity and would be announced in late fall.

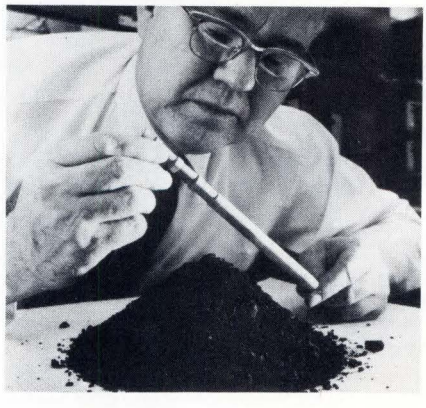
1970 Reliability Physics

Last April, IEEE Reliability Physics Symposium presented 50 papers to a record attendance of nearly 500. The ten sessions represented vital areas of interest in Reliability Physics. Among those topics discussed were: *Reliability of Plastic Encapsulated Devices, Metallization and Bonding, Silicon Interfaces, Radiation Effects, Reliability Testing and Failure Analysis.*

To fully record this and future Symposiums, the practice of printing Proceedings has been re-established. The price for IEEE members is $8 and for non-IEEE members, $12. Interested persons are urged to reserve copy(s) in advance of publication (anticipated in late October 1970). Make checks payable to "Reliability Physics Symposium" and send to Publication Chairman, Dr. O. D. Trapp, Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040.

"Unburns" Oxygen

Westinghouse Research Labs. have successfully life-tested a system to reclaim oxygen in a spacecraft. The system is based on the Westinghouse solid electrolyte battery, basically a fuel cell unit that would normally combine gaseous fuel with oxygen to produce electricity. It operates in reverse in this system, using electricity to "unburn" carbon dioxide and water vapor in astronauts' breath.



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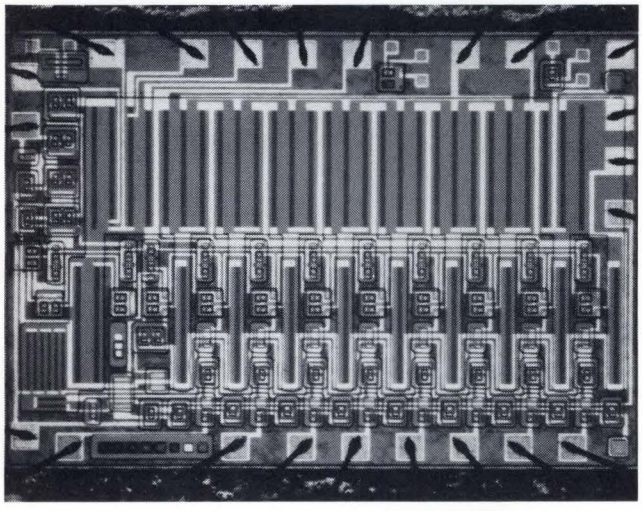

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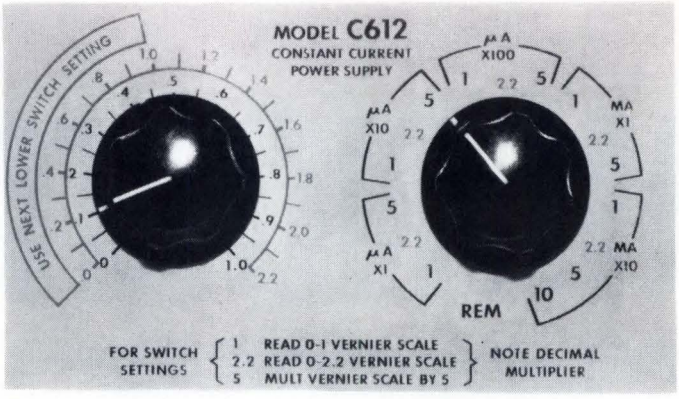

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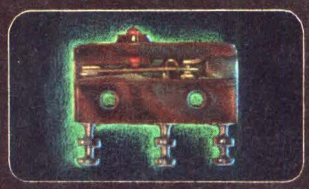

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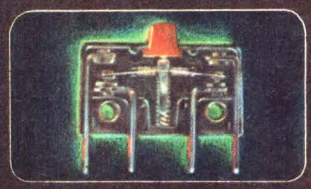

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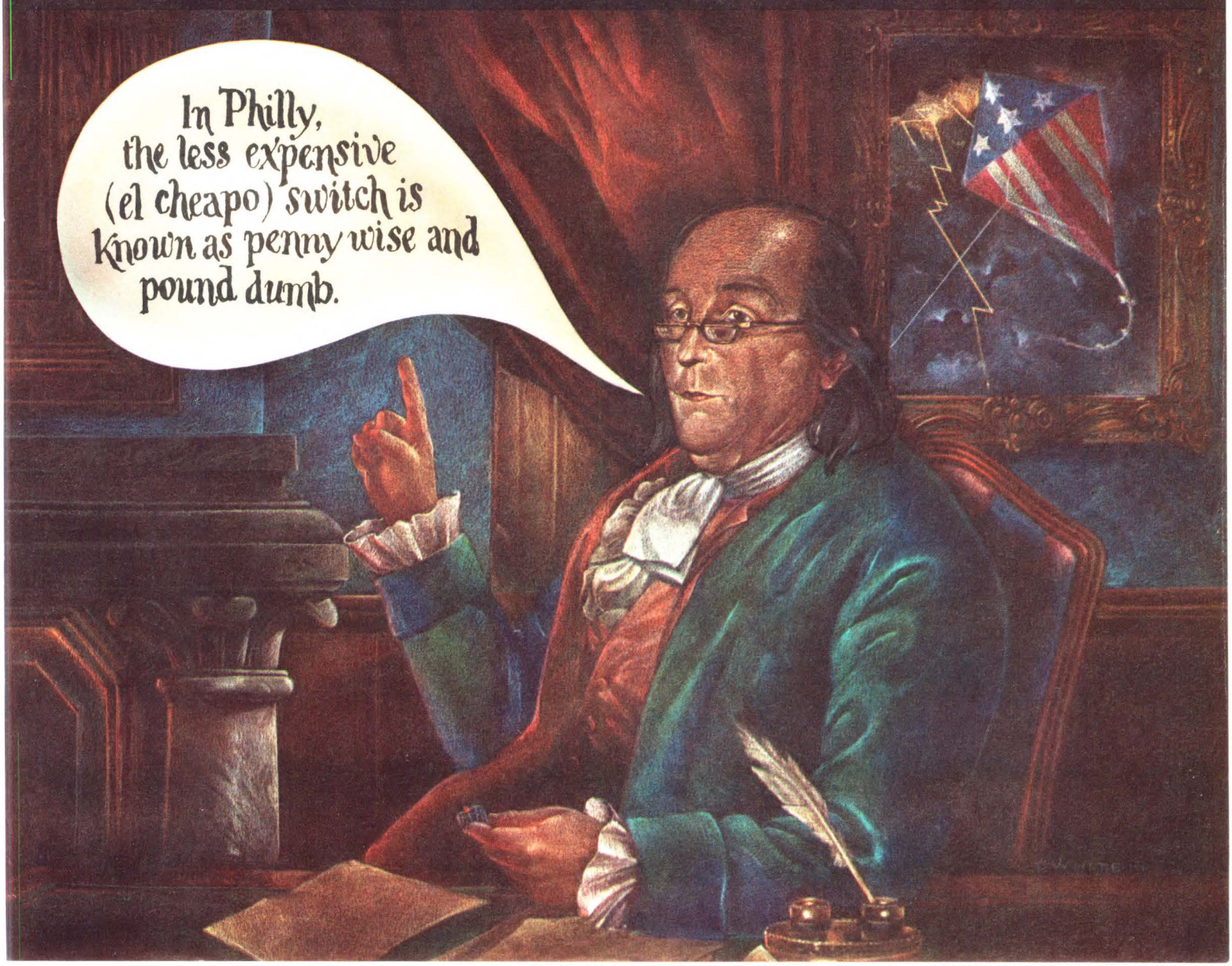


ELECTRO-OPTICS IS A MATURING INDUSTRY

Retail sales of electro-optics totals $9 billion in the Free World today. By 1980, this figure should nearly triple, says Herbert A. Elion, Senior Member of Arthur D. Little, Inc. He bases his prediction on a recently-completed ADL electro-optics study program that he directed.

Devices and systems that can operate in the optical frequency range are the synthesis of advances in optics, radiation, physics and chemistry over the past several years. Electro-optics has been attractive to industry from the start because innovations in this field might well supersede or supplement current equipment in such diverse fields as computers, missile guidance, reprographics and process control. Substantial research during the last decade resulted from this early optimism.

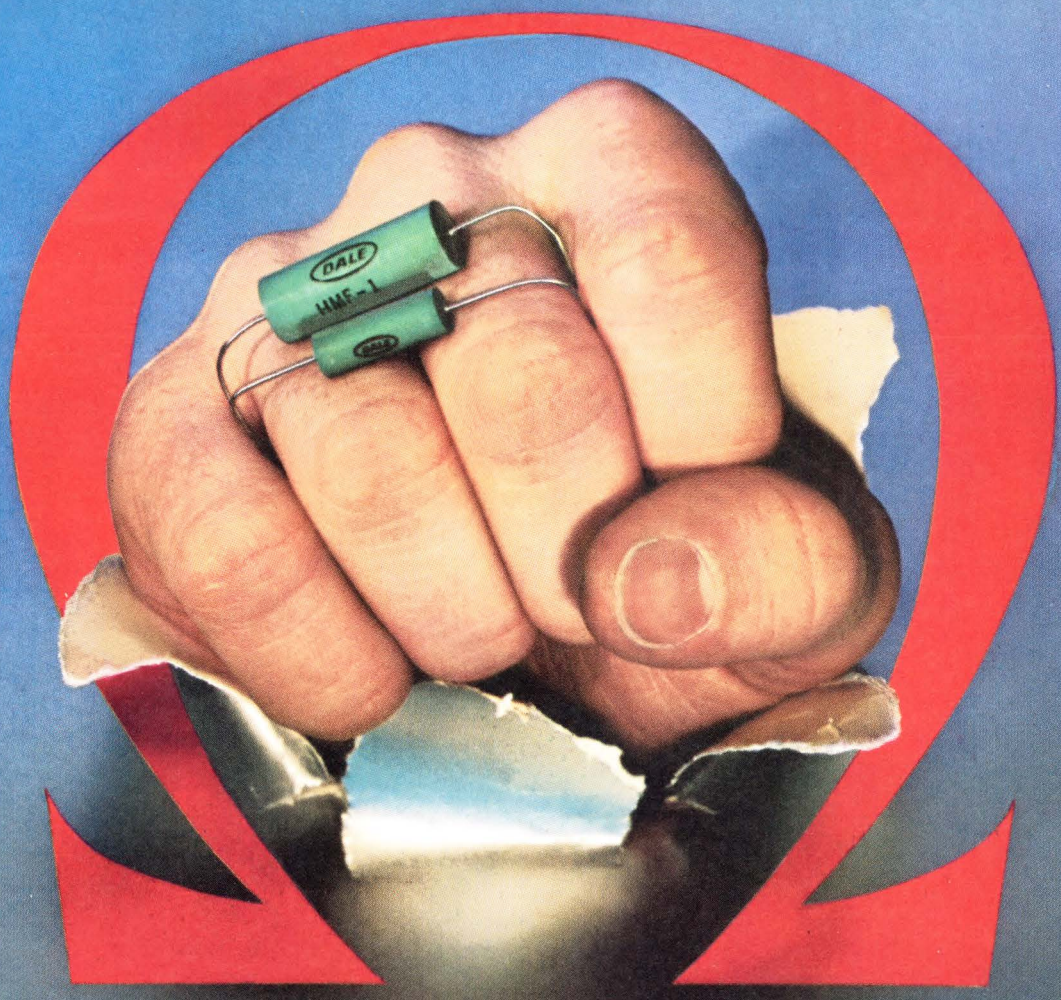
Today, as electro-optics competition takes on a more international flavor, the European and Japanese industries pose a technological threat to U.S. leadership in electro-optics. Non-U.S. companies could well seize this market leadership with new-generation products.

This trend is discernible in a just-completed, major two-part study at Arthur D. Little, Inc. Surveying 12 principal divisions of the electro-optics field, the program extended over a 22-month period and produced a 5-10 year forecast of markets, technology and competitive climate. The study was supported by commercial firms in the U.S. and abroad.

The 12 principal divisions that the study covered were: materials; modulators and detectors; computing, data processing and associated displays; communications and displays; military reconnaissance, surveillance and weapons delivery systems; night observation systems; consumer markets; display components; military and related displays; industrial processing and control applications; testing and measuring applications; and medical and scientific applications.

In the consumer area, the U.S. TV market is mature, but new large markets will develop for TV-related systems. Retail TV sales in the Free World were $7.3 billion in 1968 and should be $16.6 billion in 1975. Teleplayer systems and software could be a $1-billion world market by about 1975 and exceed $2 billion by 1980. Picture phones also are becoming important, with approximately one million to be installed by 1980.

Electro-optics is closely tied to communications and telecommunications technology in areas such as alphanumeric, graphic and picture display systems, and in the actual transmission of information at optical frequencies. Significant activity also is noted in that portion of industry concerned with making computer inputs user-oriented instead of machine-oriented. Thus, there is growth in optical pattern recognition hardware and software associated with equipment such as optical character-recognition devices, mark and bar code readers and journal tape readers. Finally, renewed activity in facsimile for transmitting graphical and pictorial information could presage its major growth by the mid-1970s.



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RESISTANCE				T.C.
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	10-30 ohms		100K-30M	50 PPM
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Tolerance: 1% standard. Special tolerances and T.C.'s available.

Applicable Mil Specifications: MIL-R-10509 (Char. C, D, E), MIL-R-22684 (RL-07, RL-20).

Power Rating:
LMF—1/10, 1/8, 1/4, 1/2 watt.
HMF—1/20, 1/10, 1/8, 1/4, 1/2, 3/4, 1 watt.
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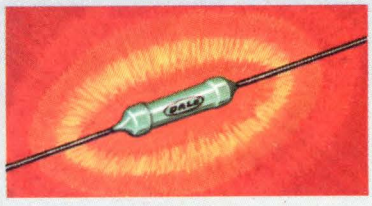

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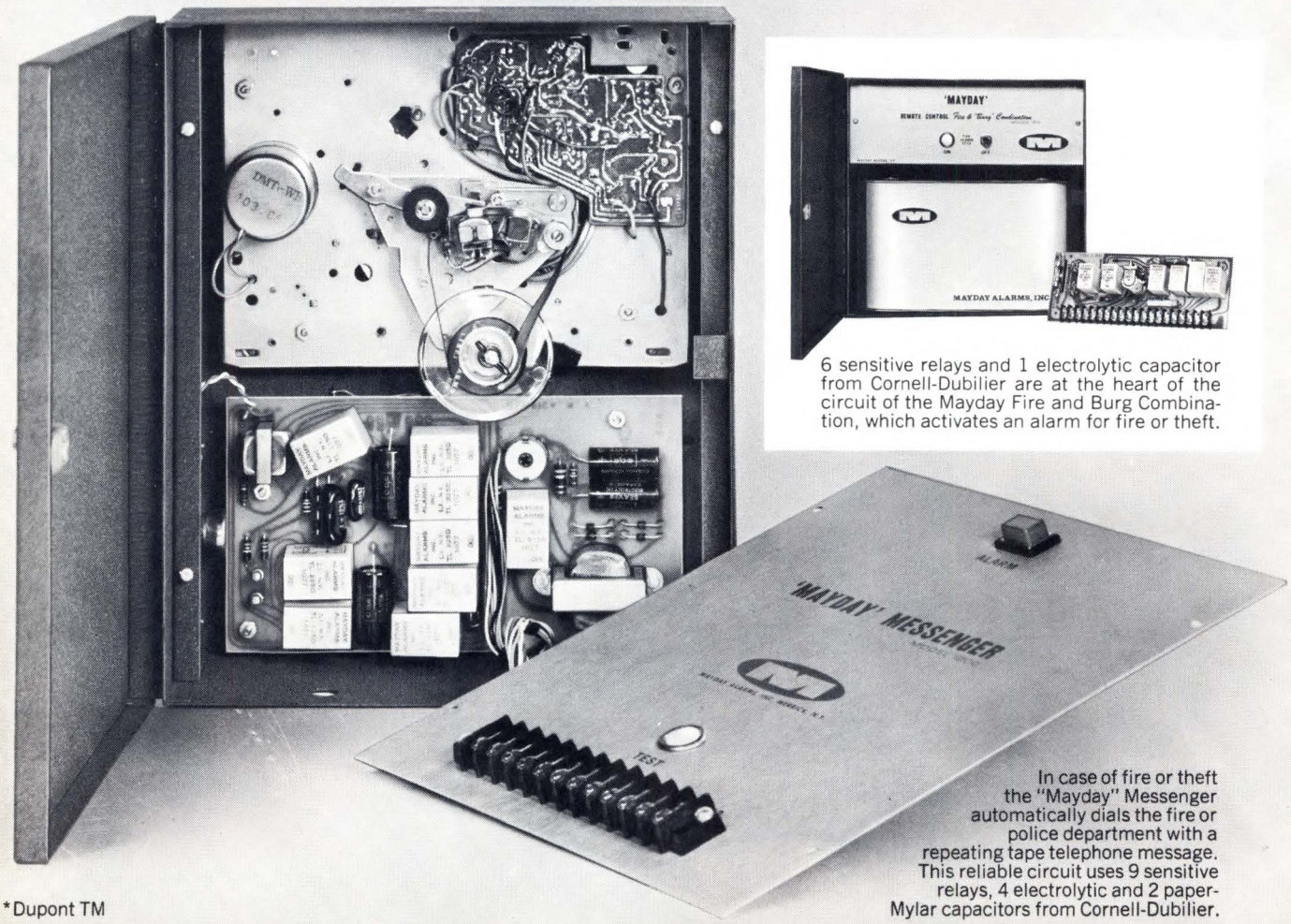


6 sensitive relays and 1 electrolytic capacitor from Cornell-Dubilier are at the heart of the circuit of the Mayday Fire and Burg Combination, which activates an alarm for fire or theft.

In case of fire or theft the "Mayday" Messenger automatically dials the fire or police department with a repeating tape telephone message. This reliable circuit uses 9 sensitive relays, 4 electrolytic and 2 paper-Mylar capacitors from Cornell-Dubilier.

*Dupont TM

CIRCLE NO. 18

MINICOMPONENTS— BUILDING BLOCKS FOR HYBRIDS

For higher performance, knowledgeable designers are shifting to hybrid circuits. To chart this new territory, EDN assembled facts and figures on currently-available minicomponents—and the pitfalls that await unwary users.

EDN Editorial Staff

Designers who hybridize a circuit design today are discovering that they can choose from the newly-available tunable inductors and transformers, as well as the more popular semiconductors, resistors and capacitors.

For insight into these new components for design, as well as an update on components that have been around for a while, EDN has assembled this report.

Active Chip Vendors Growing in Number

Partly because of the industry's growing interest in hybrids, and partly because of yield improvement and increased production capacity, many semiconductor firms are beginning to market their products in chip form. Although the service is not actively advertised, firms such as Crystalonics, Intel, National Semiconductor, Signetics and Transitron stand ready to deliver most of their standard product line in chip form. The minimum order, however, is usually $100 or 100 pieces. There are many ways to buy chips and dice, nearly as many as there are companies that will sell them. There are plenty of advantages, too, for both buyer and seller—but there also are pitfalls that can lead to sudden disaster.

(Collins Radio)

On the manufacturer's side, Intel points out that the major cost of their devices is in the dice—and they're more than happy to supply customers with "good dice only" at a cost that is typically 50% of the same device in its packaged version. Intel's orders presently amount to only a few thousand, and hybrid houses are the primary customers. Intel has the capability to make "flip chips", but they're reluctant to do so unless it's for a high volume order.

National Semiconductor will soon publish a complete dice catalog that will carry most of their standard product line. Beside their willingness to perform a 100% probe test to minimum specifications on all key parameters, National stands ready to work with customers on their special dice requirements. Like National, Signetics is publishing a complete dice catalog which offers the following in chip form: TTL, bipolar memories, their new linear ICs and phase-locked-loop devices. Signetics prefers not to offer their MOS products in chip form because MOS is vulnerable to contamination.

Crystalonics supplies its chips in any of several forms; **chips that are probed** for breakdown voltage, beta and leakage currents and have plain, gold or silver backing; **100% tested premounted chips** that are temporarily mounted on special carrier headers and 100% dynamic and static tested, then removed and shipped with silver backing and 3/8-in, 1-mil gold leads; **burned-in chips** that also are special carrier mounted and burned in at 200°C with 90% max voltage applied; **JAN and JANTX equivalent chips** with complete preconditioning and applicable Group B testing.

Transitron would rather sell entire wafers because it is less bother for them and cheaper for the customer. Wafer buying permits the customer to do his own sort with a fair confidence level of yields concerning breakdown voltage and beta versus frequency. Transitron has found that major contractors with their own test engineering departments choose the wafer buying approach because of its flexibility and economy.

Another advantage of buying wafers, according to Transitron, is availability of certain parts of the chip.

(Continued)

Minicomponents (Cont'd)

Certain ICs may have super-gain transistors on them and, while the op amp may not be operable, access to these super-gain transistors makes them useful for design.

Unlike many other companies, Transitron sells its chips (in small volume) for twice the cost of completely packaged devices. They do this because the user's ability to package chips and to put 10 or more functions into one package saves both packaging cost and PC board space. This results in an overall cost saving for the user, even though his initial chip costs were higher.

Both GE and Unitrode supply discrete semiconductor chips. GE also supplies its ICs, while Unitrode's gold-backed chips include zeners, SCRs, diodes, transistors and photoSCRs.

Sprague's transistor chips include units (both npn and pnp) to 1A with 60V BV_{ceo}. Motorola's line has up to 25A, 60V BV_{ceo} units as well as 175V BV_{ceo} 1A devices, FETs, diodes and zeners make up the uncased semiconductor chip line at Motorola.

Texas Instruments Incorporated is currently pushing only one general-purpose chip diode—the BC188A. It is a planar 75V switching-type diode with characteristics similar to the 1N4148, 1N914B and 1N4150, when properly mounted. This chip is, according to TI, suitable for about 50% of all hybrid circuit applications. They will introduce another diode chip, the BC815, that will have similar characteristics except for reverse breakdown which will exceed 200V.

Centralab's chip line includes zeners, temperature-compensated reference elements, SCRs, rectifiers, diode core drivers, switching diodes and tunnel diodes. They will introduce transistor chips soon.

Unlike lines offered by most other chip suppliers, Centralab's line has been designed specifically for use in hybrid circuits. Centralab feels that many users lack the ability to handle chips as semiconductor houses do, so they try to adjust pad size and spacing for easy wire bonding. They feel that most users can bond to a 5-mil pad with no trouble.

Both Motorola and TI will encourage customers to buy chips within a somewhat limited selection. For example, TI prefers to sell chips from their list of 322 preferred devices out of the 15,000 they manufacture.

Motorola will be introducing npn RF chips (similar to 2N159, 2N172).

Dickson offers a variety of devices including reference amplifiers, TC reference elements, zeners, FETs and bipolars. All Dickson semiconductor devices are offered in LID or channel-type packages, and zener regulators also are offered in bare chip form.

Semiconductor Services, Inc., has just announced its entry into the semiconductor marketing arena. This new firm specializes in transistor and diode chips, 100% dc probe tested, scribed, broken, 100% visually inspected and packaged to the buyer's specifications. The line includes diodes, small signal transistors and high power units capable of I_C to 20A with a BV_{ceo} to 120V in both pnp and npn types.

Feeling that "die sales are good business," Advanced Micro Devices has recently joined the fraternity of chip vendors. In announcing the availability of their standard product line (9 digitals, 9 linears) in chip form, the young firm asserted that they "understand the hybrid business, and have priced their dice with a complete knowledge of the hybrid manufacturers' packaging-yield problems." Advanced Micro Devices has extended their "unique mixing privilege" to the sale of dice—i.e., only 10 pieces of a single device type, either linear or digital, need be purchased to take advantage of quantity price breaks.

With its recent acquisitions, Varadyne aims to become a total-capability company for the hybrid market. Beginning with a chip capacitor line a few years ago, the "congeneric" company has actively expanded—and they can now supply hybrid houses with everything they need, including masks, packages and both active and passive chips. "One-stop shopping" could well become Varadyne's motto as they continue to acquire companies related to the semiconductor field. Most recently, the synergetic firm acquired Cartesian and Integrated Systems Technology, which added MOS technology to its growing capability. Developing products for the hybrid market, Varadyne recently introduced an inexpensive active chip that is a diode-transistor array (**Fig. 1**). This versatile chip, containing seven npn transistors and three zener diodes, can be custom-metallized to produce a great variety of circuits at a quantity price that approaches $0.50/chip.

