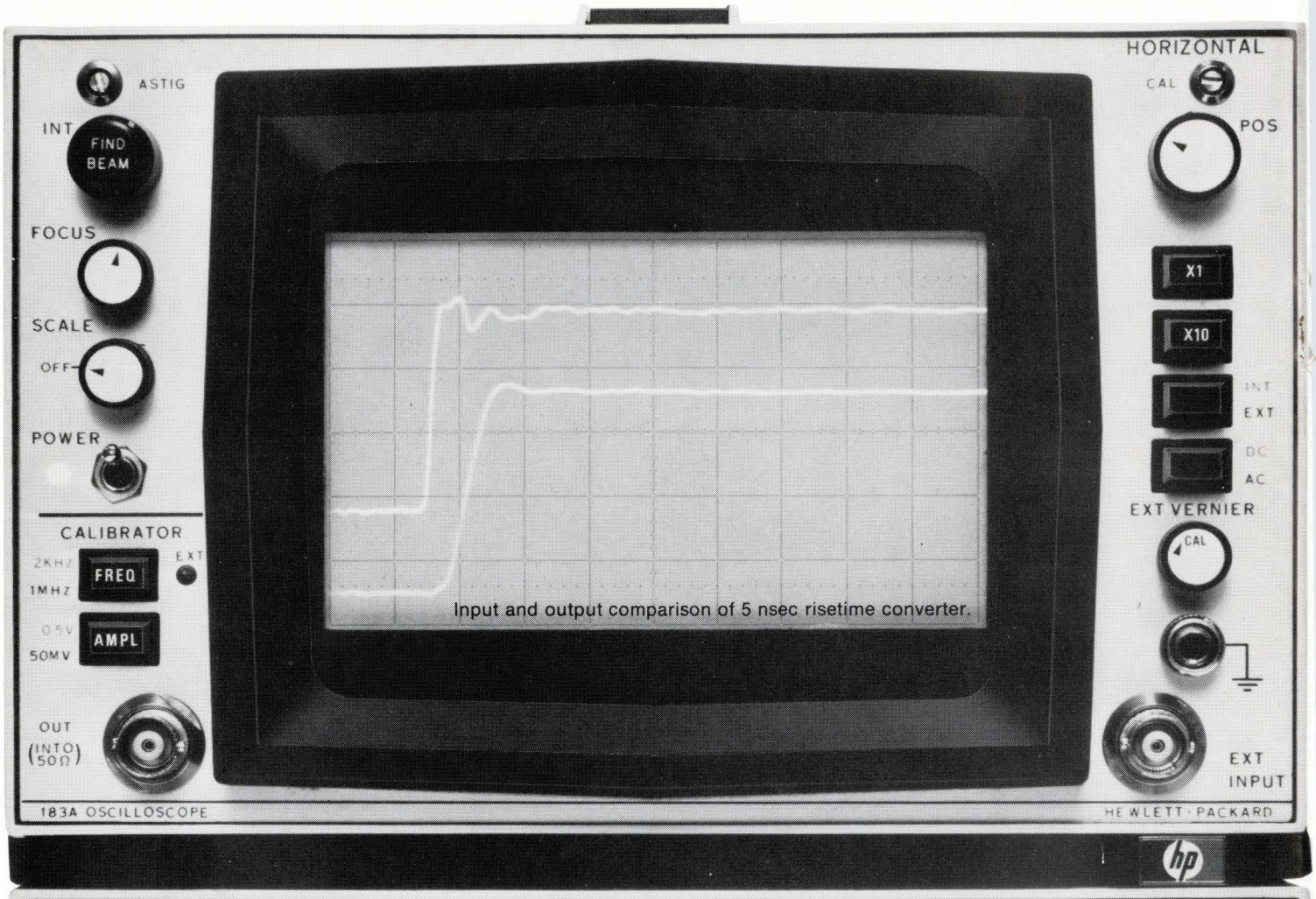
VOL. 28 NO. 11
NOVEMBER 1969

THE ELECTRONIC ENGINEER



The Performance Champ — world's fastest general-purpose real-time scope!

The HP 183A Oscilloscope system adds one more way that you **see more — do more** with the field-proven 180 scope system.

Now you can measure from dc to 250 MHz — real time! Now you have a vhf scope that also gives you a bright dual-trace with a fast-writing speed of 4 cm/nsec on a big 6 x 10 cm screen. Plus, a sensitivity of 10 mV/div for low-level signal measurements — sweep speeds of up to 1 nsec/div for easier viewing of high frequency signals — and complete compatibility with the entire 180 series of plug-ins.

Sound expensive? Well, the 183A mainframe with a 250 MHz dual-channel vertical amplifier and a >250 MHz time base costs only $3150. That's less than some systems that don't even approach this kind of high frequency performance.

The basic 183A mainframe uses the all-new step-ahead technique of a CRT transmission deflection system to provide real-time bandwidth beyond 500 MHz. And since it contains only the CRT and power supplies, future, improved plug-ins will give you full performance in the mainframe you buy now. You won't have to worry about built-in mainframe limitations — now or in the future.

If you're interested in maximum scope performance per dollar invested, then the HP 180 system is the answer. From 50 MHz, to 100 MHz, to sampling, to variable persistence and storage scopes, the 180 system has the right combination to meet your requirements. You get more for your dollar today. You get more for your dollar in the future. You get the best performing, most versatile high-frequency scope system available today!

For more information, call your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

089/14

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

ACTUAL SIZE

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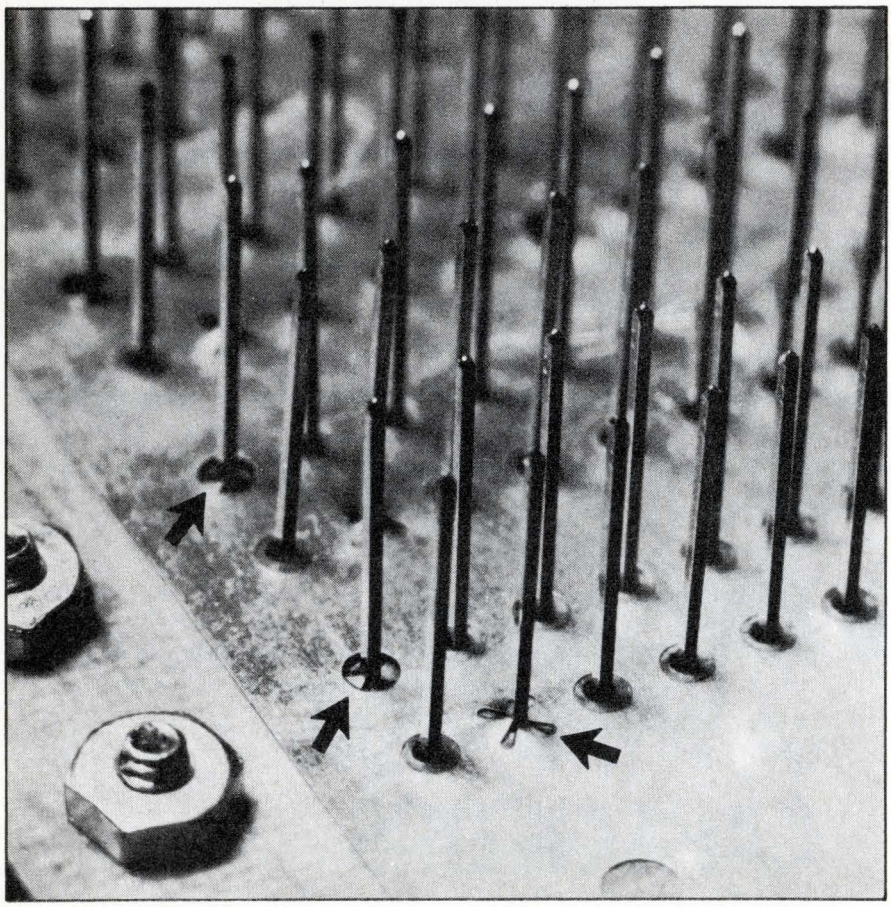
WRAPID TRANSIT™

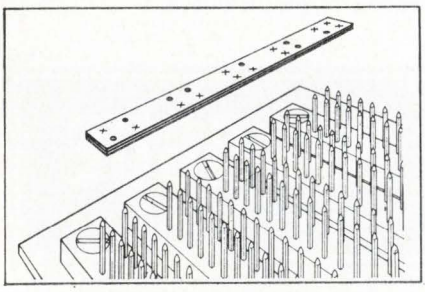


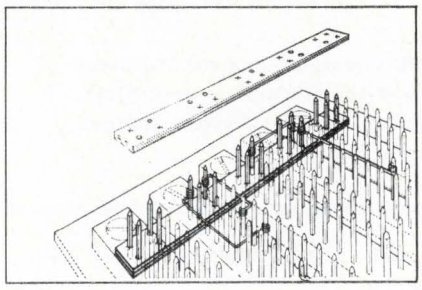
Imagine bussing an entire circuit with one push and you know what Wrapid Transit™ is all about. A simple sandwich of conductive material and insulation that presses into place for a clean, positive connection on wire wrap back panels.

Use any number of layers you need. The only limitation is the length of the wire wrap terminals. And, if you use enough layers, Wrapid Transit™'s rigidity serves as a structural member of the back plane.

Add to this our new Outside World™ connectors which provide a simple transition from stranded power wire to your solid circuit wire. It's also a unique plug/receptacle system that can be keyed into as many as 56 coded positions.

Want more? Then just call on the Viking Packaging Technology Group. They'll work out a perfect packaging system for your incredible designs. And provide you with complete service—start to finish. Call or write:





VIKING INDUSTRIES INC.

21001 Nordhoff Street
Chatsworth, California 91311
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THE ELECTRONIC ENGINEER

Nov. 1969 Vol. 28 No. 11

COVER

How are DVMs priced? What makes one more expensive than another with the same number of digits? Why does the addition of digits cause such big jumps in the price? You can find the answers to these questions along with a good comparison of different units on the market in Steve Thompson's article, "DVM specs compared." This article starts on page 69. Also, take a look at the Editorial on page 9 for some answers.

The Electronic Engineer

Vol. 28 No. 11 November 1969

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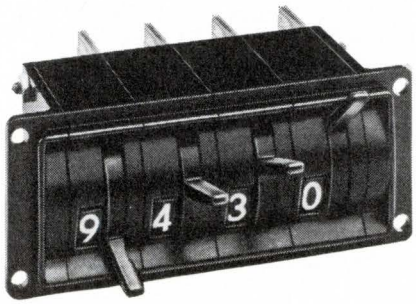
Monthly publication of Chilton Company, Chestnut & 56th Sts., Phila., Pa. 19139. (Area Code 215) SHerwood 8-2000. Controlled circulation postage paid at Philadelphia, Pa. $1 a copy. Subscription rates U.S. and U.S. Possessions: 1 yr. $12.00; 2 yrs. $20.00. Canada 1 year $14.00; 2 yrs. $25.00. All other countries 1 yr. $20.00; 2 yrs. $35.00.

The Chilton Electronics and Instrumentation Group ● The Electronic Engineer ■ Instruments and Control Systems ■ Instrument & Apparatus News ■ Medical Electronics News ■ Electronic Component News

IF YOU HAD TO FLIP SWITCHES 7,843 TIMES A DAY, YOU'D ASK FOR THE MINILEVER.™

Here's the compact switch that's built for switchers. With positive, clear-sounding click-ity-clicks that sweep over a 90-degree arc. So the right setting is easy to hit every time. And just as easy to see. Because the .200 inch high display characters—in up to 12 positions—really pop out at you. A simple sweep of the hand re-sets everything back to zero, too.

So next time your design calls for switches, think of the switchers' switch: The MINILEVER.® It's beautifully designed to be nice to operators and improve their efficiency wherever ever frequent, rapid switch-settings are a must. Besides, lots of switchers are girls, and they'll love you for it.



THE DIGITRAN COMPANY

A Division of Becton, Dickinson and Co. B-D

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There's still time to win a Bug for Christmas. Write for your entry blank and rules.

We'll go to any length to get into your memory

National's capable of going a long way (or short) to get the right MOS shift registers into your memory. The applications are unlimited.

For starters, you get a variety of bit lengths from our standard line, available immediately. Your National distributor's got them on the shelf and waiting.

If you can't find the register length your application requires, give us a call. We'll program your register length into our standard process. We've been making MOS so long, our memory's capable of anything.

How's that register?

DYNAMIC		
Dual-25	MM400	−55°C to +125°C
	MM401	−55°C to +125°C (Internal 20K pull-up resistor)
	MM500	−25°C to +70°C
	MM501	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-50	MM402	−55°C to +125°C
	MM403	−55°C to +125°C (Internal 20K pull-up resistor)
	MM502	−25°C to +70°C
	MM503	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-100	MM406	−55°C to +125°C
	MM407	−55°C to +125°C (Internal 20K pull-up resistor)
	MM506	−25°C to +70°C
	MM507	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-64	MM410	−55°C to +125°C
Accumulator	MM510	−25°C to +70°C
Triple-60+4	MM415	−55°C to +125°C
Accumulator	MM515	−25°C to +70°C
STATIC		
Dual-16	MM404	−55°C to +125°C
	MM504	−25°C to +70°C
Dual-32	MM405	−55°C to +125°C
	MM505	−25°C to +70°C
8-bit	MM408	−55°C to +125°C
Serial to Parallel	MM508	−25°C to +70°C
8-bit	MM409	−55°C to +125°C
Parallel to Serial	MM509	−25°C to +70°C
Dual-32	MM419	−55°C to +125°C
Split clock	MM519	−25°C to +70°C

Write or call National Semiconductor, 2975 San Ysidro Way, Santa Clara, California 95051.
(408) 245-4320. TWX: 910-339-9240 Cables: NATSEMICON **National/MOS**

Gyro-tuning.

A new, wideband, high speed tuning technique for coaxial magnetrons.

Gyro-tuning employs a ring gear which drives a set of rotating dielectric paddles within the magnetron coaxial cavity. A high speed synchronous motor drives the entire mechanism, which is external to the tube vacuum envelope. This arrangement provides a high degree of frequency tuning and reliability for coaxial magnetrons used in airborne search, navigation, terrain following and missile seeker radar applications. The complete tuner assembly is compact and adds only ½ pound to the basic magnetron weight.

Gyro-tuning presently achieves tuning rates of 400 Hz at frequency excursions of 250 MHz at Ku-band. It features low tuning drive power and a simple, directly driven, high voltage electrical generator readout technique to reduce local oscillator tracking problems.

Gyro-tuning is reliable. The rotary tuner mechanism provides long operating life and meets relatively stringent shock and vibration specifications. Operation outside the vacuum enhances tube life.

Gyro-tuned magnetrons are now being delivered at the 35 kilowatt level at Ku-band and 70 kilowatt level at X-band. Tubes are in development at other power levels.

For information on Gyro-tuning and other rapid tuning techniques now available or under development, contact: Electron Tube Division, 960 Industrial Road, San Carlos, California 94070. Telephone: (415) 591-8411.

LITTON INDUSTRIES
ELECTRON TUBE DIVISION

EDITORIAL

Do you really want a-m/fm, ww, ps, pb and a/c when you buy a DVM?

As scientific as a digital voltmeter looks, the art of selecting one is completely empirical. Theoretically, the price and specs should correlate, which they do—but only to a point. And at that point the choice becomes all the more difficult.

Of course, dollars buy digits, but only to a very rough approximation. For example, 3-digit DVMs start at about $240, 4-digit DVMs at $420, and 5-digit DVMs don't start before the Purchase Requisition states $1250.

Unquestionably, among the maze of types, options, characteristics and prices, a DVM can be found to fulfill your special needs. The problem is to locate that unique DVM. To simplify this task, Steve Thompson (our Western Editor) has compiled a set of tables for 3-, 4-, 5- and 6-digit DVMs that will help you in the search. (You can find these on pages 69 to 73 of this issue.)

For example, if you are satisfied with 0.01% accuracy (± 1 digit) and a temperature coefficient of 0.001%/°C, your best bet is a 4-digit DVM. No matter how much you pay for the 4-digit DVM, whether $500 or $2500, the chances are that the specs we just mentioned will stay pretty much the same.

What, then, does that $2000 buy—since it won't buy better accuracy? Well, just as you decide to add tinted glass, air conditioning and a vinyl top to the base price of the car, here, also, the name of the game is options. That $2000 will buy options such as ac voltage measurements, ohms, ratio, current measurements, autoranging, programmability, special outputs for recorders, guarding, and, one of the most expensive options of all, battery operation.

That's where the problem begins. Today, when you shop for a DVM, you no longer compare just the performance of the basic DVM, but of the options. In other words, after a certain point you are no longer paying for primary specifications, such as the number of digits and accuracy, but for secondary specifications, such as measuring speed, common-mode rejection, overrange capability, and the rest. Most of these items are of secondary importance when the instrument is read by a human being, but these same specifications assume great importance when the DVM forms part of a system.

That's what the manufacturers have in mind when they ask you to "know your application" before you specify a DVM. Still, you should put the onus on the manufacturer to prove that all the specifications and features of the DVM he's trying to sell you for an extra $1000 are indeed useful for your application. If he cannot pass this test, look at Steve Thompson's tables and see who can.

Alberto Socolovsky
Editor

Minding our own business

Even though technical magazines such as this one normally stick to technical subjects (such as the one above), and mind their own business, I am taking this space to encourage you to express your opinion on the Vietnam problem.

Perhaps you did it during the "day of moratorium," last October 15. Or, perhaps you didn't, even though you have an opinion, because you resented being compelled to express it. Whether you raised the flag, or you lowered it to half staff, whether you meditated or participated, the country needs your intelligent opinion. Vietnam is very much our business. Or else, the intelligent signals will be hopelessly drowned in the din of unintelligent noise.

If you want to express a constructive opinion, use the democratic process. Write to your Congressman, and/or write to us at

EEs on Vietnam
The Electronic Engineer
Chilton Co.
Chestnut and 56th Sts.
Philadelphia, Pa. 19139

UP TO DATE

Low-cost optical document reader

The Univac 2703, reads numbers, symbols, and marks on "turn-around" (return stub) documents which are used in such applications as utility bills, insurance premium notices, and retail customer billing. Its functions as an on-line input device to a Univac 9000 computer which controls its operation, and processes and stores the data derived from documents.

The unit's basic speed is 300 six-inch OCR (optical character recognition) documents per minute. The speed can be increased to 600 OCR documents per minute by an optional speed-up feature. Character reading speed is 1,500 characters per second.

How it works

Documents enter the unit through an input hopper which holds about 2,000 items. On command from the central processor, the documents are aligned by canted revolving brushes and accelerated to a velocity of 150 ips.

As the documents pass a high-resolution solid state photoelectric scanning system, the printed OCR characters are converted into electrical pulses. These pulses enter the recognition logic section which determines what the character is and translates it into the appropriate digital code for transmission to the central processor. Reader recognizes zero to nine plus special marks, hand-printed vertical marks, and holes in punched cards. Documents are then routed to any of three carousel-type stackers through stacker vanes.

The optical document reader can read numbers, symbols, and marks at speeds of up to 600 documents per minute.