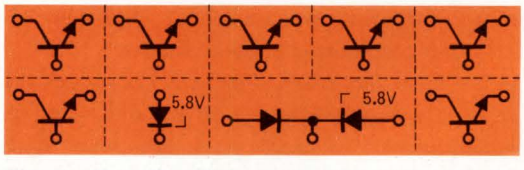


Fig. 1—**Versatile Minicomponent** contains diode-transistor array that can be custom-metallized to form great variety of circuits. Quantity priced at about $0.50 each, this active chip should entice the hybrid designer. (Transistor specs: BV_{ceo} = 45V, BV_{cbo} = 70V, BV_{ebo} = 6V, h_{fe} = 80 at 200 μA. Diode specs: BV = 70V, V_f = 0.6V at 10 mA). (*VARADYNE*).

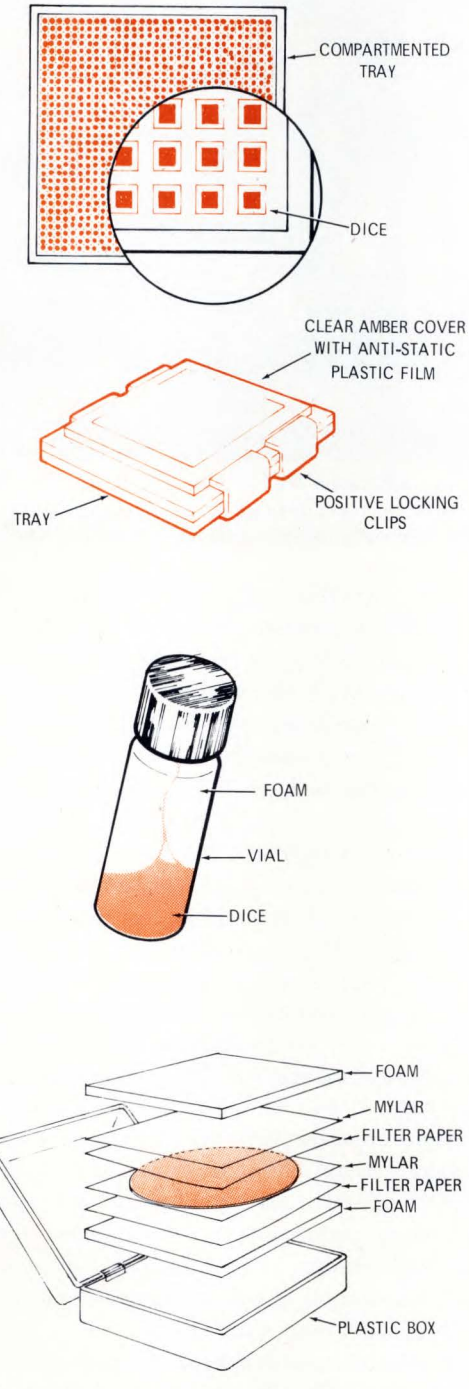


Fig. 2—**"Any way you want them"** aptly describes the way active chips are available. Diagram above shows the three common packages active chip vendors make available to their customer. (*INTERSIL*).

Bottlenecks: Handling and Testing

Generally, the active chip vendors point to the handling and testing of chips as the industry's major bottleneck.

Probe testing of chips yields limited results, namely dc and low-frequency ac parameters (typically less than 1 kHz). Even these limited probe-test parameters may change when the chip is placed into its final package. Since practically all chip vendors caution their customers against this potential discrepancy, the fledgling hybrid-circuit designer would do well to take heed.

Most chip vendors can supply their probe-tested chips in any of three forms: unscribed wafers, scribed and unsorted, or scribed and sorted (**Fig. 2**). There is an initial cost advantage to buying the "unscribed wafer" or those that are "scribed and unsorted"—but be ready to cope with the handling problems once you take delivery. Every customer's requirements will be different, depending on what in-house capability each has. As one vendor pointed out, certain customers opt the "scribed and unsorted" chips because they like to have the bad chips with the good. This permits the company to use the bad chips to break in new girls on the bonding machines. Other customers with probe-test capability will retest bad chips with the thought of using them in designs that don't demand the tolerance imposed by the chip vendor.

Siliconix foresees a dramatic increase in chip sales when the average small company can buy the equipment to test the chips. Until then, they feel that the potential for chip sales will not be met. Currently, Siliconix offers 600 standard products and 4000 special products—the latter comprising selected chips that meet tight tolerances or standard chips in unique packages. Only three of their products (n-channel JFETs) are offered as "flip chips" (**Fig. 3**). Siliconix points out that there is room for improvement in the method of delivering chips to the customer—the plastic carriers, said one spokesman "aren't so hot", indicating that they don't retain chips as well as they should. Siliconix envisions a growing trend toward beam-lead chips. The company refrained from commenting, however, when asked if they were developing a beam-lead technology.

Raytheon Semiconductor, one of the industry's leading proponents of beam leads, says that they are currently delivering 11 million discrete chips/month (including those in wafer form). Presently, about 60% of the Raytheon chip line is beam-leaded—and soon all of their conventional chips will be available in beam-lead packages. Just recently, Raytheon has made known that they have begun producing standard hy-

(Continued)

brid circuits with their beam leads. They pointed out that making their own hybrids will enable them to understand the requirements of their hybrid customers better. With an optimistic outlook, Raytheon foresees a growing demand for their beam-lead chips by hybrid-circuit designers. Aside from high reliability and silicon nitride passivation, beam-lead chips lend themselves to automated handling and testing. Once these automated handling/test systems are developed, there's bound to be a dramatic cost reduction of the beam-lead devices. Currently, Bulova is under contract to Raytheon to develop such a system. Electroglas and Transistor Automation Corp. are two other companies also developing automated production equipment for beam-lead devices.

As advice to prospective chip users, Raytheon urges a close vendor/customer working relationship to recognize cost advantages. They indicated that many customers spend more money than required because they specify chips by 2N number rather than application. Specifying chips by application usually results in cost savings because the vendor has a wider range of chips from which to choose. Looking to the future, Raytheon is considering a "burn-in" test for their chips to enhance reliability.

With a chip catalog hot off the press, Intersil is actively pursuing the hybrid market with their product line. Of the current chips being delivered, they estimate that 80 to 90% are going into hybrid circuits. Although boasting a good variety of "flip chips", Intersil does have standard products, such as their monolithic n-channel dual FETs, that they don't expect to offer in flip-chip form—unless, of course, they get a very high volume order. Intersil emphasized that the big question chip customers should ask themselves is "What can be tested—and what can't be tested?". Intersil asserts that there is no probe-test mechanism in existence that can make chips behave as they would when packaged. Therefore, customers ought to be familiar with the vendor's acceptable quality levels, as well as the sample test methods to assure device parameters. For quality assurance, Intersil continually places a sample of chips in actual device packages before testing.

Chips for GHz

In the rapidly expanding field of GHz hybrid circuits, chip devices are not a luxury—they are a necessity. At a wavelength that is only slightly more than an inch long at 10 GHz, any discrete device must be a "minicomponent", regardless of whether circuit miniaturization is a design goal. If the component is to act as a lumped element in the circuit, it must be at least an order of magnitude shorter than the wavelength

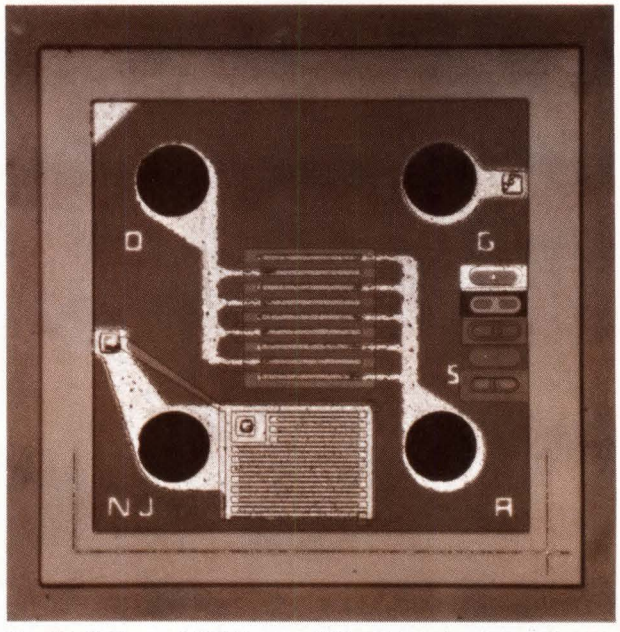


Fig. 3—**N-Channel JFET** is one "Flip Chip" developed for hybrid market. This device may be attached directly to thin- or thick-film substrates by ultrasonic bonding. (*SILICONIX*).

(0.1 in at 10 GHz) and preferably should be two orders of magnitude smaller (10 mils at 10 GHz).

Chips or separately processed add-ons are essential for completing GHz circuits at present. To get GHz operation, one must have both GHz active devices and very low-loss, wideband, passive circuitry. Even the substrate has to have "GHz performance", for its dielectric becomes a part of the circuit. Completely monolithic circuits have not yet been proven practical at GHz, because silicon is too lossy a material. Therefore, some form of hybrid construction must be used.

Uncased or bare chip transistors are best for the customer at GHz, claims a spokesman for Hewlett-Packard's Microelectronic Group. The customer comes out ahead on every count if he uses the device in chip form.
He will save money. An HP chip costs only $15 in small quantities vs $45 for the same device in a package.
He'll get superior performance. The package adds lead inductance and shunt capacitance that significantly drag down a GHz transistor's specifications. A package, for instance, can make a 10-GHz device look no better than a 6-GHz one. The Smith chart illustration (**Fig. 4**) gives an example of how a package can degrade a transistor's critical input impedance.
He'll obtain improved heat dissipation. He can bond the chip to an integral heat sink such as a beryllium oxide or boron nitride insert in the alumina or sapphire substrate.
He'll be able to assure his customer better reliability. So far, there has not been a single failure reported from

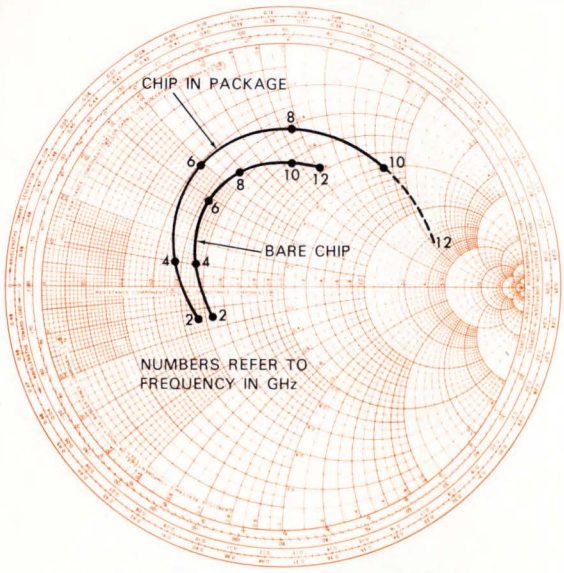


Fig. 4 – **Improved performance** of a bare chip transistor shows up on Smith chart (for input impedance S_{11}).

the 11-chip, 2-GHz amplifiers that HP has used in its GHz sweeper instruments. These chip-on-sapphire amplifiers have racked up something like 1-1/2 million device hours in the 1-1/2 years they have been out in the field.

Right now, HP supplies chip transistors with f_{max} as high as 15 GHz. These can be used as oscillators up to 8 GHz. But they also say they have 20-GHz f_{max} devices in the lab that will make 12-GHz oscillators feasible. These very high-performance devices will quite likely only be used in chip form, because any package – even a stripline type – would seriously degrade their performance.

Even when the engineer uses a GHz device in chip form, he will still have to watch how he makes his connections. Just a 20-mil long, 0.7-mil-diam bonding wire can contribute too much inductance at 10 GHz. The user will be able to see the effect when he tests his circuit in a network or spectrum analyzer. One possible solution, HP says, is to use many parallel wires in a "mesh" arrangement to lower the inductance, but added their belief that designers are starting to come up with even better solutions.

Sylvania has developed some beam-lead semiconductor devices that have been popular with GHz circuit designers. One of these is a germanium tunnel diode suitable for operation up to 18 GHz. Beam leads meld nicely into highly-miniaturized GHz circuit structures.

Little Chips: Big Specs

Ironically, as the GHz chips get smaller, their specification sheets get bigger. Some very good news for the designer is happening in this area. More and more suppliers of GHz chips – both active and passive – are supplying extensive s-parameter characterizations for their products.

Steadily increasing use of network analyzer test systems enables s-parameter measurements that can be quickly accomplished on this relatively new instrument. They are the equivalent of the "y" or "h" parameters when the device is inserted into a 50Ω linear-signal system. Hewlett-Packard's network analyzer, the first instrument on the market to make these measurements efficiently, enjoys a popularity like that of Tektronix's improved scopes back in the early 1960s. Surprising numbers of device makers and circuit-fabricators have invested the $10K to $100K price these instruments command. (Cost goes up with added computerization.)

Manufacturers who do not own analyzers make steady use of GHz testing services such as those of Computer-Metrics (a multibranch company specializing in job-lot HP network analyzer testing). Major GHz transistor manufacturers now put s-parameter characterization (for various operating bias conditions) on their data sheets. The only exception has been in the case of power transistors when they are operated in class-C mode, rather than in the linear mode of small-signal devices. However, even some power device makers publish "pseudo s-parameters" in the form of curves on the Smith chart.

Sophisticated Passive Chips

Avant-garde passive component manufacturers are beginning to follow suit. However, they need only specify two of the four s-parameters since their devices are symmetrical.

An incredible amount of thought can go into a tiny GHz passive device. American Technical Ceramics' 50-mil^3 chip capacitors with frequencies up to 14 GHz combine a respectable dielectric constant (K-15) with very, very low dissipation (0.00007). In appearance, they resemble other multilayer monolithic ceramic capacitors. The difference is that ATC uses a special low-loss porcelain that combines a dielectric constant twice as high as alumina with a dissipation factor that is five times lower.

ATC makes their multilayer chips in the small physical sizes (about the size of this lower-case "o") and low capacitance values needed for GHz circuits (from a fraction of a picofarad to 5 pF). Prices are steep for these

(Continued)

tiny units ($2 to $6), but according to ATC these small, low-loss units command this price because of the boost they can give to GHz circuit performance.

Ordinary Chips Would Explode

Take a 5W power stage at 2 GHz, says an ATC spokesman. At such frequencies and power levels it is difficult to obtain more than 5 to 7 dB gain, so probably 2W would have to be fed to the power transistor. Say that the matching network used to transform the 50Ω stage input down to the 1Ω transistor input level uses a capacitor (**Fig. 5**). Because of the impedance transformation, an RF current of about 1-1/2A would flow through the capacitor.

If an ordinary ceramic chip capacitor with a dissipation factor of, say, 0.01 at 2 GHz were used, the 1-1/2A RF current would flow through its internal resistance of about 1Ω. This would be disastrous for the circuit. Not only would the supposedly "lossless" matching network rob the stage of as much power as was being put in, but the heat build-up in the miniature chip would be so intense (2W) that it might literally explode.

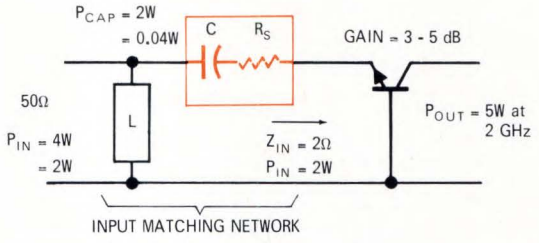
However, an ATC chip with its low dissipation factor of only 0.0001 at 2 GHz presents an internal resistance of only 0.02Ω. The 1-1/2A RF circulating current would cause a dissipation of only 40 mW. This is one reason why GHz people are willing to pay more for low-loss chips, says ATC.

Computer-Aided Chip Selection

Growing use of both active and passive fully s-parameter characterized GHz chips has led Fairchild engineers to envision a future hybrid manufacturing line for producing GHz circuits.

"The s-parameter of each individual active device will be measured at the start of the line, and then the circuit parameters to match these to the source and load will be computed on a time-share terminal. You will then tailor the parameters of the individual hybrid substrate assemblies for the individual active devices . . . keeping track of the parts so that by the time all parts reach the active-chip assembly station, the correct active chips will be put on the correct tailored substrates. You will, in the process, select the correct value of passive chip components to go on the individualized substrates." Fairchild believes this sort of an approach will be justified in GHz circuits because of the need to push each circuit to make maximum use of its active devices.

It also may be possible that laser trimming of thin-film elements on the substrate will supplement the



IF CAPACITOR DISSIPATION FACTOR = 0.01, THEN R_S = 1Ω AND P_{CAP} = 2W
IF CAPACITOR DISSIPATION FACTOR = 0.0001, THEN R_S = 0.02Ω AND P_{CAP} = 0.04W

Fig. 5 – **GHz input matching** chip capacitor must be low loss.

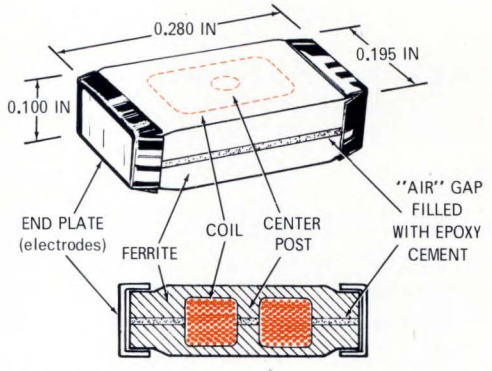


Fig. 6 – **Internal structure** of chip inductor. (*NYTRONICS*).

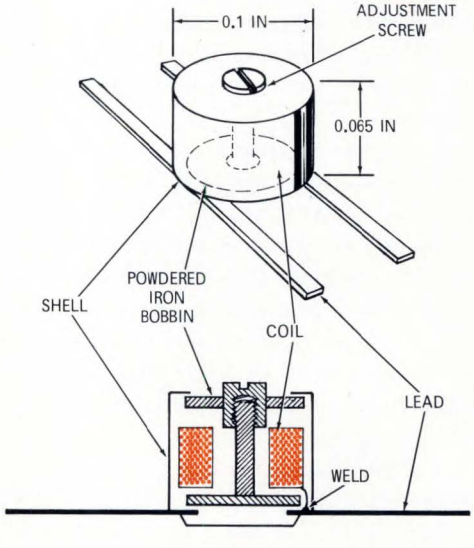


Fig. 7 – **Internal structure** used for inductor and transformer "Micro i" line. (*DELEVAN*).

chip selection process.

Finally, Miniature Inductors

Now, at last, miniature inductors and transformers are starting to become available for hybrid circuits. Nytronics, Darlington, S.C., produces some miniature chip-form-factor inductors that are only 100 mils high and have chip-type end metallizations so they can be handled and mounted like chip capacitors. Nytronics expects to come out with a new chip-like package that is only 70 mils high.

Internally, these devices are made like a pot-core transformer. Two ferrite halves form the package structure (**Fig. 6**). The coil of fine wire is laid in the annulus around the center island or post of these cores, and they are assembled with an epoxy-filled 5-mil air gap to prevent magnetic saturation of the ferrite upon current surges. Then thin copper foil caps are wrapped around the ends, the two tails of the coil being attached to these ends in the process. Since the electrodes wrap around the ends, the little chips can be mounted in almost any conceivable position – and the customer's engineers are said to mount them in many imaginative ways, even standing on end as support pillars between two miniature substrate boards.

Nytronics supplies these in the 15 to 1000 μH range with Qs of 70-80. Standard units have self-resonances between 2 and 20 MHz, but they can make custom units that won't self-resonate until several hundred MHz. They are rather expensive components ($2.50 in 10,000 lots), but they perform circuit functions unique to inductors and so are finding growing use, Nytronics says. One interesting application is for signal and power line filtering on high-speed digital logic PC boards. These little inductors can be used in conjunction with chip capacitors for efficient, compact pi-type noise filters. Despite their small size, they are completely shielded, so they do not contribute to the noise environment.

And Even Miniature Transformers

Delevan has extended its miniature pill-shaped inductor, originally brought out in the mid-1960s, to transformers. The "Micro-i" configuration (**Fig. 7**) is based on a powered-iron bobbin that has a relatively slim center post. On a custom basis, one of the flanges can be screw-adjusted in some of the models, so these miniature inductors can be made adjustable. Delevan says these make the most economical form of adjusted oscillators. The fine wires of the coil are now thermo-compression bonded. Originally, Delevan soldered these to the leads, but found that the solder joints could open during the customer's flow-soldering operation.

When two coils are wound on these bobbins, a miniature transformer results, making it feasible to attempt the hybridization of such popular discrete circuits as transformer-coupled IFs. Delevan says they have made units to operate at frequencies up in the hundreds of megahertz even though the Q goes down with increasing frequency.

Delevan covers the inductance range from a few nanohenries to 1000 μH, at some increase in package size for the higher value. Their prices for inductors run in the $0.90 range at the 1000-lot level, the exact price varying with the Q. Surprisingly, they note a demand for 15 nH inductors for high frequency operation.

At this low inductance level, the coil is merely a single hairpin loop of wire, but some customers still want the handling convenience of a packaged unit, knowing that the women on their production line will be less apt to change the inductance when they handle the unit. They also like the degree of shielding that the Delevan unit provides.

Variables and More Transformers

Miniature inductors from Cambion include variable slug-tuned units from 0.06 to 2000 μH, 5/1 adjustment, Qs from 10 to 38 and prices from $2.72 (1-9). Their fixed units range from 0.1 μH to 1 mH with Qs of about 30 and are priced at $3.60 (1-9).

Piconics also has a line of fixed and slug-tuned miniature inductors. Their variable line ranges from 0.009 to 5800 μH with Q to 60, while their fixed units range from 0.007 to 5800 μH with Qs from 10 to 90. Piconics' line also includes double tuned transformers that operate from −55 to 125°C with an operating frequency range from 1 to 100 MHz. Physical dimensions for some of these tiny components from Piconics are shown in **Fig. 8**.

Thin-Film Inductors

Thin-film chip inductors offered by Motorola have an inductance range from 28 to 230 nH, Qs from 19 to 30 and an operating current value of 250 mA. These devices are designed for UHF and microwave tuning and biasing applications.

Chip Capacitors – Where's the Market?

"Manufacturers of ceramic chip capacitors presently have the *capacity* to produce 400 million units – however, the market demand won't exceed 75 million units in 1970." This striking projection was conveyed by Jerry Lemberg, staff scientist for Quantum Science

(Continued)

Corp. The information specialist also added that by 1972, the market demand for ceramic chip capacitors wouldn't exceed 125 million units. On top of the overcapacity prediction, Lemberg foresees a growing trend away from chip capacitors in favor of screenable dielectrics. Despite the Quantum Science statistics, EDN noted that manufacturers of ceramic chip capacitors were generally very optimistic about their market growth.

Monolithic Dielectrics, Inc. expects that market demand for chip capacitors will double over the next year. Beyond their biggest customer, the automotive industry (radios and voltage regulators), they foresee a growing use by TV manufacturers for RF sections.

At Varadyne, Inc., the Packaging and Materials Div. is in the process of building a completely new facility that will automate chip capacitor production from kiln to shipping point. They see their automated production bringing the average cost of a chip capacitor down to a nickel apiece for a large volume order. Varadyne expects RCA, Delco, Sylvania and IBM to be among their biggest customers.

In projecting their statistics, Quantum Science sees 80% of the 1972 market demand for values greater than 0.01 μF (by-pass applications) with the remaining 20% demand for negative-positive-zero (NPO) types having values less than 0.001 μF. Monolithic Dielectrics doesn't expect to see ceramic capacitors used above the 1-μF value, except for very special requirements. The vendor explained that beyond 1 μF, ceramic chip capacitors require more platinum for plate area, and this makes the devices less economical to use than their tantalum counterparts.

A Closer Look at Chip Capacitors

"We want our ceramic capacitors to have two dominant characteristics—chemical and thermal equilibrium." This production mandate came from Southern Electronics Corp. who also cautioned prospective users against "garage operations that apparently work well". Southern Electronics pointed out that any cost-saving alloys or short-cut production methods almost always build failure mechanisms into ceramic capacitors. They advise customers to insist on noble-metal electrodes because they are least contaminating—and while platinum is expensive, it yields the most stable characteristic.

From USCC comes advice to beware the "K-factor misnomer". They warn that the popular K-1200 dielectric differs from one company to another. To eliminate any ambiguity, USCC further classifies their K-1200 dielectric as having a "W characteristic". **Table I** compares the popular K-1200 dielectric (W characteristic) with the more stable K-30 dielectric (NPO-type).

Looking to automated handling equipment, Southern Electronics asserts that a customer is foolish if he doesn't specify a rectangular shape for his ceramic capacitors. Rectangular shapes do not present a symmetrical ambiguity to automated handlers as square shapes do.

Although a variety of bonding techniques is available, certain chip vendors may favor one over the other for their product. Varadyne recommends reflow soldering to attach their chip capacitors. They feel that conductive epoxy also is good—but time consuming. To improve solderability, Varadyne is presently developing a copper end termination for their chip capacitor line. They also are looking into the feasibility of developing tantalum chip capacitors.

Most chip vendors provide tutorial literature that covers manual handling as well as bonding techniques. San Fernando Electric Mfg. Co. and USCC are two such companies (**Fig. 9**).

Corning makes available glass ceramic chip capacitors that pack up to 90 μF/in^3, with values available from 270 pF to 2 μF at 50 WVdc (−55 to 125°C). **Table II** shows typical dimensions of these tiny chip capacitors.

Electro Materials offers chip capacitors pretinned with solder for easy mounting. They furnish pretinned chips in production quantities at no additional charge, which is reported to be unique in the industry.

Vitramon's chip capacitors have a capacitance range from 10 pF to 0.47 μF and come with both NPO and general-purpose dielectrics. There's also a new Vitramon line of NPO chips for applications requiring high stability that range from 1 to 9.1 pF.

Aerovox's multilayer ceramic capacitors range in value from 1 pF to 0.1 μF, with working voltage of 50V for higher valued units and a temperature characteristic of ±0.5% from −55 to 125°C, and 0.1% power factor.

Solid tantalum capacitors are supplied in chip form by Components, Inc., with a capacitance range from 0.01 to 220 μF and working voltage ranges from 2 to 35V. Components, Inc., spokesmen caution that chip tantalums should be reflow soldered at about 220°C for 5s max. Also, they say that excessive stress on the anode lead can cause a fracture of the extremely thin tantalum pentoxide dielectric layer, resulting in high dc leakage.

Sprague supplies multilayer and reduced barium titanate (high value) capacitors with end pads coated with gold, solder, palladium and other materials; tan-

talum thin-film capacitors with beam leads (100-3000 pF, 12-50V) and monolithic ceramic chip capacitors (10 pF to 27 μF, 30 and 50V). Sprague also has a line of ceramic chip capacitors (0.82-4700 pF, 50V) that can be adjusted by the user with any one of several abrasive techniques. This permits circuit tuning *in situ*.

Motorola's thin-film beam-lead capacitors (1.8 to 57 pF, 100V) are designed as coupling or blocking units for UHF and microwave hybrid circuit applications. Units are of MOS construction, with gold metallization and silicon dioxide dielectric. The line soon will be expanded to cover from 1.2 to 480 pF. Also coming from Motorola (third quarter of '70) is an MOS line of bare chip capacitors. These units will offer a range from 1 to 230 pF.

Union Carbide's solid tantalum capacitors offer a voltage range from 2-50 with capacitance from 0.0047 to 220 μF. Tolerances are $\pm$20, $\pm$10 and $\pm$5%, and operating temperature is from $-$55 to 125°C.

Dickson's solid tantalum line of capacitors ranges from 0.001 to 220 μF with a 2-50V rating. These units also have tolerances of $\pm$20, $\pm$10 and $\pm$5%, and a $-$55 to 125°C temperature range.

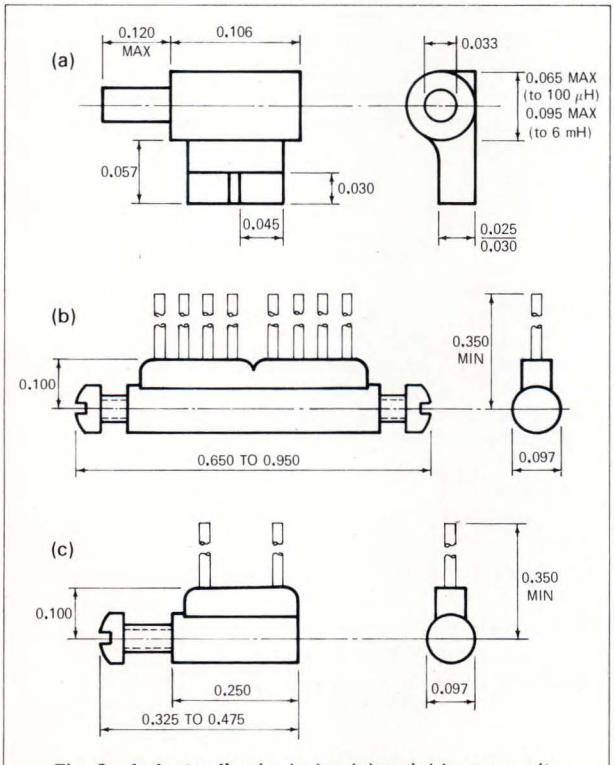


Fig. 8 – **Inductor line** includes (a) variable core units with 5/1 range, (b) double tuned transformer and (c) tank circuit for 0.75 to 105 MHz range. (*PICONICS*).

Screened-On Capacitors

The following appears in a handbook prepared by San Fernando Electric Mfg. Co.: "The recent development of 'screened-on' ceramic capacitors involves a process of firing a dielectric onto a substrate and co-firing the electrode on top of the dielectric film. This seems to be an economical and practical means of obtaining low capacitance values – however, there are several problem areas that must be understood before a designer begins to use this process. Almost anyone with a silk screen, a squeegee, and a kiln can print and fuse the dielectric materials commercially available. But repeatability is an enormous problem because the dielectric constant of any of these types of dielectric varies with formulation and firing profile, which includes time and temperature. The real problem is encountered when a subtle draft in the furnace causes a minor temperature shift or a minor print thickness change occurs in printing, and the entire production run is lost. This does not mean that these materials should not be used. On the contrary, where wide tolerances can be accepted and where dimensional fit of the ceramic-glass system is compatible with the substrate, there is some economic advantage."

Monolithic Dielectrics thinks the "ideal" in miniature capacitors would employ a screenable barium titanate which has the same thermal properties as alumina, a popular substrate. Thus, there would be no problem stemming from different expansion coefficients.

Southern Electronics Corp. reports that they have been working on a screenable barium titanate with reasonable values and characteristics. They say that they're about 2 years away from formally announcing a screenable family of capacitors that will cover one-third of the market.

Gould Ionics, Inc. promises to offer an exciting new approach with their recently developed Energy Storage Device (ESD), a capacitor-like component made with electrochemical powders pressed into wafers that yield 50 F/in^3 (that's right, we said farads) with 97% charge retention after 9-month storage. The first prototype ESDs, are available in cylindrical cans; the 1-in-diam by 7/16-in-high ESD, for example, has a value of 50F, with a maximum working voltage specified at 0.5V. Gould reports that they have recently attempted to produce a screened ESD of considerably lower capacitance. One result was a screened surface of 25 mils^2 that had a capacitance of 100 μF.

Why Chip Resistors?

With screenable inks available, one wonders about

(Continued)

the demand for chip resistors. Monolithic Dielectrics reports a heavy demand for their chip resistors. They state that in a typical hybrid circuit, 80-90% of the resistors are screenable inks and the remaining 10-20% are chips. This occurs, they explained, because inked resistance values may require different firing temperatures, and, rather than subject the hybrid circuit to costly multiple firings, the customer chooses to use resistor chips. The customer does not find mounting resistor chips a demanding added task because he usually goes through a chip mounting operation with capacitors. To this advantage, Varadyne adds the following: chip resistors lend themselves to direct breadboarding and they can be removed and replaced easily. Southern Electronics Corp. foresees that there will be a continuing need for chip resistors wherever higher power and better reliability are needed.

As a user of chip resistors, Tecnetics buys them in the range from 100 to 300Ω and from 100 kΩ up. In between, it uses paste and screening techniques.

Chip resistors are most useful in microwave applications where rescreening is not recommended. They are already toleranced, more stable (thin film) and eliminate the need for many screenings to get different resistance ranges. Chip resistors usually are glass passivated for protection and can be used for crossovers. They also are used when the precision of thin films is required. Screening, however, is cheaper. Thick-film resistors make up the line at Mini-Systems, Inc., where 50 MΩ are achieved on a 35- by 35-mil chip. The line (**Fig. 10**) ranges from 1Ω to 10,000 MΩ with TCs as low as ±25 PPM.

Sprague offers screen and fired thick-film resistor chips either singly or in networks with a range from 10Ω to 5 MΩ.

Film Microelectronics has thin-film chip resistors from 10 to 100,000Ω with TC as low as ±25 PPM/°C and power handling capability from 50 to 150 mW.

For microwave circuits, Film Microelectronics has just announced a thin-film chip line from 1 to 10Ω with TC of ±100 PPM/°C from −55 to 150°C and with the same power rating as above.

Motorola's beam-lead resistors range from 5 to 10Ω with TC of 50 PPM/°C and dissipation of 125 mW. They are designed for operation up to and including microwave frequencies.

With a power dissipation rating of 250 mW, Dickson's line of thin-film resistor chips ranges from 33 to 470 kΩ with tolerances of ±10, ±5 and ±1%. These units can be operated at full power up to 175°C.

The Interface Problem

One of the almost universal complaints among chip suppliers is the users' preoccupation with visual criteria. Most users are very finicky about how chips *look*, and they tend to reject some chips that are electrically sound for "cosmetic" reasons. Chip suppliers go to considerable pains to establish realistic visual criteria.

From the user's standpoint perhaps the most frequent complaint is the inability to characterize a device at the chip stage and be sure of its operation over the temperature extremes required of the final package. Because of this inability to characterize a device completely before putting it into a circuit, users contend with some uncertainty as to whether or not the final circuit will work. And rework is expensive.

Conversely, suppliers find that selling chips is a rough business because users expect chips to behave like packaged devices. When users have trouble, the supplier is called in and asked to account for the differences. Essentially, selling packaged devices is clean because the supplier knows what he is shipping and the user can verify the product at incoming inspection.

A communication problem exists between supplier and customer concerning diode chips. Customers often order chips by 1N-number, not realizing that many

PARAMETER	K1200 W CHARACTERISTIC	K 30 NPO CHARACTERISTIC
SIZE	Small - equivalent to tantalum in lower capacitance ranges	Large - larger than K1200 but smaller than mica or glass
CAPACITANCE	To 1.5 μF	To 0.027 μF
TOLERANCE AVAILABLE	5%, 10%, 20%	1%, 2%, 3%, 5%, 10%, 20%
COST	Low, increasing with increasing capacitance	Equivalent to a K1200 capacitor with 40 times the capacitance
DISSIPATION FACTOR	Decreases with increasing temperature	Negligible
INSULATION RESISTANCE	Decreases with increasing temperature	Decreases with increasing temperature
CAPACITANCE CHANGE WITH TEMPERATURE	Non-linear ± 10% from −55°C to 125°C	Linear 10 ppm/°C
CURIE POINT	115°C	Outside the range of interest
AGING	1% - 2% per hour decade	None
DC VOLTAGE	−15% capacitance change at rated voltage	No change
AC VOLTAGE	Capacitance increases at normal stress levels	No change
FREQUENCY	Electrical parameters begin to degrade at 1 MHz	Electrical parameters begin to degrade at 100 MHz

Table 1—K **Comparison of two popular ceramic** dielectrics highlights parameter differences. Although the K-1200 material has a higher capacitance-volumetric ratio, K30 material is much more stable. (*USCC*).

diode chips are not physically compatible with hybrid techniques. For example, few customers can handle unprotected silicon mesas adequately.

Diode chips usually take a planar form, and have a gold bottom (cathode), a passivated junction (SiO_2), and an aluminum anode contact (about 5 mils in diameter) centered on top of the chip. This form is ideally suited to hybrid techniques but presents a problem for anyone wishing to probe test. The problem arises because, prior to die bonding, the gold back makes a relatively poor ohmic contact to the test fixture. This resistance tends to degrade the forward characteristics seriously, as can readily be appreciated. The forward characteristic snaps into place as soon as the die is bonded. Probe testing of diodes either at the wafer or chip level before die bonding should be limited to testing reverse characteristics only. A satisfactory alternative is to sample each slice by bonding some dice to TO-18 headers and testing their forward characteristics.

What Do Users Say?

Bare chips are now almost the exclusive choice of users. Users queried by EDN consider LIDs (leadless invert devices) as an expensive interim measure until beam leads become generally available. Also, without exception, users wish to change over to beam leads, but until handling equipment, second sourcing, availability and cost for beam leads come more into line with these factors now existing for bare chips, the holdoff will continue.

While most bare chips are supplied unprotected (nitride passivated on request), beam-lead devices usually have a nitride protection. This protection step enhances the image of beam leads because unprotected chips pose contamination problems for users. Companies like Tecnetics would like to see chips protected so that they could eliminate the costly cleaning steps now needed with bare chips.

Motorola will introduce the following beam lead ICs soon: MCB 5400, 5440, 5453, 5454, 5460, 5472. Motorola sees a very strong demand for *packaged* beam-lead devices. Because of the beam lead's inherent reliability, customers want beam-lead ICs rather than chip-and-wire *inside* their flat packs. TI is introducing a beam-lead, npn, planar epitaxial, low-level, low-noise, high-gain transistor similar to the 2N2484. Motorola will have beam-lead devices similar to the 1N914, 2N918, 2N2222 Series, 2N2907 Series and 2N2484 Series by year's end. The 1N914 and 2N918 should be available by the end of the third quarter, 1970.

For attaching chips, the popular thermocompression gold ball bonding method is fading fast. According to Analog Devices, it is being used less frequently because of the requirement for the application of heat and the inability to break through oxides on the metallization. Ultrasonic gold ball bonding, a completely cold technique that will break through oxidation, is being used more and more.

We should, according to Analog Devices, see increasing use of ultrasonic aluminum wire bonding, which is quite popular in military applications because it eliminates "purple plague".

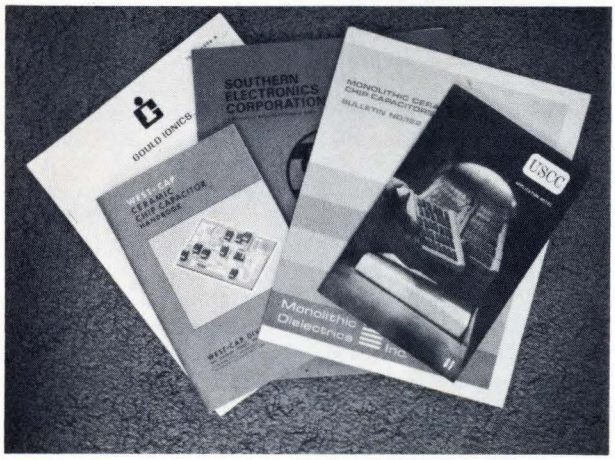


Fig. 9—**Informative literature** is supplied by most manufacturers of ceramic capacitors, USCC and San Fernando Electric Mfg. Co. are two companies that went so far as to prepare tutorial handbooks—free for the asking.

CAPACITANCE (pF)	L (MAX) (inch)	W (MAX) (inch)	T (MAX) (inch)	WEIGHT (grams)
270 TO 51k	0.185	0.060	0.060	0.06
12k TO 100k	0.185	0.080	0.085	0.12
22k TO 270k	0.310	0.085	0.090	0.2
1 μF	0.790	0.185	0.090	1.05
2 μF	0.790	0.185	0.180	2.00

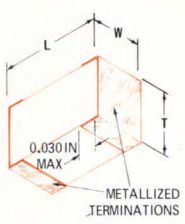


Table II—**Typical dimensions** for Glass-K chip capacitors with a range from 270 pF to 2μF. (*CORNING*).

Changes Have Been Happening

The past 2 years have brought about a number of improvements in minicomponents for substrate attachment. These include: more beam-leaded devices, more manufacturers cataloguing chips, perfection of thick-film pastes approaching thin-film levels for stable high-precision circuits, availability of higher performance and higher value capacitors, more dual transistors (bipolars, JFETs and MOSFETs), thin-film circuits now made as cheaply as thick films, price reductions, more types of chips available, higher resistance pastes with better TCs, introduction of ruthenium inks for low TCR, and inductor and transformer improvements.

(Continued)

Minicomponents (Cont'd)

What's Needed Now?

Among users of minicomponents there exist today some special needs. These needs include passivated transistor chips with the combined parameters of V_{ceo} to 150V, I_C of 1A, V_{sat} of 0.4V, 1-MHz operation and 0.5 μs rise and fall times (Tecnetics); precision transformers; precision (1%) capacitors; small but high value capacitors; power chips (SCRs and triacs); UJTs and temperature compensated precision zeners, (Film Microelectronics); miniature inductors (Sprague); matched monolithic FETs and 1 mV offset and 10 pA input current; a wider variety of dual transistors at moderate prices; cheap beam-lead devices (NOVA Devices); larger value inductors with higher Qs and rigid leads; higher power resistors (1-2W derated); larger value, smaller size capacitors (Raytheon Missile Systems Div.); tantalum slugs with end connections; higher value capacitors with smaller size (Teledyne Philbrick/Nexus); wider range of beam-lead devices; passivated chips to eliminate hermetic packages; small inductors with high Qs and moderate inductances at high frequencies; miniature inductors (RCA Aerospace Systems Div.); and more beam-lead devices (Sylvania).

For The Future

The future can't appear anything but bright for the user of minicomponents in hybrid circuit design. Here are some of the things that can be expected in the next 2 years: more availability of beam leads and bare chip circuits; more minicomponents; more influx of hybrids into the entertainment field; more complex MSI circuits available; nitride passivation for both ICs and discrete semiconductor chips; greater number of standard values of R, C and SCs; high value capacitors; a proliferation of beam-lead manufacturers and suppliers; more miniature inductors and chip inductors; ultrasonic bonding using all aluminum or all gold systems; laser trimming as becoming standard; printed Rs on top of capacitors; component cost of R and C inks causing a drop out of chips; and as packaging and components improve, hybrid circuits will become minicomponents themselves and more devices will be furnished in microtab packages for power devices. □

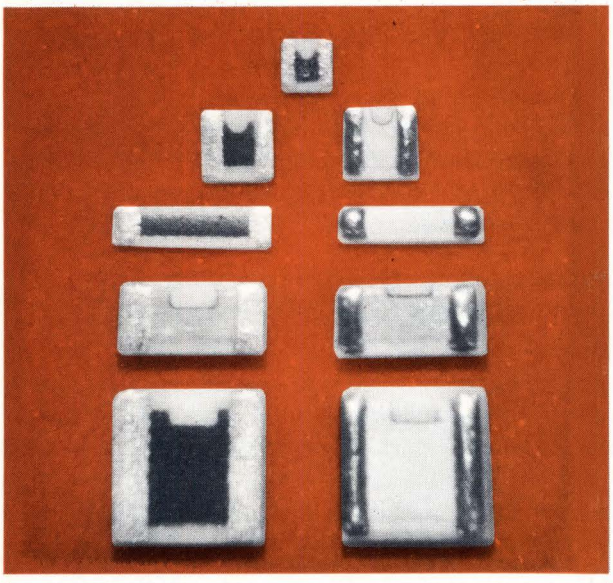


Fig. 10—**These thick-film resistor** chips range from 35 mils on a side (capable of dissipating 35 mW with a range to 50 MΩ) to a size capable of handling 500 mW with a range to 10 MΩ. Chips not shown can handle up to 3W. (*MINI-SYSTEMS*).

ACKNOWLEDGEMENTS

EDN greatly appreciates the help given by many individuals and their companies. To them go our thanks for providing information that made this feature story possible.

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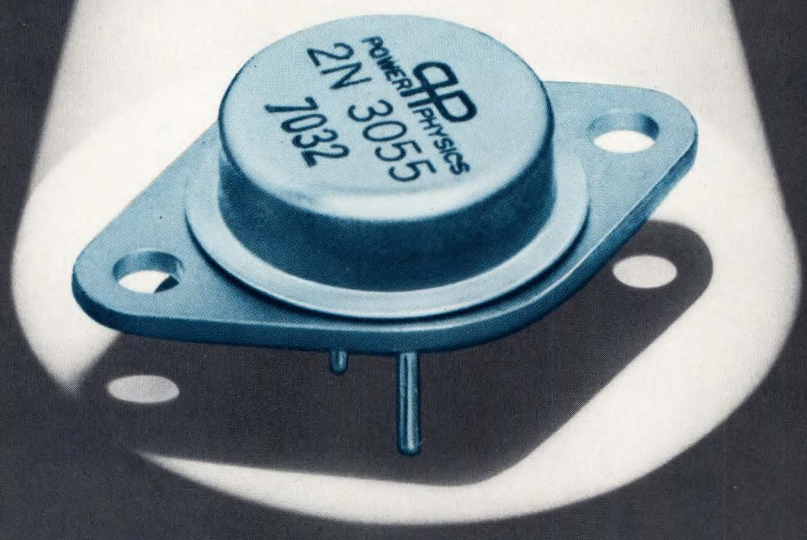

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CIRCLE NO. 23

CONSTANT CURRENT SOURCES GAIN NEW CAPABILITIES

While constant voltage source development has grabbed the spotlight, constant current sources have quietly acquired a new set of capabilities. Here's the design approach that makes them highly practical for many new applications.

WILLIS C. PIERCE, JR., Hewlett-Packard Co.

An ideal current source would be a current generator that has infinite internal impedance. It provides any voltage necessary to deliver a constant current to a load, regardless of the size of the load impedance. It will supply this same current to a short circuit, and in the case of an open circuit it will attempt to supply an infinite voltage (**Fig. 1**).

In practical current sources, neither infinite internal impedance nor infinite output voltages are possible. In fact, if the current source is to be used as a test instrument, it should have a control for limiting its maximum output voltage so its load will be protected against the application of excessive potentials. Its output impedance should be as high as possible, of

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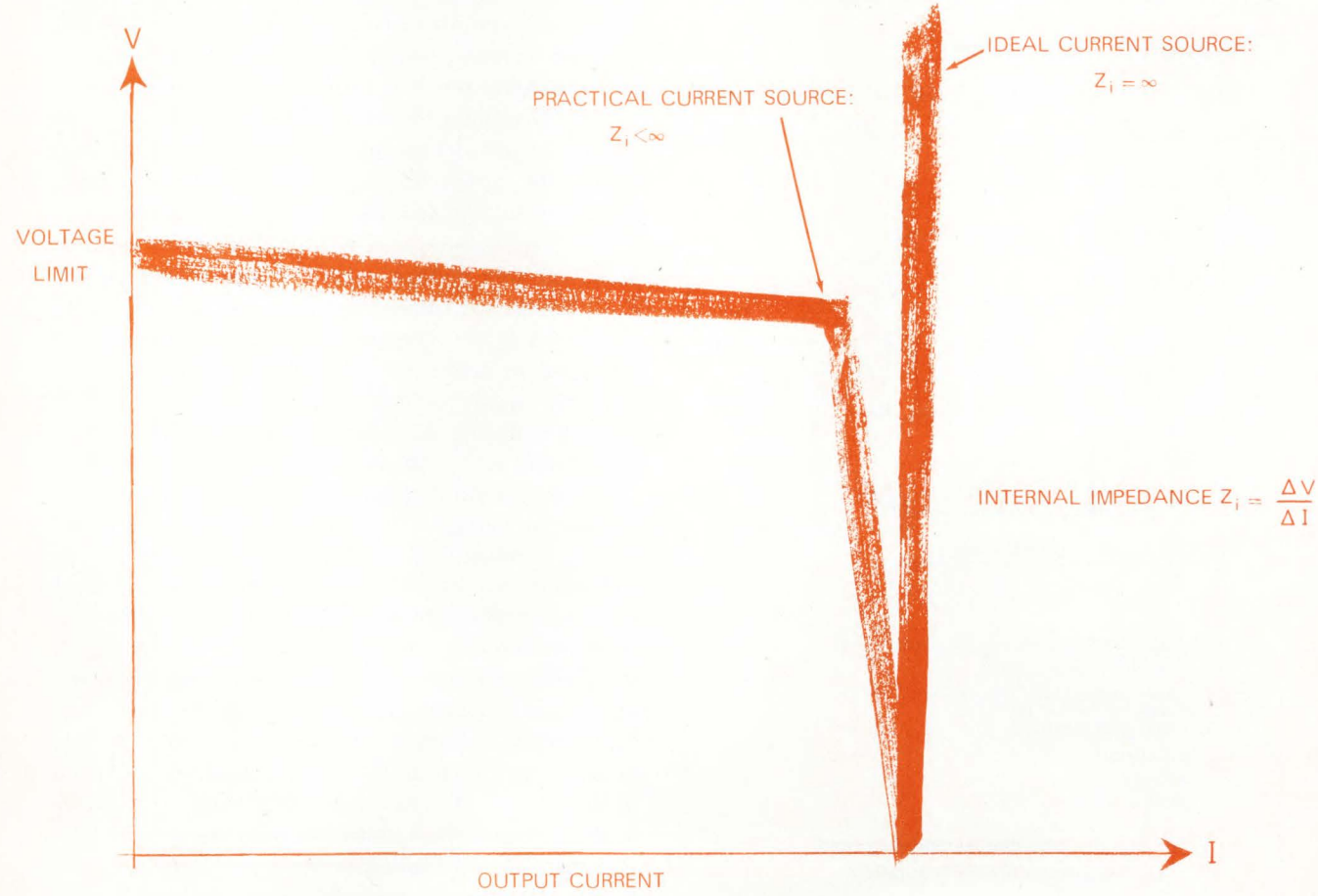

Fig. 1 – **Ideal current source**

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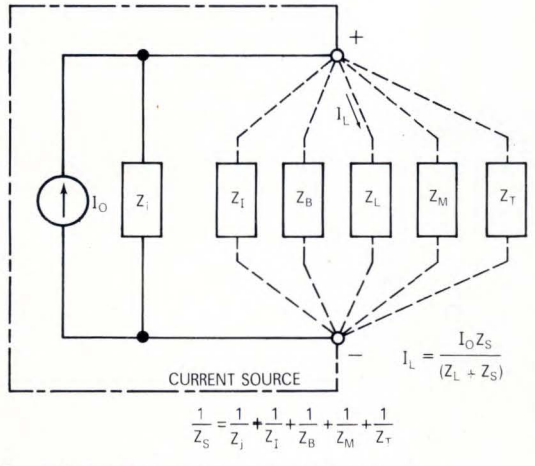
course, and should remain high with increasing frequency to limit current transients in rapidly changing loads. A capacitor across the output terminals should be avoided, since it will lower the output impedance, store energy which can result in undesirable current transients and decrease the programming speed.