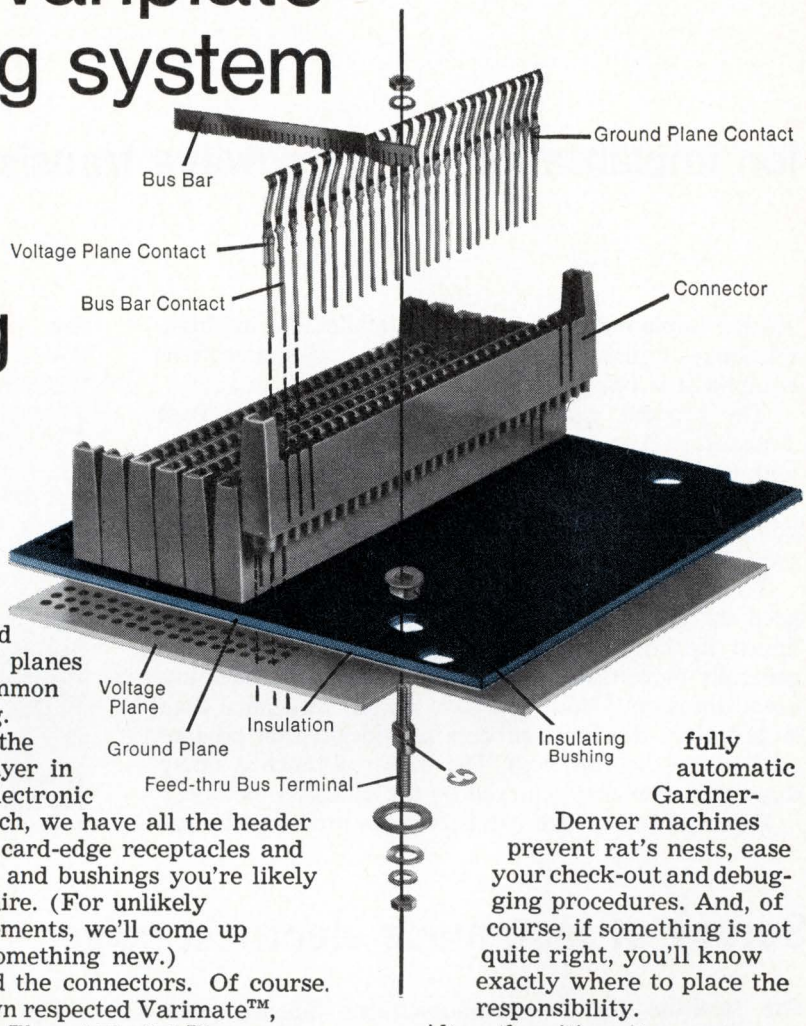
Metric system advisory panel formed

A newly formed Metric System Study Panel will serve as an advisory group to the Secretary of Commerce, the Director of the National Bureau of Standards, and the Metric System Study Group to receive and review periodic reports on the use of the Metric System.

The panel will review reports on the planning, conduct and progress of the study from the study group and advise the Secretary, Director, and the Study Group of their views and recommendations concerning the study. Likewise the final report to be submitted to Congress will be similarly reviewed by the panel for the endorsement or comment.

The Advisory panel will provide advice and information on the Study Group necessary for carrying out the various directives of the Act. The panel consists initially of 43 members representing a wide cross-section of industry and society ranging from agriculture to machinery, retail trade to construction, and consumers, to petroleum refining. Additional members may be added at the discretion of the secretary. (It certainly looks like they are serious about having us move to the metric system.)

How our Variplate™ connecting system keeps your fifty-cent IC's from becoming four-dollar headaches.



IC's don't cost much. Until you use them. You can buy, say 20,000 IC's for the innards of a compact computer, packed in the transistor cans, flat packs, or Dual-in-Line (DIP) packages, for a unit cost of less than fifty cents.

Great.

But then you have to connect them.

Not so great.

Because those 20,000 IC's have anywhere from 200,000 to 280,000 leads waiting to be connected. Fine leads. Closely spaced. And, of course, you want to pack the IC's as densely as possible. So it's really no surprise that your *in-place* cost of an IC can climb to $4.00.

Fortunately, we have a system that can keep your in-place cost down: the Variplate interconnection system.

With the Variplate system, you can pack those IC's—and all the pc boards and other components you have—as densely as the application demands. You can do it on automated equipment—and we'll even do the wiring for you.

All the components you need.

The system begins with the base plate, a self-supporting structural member. It carries the insulated contact modules, accommodates secondary components and hardware, and provides for mounting to support framework.

The plate can be a single metal sheet that provides a ground plane, or it can be a sandwich that provides both voltage and ground planes for common bussing.

For the next layer in your electronic sandwich, we have all the header plates, card-edge receptacles and guides, and bushings you're likely to require. (For unlikely requirements, we'll come up with something new.)

And the connectors. Of course. Our own respected Varimate™, Varicon™, and Varilok™ connectors, or standard fork-and-blade, terminal stud, card-edge, or bus strip contacts. Your choice.

No holes barred.

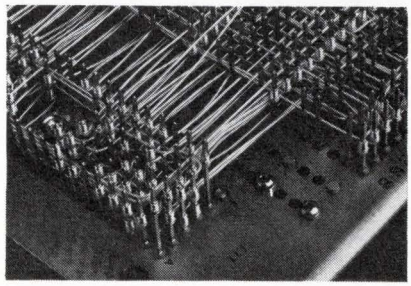
We put all these components together in any size, any shape, and almost any density of package you require. Plates can be any size. Contacts can be spaced on .100″, .125″, .150″, or .200″ centers, in square or offset grids—on non-standard configurations where you need them.

What you get is a solid electrical and mechanical foundation for your electronic network, so precisely made that any automated assembly equipment can take over from there.

However.

You'll save time and money if you let us go one step further and wire your network for you. Our fully automatic Gardner-Denver machines prevent rat's nests, ease your check-out and debugging procedures. And, of course, if something is not quite right, you'll know exactly where to place the responsibility.

Altogether, it's quite a system. And worth all the work we've put into it. Because if we can save you just a nickel on the cost of installing each of your 20,000 IC's you can add a thousand dollars to your company's profits.



We're sure we can save you that nickel, and more. For more information, write, wire, call, or TWX us for our Variplate interconnecting systems catalog. Elco Corporation, Willow Grove, Pa. 19090. 215-659-7000; TWX 510-665-5573.

ELCO Variplate Connectors

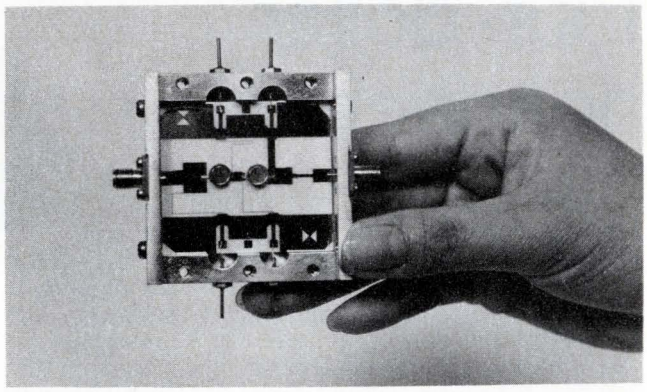
Ion implantation for microwave transistors

An ion-implantation technique for manufacturing high-efficiency transistors for microwave communications equipment is being used by Toshiba, Japan.

The process, called "IBT" (Ion-Implantation Base Transistor Technology), ionizes and accelerates boron and phosphorous atoms with voltages up to several hundred kilovolts and implants them into a single semiconductor crystal. (For more on ion implantation, see page 68 of our January, 1969 issue.)

To achieve high-performance, microwave transistors need extremely thin, low-resistance bases. Bases produced by conventional planar diffusion methods are generally more than 0.15 micron in thickness, have unusual diffusion effects, and have greater resistance than is desirable. Toshiba's process provides a thin base of 0.05 micron in thickness. The base resistance is many times less than that achieved by the diffusion method.

Experimental microwave transistors produced by the new system provide 9 GHz cut-off frequency, 9 dB power gain, and 4 dB noise figure in the 4 GHz band. Better results are expected in the near future.



Two high-efficiency transistors produced by ion implantation are shown in a microwave amplifier.

Survey of man-made electrical noise

The Institute for Telecommunications Sciences and Aeronomy (ITSA) and the General Electric Company conducted a survey aimed at improving the available data on the expected man-made noise levels in populated areas. This man-made noise is the chief determinant of the signal quality of urban voice-broadcasts at frequencies from hf to uhf.

In this survey, the output of a narrow-band receiver was fed to a group of level detectors that recorded the number of times the noise exceeded certain levels. This data lets you compute the amplitude distortion of the noise. Because the narrow bandwidth of the receiver makes the noise pulse-width essentially constant, the average noise power can be calculated from the amplitude distortion.

The survey, conducted at several sites in the New York City-New Jersey metropolitan area, was aimed at augmenting and verifying existing data at hf and vhf and obtaining basic data at uhf.

The absence of intentionally generated signals about a particular frequency determined at which frequencies the tests would be run. These were about 20 MHz for hf, 109 MHz for vhf and 800 MHz for uhf. The tests measured both true and weighted rms values.

The survey consisted of three phases. The first was preliminary field measurements during which data collection techniques were established. The second phase was the formal data gathering tests and the third consisted of data compilation and reduction.

The results of the survey show that a wide range of noise levels can be expected in urban areas. The noise tends to increase as population increases, however the relationship is weak. Rather, the noise level appears to be more closely related to the proximity of main and secondary thoroughfares.

Documentation on the survey is available from: Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. The reference number is TSP-10308 and price is $3.00.

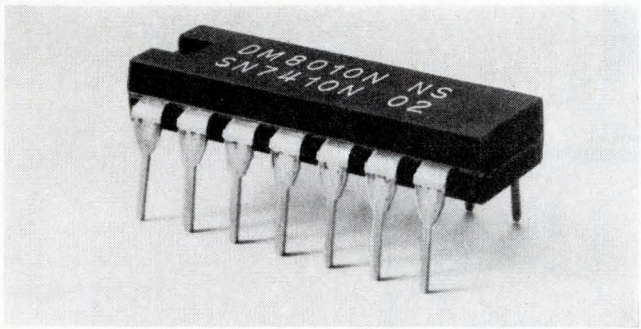
New aircraft electronics reports

The Radio Technical Commission for Aeronautics has approved the third and fourth of a series of reports for aircraft sharing the common airspace, and using the Nation's air traffic control system. One new RTCA document (DO-140) deals with Airborne Area Navigation Systems; the other (DO-141), with Airborne DME Systems. This series of RTCA documents is a fresh approach to the long-standing problem of developing minimum requirements for airborne systems.

Copies of the documents No. DO-140, minimum operational characteristics for Airborne Area Navigation Systems, and DO-141 on Airborne DME Systems, are available at $3.00 each from the RTCA Secretariat, 2000 K Street, N.W. Washington, D.C. 20006.

Why National Semiconductor buys Teradyne J259's by the dozen

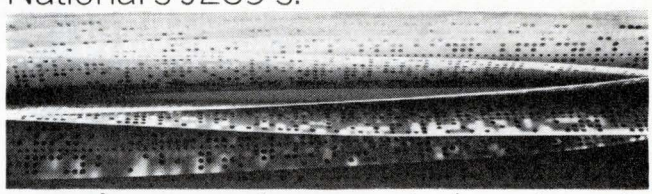
National Semiconductor can trace its considerable success as an IC manufacturer to many factors. One of the most important is the productivity of its testing facility, built around a lineup of 12 Teradyne J259 computer-operated test systems. "The Teradyne systems," according to Jeff Kalb, National's TTL product manager, "give us the economy of testing that is so important to profitable high-volume production."