One approach to the design of a current source is to add a high series resistance to an ordinary voltage source. However, it is difficult to achieve good current regulation with this design approach. Typical applications for current sources call for output impedances of a few megohms to a few hundred megohms and currents of tens or hundreds of milliamperes. This means the source voltage would have to be tens of kilovolts or more. Such a high-voltage supply will cause noise problems, will be difficult to modulate or to program rapidly, will be dangerous, very large, and will waste considerable power.

Electronic current regulation is a much more tractable way to obtain high output impedance, although there are still design problems such as leakage.

Leakage vs. Regulation

The current regulation of a current source, as seen at the load, is degraded by any impedance in parallel with the load. If I_0 is the current generated by the source, I_L is load current, Z_L is load impedance, and Z_S is the total impedance shunting Z_L, then $I_L = (I_0 Z_S)/(Z_L + Z_S)$.



Z_I = OUTPUT (INTERNAL) IMPEDANCE OF CURRENT SOURCE.
$Z_I = \infty$ FOR IDEAL CURRENT SOURCE.
Z_I = INSULATION IMPEDANCE ANYWHERE INSIDE OUTPUT TERMINAL OF CURRENT SOURCE.
Z_B = CIRCUIT BOARD IMPEDANCE.
Z_L = LOAD IMPEDANCE.
Z_M = METER IMPEDANCE.
Z_T = TEST LEAD INSULATION IMPEDANCE.

Fig. 2 — **Impedances shunting load** degrade current regulation

When the output impedance of the current source is high, then even very small leakage currents can become significant (**Fig. 2**). Such things as the input impedance of a voltmeter measuring the load voltage, the insulation resistances of wiring and terminal blocks and the surface leakage currents between conductors on printed circuit boards will all take current away from the load unless special design precautions are used.

CCB Current Sources

In the Hewlett-Packard CCB current sources, leakage at the output terminals is negligible, owing to a combination of techniques, including guarding, shielding, and physical isolation. Feedback regulation makes the output impedance high (3.3 to 10,000 MΩ), and there is no output capacitor to lower the output impedance or store energy. Low leakage and high output impedance result in precise current regulation.

The CCB design shown in **Fig. 3** includes three key sections which determine its unique regulating properties — the programming/guard amplifier, the main current regulator and the voltage limit circuit.

The programming/guard amplifier is an independent, variable voltage source, whose output voltage E_G is linearly dependent upon the setting of R_Q, being equal to $E_S R_Q / R_S$. The guard aspects of this circuit are discussed in detail later; it is sufficient to note here that this circuit permits linear output current control while facilitating the common point connection (C) at the inboard side of the current monitoring resistor.

The programming/guard amplifier provides the programming voltage E_G for the main current regulator. This dc voltage, which is negative with respect to circuit common, is applied to one of the inputs of the differential current comparison amplifier. The other input of this differential amplifier is connected to the current monitoring resistor R_M. The current comparison amplifier continuously compares the voltage drop across the current monitoring resistor ($I_O R_M$) with the programming voltage (E_G). If these voltages are momentarily unequal due to a load disturbance or a change in the output current control setting, this error voltage is amplified and applied to the series regulator transistors, altering the current conducted through them

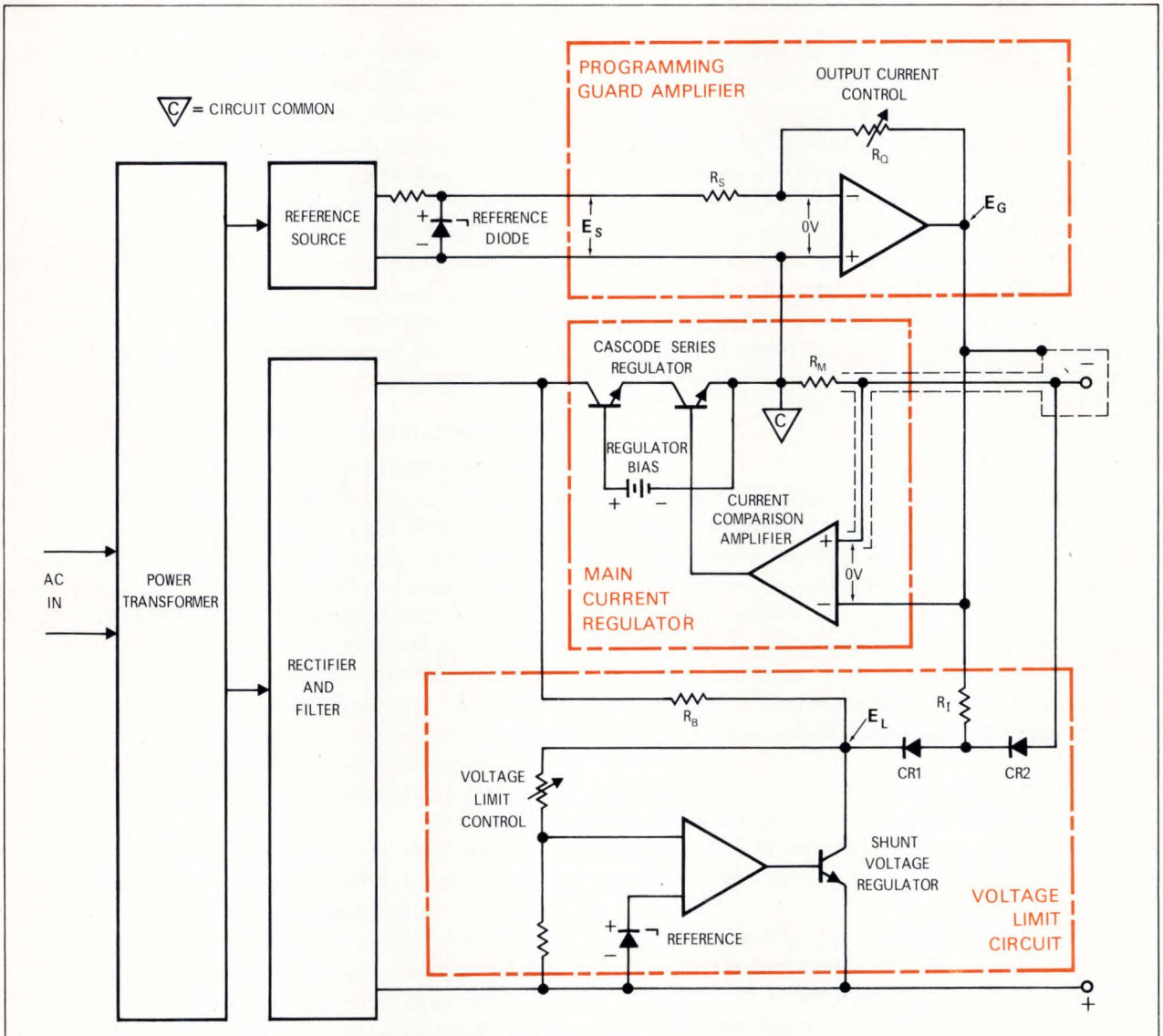


Fig. 3 – **Block diagram** of CCB current source

and forcing the voltage drop $I_O R_M$ once again to equal E_G.

The output current is related to the programming voltage and reference voltage by the relationship

$$I_O = E_G/R_M = (E_S/R_M \cdot R_Q/R_S).$$

As this equation suggests, R_M is a critical component and is selected to have low noise, low temperature coefficient, and low inductance. Its ohmic value is large enough to give an adequate current monitoring voltage, yet small enough to minimize its temperature rise and the resulting resistance change caused by its own power dissipation.

Programming/Guard Amplifier

Returning to the guard duties of the programming/guard amplifier, the output of this amplifier (E_G) is connected to a guard conductor which surrounds the positive output terminal, the current sampling resistor, and the (+) input to the current comparison amplifier. Since E_G is held at the same potential as the positive output terminal by the main current regulator, no leakage current flows from the positive output terminal or any of the internal circuit elements connected to it. The leakage currents that would normally flow from the positive output circuitry flow instead from the

(Continued)

guard conductor, whose current is supplied by the programming/guard amplifier. Notice that since the programming/guard amplifier is a low impedance source referenced to (C), any leakage current fed by the guard originates from circuit common via this amplifier, bypassing R_M. Only the output current flows through R_M. In this way leakage current flowing directly between the supply's two output terminals is eliminated, and precise load regulation is obtained.

The programming/guard amplifier output may also be used as a convenient point to connect indicating meters, since the current to drive these meters will not affect the regulated output current, I_O.

Voltage Limiting

A voltage-limit circuit should eliminate dangerous high-voltage or high-current transients that might occur under certain load conditions. For example, when the load is suddenly removed from an ordinary constant-current power supply, the output voltage attempts to rise to the raw supply voltage of the instrument, which can be hundreds of volts. Or, when the load is suddenly reconnected to a supply operating with its series regulator saturated, a high-current transient can occur.

The voltage limit circuit in CCB current sources virtually eliminates voltage or current overshoot and undershoots when going in and out of voltage limit, without adding any significant leakage path across the output terminals.

Normally, when voltage limiting action is not occurring, the setting of the voltage limit control establishes across the shunt voltage regulator a preset voltage limit E_L which is higher than the positive output voltage and its twin, the guard voltage E_G. Since there is zero voltage across the series combination of isolation diode CR2 and resistor R_I (5 kΩ or less), no current flows through them, and the potential E_G is also present at their junction, thus back-biasing isolation diode CR1. Any small leakage through back-biased diode CR1 flows through R_I and the output of the programming/guard amplifier, but does not flow into CR2 or the positive output terminal. The shunt voltage regulator allows a "standby" current through shunt regulator bias resistor R_B; this current insures that the shunt voltage regulator is operating in its linear region, ready to react quickly when voltage limiting action is required, thus preventing crossover transients.

If the output voltage exceeds the preset voltage limit value, CR1 and CR2 conduct, and the shunt voltage regulator passes a portion of the current which otherwise would flow to the load, thus clamping the output voltage to the preset limit value.

Even during voltage limiting action, E_G continues to be maintained at a value equal to the potential at the positive output terminal. Both guarding action and the normal control action of the main current regulator continue, minimizing any output transients which might tend to occur when the output transfers from voltage limiting to its normal output current mode.

High Output Impedance

The high output impedance of CCB current sources is a result of several factors, both electrical and mechanical. The series-regulator transistors are in a cascode configuration, which inherently has a high output impedance. Since the open-loop gain of the error amplifier is high, the closed-loop output impedance is greatly increased by feedback.

Output capacitors have been eliminated. Although the output impedance falls off with frequency because of the necessary gain and phase compensation in the amplifier circuits, it is much higher than it would be if a capacitor were connected across the output terminals.

The importance of low output capacitance should not be underestimated. Excessive output capacitance would cause the output impedance of the current source to fall off with increasing frequency, producing undesirable transients in rapidly changing loads. Large capacitors store large amounts of energy which, if discharged suddenly through the load, may cause damage. Negative-resistance devices are particularly susceptible to this kind of damage. Finally, an output capacitor would slow down the response of the current source to changes in the external programming signal.

In the interest of keeping the output impedance high, the impedances of internal leakage paths have been made as high as possible by careful mechanical design and hygienic construction techniques. Leakage, both internal and external, is further reduced by guarding the positive output terminal.

In addition to eliminating leakage current, as described earlier, the guard can also be used to measure the output voltage without drawing current away from the load. Connecting a voltmeter between the negative output terminal and the positive output terminal will

lower the output impedance, but a voltmeter connected between the negative output terminal and the guard has no effect on the output impedance. The meter still measures the output voltage because the guard is at the same potential as the positive output terminal. The front-panel voltmeter is internally connected to the guard. If greater accuracy is needed, a voltmeter can be connected externally.

Transformer Shielding Eliminates Ripple

The CCB current sources meet their low ripple specifications regardless of which output terminal, if either, is connected to ground. High-gain current regulation is one reason for the low ripple. Another is special shielding to keep ac voltages in the power transformer from being coupled into the output via the capacitance between the transformer windings and the output or ground.

One potential source of ripple current is capacitive coupling between the primary winding and the negative output terminal. In the CCB current sources, this problem is eliminated by enclosing the primary winding in an electrostatic shield which is connected to ground. A second source of ripple current is capacitive coupling between the secondary winding and ground. To keep this current from affecting the output, the secondary winding is enclosed in an electrostatic shield which is connected to the negative output terminal. This causes the ripple generated by the secondary winding to be confined to a closed loop inside the instrument.

Applications

The following examples are representative of the kinds of applications for which HP CCB current sources are well suited.

– Semiconductor testing: evaluating reverse breakdown characteristics by supplying just enough voltage to induce avalanche breakdown, but at a controlled current low enough not to cause damage: measuring forward I-V characteristics of pn junctions. CCB advantages: no output capacitor to cause current transients, guard circuit for monitoring the output with a voltmeter or X-Y recorder, programmability for automated measurements.

– Measuring dynamic or incremental impedance: dynamic impedance of zener diodes, or the small-signal h parameters of transistors. CCB sources are useful here because ac modulation can be superimposed on their dc output currents; hence one current source supplies both bias and modulation.

– Measuring resistances on a production line. Measurements can be absolute-value or comparative. The known current reduces resistance measurements to voltage measurements. CCB advantages: guard circuit for measuring output voltage without perturbing load current, precise regulation.

– Measuring small resistances where contact resistance can be as high as the unknown and can vary widely, as in probing integrated circuits to measure surface resistivity. The known current supplied by a current source is independent of contact resistance.

Other applications calling for well-regulated currents include precision electroplating; testing and sorting resistors, capacitors, relays, and meters; analytical testing; operating IMPATT diodes; and supplying accurate currents to Hall-effect devices. □

DATABANK

The author recommends the following references:

1. "Meter Circuit for Power Supply", U.S. Patent 3,401,335 granted to Joseph C. Perkinson. Describes a method for the design of a constant current power supply to permit instrumentation without loading the output.

2. "Electronic Devices and Circuits", Jacob Millman and Christos C. Halkias, McGraw-Hill Book Co., 1967, Section 12-11 'The Cascode Transistor Configurations'. A brief analysis of the cascode transistor circuit used in the CCB series regulator.

3. "Pulse Digital and Switching Waveforms", Jacob Millman and Herbert Taub, McGraw-Hill Book Co., 1965, Section 1-9 'A Current Feedback Amplifier'. A brief discussion of the feedback control loop to provide constant current regulation.

4. "DC Power Supply Handbook", H-P Application Note AN90A, 1970. A comprehensive discussion of all types of dc power supplies including performance characteristics and design considerations. This handbook is available by letterhead request to Richard Gooding, Marketing Services Dept., Hewlett-Packard, 100 Locust Ave., Berkeley Heights, N J 07922.

Also, available by writing to the source listed above is a copy of "Applications of a DC Constant Current Source", Application Note 128.

Willis C. Pierce, Jr. is a Hewlett-Packard (N. J. Div.) project engineer whose duties include design and development of constant-current dc power supplies. His B.S is from California State Polytechnic and M.S.E.E. from Stevens Institute of Technology. Pierce holds one patent, with three others pending.

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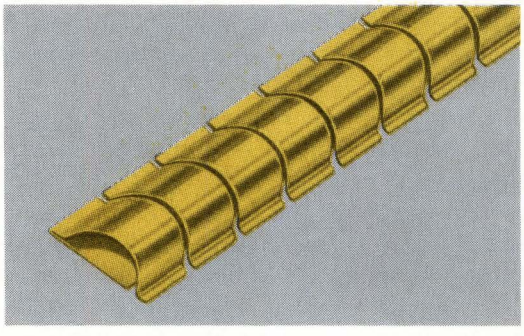

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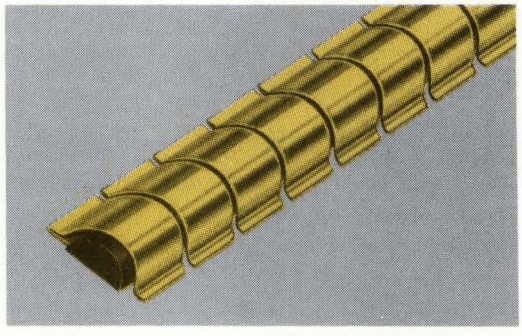

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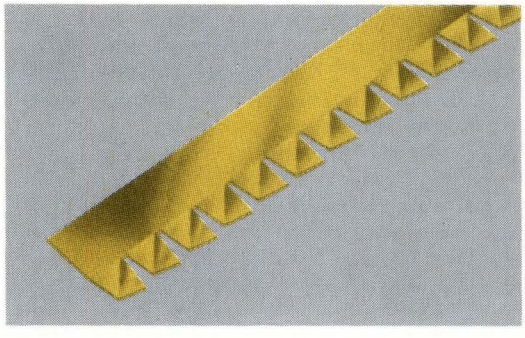

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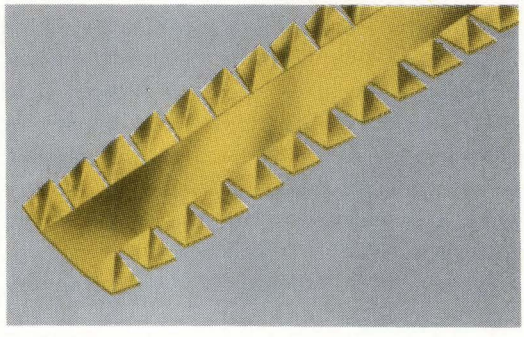

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CIRCLE NO. 21

Design T/π Networks With Compass and Straightedge

Keep a scale and a compass handy if you plan to design any T- or Pi-networks. A semicircle and a few straight lines will yield a solution.

HENRY S. KEEN, Airborne Instruments Lab, Inc.

Both T- and Pi-networks may be regarded and computed as a pair of cascaded L networks that match the two terminal impedances, Z_1 and Z_2, to some internal transfer impedance. Choice of these impedances determines the Q of the network.

A graphical solution for the T-network parameters results from the following procedure.

1. Select an appropriate scale of ohms-per-unit-length, and construct a semicircle whose diameter is longer than the sum of the terminal impedances drawn to scale. The larger the diameter, the higher the Q of the network.

2. Starting from opposite ends of the diameter, mark off segments proportional to the terminal impedances Z_1 and Z_2. At these points, erect perpendiculars intersecting the semicircle at points A and B, respectively.

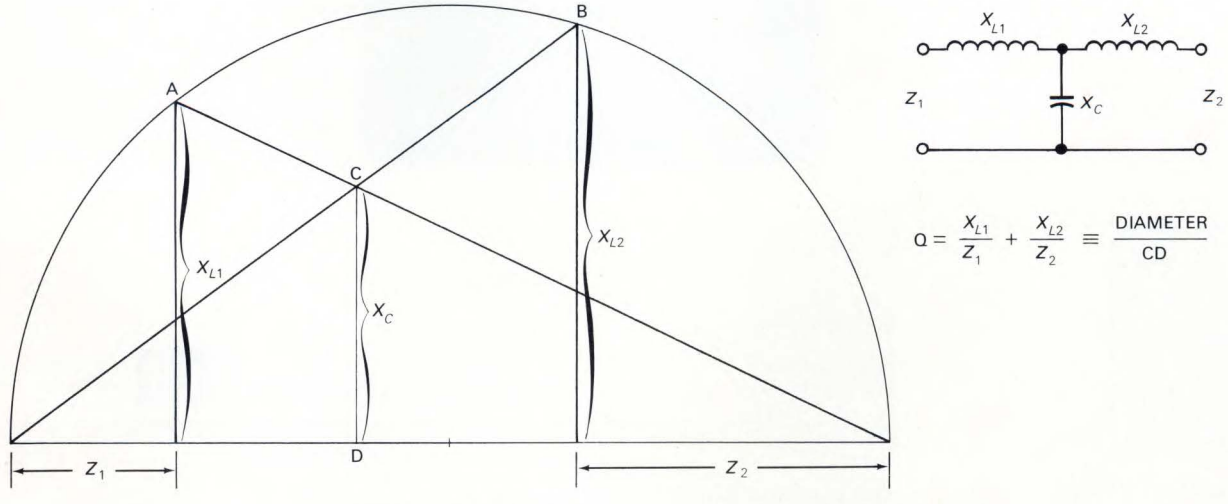
3. Connect points A and B to the opposite ends of the diameter, intersecting each other at point C. From point C, drop a perpendicular line, CD, to the diameter.

4. The perpendicular CD is proportional to the reactance X_C of the shunt capacitor. The perpendicular erected at Z_1 is proportional to the reactance X_{L1} of $L1$, and the perpendicular at Z_2 is in turn proportional to the reactance X_{L2} of $L2$. Q of the network is proportional to the diameter divided by line CD. Network Q is equal to the sum of the Qs of the two L networks that make up the T.

Pi-networks are probably of more general interest. All that is necessary to solve Pi-networks is to convert all terms to admittances and apply them to the same diagram. Z_1 is replaced by Y_1, X_{L1} by B_{C1}, X_C by B_L, etc. This maneuver is automatic because of the dual nature of the two networks.

If the diameter is chosen equal to the sum of the terminal impedances, the magnitude of all reactances will be identical, and what amounts to a 1/4 wavelength matching transformer results. If lumped constants are used, their magnitudes are the geometrical mean of the terminal impedances. □

Henry Keen, an engineer for 20 years at Airborne Instruments Lab., A Div. of Cutler-Hammer Inc., does microwave design. He graduated as an E.E. from Polytechnic Institute of Brooklyn in 1931 and has been a radio amateur since 1925.



T NETWORK SOLUTION

$$Q = \frac{X_{L1}}{Z_1} + \frac{X_{L2}}{Z_2} \equiv \frac{\text{DIAMETER}}{\text{CD}}$$

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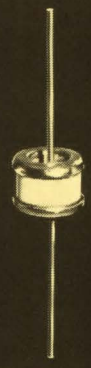

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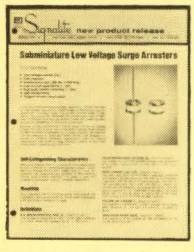

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Inductive MODEM Transmits Via Receiver

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Prior to the Carterfone decision (See EDN, July 15, 1969, p. 28) handed down by the Federal Communications Commision in June 1968, it was considered "illegal" to make electrical connections to the telephone company's equipment. As a result, a number of "wireless" MODEMs appeared on the market, but they all took the conventional approach of coupling acoustical energy into the carbon-granule transmitter of the handset.

Engineers at Tally Corp., Seattle, Wash., decided that acoustical couplers impose severe limitations on the data-transmission-system capabilities. In addition, wide variations in transmitter quality exist between manufacturers of telephones.

To overcome these drawbacks and limitations, Tally decided to inductively couple data into the handset receiver. An electromagnetic driver inductively moves the iron diaphragm and at the same time induces current flow in the receiver coil. Approximately half the energy drives the coil while the other half drives the diaphragm. For maximum operating efficiency, it is important that the dia-

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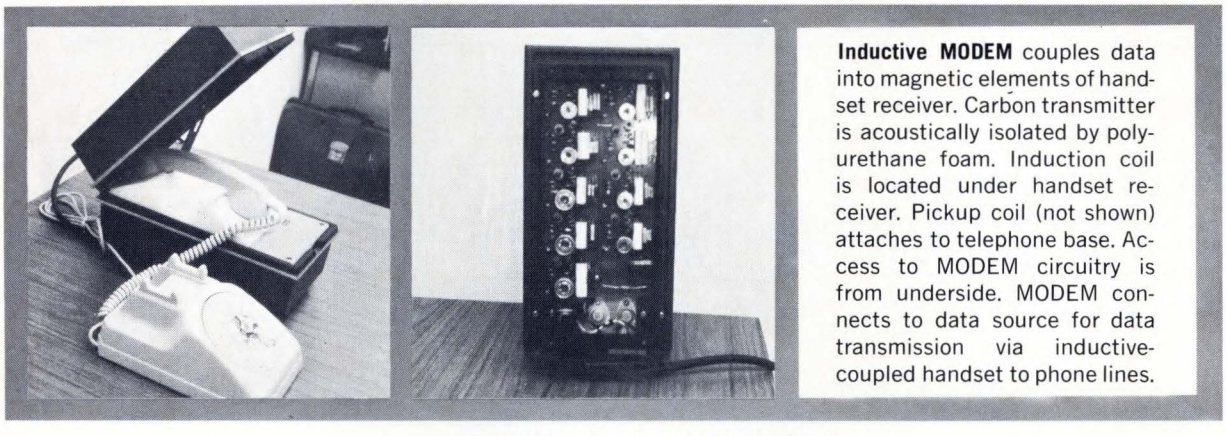
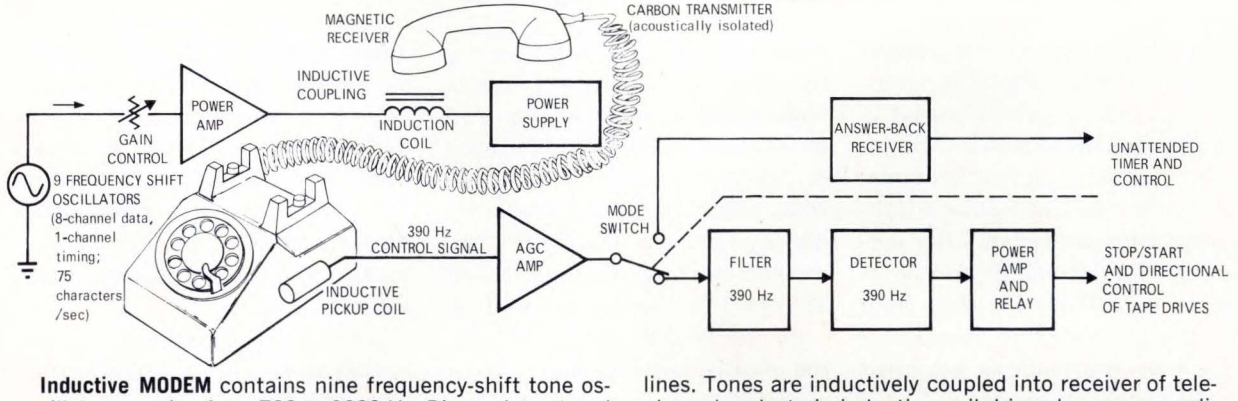


Inductive MODEM couples data into magnetic elements of handset receiver. Carbon transmitter is acoustically isolated by polyurethane foam. Induction coil is located under handset receiver. Pickup coil (not shown) attaches to telephone base. Access to MODEM circuitry is from underside. MODEM connects to data source for data transmission via inductive-coupled handset to phone lines.



Inductive MODEM contains nine frequency-shift tone oscillators ranging from 700 to 2200 Hz. Binary data stored on punched-paper or mag tape shifts frequency of respective oscillator tone for transmission over telephone lines. Tones are inductively coupled into receiver of telephone handset via induction coil driven by power amplifier. Incoming 390-Hz signal controls stop/start and direction of tape drives.

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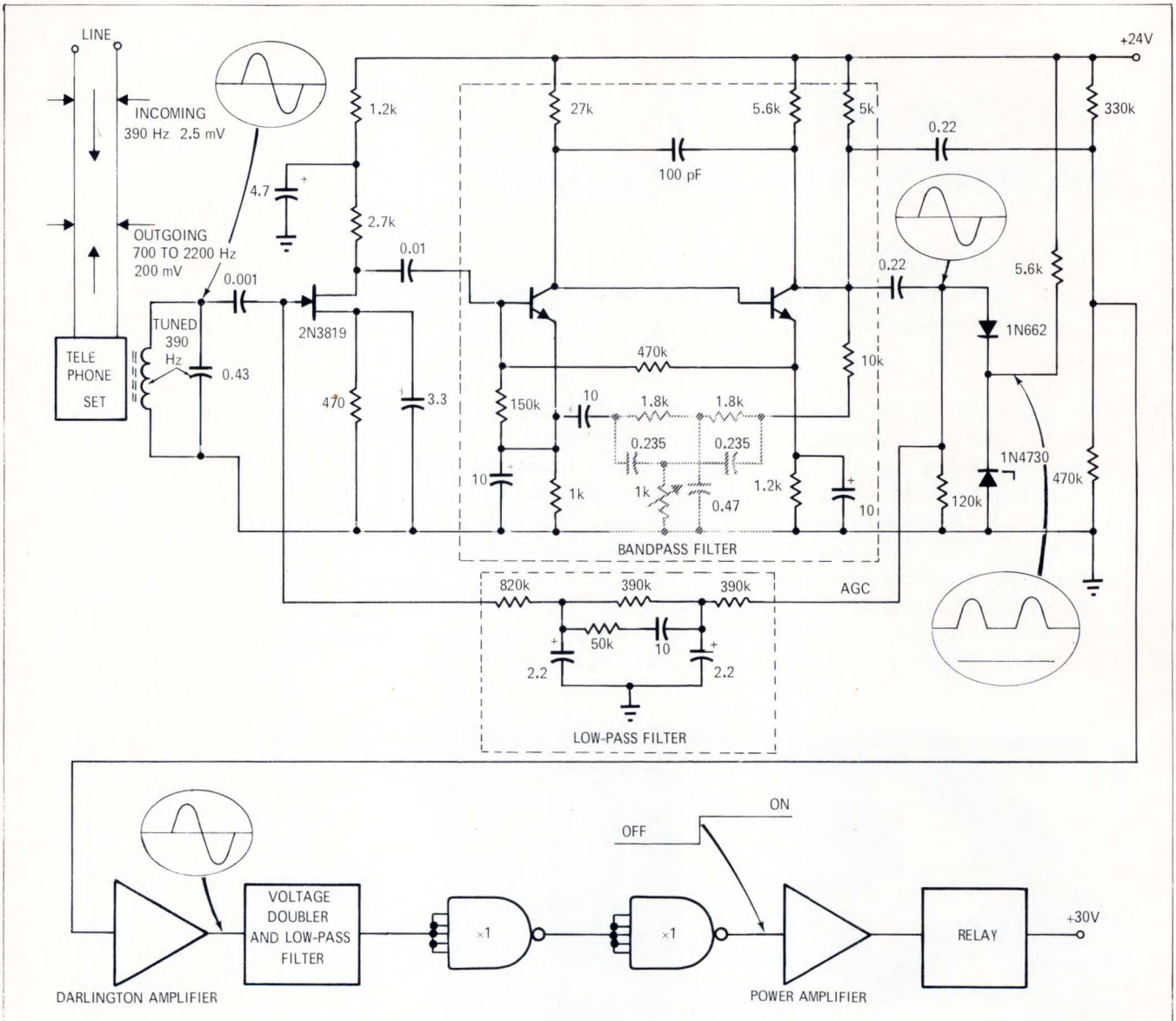


Selective Amplifier

While data is being transmitted via the inductive MODEM, an incoming 390-Hz control signal is simultaneously received. This incoming signal provides directional control to the tape-drive mechanisms thus permitting error correction. The incoming control signal is inductively coupled from the telephone circuits into a tunable iron-core inductor attached to the telephone base.

The incoming 390-Hz control signal is typically 2.5 mV on the phone lines and is buried among the many outgoing data signals having tone frequencies from 730 to 2200 Hz. Outgoing data level is typically hundreds of millivolts. Because of the single-frequency nature of the control signal, the inductive pickup is tuned and the amplifier made selective.

By means of an adjustable core, the pickup inductor and a fixed capacitor are resonated at the control-signal frequency. To preserve the Q of the tuned circuit, a high input impedance FET amplifies the signal. It then passes through a twin-T active filter. At this point an AGC voltage is developed to control the g_m of the FET. After further amplification, the signal is detected, shaped and applied to a power transistor that actuates a relay.

This selective amplifier is used in Tally's Inductive MODEM to detect and process the incoming error-correction and directional control signals.

phragm motion be induced in phase with the electrical currents generated.

Inductive coupling permits data rates in excess of 50 characters per second or 500 bauds serial. Data is not distorted, and because of the VDR (voltage dependent resistor) across the receiver coil, the energy transmitted is self-limiting by impedance limit and cannot overload the phone lines.

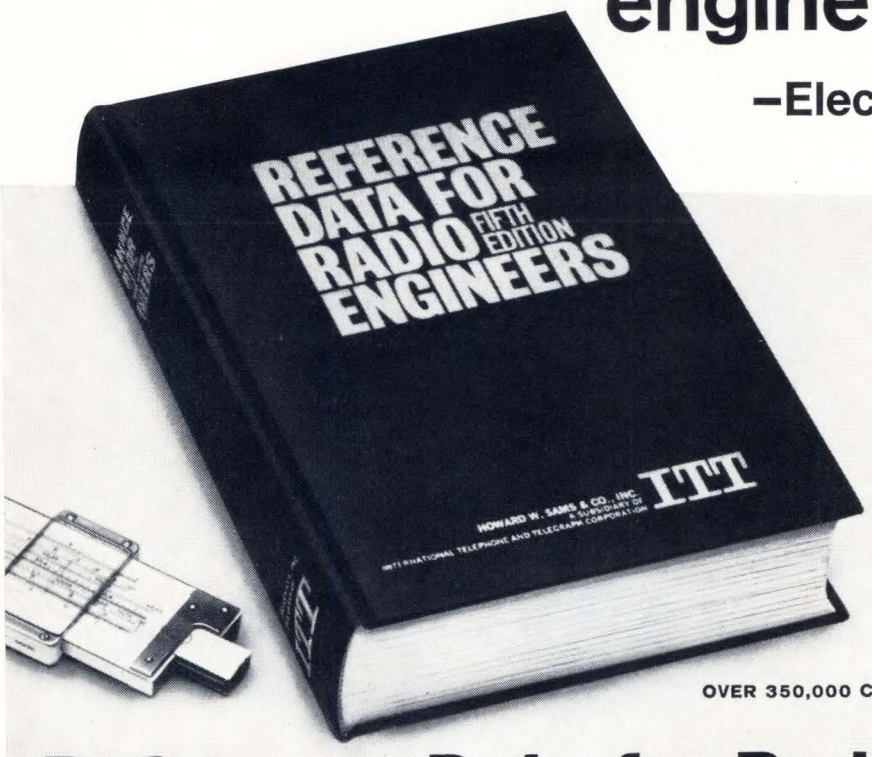
In practice, the handset is placed in the MODEM which is designed to acoustically isolate the handset transmitter and to locate the electromagnetic driver coil in proper proximity to the receiver to assure correct phasing. Data stored on mag tape, punched-paper tape or any other storage medium is then transmitted via the MODEM circuitry, coil driver and handset onto the telephone lines at a −9 dBm maximum level.

A control signal for directional control and unattended operation is simultaneously received at this MODEM station from a central DEP location. This 390-Hz signal, generated at the central station controls the data-storage and transmitting equipment at the sending end and is picked off the lines via an inductive pickup located in proximity to the telephone base. This pickup is similar to those sold for recording phone conversations. The 390-Hz control signal may be 40 dB below the transmitted data and requires a selective amplifier to separate and amplify it. (The selective amplifier is described in the boxed information). □

Dick Thomas, Manager of Advanced Design Engineering at Tally Corp., Kent, Wash., directed development of the inductive MODEM. He also holds patent on a grid-controlled thyratron.

"Bigger and better...this engineer's bible..."

–Electronics Magazine



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CIRCLE NO. 24

CUSTOMER ENGINEERING CLINIC

GHz Transistor Destroys Itself at UHF

ROBERT H. CUSHMAN, New York Regional Editor

Problem: An engineer who has been using a number of state-of-the-art 2-GHz, 5W microwave power transistors for 2-GHz amplifiers on one project thought these devices ought also to be excellent for his next assignment, a broadband 200 to 500-MHz UHF amplifier, as well. Like most microwave devices, the gain of these transistors increases at a 6-dB/-octave rate as the operating frequency drops. While their power gain was only 5 dB at 2 GHz, it was up to 17 dB by the time the frequency had been lowered to 1/2 GHz. He reasoned he could trade this increased gain at the lower frequencies for greater bandwidth by using feedback and low-Q matching networks. He felt that the smaller change of this GHz device's parameters over UHF band would aid him in achieving broadband operation.

His breadboards, however, showed him that he ran the risk of unexpected harmonic oscillations (higher than signal frequency, as well as lower, because of the high-frequency capability of the transistor). There also existed a distinct possibility of device burnout when the stage was called upon to deliver full power, even though this power was the same 5 W that he had already safely achieved with the same devices at 2 GHz!

Discussion: State-of-the-art GHz power transistors can operate at higher power levels at their specified GHz frequency than at lower frequencies because of the high-frequency phenomena that work in their favor. Among these is current-spreading or skin-effect—current flow moves out to the surface as signal frequency increases.

Hon Lee, microwave transistor applications, RCA, says that very small internal dimensions are necessary to achieve GHz operation. The transistor's base, especially, must be small. Thus, for GHz power transistors which must have very low impedances to produce the power at their relatively low operating voltages, the current densities will be very high —10^4 to 10^5 A/cm^2. With these high current densities, it is vital that all areas of the device carry their honest share of the current. The skin effect helps the transistor do this, for it spreads the current out evenly among the emitter stripes (see **A** in illustration).

When a transistor designed to take advantage of the skin effect at 2 GHz is run at 1/2 GHz, the currents in its emitter fingers will no longer be so well balanced. One of the emitters will probably start to carry more current than the others, and a hot spot will develop in a tiny area of the chip and the transistor will burn through at this point.

The current-spreading across the face of the chip should not be confused with the current concentration at the emitter-finger edges—**(B)** in the illustration—that also occurs at higher frequencies. The current concentration **(B)** is attributable to the inability of base drive current, which must

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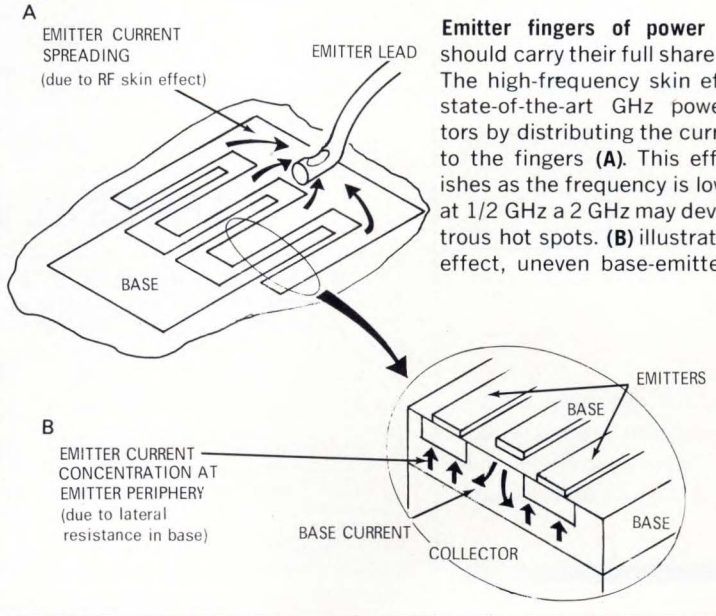


Emitter fingers of power transistors should carry their full share of current. The high-frequency skin effect helps state-of-the-art GHz power transistors by distributing the current evenly to the fingers **(A)**. This effect diminishes as the frequency is lowered, and at 1/2 GHz a 2 GHz may develop disastrous hot spots. **(B)** illustrates another effect, uneven base-emitter turn on.

Engineering Clinic

flow laterally to turn on the center of the emitters. While it is not a desired effect, it also protects the transistor at higher frequencies because it reduces the gain.

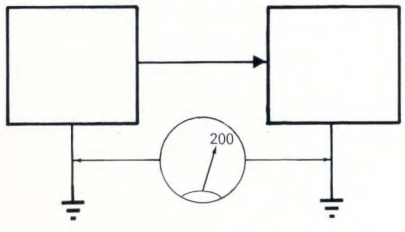
Solution: For these reasons, the designer should not have falsely assumed he was achieving a "safety margin" by using a 2-GHz transistor at 1/2 GHz. He should have used a transistor specified closer to the 1/2 GHz required. He would then have a much more rugged device and one designed to have the proper current sharing at that frequency. (Many of the UHF power transistors use built-in emitter-strip resistors to augment the lesser skin effect at these "lower" frequencies, explains Jim Benjamin, Kertron, Inc.)

He also will have a more economical design, for now he can get suitable transistors for $10 or so, compared to the $50 he might have to pay for a 2-GHz, 5 W device. □

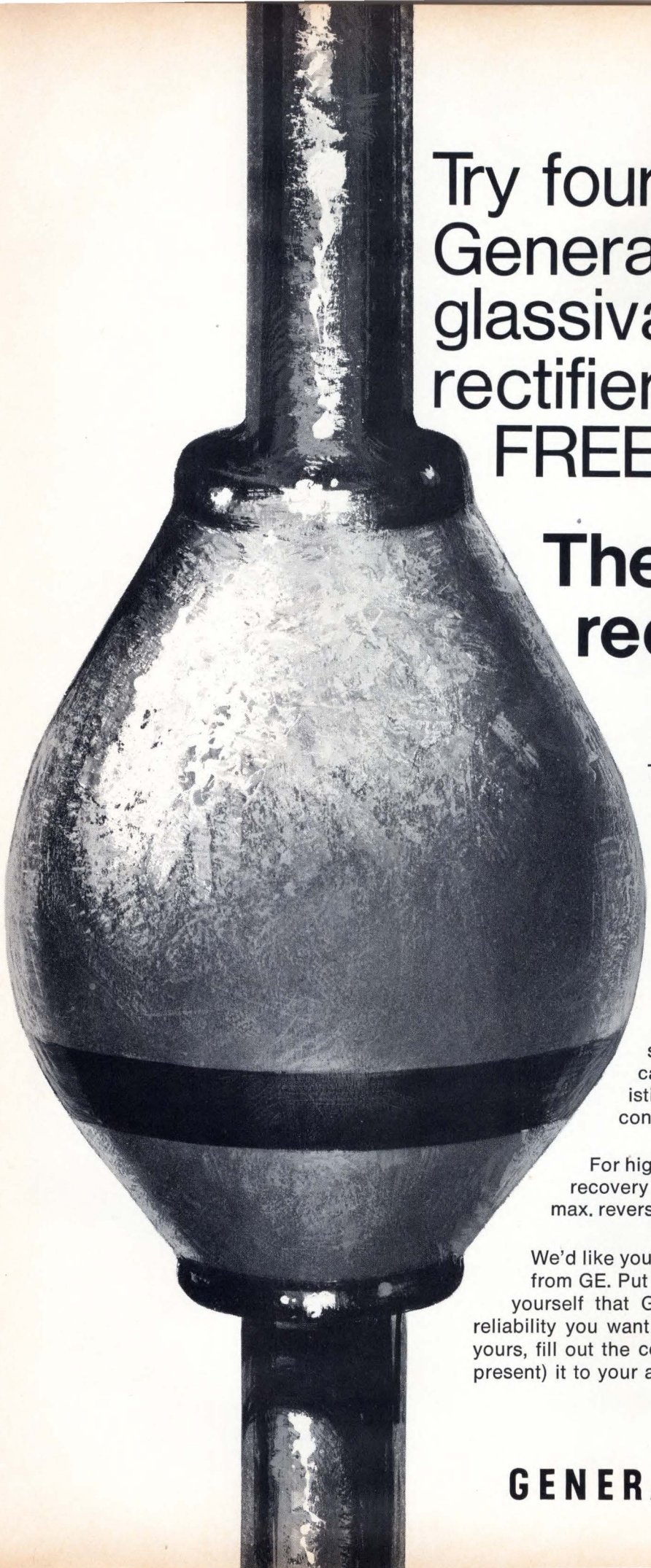
EDN will pay $50 for any problem-solution article accepted for publication.

NEXT ISSUE'S PROBLEM:

Simple Scheme Isolates System Grounds Optically



Next month's clinic describes a simple approach to obtain ground isolation up to 200V between systems and still maintain a dc-to-1-MHz bandwidth.



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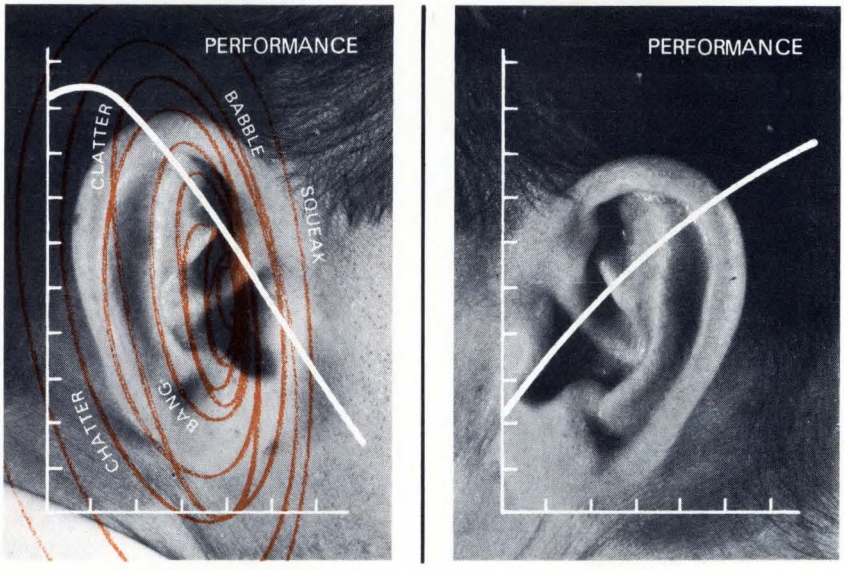


Designers/Distraction: How Much Hush?

Between "I can't hear myself think!" and the eerie sensation of absolute silence lies the ideal noise level for comfortable, efficient engineering activity. Here's how three companies wage war on the noise that can rob them of their engineers' best efforts.

A. F. Novak, Staff Writer

Today's designer doesn't have to try to concentrate in an environment of industrial-machinery roar, rock-and-roll blast, garbage-can clank or car-horn honk. But the noise pollution of his office environment may still distract him and lower his productivity, effectiveness and accuracy.

How do employers protect their design engineers (and their profits) from in-house noise? Some don't. Just because the decibel level in an engineering office is so far below that in a manufacturing plant, these employers don't consider noise to be much of a problem.

Increasingly, however, employers realize that even a typewriter's clatter or the murmur of nearby conversation can seriously handicap some designers' job performance. These employers take a wide variety of approaches to the solution of the problem. When they have the chance, engineering managers often work with facilities planners to design out noise, carefully planning physical structure and layout. Barring this opportunity, they may "blot up" noise with acoustical materials or mask it with "white noise" (a heterogeneous mixture of sound waves that extends over a wide frequency range, used as an "acoustical perfume" to blanket distracting sounds).

Noise = Unwanted Sound

"Noise" (whose word root is related to that of "nausea") means unpleasant sound or sound that carries unwanted information (communicated knowledge). But who decides which sound is unpleasant or unwanted? Almost any sound can be agony to one person and ecstasy to another—and the difference is as subjective as you can get. At the two extremes of the sound spectrum, total silence has been established as unendurable by humans, and sound intensity above 140 decibels has been established as damaging. But between the two extremes, there is a wide variation of opinion as to what constitutes "acceptable" noise levels.

Dr. James L. Flanagan, head of Bell Labs. acoustics

(Continued)

research department, reports in the *Bell Telephone Magazine*: "We've been able to control noise levels and determine how much background masking is acceptable in certain situations. But problems arise because an individual's threshold of noise tolerance can differ from day to day. This could be the result of metabolic changes, or it could be because of variations in work tasks. How and why tolerances fluctuate is something we're trying to learn about."

Bell Labs. has investigated this subjective difference in many of its noise research studies. It has, for example, tried to determine if certain noises, such as the clicks an operator hears in her headset, could be annoying or disrupting.

Because of the individual variables involved in noise measurement, no one noise standard has developed. However, scientists have devised several scales that are useful. The basic measuring unit of sound is the decibel (see boxed information). The most common weighting system is the "A" scale, or dBA, which gives greater weight to high tones and most closely matches the effect of sound on people.

Other scales that have evolved are the "B", "C", "PNdB" (perceived noise), "SIL" (Speech interference level), and the "sone" and "phon". None of these scales provides the complete answer to the question of appropriate noise level, because of the incalculable psychological factors involved. These unknowns prevent planners from determining precisely what kinds and how much noise will bother which designers when and where.

Within this range of noise sensitivity, therefore, planners must generalize and aim to please the overly-sensitive who is bothered by the sound of a typewriter, as well as the "nothing bothers me" type who is capable of mentally excluding every sound but that of his own name called three times. Within this framework,

Planners must generalize and aim to please the overly-sensitives.

they must also try to determine the noise suppression needs of the average designer, his average mood and his average project.

Care and Protection of Designer's Ears

Companies take several approaches when housing engineers. Some prefer the "bullpen" approach—an open area in which many engineers sit desk to desk. Bullpenning was the standard approach for many years. Engineers, however, tend to dislike such arrangements and noise is a major reason for this dislike.

Other companies choose the partition technique and group engineers on the same project into team cubicles. Still others build completely enclosed, separate offices for their engineers. Three engineering firms in EDN's area typify these approaches.

Martin Marietta Corp., Denver Div., recently converted its Engineering Building from bullpens to modular offices. The work area is divided into offices by wood-grained vinyl panels. Each office has floor to ceiling walls and a door that shuts out more noise and insures privacy.

Each supervisor has his own office. Nonsupervisory engineering personnel share offices—the usual practice is two to four engineers in a 10- by 15-ft room. The

The Level of Noise

The standard unit for measuring the relative loudness of sounds, the decibel, which is an expression of the sound pressure that moves the eardrums, was developed by Bell Telephone Labs., and is named after Alexander Graham Bell. The scale, which is in logarithmic form, begins at 0 dB, which is the weakest sound that can be picked up by the healthy ear.

The ear can take noise up to 140 decibels before the noise becomes painful. However, long-term exposure to decibel readings over 80 can cause hearing loss. Permanent damage and hearing loss can result even with short exposures if the sound is about 140 decibels.