National, along with most other major IC producers, has found that the J259 boosts productivity in many ways. No other test system, for example, gives its user as much multiplexing freedom as does the J259, which lets National leverage its investment by making each J259 support several test stations doing several different jobs.

Reliability is another all-important key to productivity. National experiences minimal downtime with its J259's. This is as it should be; we design and build our equipment to work shift after shift, year after year, in *industrial* use. Teradyne systems are right at home on production lines like National's, where the workload is heavy and continuous. And operation never has to be interrupted for calibration; the J259 has no calibration adjustments.

The J259's great versatility is also put to good use at National. The same systems that test wafers and packages also generate the distribution and end-of-life data that engineers need to control production processes and ensure high device reliability. Production, engineering, QC, and final test – all share simultaneously in the benefits from National's J259's.



A computer-operated system is only as good as its software, which in the case of the J259 is the best there is. National's J259's are orchestrated by Teradyne-supplied master operating programs for datalogging, classification, and evaluation. As Teradyne updates and improves its software, National is kept fully informed.

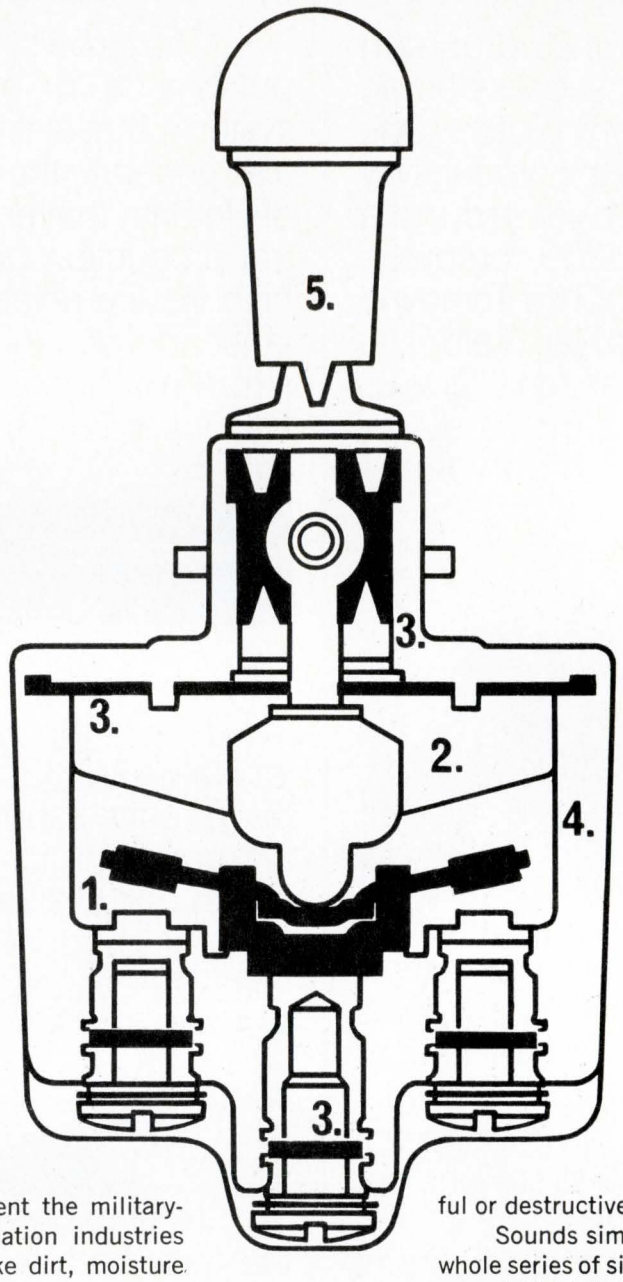
National's array of J259's handle the testing of its digital IC's smoothly and economically. For its linear-IC testing, National has turned to Teradyne's J263 computer-operated linear-IC test system.

Teradyne's J259 makes sense to National Semiconductor. If you're in the business of testing circuits – integrated or otherwise – it makes sense to find out more about the J259. Just use reader service card or write to Teradyne, 183 Essex St., Boston, Mass.

Teradyne makes sense.

Circle 12 on Inquiry Card

Before we seal our TL toggle switches, we make sure they're worth sealing.



Consider all the punishment the military-aerospace and commercial aviation industries give a toggle switch. Things like dirt, moisture and severe operating environments.

Well, MICRO SWITCH has a device that can take it all. Our TL.

Small wonder it's in wide use.

Just take a look at the new contact configuration (**1**). Any trouble here and the entire switch is out of whack. So we improved our silver cadmium oxide contacts to provide better toggle action and more positive detent in center position. Then made them larger to improve mating capability.

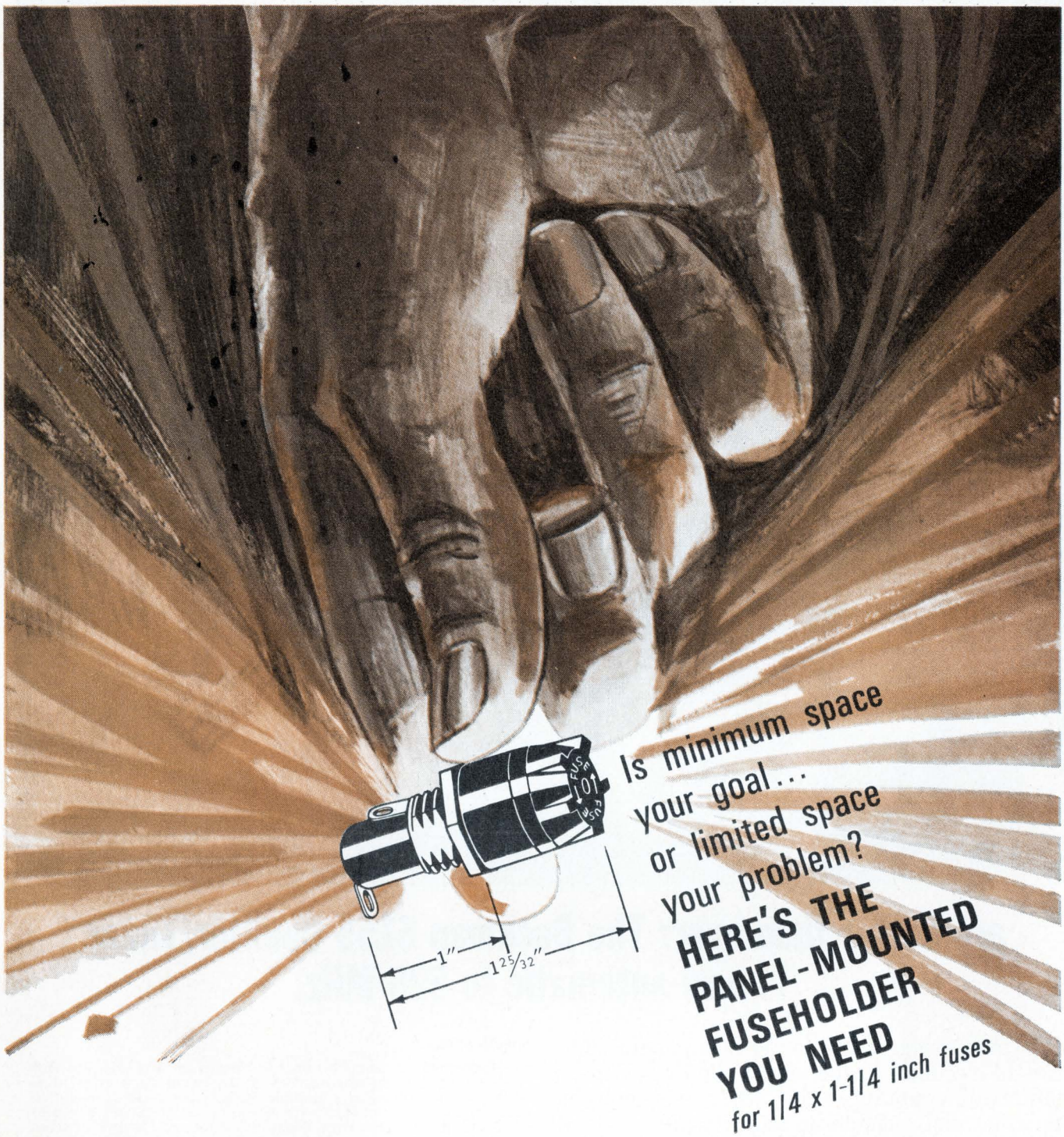
A sealed switching chamber (**2**) protects the contacts from pressure variations, moisture and most other harmful or destructive contaminants.

Sounds simple, but to make it work takes a whole series of silicone elastomer seals (**3**). And a special high-impact, arc-resistant case (**4**) that's able to withstand temperatures from −85°F to +160°F. Together, they meet the requirements of MIL-S-3950.

TL switches are available in 1, 2, or 4-pole circuits. In 2 and 3 position with momentary or maintained action and special "on-on-on" circuits. And with standard or "pull-to-unlock" levers (**5**).

It's all in Catalog 52. Plus a lot more. You can get a copy from your MICRO SWITCH Branch Office or Distributor. (They're in the Yellow Pages under "Switches, Electric.") Or drop us a line and we'll rush one to you. In a sealed envelope, of course.

MICRO SWITCH
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL



Is minimum space your goal... or limited space your problem? HERE'S THE PANEL-MOUNTED FUSEHOLDER YOU NEED

for 1/4 x 1-1/4 inch fuses

The BUSS HTA fuseholder measures only 1-25/32 inches in overall length and extends behind the face of the panel only one inch.

The holder features the popular bayonet type knob. A strong coil spring inside the knob assures good contact when the fuse is inserted into the holder. If a test hole in the knob is needed, a breakaway hole can be punched out to allow use of a test probe.

Rugged in construction to withstand vibration and shock, the HTA fuseholder can also be furnished with a special washer to make it drip-proof from the front of the panel. And the best feature of the HTA fuseholder is that it has *famous built-in BUSS quality*. You can't get it anywhere else.

For more information on the HTA fuseholder, or anything else in the complete line of BUSS small dimension fuses, fuseblocks, and fuseholders, write for BUSS Bulletin SFB.