On the decibel "A" scale, some common sounds have these intensities:

Private Business Office	50
Conversational Speech (3 ft)	60-70
Typewriter	65
Accounting Office	70
Average Traffic (100 ft)	70
Office Tabulating Machines	80
Alarm Clock	80
Heavy Traffic (25-50 ft)	90
Food Blender	100
Rock and Roll Band	105
Loud Power Mower	110
Construction Noise (Compressors and Hammers at 10 ft)	110
Threshold of Pain	140
Jet Plane (at take off)	150
Rocket Launching	175

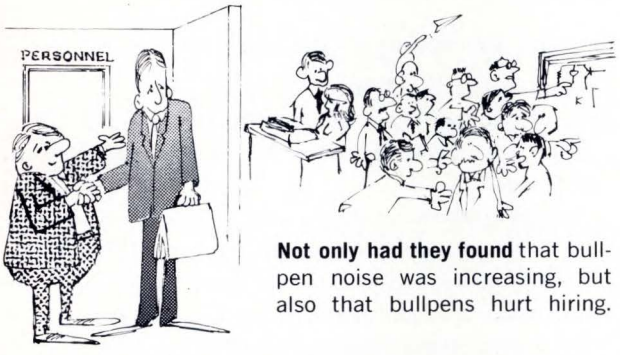
entire area is carpeted.

EDN asked Walter Martynec, Jr., Manager Engrg. Administration, and Bill Roberts, Facilities Planner, why Martin Marietta Denver converted to the modular office system.

Mr. Martynec explained that not only had they found that bullpen noise was increasing, but also that bullpens hurt hiring. During a 1968 recruiting campaign, Martin Marietta management became concerned because of the adverse reaction of engineering talent to its bullpens.

A Martin Marietta team toured other aerospace concerns and then devised a plan that incorporated the best of several ideas. The result was the modular-office concept with carpeting.

It took a "hard-sell job to re-educate some people," because many of Martin Marietta's managers were married to the bullpen concept. But, the plan was approved and the company began converting building by building. By the end of 1968, remodeling of the Engineering Building, which houses 1200 engineers, was completed. Initial appropriation for these capital improvements was $1.3 million, much of which already had been allocated for maintenance and repairs.



Not only had they found that bullpen noise was increasing, but also that bullpens hurt hiring.

During this remodeling, noise prevention was a prime consideration. For example, air-conditioning equipment was redone and flexducts were installed that provide better sound attenuation.

All the floors were completely carpeted—before the walls were put in. The walls, which use metal studs and anchor by screws to the ceiling and floor, can easily be taken down and offices reassembled in different locations and in different sizes according to project needs.

Martin Marietta decided on carpeting because it cuts noise and because it cuts cost. It is cheaper to maintain per square foot than linoleum or tile. (Carpeting is very unusual in most engineering offices. It is usually reserved as a status symbol to designate those with executive status.)

Bill Roberts, Facilities Planner, says, "We constantly rework our modularization. At first, we had too many offices and some were too small. We found, for example, that small offices were not functional for drafting requirements so we took down the walls and put a maximum of 20 draftsmen into large drafting rooms."

Martin Marietta does not use any masking sounds. They feel that such devices as background music distract engineers. As Mr. Martynec says, "When someone is working on a problem, he doesn't want any additional noise, he makes his own."

Modular offices are clustered together by projects. Secretaries are located in the foyers. The engineers do not complain much about typewriter noise. However, the large, special-purpose typewriters that make more noise must be isolated.

Technicians are spread throughout the building, mostly in labs. Martin Marietta tries to locate the labs and design engineers close together.

Mr. Roberts reports that if someone complains that his area is too noisy, "I go in and design out the problem. For example, one executive complained that his office was not completely soundproof and this was annoying when he had customers in his office. So his walls were taken down and extra insulation was added."

Martin Marietta presently must utilize some bullpens in its Space Support Building until more space is available. Each of these bullpens holds almost 100 people—and their noise.

One year after occupancy in the new office modules, Martin Marietta surveyed engineering supervisors. The survey showed overwhelming enthusiasm for the modular office areas. The aspects most appreciated were: noise reduction; privacy when desired; fewer distractions and confusion; quality of visits improved; quantity of visits decreased; bull sessions decreased; work discussions and concentration improved; morale and work quality raised.

Honeywell utilizes divided areas—cubicles where teams work together. The dividers offer seclusion and lower the noise level. Each cubicle usually holds four to six engineers, with design aides and secretaries close by.

Roland Johnson, Honeywell Manager Engrg. Services, says that these cubicles are 7 to 8 ft tall, and the upper half is covered with acoustical tile. "If engineers know they are going to be testing a device and the noise level will be high, they go to an available isolated testing room that is soundproof. There they can be as noisy as they want. Honeywell makes sure that these 'noisy' rooms are located convenient to the engineering teams so they don't have to go running around the building."

Honeywell installed background music 1 year ago because "all the industrial psychology books said that it was conducive to creative environments. However, we found that our creative types didn't like it at all.

(Continued)

They complained a lot and said that music inhibited their thinking. So we eliminated music in the engineering areas, and put the engineers back to their own noise level. Music was kept in areas where routine work is done."

Mr. Johnson reports that Honeywell does not have carpeting. "We found that tile is functional and we have no complaints about it from the engineers. We do have carpets for executives who are in the public eye.

"We have no question about the desirability of the team-area approach. Several years ago we had open bullpen engineering areas where 40,000 different engineers were working and talking about 40,000 different projects all at the same time, all in the same area. The noise level was totally unacceptable. Then Honeywell went to individual offices for each engineer. But then he had to run his legs off trying to get anything done—running around getting together with other engineers working on the same project and trying to meet in small areas. This was not functional so the team cubicles were set up. We found that the small team does not create that much more noise because you have a few engineers all talking the same language about the same project. The noise level actually is helpful—it provides participation, not conversational competition.

However, we found that our creative types didn't like it at all.

"After the pendulum had swung to both ends—from complete open space to complete closed space, we have our equilibrium with the team cubicles."

Hewlett-Packard's Colorado facilities are designed by architect Art Bush. He is presently building a new HP unit in Loveland, Colo., which will house 240 engineers working on R&D in instrumentation, calculators and computers.

Mr. Bush says that the 112- by 400-ft area will be completely open and will contain 60 small modules inside four large modules. Each engineer will have his own individual work area. His desk, lab bench and book rack will separate him from his team workers. Supervisors will have the same type of module setup.

"HP believes in as few offices as possible," explains Mr. Bush. "The engineers don't object about the noise level. They become accustomed to it and mentally block it out." He reports that HP does have an intercom system and uses background music that helps to blank out background noises.

"We will not carpet the building—again this is against corporate policy. Only critical areas, such as the data processing areas will be carpeted. The ceiling will be composed completely of acoustical material to reduce sound."

Mr. Bush says they may hang baffles as visual and acoustical dividers. These baffles will break up the area and give more scale to the four large modules.

The secretarial area is next to the managers. However, there are few secretaries and typewriter noise does not bother the engineers.

Mr. Bush points out that the open area has the advantage in that the layout is easy to shuffle around. He also explains that each cubicle will have a tack board that is acoustical. And, of course, the books and instruments add acoustical value.

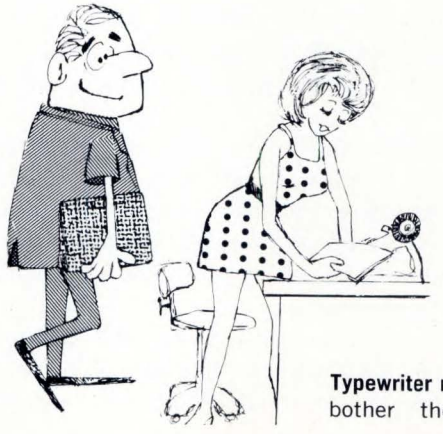
Music—Soothing or Annoying?

Does background music improve the design engineer's job performance? Again, because subjective factors are involved, there are strong opinions on either side.

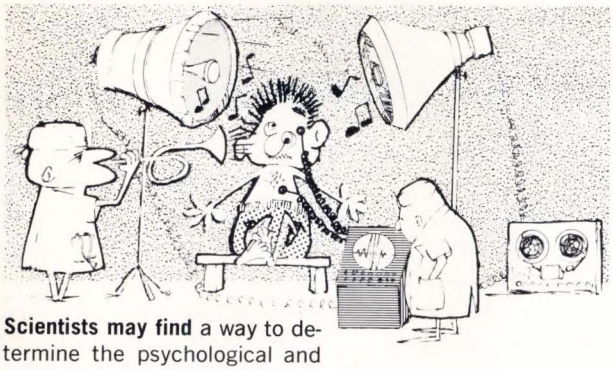
Background music seems to benefit most those employees doing repetitive and monotonous work. It also is very beneficial in work areas where the noise of the office machines or of plant equipment produces sound fatigue, and on jobs where nervous tension may occur.

David Dodge, vice president-manager of Muzak's Denver office, reports that Muzak defines its program as "work music scientifically planned to create an efficient and profitable work mood by masking undesirable noise and by creating a stimulating work environment."

Muzak's studies, however, have concentrated on the effect of music on the industrial employee performing routine tasks and in this case, it feels that music does help alleviate the debilitating effects of boredom and



Typewriter noise does not bother the engineers.



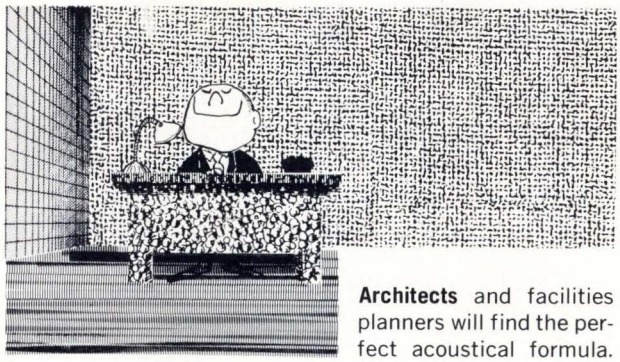
Scientists may find a way to determine the psychological and physiological effects of noise.

fatigue.

Does background music help the design engineer? The question must be answered by each designer and by each company.

Someday

Soon acoustics scientists may find a way to determine precisely the psychological and physiological effects of noise. Then companies will be able to prevent, block or muffle just the right amount of noise for each designer. Architects and facilities planners will find the perfect acoustical formula and will work with improved acoustical materials and techniques to outfit the designer's office with just the right amount of white noise, thick carpeting, acoustical tiling and fuzzy furniture (noise-absorbing, felt-covered desks already are on the market).



Architects and facilities planners will find the perfect acoustical formula.

Someday the design engineer may sit at his desk and select the noise level that suits his particular mood at a particular moment and that will enable him to work most effectively on a particular project. ▭

Connector Strain Relief Curtails Assembly Time

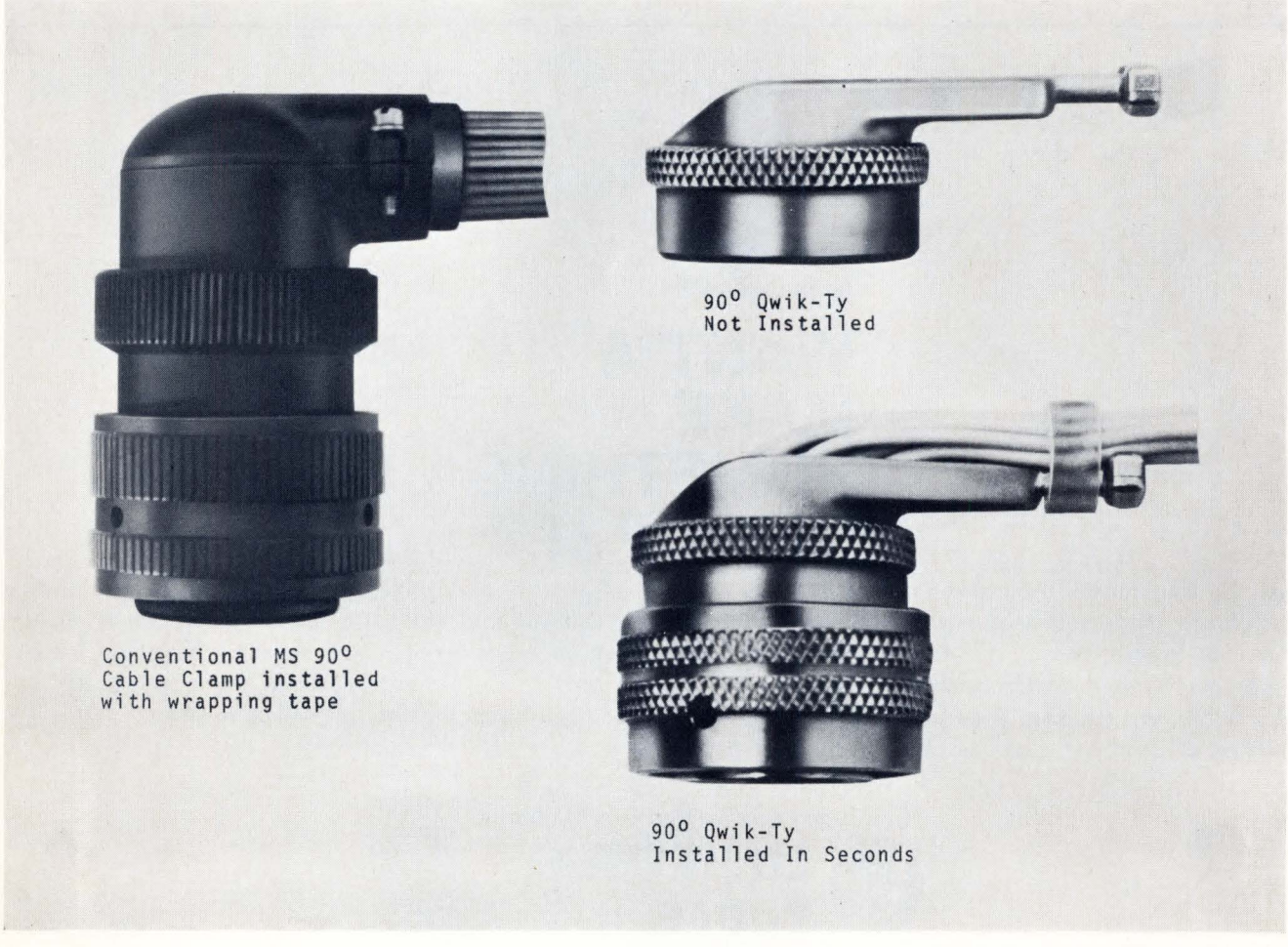
Glenair's "90° Qwik-Ty", newest member in the Qwik-Ty family of connector strain reliefs, offers a completely new approach for clamping wire bundles to an electrical connector. This simple but secure attachment eliminates the frequent need for building up the bundle diameter to a point where conventional clamp saddles become effective. With "90° Qwik-Ty", the assembly procedure is extremely simple—secure the wire bundle to the fixture with a plastic tie strap or lacing tape. This whole operation takes just a few seconds.

The "90° Qwik-Ty" is directly interchangeable with conventional clamps. It attaches to the connector exactly like the equivalent standard 90° clamp, assuring compatibility and preserving the integrity of the connector. Also, the "90° Qwik-Ty" is equipped with the same anti-rotation clocking features as the connector that it accommodates. This feature allows the user to orient and lock the "90° Qwik-Ty" in the most desirable cable-exit position. For connectors without the special antirotation clocking feature, a set-screw securely locks the "90° Qwik-Ty" in position.

Any commercial plastic tie strap or lacing tape may be used with the "90° Qwik-Ty" for the temperature range of −67 to 250°F. For temperatures exceeding 250°F, Teflon-treated Fiberglas lacing tape is recommended.

With most connectors, "90° Qwik-Ty" provides a low profile for compact installation—an important factor when space is limited. This attachment weighs 50% less than the conventional 90° clamps. In addition, there is substantial weight saving because the tape and bushings used with the standard clamps are not required.

The 100 quantity price is $2.50 to $4/attachment. Beyond the initial cost, significant cost savings accrue to the user because of reduced assembly time. For further information, technical literature is available. *Glenair, Inc., 1211 Airway, Glendale, CA 91201.* **375**

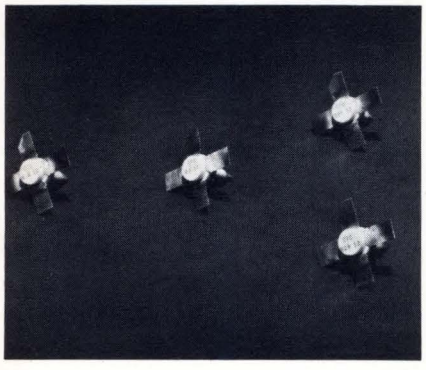


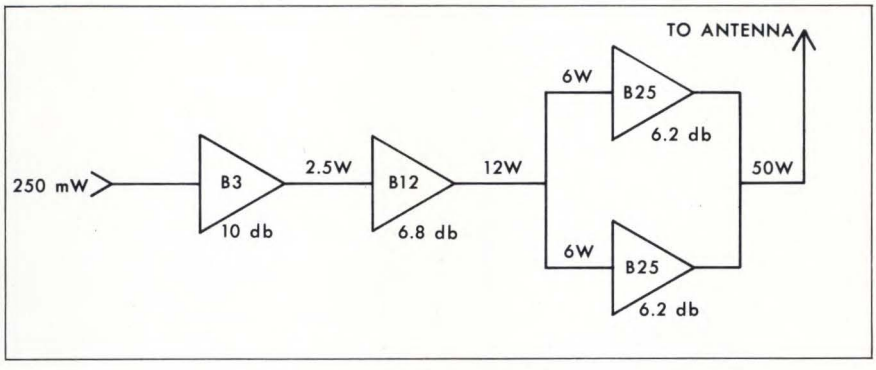
High-Gain Transistor Chains for Land Mobile Communications

As its initial product line, Communications Transistor Corp. offers three compatible 12V VHF transistors aimed primarily at the land-mobile communications market. The new semiconductor company, a Varian affiliate, designates them B3-12 (3W at 10 dB gain), B12-12 (12W at 6.8 dB gain) and B25-12 (25W at 6.2 dB gain). These monolithic devices boast the highest gain lineup in the industry. Used in an amplifier chain (see diagram), they can develop a 50W output from a 250 mW input. Also, because of rugged mechanical and electrical construction, the new entries can withstand infinite VSWR through all phase angles.

In developing their initial product line, Communications Transistor Corp. has produced a strikingly small emitter geometry; emitter width measures 0.12 mil, as does the spacing between emitter fingers. After a transistor chip is mounted to a beryllia substrate, it is bonded to the lead frame with 2-mil aluminum wire. The final package employs a very rugged ceramic-to-metal seal.

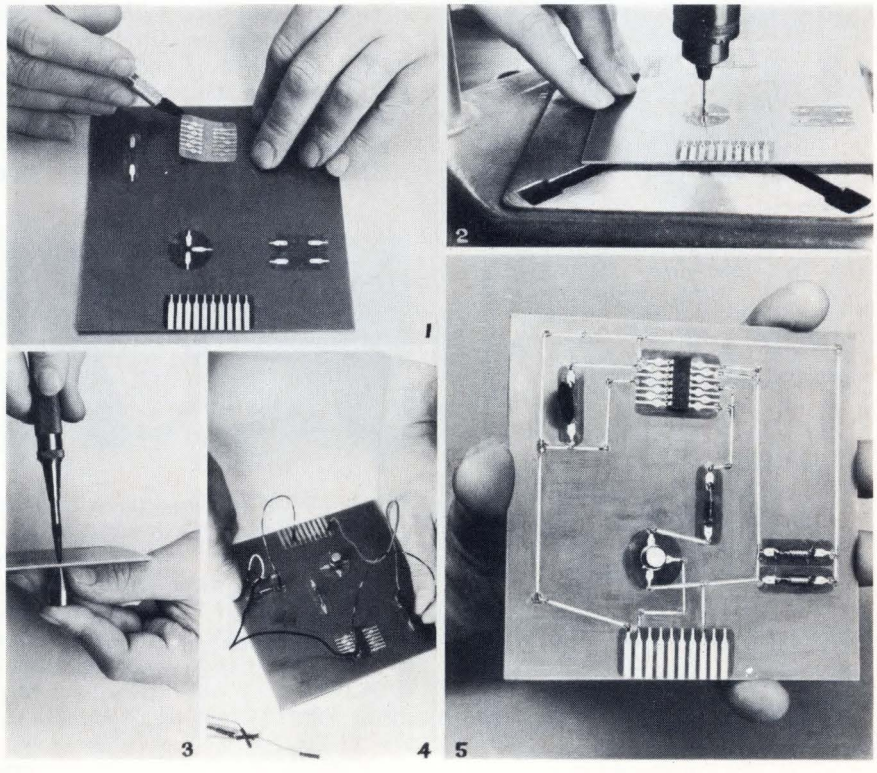
For those working at higher frequencies, a similar series of 12V UHF transistors is available. Also, to satisfy military requirements, 28V versions of both the VHF and UHF devices are available. Price for the "B" Series lineup of three VHF transistors (see photo) is $37.82 in quantities of 100 or more. Communications Transistor Corp., 301 Industrial Way, San Carlos, CA 94070. **325**



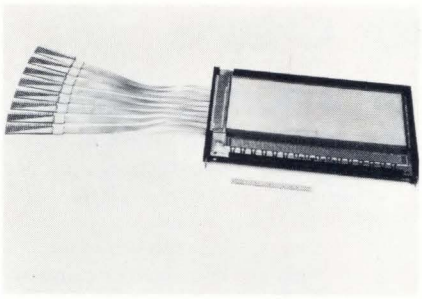


Zip Through Breadboarding with "Circuit Zaps"

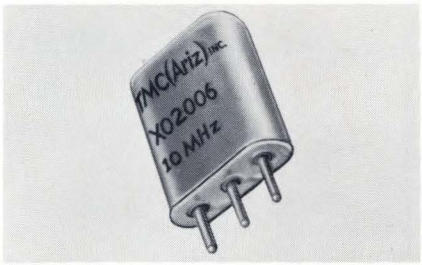
From the West Coast come stick-on copper shapes that permit quick breadboarding of prototype circuits. Called "Circuit Zaps", the conductive patterns come in a variety of shapes that can directly accommodate TO cans, DIPs and flatpacks. The variety of patterns, which satisfy MIL-P-5510B, also includes conductor paths, connector strips, resistor/diode pads and terminal strips. Backed with pressure-sensitive adhesive, each conductive pattern is precision-etched from 1 oz copper on 0.0035-in glass epoxy film. All conductor paths have standard 0.031-in widths. Assembly is straightforward (see photos). All you need to make a quick prototype circuit is a clean laminate board, sharp knife, solder station and—of course—"Circuit Zaps". Bishop Graphics, 7300 Radford Ave., North Hollywood, CA 91605. **326**



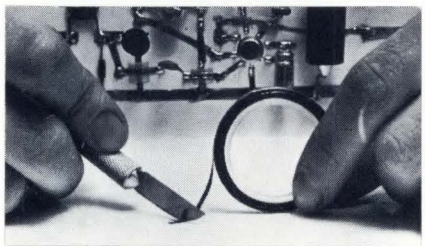
Five steps to a PC board. (1) Position self-adhering "Circuit Zaps" on standard board. (2) Drill holes for components and terminals. (3) Drive in stakes with insertion tool. (4) Connect terminals with jumper wires to check circuit. (5) Replace jumpers with connector strips.



Plated-wire memory stack, NS-500 Series, is intended for medium-capacity, high-speed and low-cost memory systems. Consisting of two planes, the stack's maximum capacity is 163,840 bits. Half- and quarter-stack configurations are available for smaller systems. Price is $0.01 to $0.02/bit in quantity. Nemonic Data-Systems, Inc., 1301 W. Third Ave., Denver, CO 80223. **327**

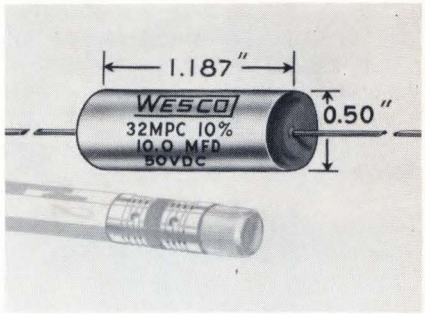


Crystal oscillator Series XO-2006 has frequency range of 10 to 25 MHz with stability of ±3 PPM from 0 to 50°C and ±5 PPM from −20 to 75°C. Contained within a standard crystal can (0.75 by 0.345 by 0.775 in), the oscillator has an output capable of driving TTL. Required input is from 3 to 8V dc at 2 to 3 mA. TMC Systems, Inc., 930 West 23rd St., Tempe, AZ 85281. **328**



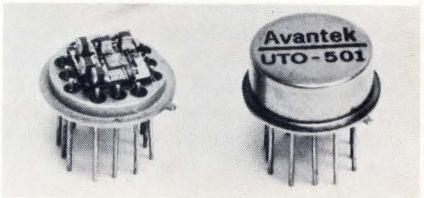
Adhesive-backed copper tape for building prototype circuits exhibits electrical properties that closely match production printed circuits. Either Mylar or Scotch tape may be used for insulating cross overs. Components can be attached with normal soldering, and the adhesive bond strengthens with age. Prices (including postage) for 12-ft roll are $1 for 1/16 in, and $2 for 1/8 in. Tape-A-Circuit Co., Box 3268, Scottsdale, AZ 85257. **329**

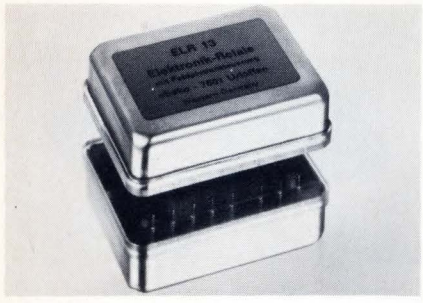
Metallized polycarbonate capacitors, Type 32MPC, have voltage ratings ranging from 50 to 200V dc. Capacitance range is 0.012 through 10 MF. A 10 MF unit occupies <0.8 in^3. Capacitance change is <±0.25% from 25 to 85°C. Standard tolerance is ±10%, and ±1% can be obtained by request. Wesco Electrical Co., 27 Olive St., Greenfield, MA 03101. **330**



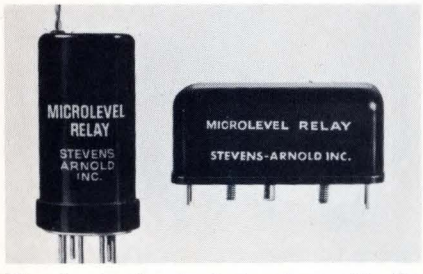
Digital read-out device uses fiber optics to achieve greater clarity and illumination. A disposable seven-lamp module at the rear of the unit provides illumination and optic fibers form a seven-bar readout. The 0.5- by 0.43- by 1-in unit displays a 0.4-in high, 0.25-in wide character. Choice of color for the digital presentation is an added feature. Rank Precision Industries, Inc., 260 North Route 303, West Nyack, NY 10994 **331**

Wideband VHF/UHF cascadable amplifiers, UTO-500 MIC Series, combine the technology of thin films, microwave transistors and wideband RF circuit engineering. Three versions cover 5 to 500 MHz with a flatness of ±1 dB worst case. Noise figures vary from 3.5 dB to 6 dB at 500 MHz depending upon version used. VSWR over 5 to 500 MHz spectrum is typically 1.3:1 and 1.7:1 at band edges. Packaged in a TO-8 can, these units weigh 2g. Avantek, 2981 Copper Rd., Santa Clara, CA 95051. **332**

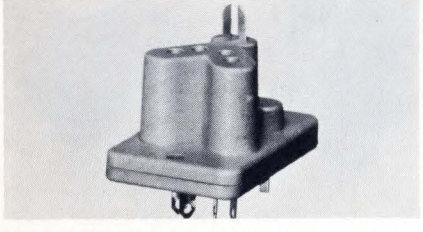




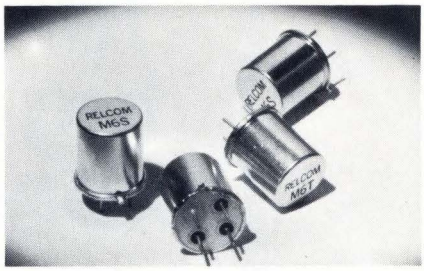
Contactless solid-state relays, ELR 11 to 14, feature complete isolation between input and output, high operating speeds and absence of moving parts. Units respond to inputs of dc up to 30 kHz (pulses). Normal load current is 200 mA with higher value versions available. Operational modes are Form A, B, C and self-holding. EBEKO, 1241 Welsh Rd., Huntingdon Valley, PA 19006. **333**



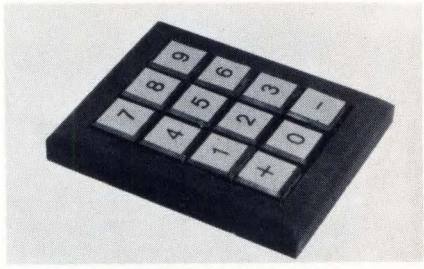
Microlevel relay is designed specifically for nanovolt switching. It has a 2-billion no-bounce rating, with a mere 40 nV offset resulting from changes in ambient temperature. This relay can be driven with pulses as short as 200 μs. Price range is from $21.10 to $42.50, depending upon the quantity. Stevens-Arnold, Inc., 7 Elkins St., South Boston, MA 02127. **334**



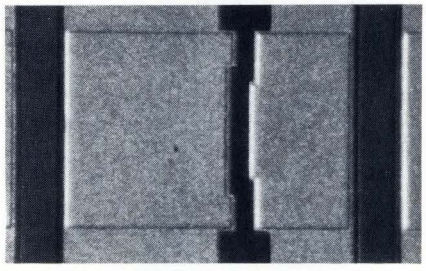
Heat-resistant test socket accommodates either TO-3 or TO-66 devices at high-junction temperatures. Constructed for repeated test insertions, the test socket allows for continuous operation at 250°C with no degradation of contacts or body material. Socket is designed for rivet or screw mounting, weld or solder connections, and the small size makes it suitable for high-density placement. Textool Products, Inc., 1410 Pioneer Dr., Irving, TX 75060. **335**



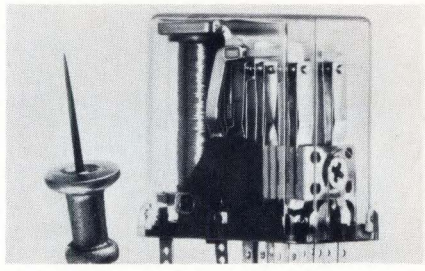
Miniature double-balanced mixers, Models M6S and M6T, are <1/32 in³ and weigh 1.4g. Model M6S covers the 0.4- to 100-MHz frequency range, while the Model M6T has a 10- to 500-MHz frequency band. Typical noise figures are only 5.3 dB (M6S) and 5.8 dB (M6T). At low frequencies typical isolation is better than 60 dB. Relcom, 2329 Charleston Rd., Mountain View, CA 94040. **336**



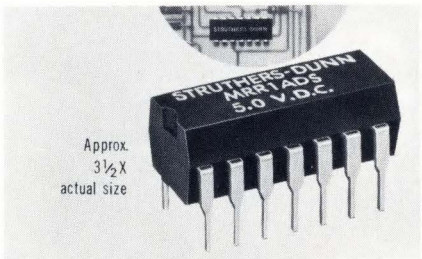
Integrated keyboard design combined with conductive plastic technology makes possible volume prices approaching $0.25/key. This keyboard is available with any number of keys on 3/4-in centers. Switches are rated for over 10^6 operations at 40 mA and 30V dc. Actuating force is 2 oz. Standard 12-key arrays are available at $9.50 each. Chomerics, Inc., 77 Dragon Ct., Woburn, MA 01801. **339**



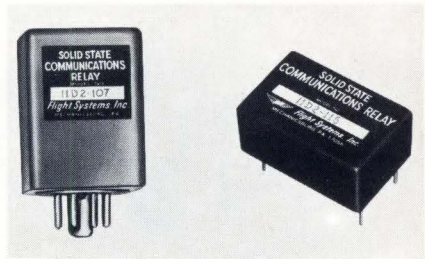
MOS capacitor chip series consists of six different geometries of single and dual units. Capacitances are 0.5 to 220 pF with 25 to 75 WV. Chip sizes range from 20 to 45 mils square, 6 mils thick. Any chip may be ordered in probed, uncut slice form. Dionics Inc., 65 Rushmore St., Westbury, NY 11590. **337**



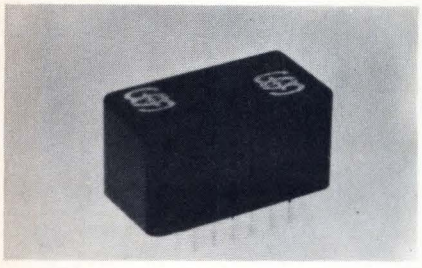
General purpose miniature relays require <1 in³ of space and are available as 2-, 4- and 6-pole configurations. A magnetic structure enables a single-pole double-throw relay to operate as low as 35 mW. All terminals and contacts are gold plated and all bearing parts are nickel plated. Deutsch Relay Div., 25 Daly Rd., East Northport, NY 11731. **340**



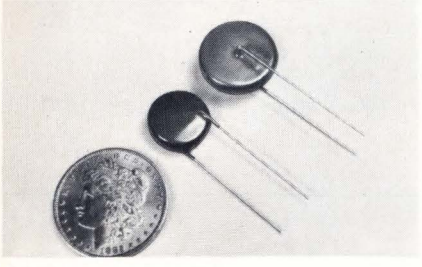
Miniature reed relays, MRR1ADS, can be inserted into the same printed-circuit board spacing as typical 14-terminal dual-in-line ICs. Relays with 5V dc coils are available for use with DTL and TTL logic. 12V dc coils for use with high-noise-immunity logic can also be obtained. Both types have one Form A (SPST, normally-open) contact. Prices range from $1.50 to $2.50 in 1000 lots. Struthers-Dunn, Inc., Lambs Rd., Pitman, N J 08071. **338**



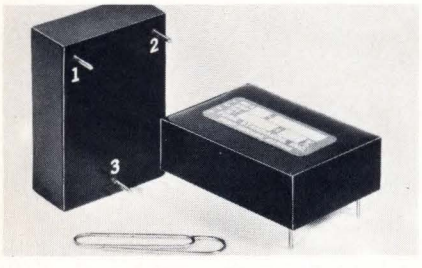
Solid-state communication relays comprised of seven different models cover all neutral, polar and complementary input/output combinations. These relays offer unlimited life, withstand severe shock and vibration, and have a repetition rate of 2400 operations/s (4800 baud). Distortion is <1% at 400 baud. Price range is from $18.80 to $38.95, depending upon configuration and the number of units. Flight Systems, Inc., Box 25, Mechanicsburg, PA 17055. **341**



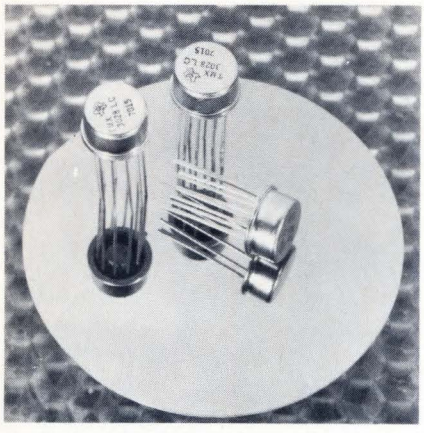
Digital signal isolator, Model DSI-192, is a high-speed, four-terminal switching device capable of isolating and transferring digital (or other) signals. Features of the DSI-192 include: dc to 3 MHz switching range (150 ns ON and 50 ns OFF), 600V isolation, up to 35 mA switching currents and compatible with integrated circuits. Solid-state Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **342**



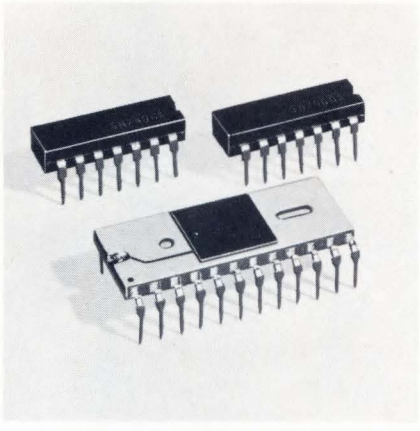
Ceramic disc capacitors come in three capacitance values: 1000 pF at 9 kV dc, 2000 pF at 9 kV dc and 2500 pF at 10 kV dc. These units are 0.375 in thick, and the diameters range from 0.85 to 1.3 in. Coating for all types is blue epoxy resin. Pricing is as low as $0.21 each in 5000 piece lots. Centralab, 5757 N. Green Bay Ave., Milwaukee, WI 53201. **343**



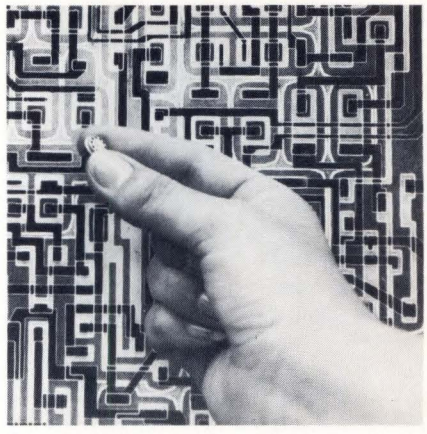
Compact crystal oscillator, Model AQ, spans the frequency range from 180 kHz through 10 MHz. Typical rise and fall times for the square wave output are 15 and 8 ns respectively. Designed for printed circuit board mounting, the device covers a board area of 1-1/8 by 1-5/8 in and is only 1/2-in high. Unit price for quantities of 100 begins at $22.50, depending upon frequency range and accuracy. Fork Standards, Inc., 211 Main St., West Chicago, IL 60185. **344**



Dual 128-bit MOS static shift register TMS3028LR operates from dc to 1 MHz, requires two supplies of −14 and −28V and one external clock. It can be interfaced directly with other logic forms without adding active components. Available in a TO-100 package the unit is priced at $10.30 in lots of 100 to 249 units. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, TX 75222. **345**

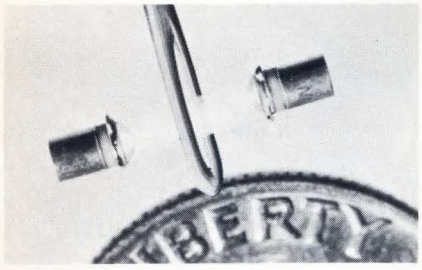


MOS read only memory UC6525/7525 can handle both input and output logic levels of any DTL or TTL device without external resistors or translators. Logic 1 input is 2.4V min, and logic zero is 0.4V max. Access time is 500 ns, temperature range is from −55 to 125°C and the unit is packaged in either a rectangular flat pack or ceramic dual in-line 24-lead container. Solitron Devices, Box 1416, San Diego, CA 92112. **346**

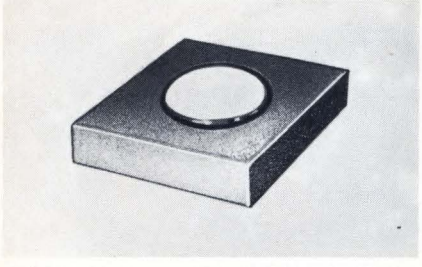


Phase-locked loop linear ICs can multiply and divide frequencies in virtually any ratio. They can divide a fundamental frequency by 10/3 if desired. Operating range of the 562, a dielectrically isolated unit, is 0.1 Hz to more than 50 MHz. The 565 operates from 0.1 to 500 kHz. The 100 piece quantity prices are $18 (562) and $6.35 (565). Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **347**

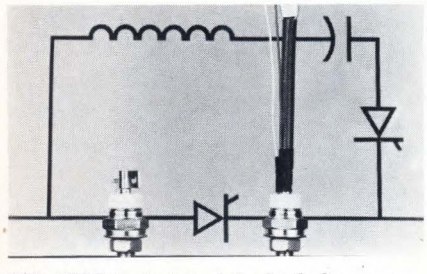
New SC's



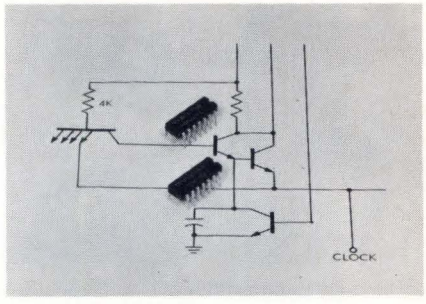
Gallium arsenide emitter SD 2450 and silicon detector SD 2440 are offered as a matched pair combination of source and sensor. They are ideally suited for high density PC board mounting. Applications include punched card and tape readers, character recognition, shaft encoders, position indicators and warning devices. Spectronics, Inc., 541 Sterling Dr., Richardson, TX 75080. **348**



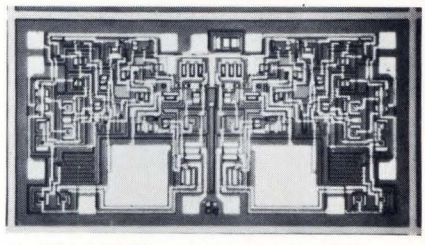
Chip varactors in the 1N5139-48 Series are ordered simply by adding the prefix "C" before the JEDEC number. The diodes' 4V capacitance values vary from 47 through 6.8 pF with corresponding Q values as high as 350 measured at 50 MHz. In lots of 100 to 999, price is $3.55 each. MSI Electronics, Inc., 34-32 57th St., Woodside, NY 11377. **349**



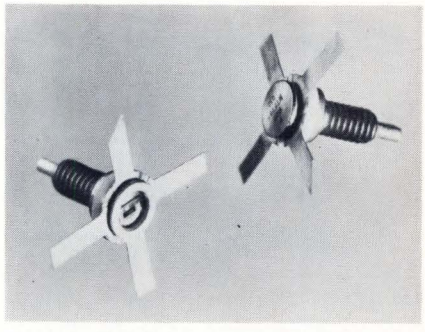
SCR T507 is designed for high frequency, high power operation up to 10 kHz for half-sine-wave operation. Characteristics include a dynamic forward voltage drop of only 4.5V max, and the unit can handle forward currents up to 110A. Gate trigger requirement is 150 mA max, and reverse blocking voltages up to 1200V can be obtained. Price for a 600V unit in lots of 10 to 99 pieces is $43.50. Westinghouse Electric Corp., Box 868, Pittsburgh, PA 15230. **350**



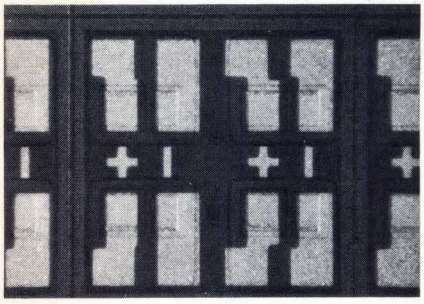
High-speed TTL ICs have had added two new 50 MHz J-K flip flops. Type US74H-571A is an AND-OR input and Type US74H572A is an AND input unit. Typical power dissipation is 60 mW, temperature operation is from 0 to 70°C and price in quantities from 100 to 999 is $3.15 each for both types. Sprague Electric Co., 491 Marshall St., North Adams, MA 01247. **351**



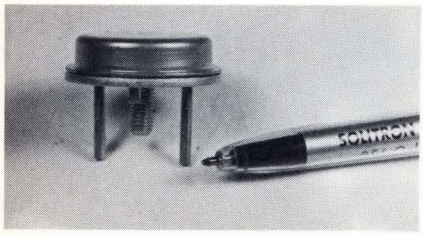
IC op amp 747 is a dual version of the popular 741 unit. It is designed for such applications as active filters, oscillators, tracking voltage references, integrators and summing amplifiers. It is priced at $18 in lots of 100 to 999. Teledyne Semiconductor/Amelco, 1300 Terra Bella Ave., Mountain View, CA 94040. **352**



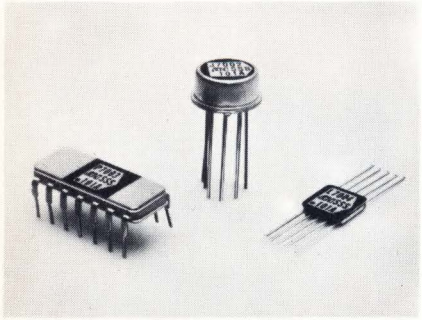
Microwave transistors are designed for use in Class C amplifiers through 1.5 GHz and oscillators through 2 GHz. The silicon nitride passivated units offer power ranges from 1 to 20W across the L-band, with the price for a 5W unit at $40.50 in lots of 100 to 249. Fairchild Microwave and Optoelectronics, Div., 2513 Charleston Rd., Mountain View, CA 94040. **353**



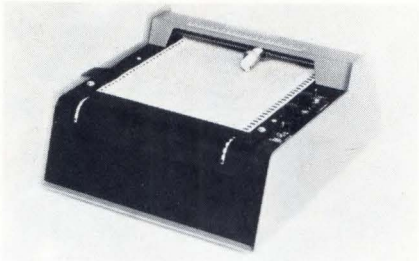
Monolithic quad diode chips designated DI 914-1QM, -2QM and -3QM have a 1 mV forward matched characteristic and are dielectrically isolated from each other and from the bottom of the chip with more than 1000V isolation between individual diodes. Construction is radiation-resistant. Dionics, Inc., 65 Rushmore St., Westbury, NY 11590. **354**



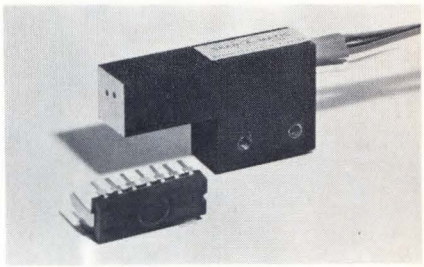
PNP germanium power transistors SDT-1808-10 Series and the 2N4048-53 Series offer high current capability and low V_{CE} sat. voltages. Typical specs include an I_C of 65A, V_{CE} sat. as low as 0.3V, V_{CBO} from 40 to 80V and V_{CEO} from 30 to 60V. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. **355**



IC op amp, Model SSS 101A offers an input offset voltage of 1.8 mV max, input offset current of 5 nA max, temperature operation from −55 to 125°C, large signal voltage gain of 100,000 and a price in lots of 100 units of $30 each. A second unit, SSS 201A, is priced at $12 each in similar quantities. Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, CA 95050. **356**

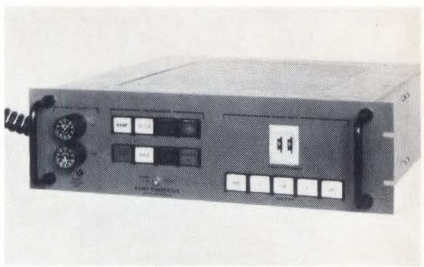


Servo graphic recorders, Series GP702, are priced between $275 and $345 yet provide true potentiometric servo null system, 20 in/s pen response, a variety of chart speeds and full scale spans and a total limit of error <0.5%. Precision Standards Corp., 1701 Reynolds, Santa Ana, CA 92705. **357**

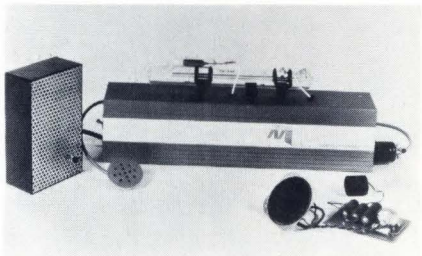


Two-channel coaxial scanner for reading printed code uses fiber optics and has a 0.015 in field of view at 0.1 in. Lamp design life is 40,000h at 5V. Sensor rise time is 1.5 μs typical, fall time is 15 μs maximum. Power dissipation is 50 mW at 30V dc. Skan-a-matic Corp., Box 68, Skaneateles, NY 13152. **360**

LSI tester performs true dynamic, functional testing of complex logic cards, LSI circuits and digital subsystems. Model 7010 permits the varying of test bit rates from nearly static to 8 MHz on 72 output driving and 84 input comparator channels. Its operator has direct control of test conditions by use of the analyzer's bit rate, plot width, clock skew and input/output voltage level controls. Canoga Digital Systems, Canoga Park, CA 91306. **358**

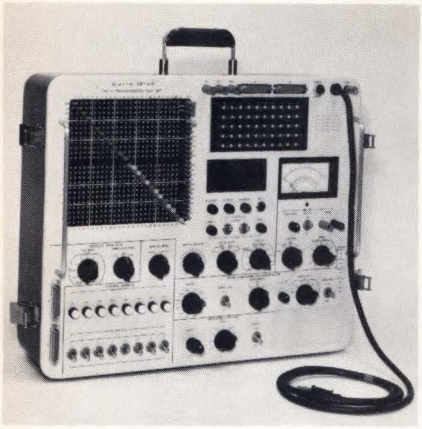


Digital ramp generator can provide variable sub-audio, sawtooth voltages over a 10 ms to 168h time range while operating under digital computer instruction. Model IDA-6612V provides full-scale signal from −10V to +10V for the lower (negative) limit control, and from 0 to +10V for the upper (positive) limit control. Voltage rate is adjustable from 0.01 to 9900V/min by a dial switch. Price is $6950. Intercomputer Electronics, Inc., 1213 Walnut St., Lansdale, PA 19446 **361**

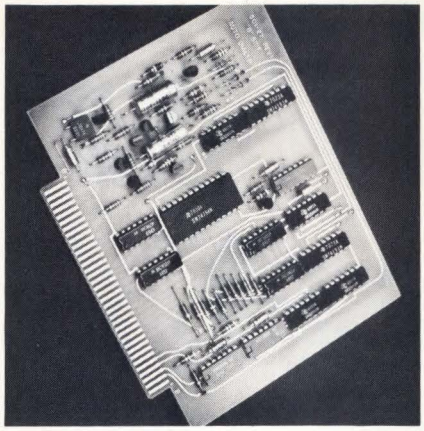


Laser communicator, priced below $150 in kit form and below $200 completely assembled, provides two-way communication over laser beams. System bandwidth is 0.75 MHz, and output power is 0.3 mW. Power consumption is 15W for transmitter and 50 mW for receiver, and both line- and battery-powered versions are available. Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, N J 08030. **359**