Bussmann Mfg. Division
McGraw-Edison Co.
University at Jefferson
St. Louis, Mo. 63107

SUPPLIED THE ECONOMICAL WAY . . . THRU DISTRIBUTORS
BUSS QUALITY FUSES

are better than ever: The Beckman 6155 Counter/Timer is now automatic to 525 MHz.

Beckman brings you a brand new plug-in addition to its counter...the Model 606 Prescaler for automatic counting to 525 MHz. No knobs to turn; no dial numbers to add. Results are read directly on the 6155's display, with direct BCD output of the total count.

If you buy a "plug-in" counter because you need expandability, today or tomorrow, Beckman offers a complete line of plug-ins today—*and* continues to provide *new expandables* for tomorrow's needs.

For complete information, contact your local Beckman office, sales representative or the factory direct.

Specifications

Model 6155 *Measurement Modes:* Frequency: 100 MHz (to 12.4 GHz with optional plug-in). Period: To 100 ns (to 1 ns or 10 ns with optional plug-in). Multiple Period Averages: 1 to 10^5 in decade steps. Ratio: X/Y with X = 0 to 100 MHz and Y = 0 to greater than 1 MHz. Pulse Width & Separation: (To 1 ns or 10 ns with optional plug-in). Voltage & Current: (Optional plug-in). Scaling: By decades up to 10^9. *Crystal Frequency:* 1 MHz. *Stability:* Better than 3 parts in 10^9 per 24 hours. (5 parts in 10^{10} per 24 hours optional). *Output Frequencies:* 0.1 Hz to 10 MHz in decade steps selected by front-panel TIME BASE selector. *External Frequency:* 1 MHz, 1V rms into 1000 ohms required at rear-panel BNC connector. *Display:* 8 inline digits of glow-tube display, 9th digit optional. *Signal (X input) Sensitivity:* 100 mV rms. *Digital Output:* Fourline, 1-2-4-8 BCD output at rear panel. Output compatible with Beckman 1453 Digital Printer. *Power:* 115/230 Vac, 50 to 400 Hz, 80 W. *Size:* 5¼ in. high, 16¾ in. wide, 19 in. deep. *Weight:* 30 lbs. *Price:* $2,450.

Model 606 *Frequency Range:* 1 MHz to 525 MHz. *Sensitivity:* 50 mV rms. 10 Volts rms (max.) or 50 Volts Peak. *Impedance:* 50 Ω. *VSWR:* ≤ 1.2. *Price:* $525.

Beckman® INSTRUMENTS, INC.
ELECTRONIC INSTRUMENTS DIVISION
RICHMOND, CALIFORNIA • 94804

INTERNATIONAL SUBSIDIARIES: AMSTERDAM; CAPE TOWN; GENEVA; GLENROTHES, SCOTLAND; LONDON; MEXICO CITY; MUNICH; PARIS; STOCKHOLM; TOKYO; VIENNA

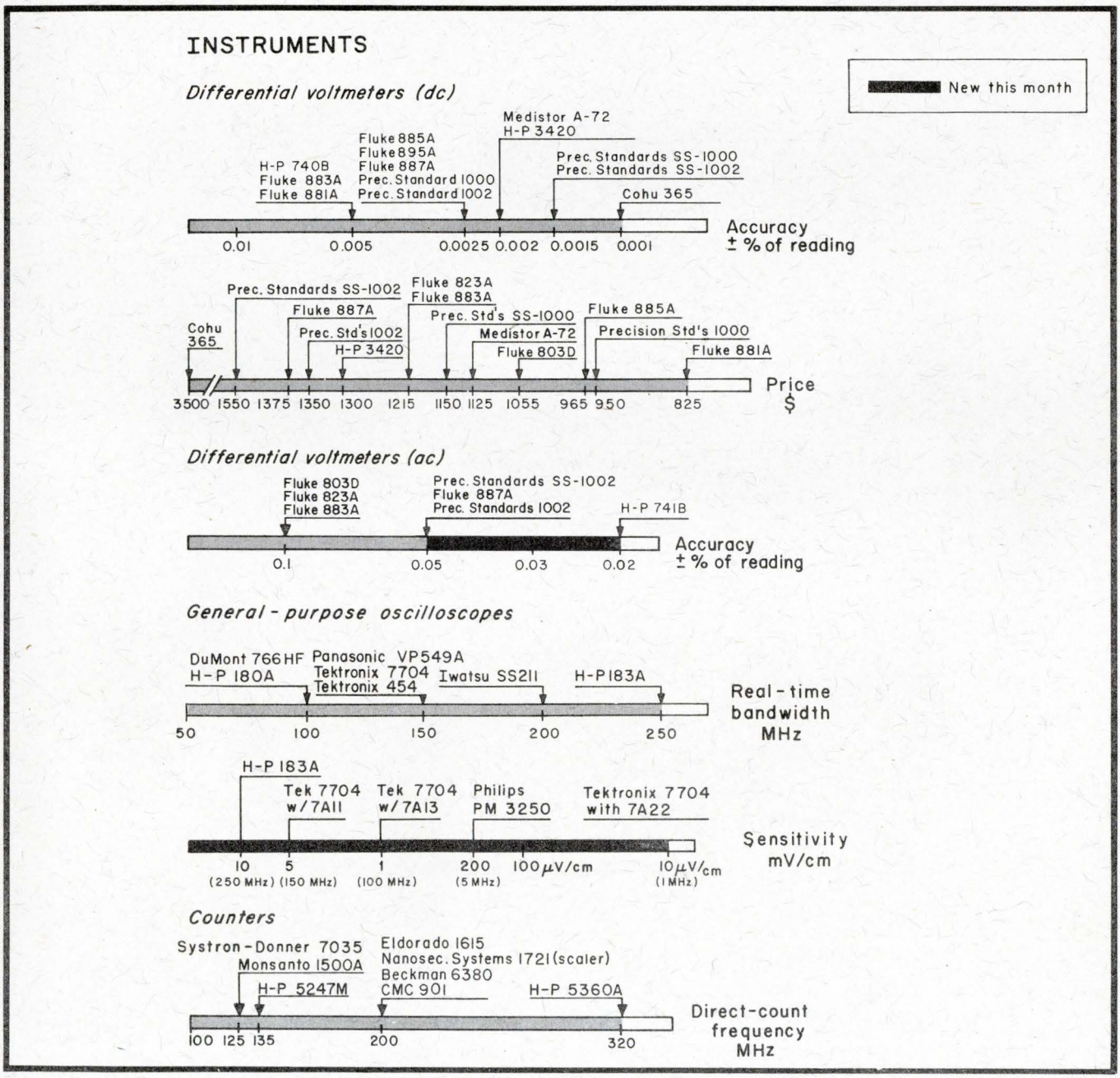
FOREFRONT

The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

A word of caution

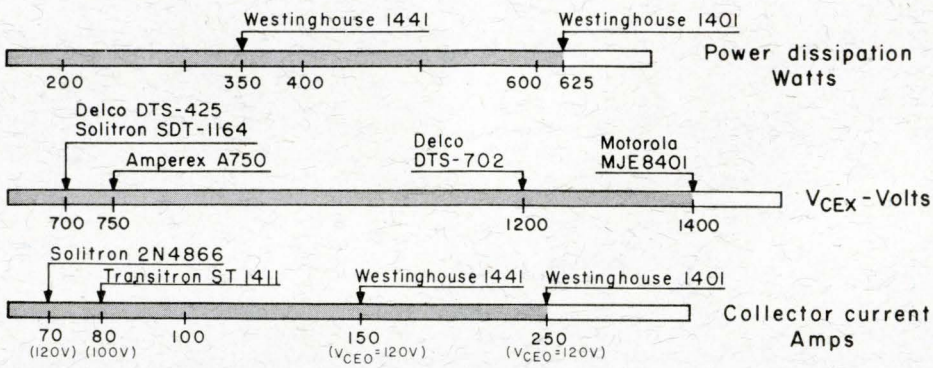
Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.

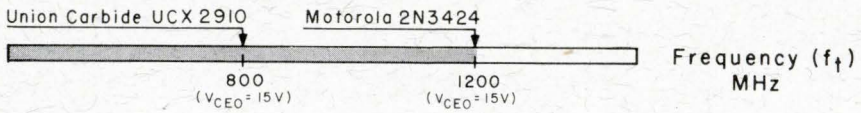


SEMICONDUCTORS

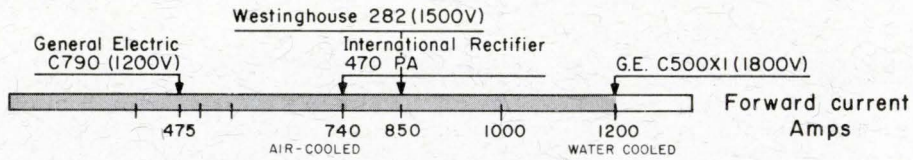
Silicon power transistors (npn)

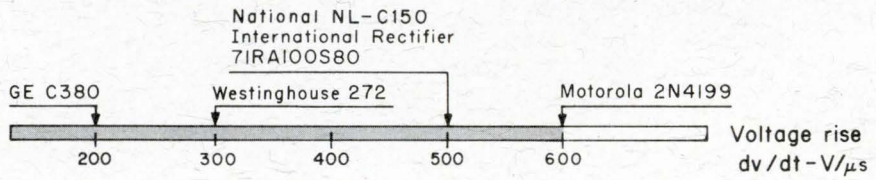


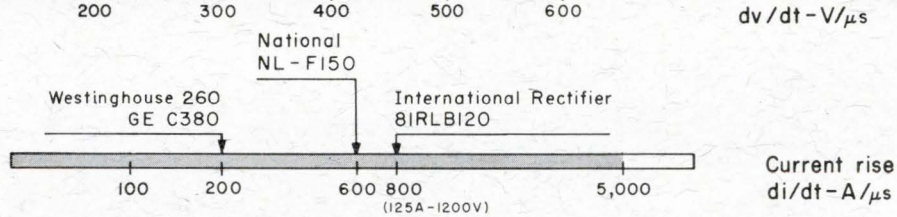
Dual bipolar transistors



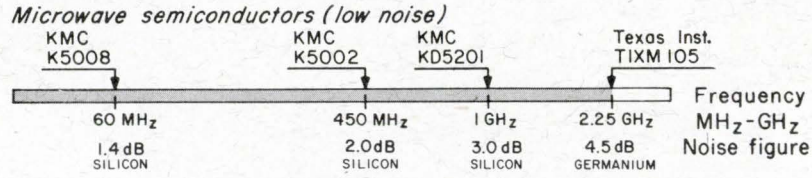
Thyristors



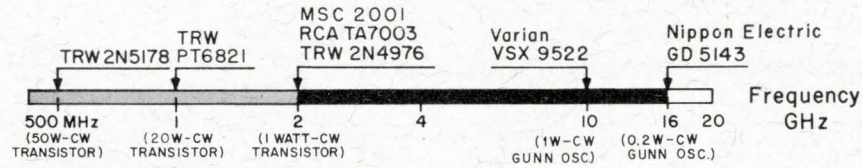




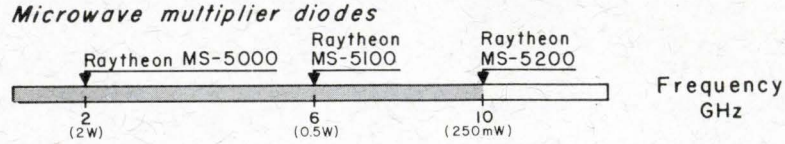
Microwave semiconductors (low noise)



Microwave semiconductors (power)



Microwave multiplier diodes



SSPI announces the world's first high-voltage transistors designed for power switching.