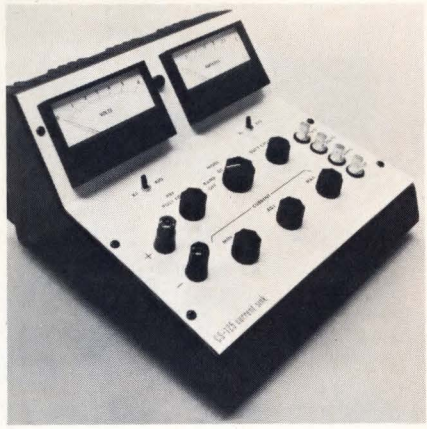
Digital magnetic tape transport, Model 1210, is a serial-in/serial-out machine that features read/write speed of 5 in/s, bidirectional read and write, packing density variable up to 1600 bpi and a start/stop of less than 20 ms. Built around Model 1100 transport mechanism, the new unit uses a standard cassette. Price per unit is $980. Compucord, Inc., 225 Crescent St., Waltham, MA 02154. **362**



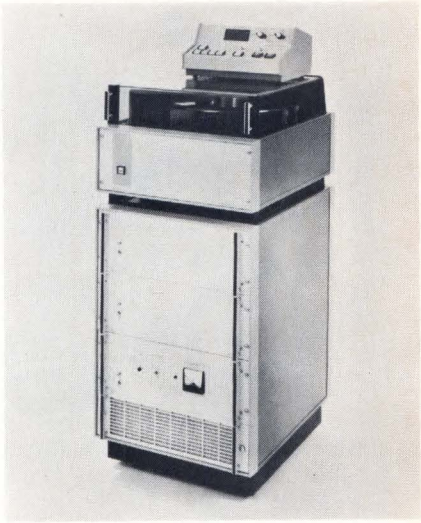
Data transmission test set, Model 1914B, is designed for installation, maintenance and troubleshooting tests by telephone company personnel, MODEM users and manufacturing time-sharing computer companies. Equivalent to the Bell 914B Data Test Set, the unit conforms to EIA RS-232 interface specifications and is compatible with most MODEMS. Sierra Electronic Operation, Philco-Ford Corp., 3885 Bohannon Dr., Menlo Park, CA 94025. **363**



Automatic telephone dialing system will, upon command, dial over the regular switched telephone network up to eight pre-determined telephone numbers, composed of 11 digits maximum. On uncompleted calls the unit will redial at intervals. Three user-furnished control signals are required. Price of the Model ATD 811 System is as low as $120. National Midco Industries, Inc., Box 5433, Trenton, N J 08638. **364**

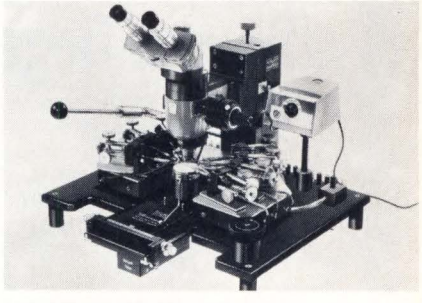


Power supply tester, Model CS-125, has maximum ratings of 60V and 25A. In manual mode the unit provides a continuous equivalent resistance change from 0.016 to greater than 6000Ω. In pulse mode, it makes step transitions in less than 1 μs at any frequency between 0.01 and 1000 Hz. In ramp mode, the load current may be increased linearly at any rate up to 25,000A/s. Price is $295. Microcomp, Box 181, Newtown, CT 06470. **365**



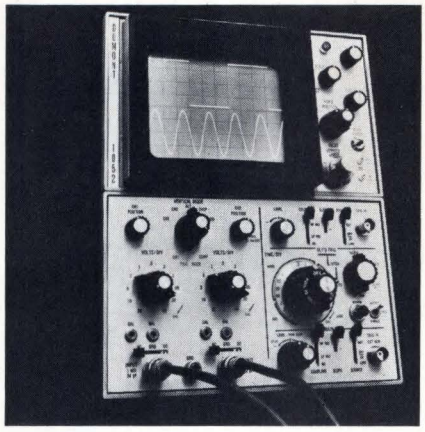
Disc recorder for transients can be made to record a single transient event automatically, from 1 μs to 20s in length, shut off the recording process and under remote command, play back the entire transient repetitively—or repetitively to play back selected portions of the transient equal to one period of the disc's revolution. The 3000-I Series has four models with prices starting at $17,500. Data Disc Inc., 1275 California Ave., Palo Alto, CA 94304. **364**

Disc memory, the 12.8-million bit Model 7207, features plug compatibility that allows field expansion of the memory without danger of data loss. Its power supply has memory-protect circuits to prevent data loss in case of power interruption. Unit price is $17,000 and OEM quantity prices are as low as $11,000. Data Disc Inc., 1275 California Ave., Palo Alto, CA 94304. **365**

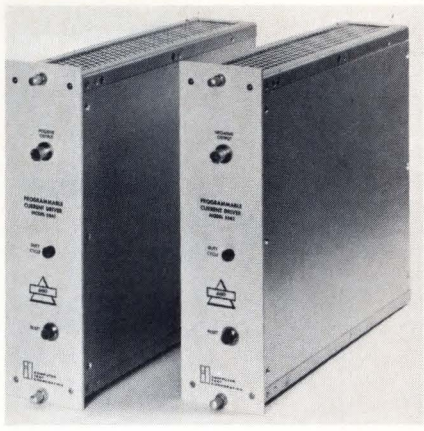


Micromanipulator test station, Model 6000, can probe the smallest devices made. Probe tip radius is approximately 0.00001 in, and microscope magnification is up to 660X. The Micromanipulator Co., 520 W. Second Ave., Escondido, CA 92025. **366**

X-Y analog plotter features noncontact feedback controls for each axis, insuring 0.25% pen positioning and eliminating electrical noise and mechanical wear. The Model 1000 has writing speed of 100 in/s in both directions and total response time to a full-scale step input is 300 ms maximum. Both slide and writing head travel on roller band assemblies. Brush Instruments Div., Gould Inc., 3631 Perkins Ave., Cleveland, OH 44114. **367**

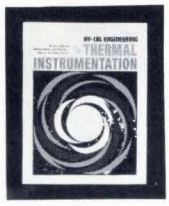


Dual-trace 50 MHz scopes, Model 1052 with delayed sweep and Model 1053 with nondelayed sweep, have vertical sensitivities from 10 mV to 20V/cm from dc to 50 MHz. Both models feature 8- by 10-cm display area with parallax-free internal graticule and constant-amplitude triggering to the full bandwidth. Price is $2045 for Model 1052 and $1845 for Model 1053. Dumont Oscilloscope Labs., Inc., 40 Fairfield Place, West Caldwell, N J 07006. **368**

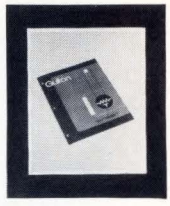


Programmable current drivers, Model 5561 (positive) and 5562 (negative), are digitally programmable and designed to supply precise, highly repeatable pulses. Featuring high source impedance, low output capacitance and high voltage compliance (±75V), they deliver fast, clean linear pulses into a wide range of inductive or non-inductive loads. Computer Test Corp., Three Computer Dr., Cherry Hill, N J 08034. **369**

"Micro-Brute Broad Band, Low-Pass EMI Filters" is a 16-page catalog that features application and specification data for Series 8000 filters. The Potter Co., 500 W. Florence Ave., Inglewood, CA 90301. **425**



Thermal instruments and systems are covered in 20-page bulletin, A-102. Thermal and solar energy conversion tables are included. Hy-Cal Engineering, 12105 Los Nietos Rd., Santa Fe Springs, CA 90670. **429**

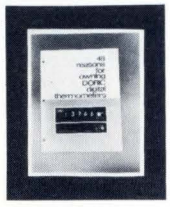


Thermistors are covered in a 32-page company catalog that includes bead, bead-in-probe, disc, rod-and-wafer and experimenters' kits for product evaluation. Gulton Industries, Inc., Metuchen, N J 08840. **433**

Test equipment and components are covered in a 48-page bulletin 93. Power supplies, delay lines, pulse networks and transformers and servo motors also are included. Lectronic Research Labs., Inc., 75-19 Arch St., Philadelphia, PA 19106. **426**

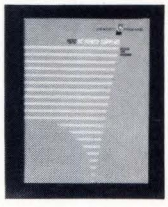
Precision test equipment for quality control, reliability and evaluation engineers is described in a six-page brochure. Peak voltage memory and A/D converters also are included. Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, CA 90250. **430**

Microwave components are covered in a four-page catalog that includes bandpass and bandwidth filters, multiplexers, integrated microwave components, doublers, electromechanical switches, circulators and isolators. Teledyne Microwave, 815 Stewart Dr., Sunnyvale, CA 94086. **434**



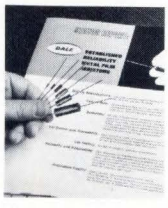
Digital thermocouple measurement is described in 14-page bulletin T3 3-70, with emphasis directed towards noise, drift with time and temperature, scaling and linearization. Doric Scientific Corp., 7601 Convoy Ct., San Diego, CA 92111. **427**

Electronic communications devices and systems include data communications equipment, telephone equipment, communications switching equipment and remote control supervisory equipment. Pulse Communications, Inc., Box 1225, Alexandria, VA 22313. **431**



DC Power Supply catalog/handbook includes 80 pages of detailed specifications, descriptions and illustrations for over 100 models. Applications also are included. Hewlett-Packard, New Jersey Div., 100 Locust Ave., Berkeley Heights, N J 07922. **435**

Radiation Hardened Silicon Power Transistor manual contains information on analyzing neutron irradiation effects. Post-radiation data with emphasis on h_{FE} and collector saturation voltage parameters are included. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. **428**



Established Reliability of Metal Film Resistors lists complete electrical and physical specifications, summarizes testing data and types of screening available for a line of EMF resistors that range from 1/20 to 1W. Dale Electronics, Inc., Dept. 860, Box 609, Columbus, NE 68601. **432**

MSI complex array ICs, Series 54/74, are covered in a comprehensive 100-page brochure No. 25655. General design characteristics, electrical characteristics and parameter measurement information comprise the three-section handbook. Sprague Electric Co., 491 Marshall St., North Adams, MA 01247. **436**

"The Non-Existent Product" is a four-page brochure that covers a company's capability in design of equipment and systems. ITRON Corp., 11675 Sorrento Valley Rd., San Diego, CA 92121. **437**

"Truth" brochure on the economics of reliability covers both discrete components and integrated circuits. STL Electronics, Inc., 2821 Ladybird Lane, Dallas, TX 75220. **441**

Resistor networks packaged in dual-in-line containers are described in a bulletin from Micro-Electronic Subsystems, Inc., 20 Burr St., Framingham, MA 01701. **445**

Low pass broad band filters include L, Pi and T network filters in five series with voltage ratings from 50 to 300V dc and 125 to 185V ac. The 32-page catalog is available from Gulton Industries, Inc., Metuchen, N J 08840. **438**

QRD dual and twin dual power supplies, including seven models ranging in output from 15 to 60V, are described in eight-page brochure. Raytheon Co., Sorensen Operation, Richards Ave., Norwalk, CT 06856. **442**

Series 54/74 TTL circuits now include 51 members of the family. A parts description and price list is available in addition to a reliability report. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **446**

Digital and linear IC testers are covered in a four-page brochure. Microdyne Instruments, Inc., 203 Middlesex Turnpike, Burlington, MA 01803. **439**

Portable oscillograph Model 0-501 weighs only 14 lb and is priced at $725. Esterline Angus, Div. of Esterline Corp., Box 24000, Indianapolis, IN 46224. **443**

TWTs for space communications are described in a nine-page booklet. Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, CA 90509. **447**

TV display driver, AAT-101, is described in an eight-page brochure that also outlines applications. Ann Arbor Terminals, Inc., 918 Green St., Ann Arbor, MI 48104. **440**

Filters, including band pass, low pass and high pass as well as duplexers, attenuators and limiters, are described in new literature. American Electronic Labs., Inc., Box 552, Lansdale, PA 19446. **444**

Scanning electron microscopy service and applications are covered in a four-page brochure. Prices also are included. Structure Probe, Inc., 535 E. Gay St., West Chester, PA 19380. **448**

Transformer, inductor and magnetic components catalog contains complete specifications, dimensions and prices. Ferrodyne Corp., 4240 Glencoe Ave., Venice, CA 90291. **449**

Filter Model N408 is described in a brochure that includes Bessel and Butterworth filters with 12 high-pass and 12 low-pass cutoff frequencies. Bulletin 255 is available from MB Electronics, A Textron Co., New Haven, CT 06515. **450**

Two-wire EMF/I transmitters that permit use of standard copper lines in place of thermocouple leads are described in Bulletin No. 9908. Airpax Electronics, Box 8488, Fort Lauderdale, FL 33310. **451**

Phase angle voltmeter Model 215C operates at any four spot frequencies in the 30 Hz to 20 kHz range. North Atlantic Industries, Inc., Terminal Dr., Plainview, NY 11803. **452**

"Electronic Packaging Hardware and PC Boards" is the title of 15-page catalog 10,000B. It covers a new concept in electronic packaging hardware. Rosemount Engineering Co., Box 35129, Minneapolis, MN 55435. **453**

Mini-indicator Model 240 is covered in a bulletin that includes specifications and application suggestions. Bulletin EDS 9 is available from Jewell Electrical Instruments, Inc., Grenier Field, Manchester, NH 03105. **454**

Wire and cable reference chart aids engineers in selecting from among the wide variety of wires and cables now available. Electronized Chemicals Corp., S. Bedford St., Burlington, MA 01803. **455**

Hermetically sealed ac- and dc-operated subminiature repeat cycle timers are described in two-page bulletin MC301-R1. A. W. Haydon Co., 232 N. Elm St., Waterbury, CT 06720. **456**

Electronic keyboards including both standard and custom types are described in a four-page applications brochure. Controls Research Corp., 2100 S. Fairview, Santa Ana, CA 92704. **457**

Metal shell flat conductor cable connector, "FLEXMATE", is described in a four-page bulletin. Units are available with pin layouts ranging from 9 to 51. Microdot Inc., 220 Pasadena Ave., South Pasadena, CA 91030. **458**

Power pulse generator, Model 605P, is a 24 kW unit that offers pulse width from 50 ns to 10 ms and outputs up to 2200V at 11A. Cober Electronics, Inc., 7 Gleason Ave., Stamford, CT 06902. **459**

Modular regulated power supplies for op amp instrumentation supply and transducer excitation are detailed in Data Sheet No. 50. California Electronic Mfg. Co., Inc., Box 555, Alamo, CA 94507. **460**

Troublesome H_2

More on May 1 Clinic (Letter to the author, J. Snodgrass)
Dear Jim:
"I want to thank you for your little note in the "Customer Engineering Clinic" entitled "Hydrogen Turns Resistors Into Conductors" which appeared in the May issue of EDN. As I was about to package some IC circuitry in a closed atmosphere with two motorcycle batteries, your note eliminated at least one of my problems!

Thanks again for circulating this information. My equipment is destined for use in the Tsunami Warning System and faulty operation will degrade the relationship between the public officials and the public.

Wm. Mansfield Adams
University of Hawaii
Tsunami Research Group

I assume the hybrid circuits were hermetically sealed units. If they were not, then what Mr. Snodgrass says is most correct. However, if they were not hermetically sealed there is a good chance that a small amount of hydrogen was absorbed into the packages themselves when they were being fired. A high temperature vacuum bake ≧200°C for 96h should help remove any trace of hydrogen. This bake should be performed on the empty packages before assembly starts. The assembled units should then undergo another bake at 150 to 175°C prior to sealing.

If the sealing atmosphere is dry nitrogen, backfilling the package with dry air will improve performance. Can type packages are found to be less susceptible to this failure mode than flat packs as the majority of flat packs are sealed in nitrogen while cans are mostly resistance welded in dry air boxes.

Richard A. Sorensen
Product Marketing Manager
Philco-Ford, Hybrid Microelectronics

Converts

Dear Mr. Boe:
Your editorial on metric measure, and the resulting response, has moved me to at least drop you a line.

Mills Resistor Co. makes precision wirewound resistors, and while our market and use no longer set the electronic world on its ear, you might be interested to know that we have at least cast our straw in the wind.

We have converted a good portion of our standard catalog sizes to metric dimensions, and printed it as an addendum to our regular catalog. This is not just a cop-out to translation to cm's to the nearest thousandth, but rather a general translation, changing the various sizes to something that makes sense to the measuring world.

Copies are available to those of your reading audience that would also cast a straw with us.

B. T. Mills
Mills Resistor Co.
10810 Kaylor St.
Los Alamitos, CA 90720

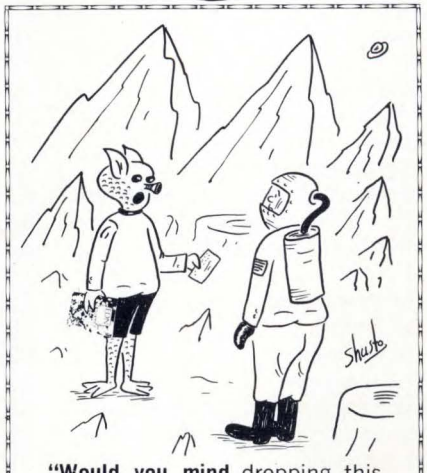
Bugged Analysts

Gentlemen:
As engineering people are notoriously those who feel with their heads, and use their hearts for pumps, I was pleased to note the sentence in your editorial, "Software Limited" (June 1, EDN).

Like most who write in I wish to object some, too. Namely, to "pride in the staggering array" of hardware and to "There are no programmers or systems analysts to create society's software."

Is it not true, Mr. Boe, that our staggering array of hardware is objectionable? And is it not true that because of the country's hardware-profit orientation that our young and our union ties have felt it necessary to become analysts of this system and are in fact debugging their programs in the streets and campuses?

Bob J. Baker
19900 So. Normandie
Torrance, CA 90502



"Would you mind dropping this Reader's Service card in the mail when you get back down?"

$\sqrt{\text{SLIDE RULE}}$ or $(\text{Slide Rule})^{-2}$

Gentlemen:
Mr. Spryn's method for division by slide rule (July 1, 1969) is a good one, but I couldn't help trying to improve on it, as follows:

$$\frac{4562}{29} \cong 157.3 \text{ (by slide rule)}$$

$$157 \times 29 \cong 4550 \text{ (by slide rule)}$$

But last digit is obtained by multiplying 9×7 of the multiplicands, arriving at 4553 (or multiply longhand and get 4553).

$$\frac{4562}{29} = 157 + \frac{9}{29} = 157.310$$

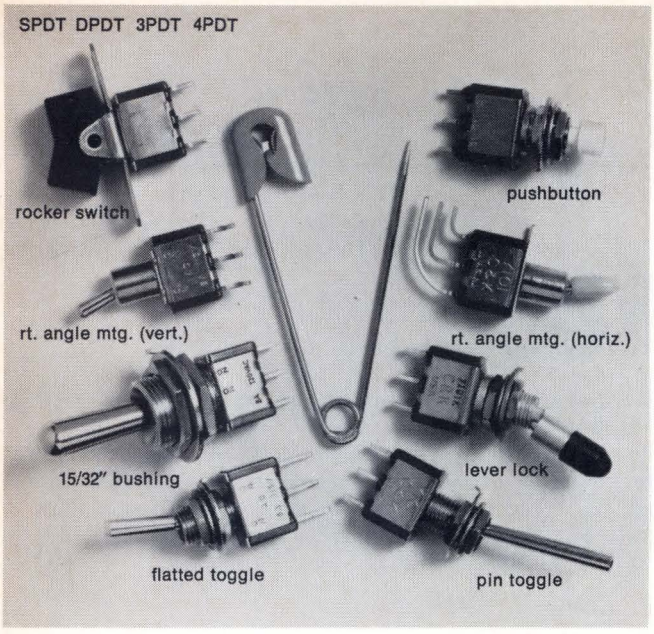
Checking: $157.31 \times 29 = 4561.99$.

W. M. McCampbell
Aerospace Technologist
George C. Marshall Space Flight Ctr.

Advertiser's Index

Subject Index to Articles

Index to Ads, Products and Literature



8 tiny, new additions to our family.

There they are – in a proud family portrait.
And like all C&K subminiature switches,
they're competitively-priced and Made-in-America.
Ask for our new catalog.

C&K COMPONENTS, INC.
103 Morse Street, Watertown, Massachusetts 02172
Tel: (617) 926-0800

CIRCLE NO. 49

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"STOP COSTLY REWIRING IN THE FIELD!"

Debugging faulty wiring in machine tool and process controls, EDP equipment, test systems, special machinery, and similar applications, costs you big money, makes customers unhappy, steals profits. Harbour Industries offers RELIABLE Teflon TFE* and Teflon FEP* wire and cable with upper service temperatures, overload current and fire protection, soldering iron resistance, superior electrical properties and stability, *plus* resistance to chemicals, weather, and mechanical abuse. We lead in *quality, fast service, wide range of types and sizes.* Ask for specifications and samples. *Registered DuPont Trademark

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CIRCLE NO. 50

Driving without safety belts is really asking for it.

Advertising contributed for the public good

Fast electronic solders

Formulated to meet the need of high speed production of the electronic industry, Bow Solders are non-corrosive, non-hygroscopic, non-conductive and fungus-resistant. They have received QPL approval and certification and are available in four types: AE16 Rosin Core, XX Rosin Core, WW Rosin Core and Tri-Pure Bar. For technical advantages and prices, write for the new data sheet GC1169,

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BOW SOLDER PRODUCTS CO., INC.
25 Amsterdam St.,
Newark, N.J. 07105.

Also manufacturers of Rosin Fluxes, Acid Core Solders, Bar Solders, Fusible Alloys, Organic Fluxes, Solder Paint, Electro Solder Paste & Solder Preforms.

CIRCLE NO. 51

Application Notes

"NASA Astronauts Take a Dive" is the title of a four-page application bulletin 8-98. It covers the astronauts performing tasks in a tank designed to duplicate the effects of space weightlessness. COHU Electronics, Inc., Box 623, San Diego, CA 92112. **475**

Integrated circuit application kits contain eleven different uses for various types of ICs. One kit explains uses for SUHL I and SUHL II, TTL digital circuits. The other kit describes applications for MSI arrays. Sylvania Electric Products Inc., 730 Third Ave., New York, NY 10017. **476**

"Design Guide for Wideband Operational Amplifiers" offers 12 pages of basic design theory and key parameters of wideband amplifiers. Applications include high speed D/A and A/D conversion, video summing, coaxial line driving and high speed integration. Intronics, Inc., 57 Chapel St., Newton, MA 02158. **477**

"The ABC's of Monitoring" is a 12-page note that explains how to apply lab-developed methods for using specific ion electrodes to monitor continuously flowing streams such as process solutions, industrial wastes, ion exchange effluents and natural waters. Technical Services Dept., Orion Research Inc., 11 Blackstone St., Cambridge, MA 02139. **478**

"N-Bit Bit Binary Adder and Subtractor Using US5480 and US7480 Gated Full Adders" is the title of a four-page application note, 25656.80-1, on expandable-to-N-bits adders and subtractors. Sprague Electric Co., 491 Marshall St., North Adams, MA 01247. **479**

"Modern Microwave Absorbers and Applications" is a paper that discusses absorbers of anechoic chambers, anechoic caps for antennas, absorber reflectivity measurements and the latest ideas in anechoic chamber design. Microwave Products Div., Emerson & Cuming, Inc., Canton, MA 02021. **480**

"Poopsheet" is a quarterly newsletter for the users of electrical and electronic components. Application suggestions for interconnection devices used with PC boards as well as a new type of SCR driver circuit are covered. Design and Production Assoc., 1600 N. Arrowhead Ave., San Bernardino, CA 92405. **481**

"Handling and Mounting of RCA Molded-Plastic Transistors and Thyristors" is an eight-page application note (AN-4124) that shows many different types of packages. It also contains suggested mounting hardware to accommodate various mounting arrangements. RCA Electronic Components, Commercial Engineering, Harrison, N J 07029. **482**

"Properties and Applications of NTC Thermistors" is a comprehensive coverage of device terminology, voltage and current-time characteristics, dissipation constant and time constant. Sensitron, Inc., 225 Paularino Ave., Costa Mesa, CA 92626. **483**

Ultraviolet Photochemical Etching is a two-page application sheet that describes the control aspects of photochemical exposures. Spectral and total energy characteristics of sources and their effects on photoresist are covered. International Light Inc., Dexter Industrial Green, Newburyport, MA 01950. **484**

"Environmental Protection of Semiconductor Devices" covers new developments in silicon resins as molding compounds. Laboratory evaluations with suggested methods of encapsulation are included. Technical Report CDS-2048 is available from General Electric Co., Silicone Products Dept., Waterford, NY 12188. **485**

"Signal Averaging Enhancement of RF and Pulse Measurements" contains 20 pages that describe how increases greater than 20 dB in the sensitivity of RF and microwave instruments can be obtained by signal averaging techniques. Application Note 127 is available from Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. **486**

Reprints Available **in this issue are offered as follows:**

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