Now, let's make something out of it.

Like, say, a high-voltage circuit with about half as many components.

Because we now offer you power-switching transistors that sustain up to 325 volts, guaranteed high speed switching (total turn-on turn-off time of less than a microsecond) and throw in saturation voltages less than .4 volts at three amps in the bargain.

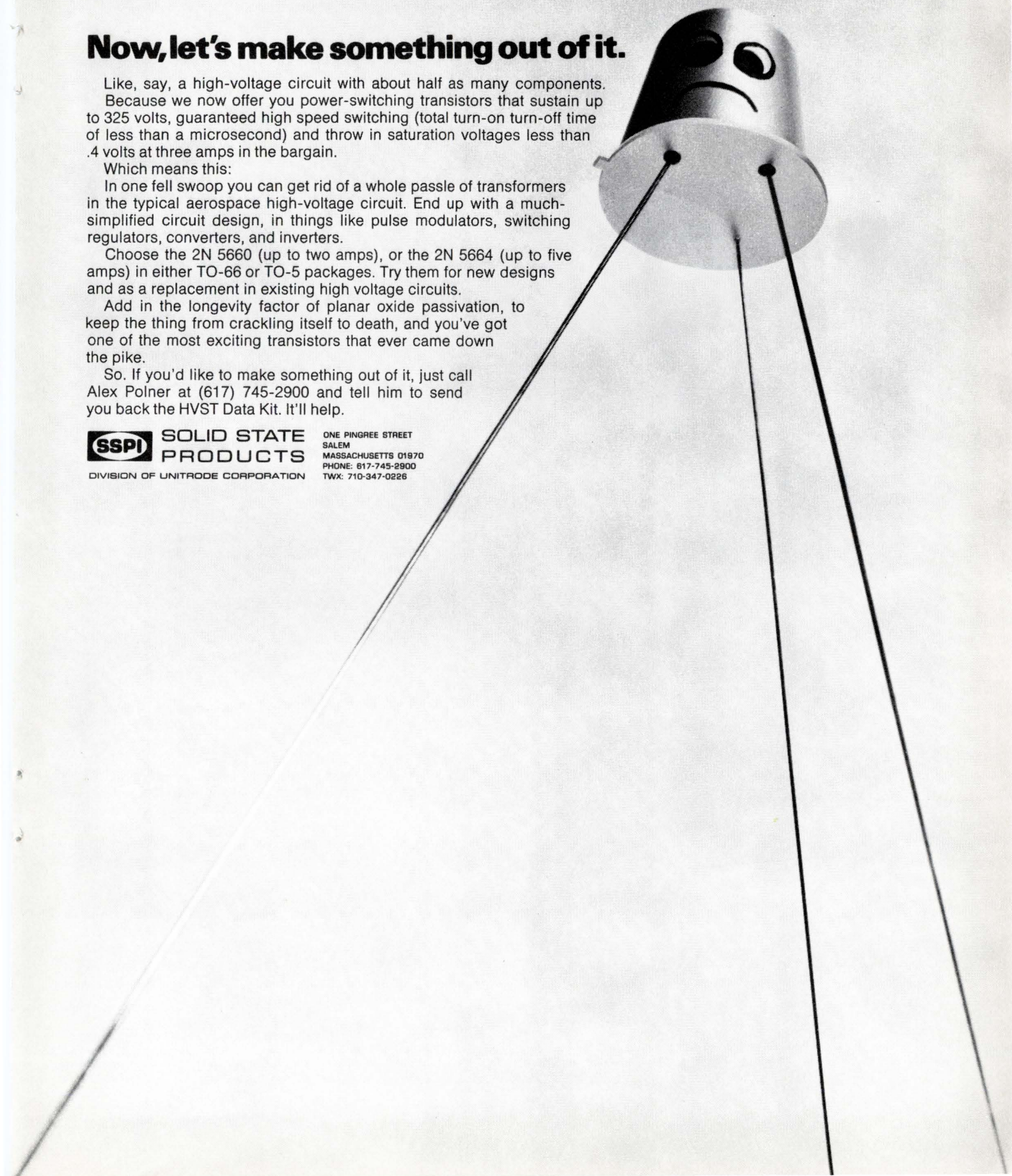
Which means this:

In one fell swoop you can get rid of a whole passle of transformers in the typical aerospace high-voltage circuit. End up with a much-simplified circuit design, in things like pulse modulators, switching regulators, converters, and inverters.

Choose the 2N 5660 (up to two amps), or the 2N 5664 (up to five amps) in either TO-66 or TO-5 packages. Try them for new designs and as a replacement in existing high voltage circuits.

Add in the longevity factor of planar oxide passivation, to keep the thing from crackling itself to death, and you've got one of the most exciting transistors that ever came down the pike.

So. If you'd like to make something out of it, just call Alex Polner at (617) 745-2900 and tell him to send you back the HVST Data Kit. It'll help.



SSPI SOLID STATE PRODUCTS
DIVISION OF UNITRODE CORPORATION

ONE PINGREE STREET
SALEM
MASSACHUSETTS 01970
PHONE: 617-745-2900
TWX: 710-347-0226

Circle 17 on Inquiry Card

THE WESTERN COLUMN

To share or not to share

Timesharing, which some predict will be a one-billion-dollar industry by 1973, has given the industry its share of problems as well as problem-solving. To many, the decision for going with an in- or out-house capability represents a costly, and potentially repercussive, decision.

To help you make this decision, Honeywell is holding timesharing seminars around the country, centered around their entry into the field, the H1648.

At one of the seminars, Allen Hammersmith, president of Time-Sharing Enterprises, pointed to the fast growth of timesharing. As evidence, he said that there are now 138 companies in the timesharing services business. Six months ago the market was divided as follows:

GE	40%
SBC	19%
Call-a-computer	7%
Com-share	6%
Tymshare	5%
Allan Babcock	3%
All others	20%

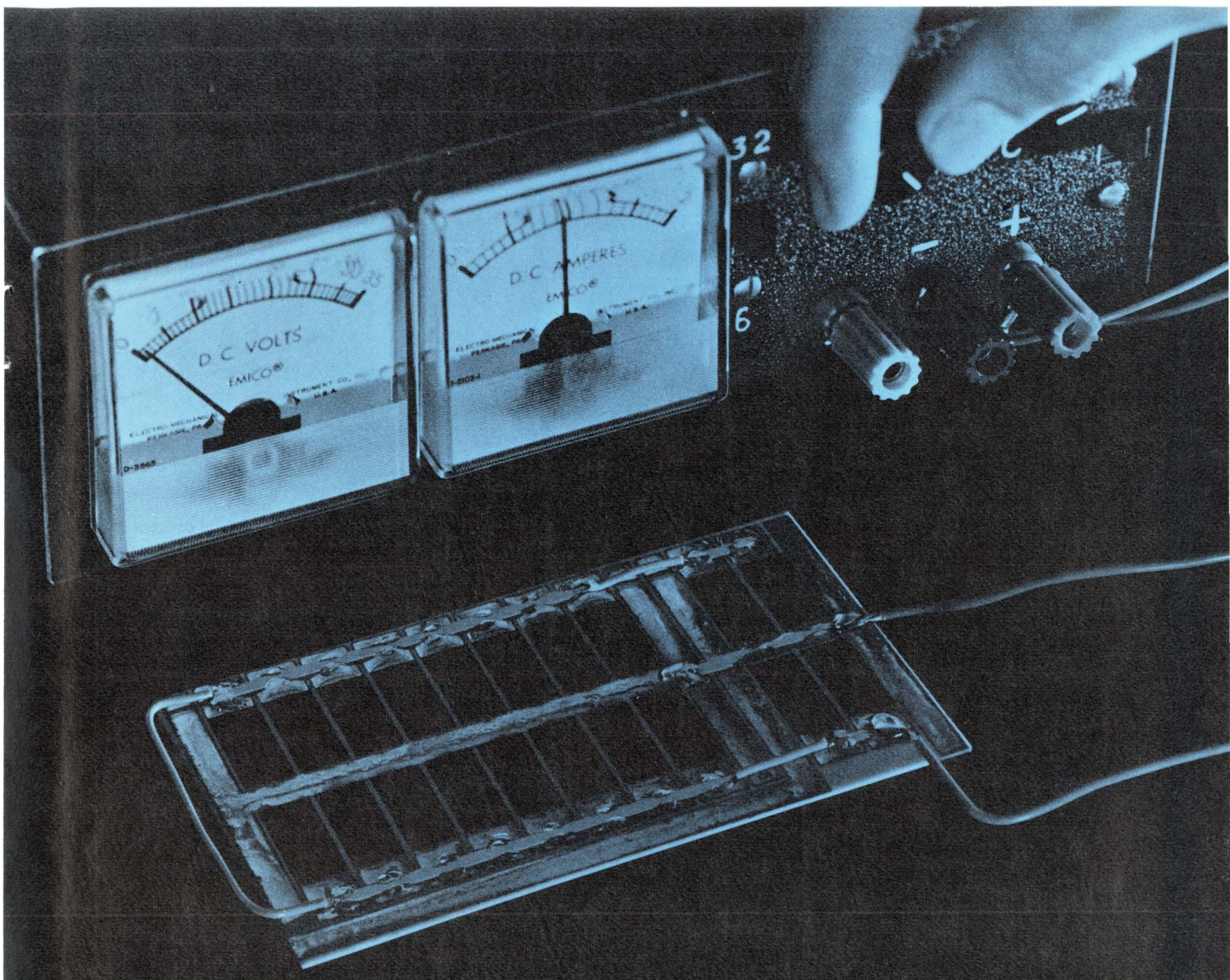
Mr. Hammersmith cautioned users not to install an in-house system, unless they have experience with timesharing. His advice is that the uninitiated should subscribe to a service and gain familiarity with timesharing and its limitations before selecting a system. The out-house system would also give him a quicker startup and probably be more reliable.

He also warned against trying to rewrite or modify the software of the in-house system, and against justifying the purchase by assuming that your excess capacity could be sold on the outside. The competition from the other 138 companies is formidable. Further, since no system can solve all problems, be prepared for some of your people to continue using outside services in some areas.

As a rule of thumb for when to purchase an in-house system, John Taft—vice-president of Honeywell's Computer Control Division—suggests that you should consider it only if your terminal costs are running at $8,000 per month or more.

Stephen A. Thompson, Western Editor

Circle 18 on Inquiry Card ⟶



Dale puts the power in thick film networks

Dale makes thick film R-C networks as standard as this dual in-line package and as small as this 1/4-inch square model.

Within this broad capability we've become known as power specialists. Our ability to work with substrate, heat sink, package density and all the other network variables lets us deliver the power you need—in the size you need. "Big" jobs like the one shown above (5" x 2-1/2", 20 resistors, 60 watts) don't scare us a bit. Whether your next network is tremendous or tiny, give us a shot at it.

PROTOTYPES ON MOST DESIGNS IN LESS THAN THREE WEEKS... Call 402-564-3131 for complete details or write for Catalog A.

GENERAL NETWORK SPECIFICATIONS

Temperature Coefficient: ±250 PPM max. from −55°C to +150°C. T.C. as low as ±50 PPM in limited resistance ranges.

Tolerance: Standard ±10%. As low as 1% when required.

Power Loading: 16 watts/in.^{2} standard with aluminum oxide substrate .015"-.040" thick. Substantially higher with heat sinking and beryllia substrates.

Terminations, Conductors and Land Areas: Platinum gold, palladium gold, gold and silver, depending upon application. Crossovers can be made. Lands for attaching active or passive components can be provided.

Moisture Changes: Meet Method 103, MIL-STD-202.

Resistor Patterns: Thick film resistive materials with resistivities from 1 ohm/sq. to 1 megohm/sq. can be used. Patterns can be made from 1/10 square to 10 squares.

Capacitors: Screened = .01 μfd/in.^{2}; Chip = up to 5 μfd ±10% to ±20% or GMV. Dissipation Factor = Less than 1.5%. Working Voltage = 50.

Packaging: Dual-in-line packaging can be used with plated Kovar or other types of leads. Also conformal coatings can be applied to modules with wire or ribbon leads. Screened and cured silicone coatings can be used to protect specific areas of the circuit.

DALE ELECTRONICS, INC.
1372 28th Ave., Columbus, Nebr. 68601
In Canada: Dale Electronics Canada, Ltd.
A Subsidiary of The Lionel Corporation

DALE®

see our data in VSMF VISUAL SEARCH MICROFILM FILE

CALENDAR

NOVEMBER

9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Nov. 18-20: Fall Joint Computer Conf., Las Vegas Conv. Ctr., Las Vegas, Nevada. Addtl. Info.—AFIPS Hdqs., 210 Summit Ave., Montvale, N.J. 07645.

Nov. 18-21: Conf. on Magnetism & Magnetic Materials, Benjamin Franklin Hotel, Phila., Pa. Addtl. Info.—J. D. Blades, Franklin Inst. Res. Labs., Phila., Pa. 19103.

Nov. 20-21: Assembly of the Radio Tech. Comm. for Aeronautics, Marriott (Twin Bridges) Motel, Washington, D.C. Addtl. Info.—Radio Tech. Comm. for Aeronautics, 2000 K St., N.W., Washington, D.C. 20006.

DECEMBER

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Dec. 8-9: Symp. on Consumer Electronics, Conrad Hilton Hotel, Chicago, Ill. Addtl. Info.—C. Hepner, Zenith Radio Corp., 6101 W. Dickens Ave., Chicago, Ill. 60639.

Dec. 8-10: National Electronics Conf. & Exhibition, Conrad Hilton Hotel, Chicago. Addtl. Info.—Oakbrook Exec. Plaza #2, 1211 W. 22nd St., Oak Brook, Ill. 60521.

Dec. 8-10: Int'l Symp. on Circuit Theory, Mark Hopkins Hotel, San Fran., Calif. Addtl. Info.—R. A. Rohrer, Fairchild Semicond., 4001 Junipero Serra Blvd., Palo Alto, Calif. 94304.

Dec. 8-10: Third Annual Conference on Applications of Simulation, International Hotel, Los Angeles, Calif. Addtl. Info.—Arnold Ockene, Simulation Associates, Inc., 600 N. Broadway, White Plains, N.Y. 10600.

Dec. 8-10: IFIP Conference on Computer Management '69, Manchester, England. Addtl. Info.—Prof. Malcolm H. Gotterer, Computer Science Dept., Penn. State Univ., 426 McAllister Bldg., University Park, Pa. 16802.

Dec. 10-12: Conf. on Reliability in Electronics, London, England. Addtl. Info.—IEE, Savoy Palace, London W. C. 2 England DL 4-1-69.

JANUARY

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Jan. 14-16: 3rd Hawaii International Conference on System Sciences, Honolulu, Hawaii. Addtl. Info.—Dr. Richard H. Jones (HICSS), Info. Science Program, 2565 The Mall, University of Hawaii, Honolulu, Hawaii 96822.

Jan. 25-30: 1970 IEEE Winter Power Meeting, Statler Hilton Hotel, N.Y. Addtl. Info.—W. C. Hayes, Publicity Chairman, 1970 Winter Power Meeting, 33rd St. & 7th Ave., N.Y., N.Y. 10017.

Jan. 27-29: Reliability Symposium, Ambassador Hotel, Los Angeles, Calif. Addtl. Info.—W. R. Abbott, D60-01/B104, Lockheed Miss. & Space Co., POB 504, Sunnyvale, Calif. 94022.

'69-'70 Conference Highlights

NEC—National Electronics Conference & Exhibition, Dec. 8-10; Chicago, Ill.

IEEE—Institute of Electrical and Electronics Engineers Int'l Convention & Exhibition, March 23-26; New York, New York.

WESCON — Western Electronic Show and Convention, Aug. 25-28; Los Angeles, Calif.

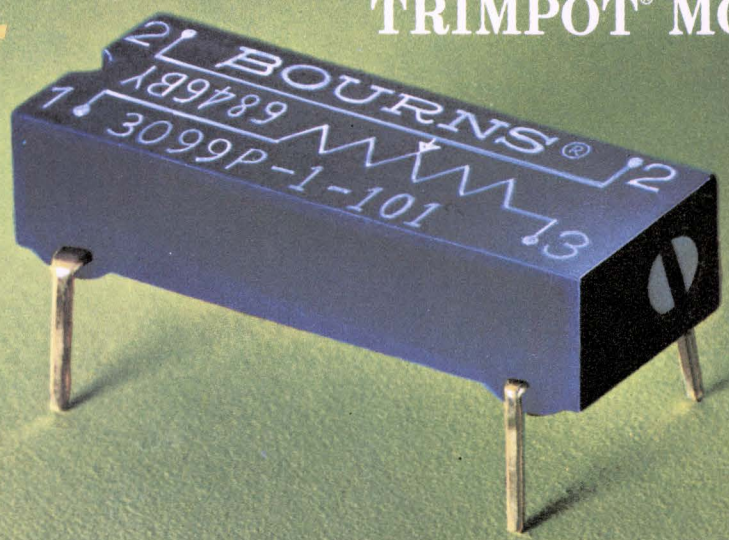
Call for Papers

Apr. 7-9: IEEE Reliability Physics Symp., Las Vegas, Nevada. Submit ten copies of both a 30-50 word abstract and a 300-500 word extended abstract appropriate to a 20-minute paper stating: (1) the purpose of the work, (2) how much it advances the art, and (3) what results have been obtained. Send these on or before **Dec. 1, 1969,** to Dr. K. H. Zaininger, Tech. Prog. Chairman, 1970 Reliability Physics Symp., RCA Laboratories, Princeton, N.J. 08540.

Apr. 1-2: Symp. on Submillimeter Waves, N.Y. Submit a 500 word abstract by **Dec. 1, 1969** to Prof. Benjamin Senitzky, Chairman of the MRI Symp. Comm., Polytechnic Institute of Brooklyn MRI Symp. Comm., 333 Jay St., Brooklyn, N.Y. 11201.

1st DUAL IN-LINE CERMET POTENTIOMETER

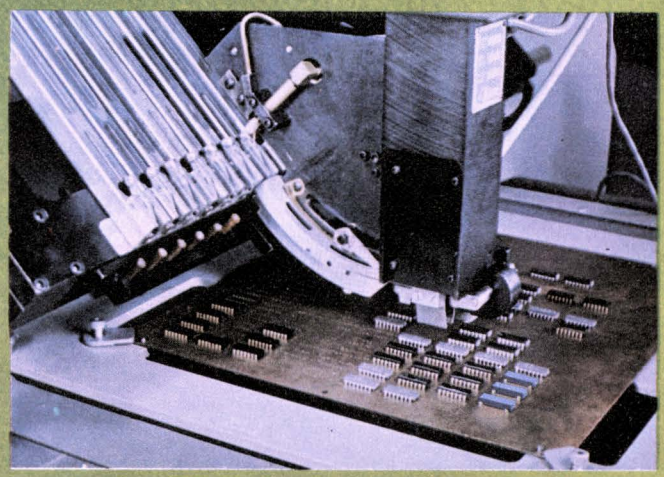
TRIMPOT® MODEL 3099



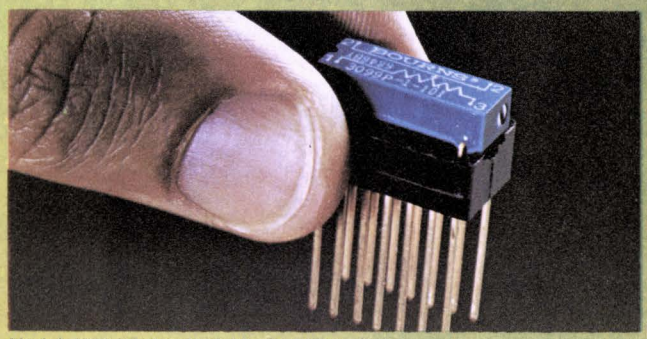
Designed for Automated Insertion . . . TC 100 PPM / °C over entire resistance range of 10 ohms to 2 megohm!

The new Trimpot Model 3099 dual in-line cermet element potentiometer has standard DIP construction with a TO-116 case. Today's ever-accelerating computer industry requires dual in-line components for socket or modern state-of-the-art automated assembly. The Model 3099 utilizes this mounting and is completely compatible with manual or automatic insertion equipment.

Let us tell you the complete technical story on this newest potentiometer innovation in the industry! For full details on the Model 3099, please contact the factory, your local field office or representative!



Model 3099 is designed for use with DIP automatic insertion equipment.



Model 3099 in standard 14 pin DIP socket.

BOURNS

BOURNS, INC,. TRIMPOT PRODUCTS DIVISION
1200 COLUMBIA AVENUE, RIVERSIDE, CALIFORNIA 92507
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COURSES

Design/Fabrication: Nov. 17-Dec. 12, $10,000. Each student will design and fabricate his own IC to his circuit requirements. Laboratory, materials and technicians will be provided. Intensive class sessions and ICE's Process Compendium containing complete procedures and recipes for all IC processing techniques are included in this course open to all engineers familiar with basic solid-state theories. Harold Bell, ICE Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018.

Image Storage and Transmission for Libraries: Dec. 1-3, Gaithersburg. NBS Office of Technical Information and Publications, Room A500/101, Washington, D.C. 20234.

Integrated Circuit Engineering Course: Dec. 1-4, Phoenix, $500. Features latest state-of-the-art techniques. Seminar Registrar, ICE Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018.

Computer Aided Design: Dec. 2-4, Miami Beach, $395. Opportunity to participate in actual computer-aided design sessions using terminals for remote access to time-sharing computers. John Stockwell, Seminar Mgr., McGraw-Hill Book Co., 330 W. 42nd St., New York, N.Y. 10036.

Failure Analysis: Dec. 5-6, Phoenix. $275. Through the use of equipped laboratories, the attendees obtain first-hand experience by observation and operation of the fabrication equipment. Seminar Registrar, ICE Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018.

Extrusion Principles & Practices: Dec. 8-12, N.Y.C., (Hotel Manhattan). The course will provide personnel with an understanding of phases of extrusion operations including production, theory, materials, applications and design. Fran Zimmer, International Plastics Industry Consultants, Inc., Hotel Manhattan, New York, N.Y. 10036.

Computer Control: Dec 11-12, University of Wisconsin, Madison, $70.00. Designed to provide engineers, programmers and managers with a summary of the current state-of-the-art along with economic guidelines for successful control computer applications. David P. Hartmann, Institute Dir., 725 Extension Bldg., 432 N. Lake St., Madison, Wisc. 53706.

No other multimeter gives you all this

and no one but Cimron can make a claim like that stick

Here's the first and only 4-digit instrument that you can take with you and hook up for full multimeter performance anywhere. Cimron, the Customer Concern Company, puts your needs first. That's why this new Cimron 6453 is just one more the competition will have to catch up with.

You get the most advanced MSI and IC construction plus a thin film attenuator . . . which, by the way, eliminates 75% of the normal calibration requirements. Single plane Digivac readout tubes result in the lowest power consumption of any digital multimeter, and make full-day battery operation possible. The same amplifier used in the most costly instruments provides an input impedance ten times greater than any meter in its class.

The basic instrument gives you 5 ranges of DC voltage measurement with 5th digit overrange, autoranging in all functions, autopolarity, and pushbutton selection. Add remote control, AC, resistance, print output and the 8-hour battery pack options, and you have full remote programming capability anywhere. And it's computer compatible. The 6453 . . . just 8 pounds and 3½″ × 8″ × 12″, sells for only $1,125. A full multimeter is less than $1,600. *Call us for a demonstration.* Phone (714) 276-3200 or write Cimron, Dept. D-112, 1152 Morena Blvd., San Diego, Cal. 92110.

CIMRON
first name in measurement

LEAR SIEGLER, INC. / *CIMRON DIVISION*

Circle 22 on Inquiry Card

Let TI's special HI-REL Task Force take you through the turbulent sometimes uncharted universe of MIL-STD-883.

We'll keep you on course.

Scout's honor.

Others have called 883 a lot of confusion, a mixed bag, and even "unprintable words."

But we have tried to keep our mouth shut, our shoulder to the centrifuge, and our nose to the stress levels.

While our best minds solved the problems.

Quietly, TI has committed itself to 883. Money, manpower and facilities.

And we're ready to deliver "in accordance to MIL-STD-883."

In fact, we've been delivering 100% tested ICs for years. Millions of them for Minuteman, Sprint, Poseidon, F-111 and other programs.

And some of these had even tighter requirements than 883!

From this experience, TI has organized special HI-REL Task Forces to help you meet 883. A special Task Force has been created for DTL, another for linear, and the one pictured here for TTL ICs.

Its members are some of TI's top managers in the areas of reliability engineering, process engineering, product sales, military marketing, product planning, product engineering, quality control engineering, manufacturing and HI-REL assembly.

They're specialists in Series 54 and 54H TTL ICs, now available from TI in both flat pack and ceramic dual-in-line packages... standardized for 883 Classes A, B and C.

The Task Force's assignment starts with your problem: determining the specific test procedures and levels you'll need to satisfy 883 requirements.

Once the most practicable test plan has been devised, the Task Force sees it through. Thousands of TI personnel in many departments may be involved in your program, but the Task Force is responsible for its success.

Task Force members can cross departmental boundaries, step on toes and crack bottle necks, if need be, to keep your program on target.

In addition, you have the industry's best test facilities going for you at TI... from more than 50,000 burn-in sockets to environmental shake, rattle and roll labs, to IR scanners, microprobes, Radiflo and variable data loggers.

One thing more.

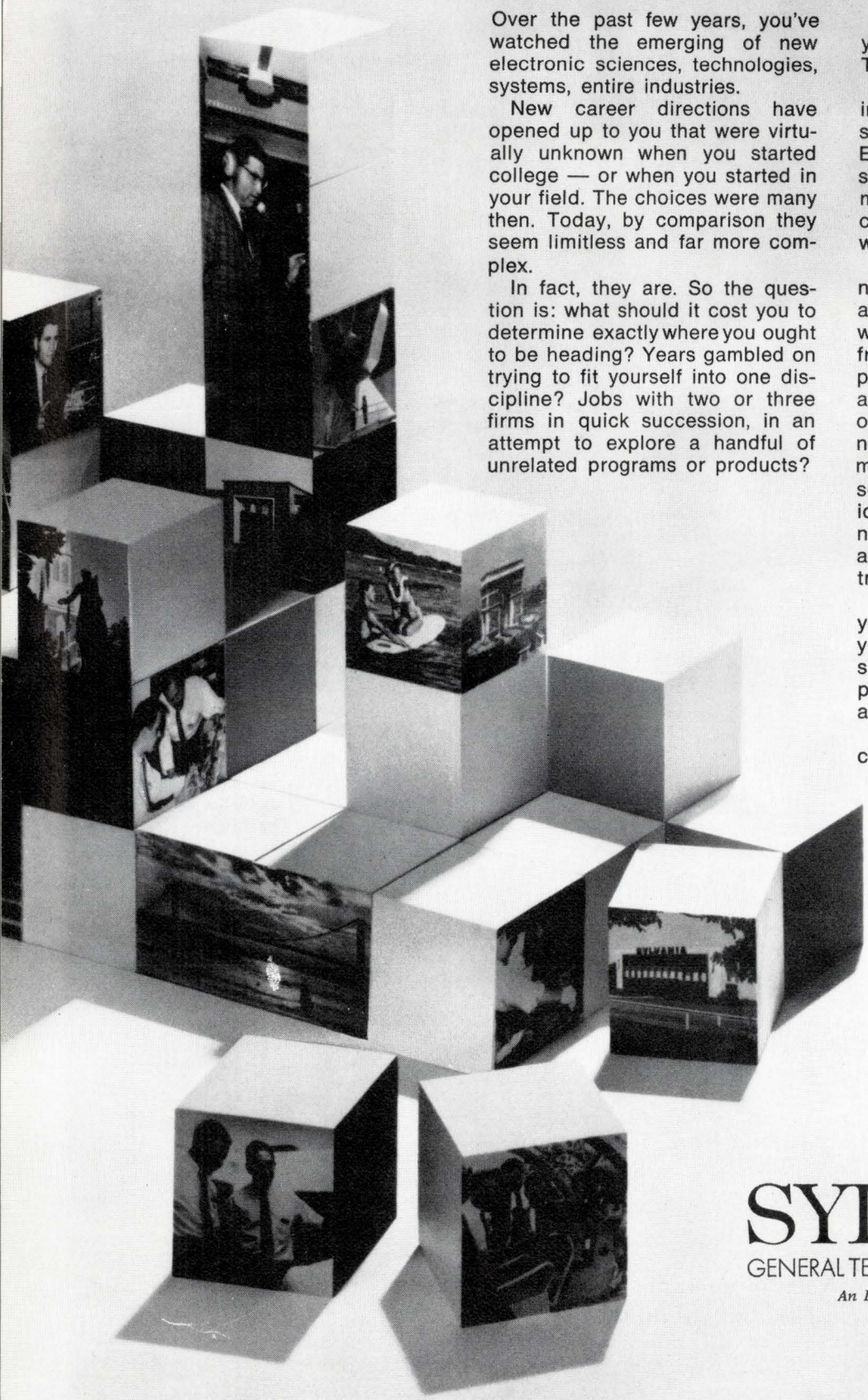
TI has prepared a comprehensive 40-page procurement specification incorporating MIL-STD-883 – supplemented by 100 pages of detailed product specifications. From your first source for TTL ICs.

Use it to plot your course, and TI's HI-REL Task Force will keep you on it. Scout's honor.

Write for "MACH IV High Reliability Procurement Specification MIL-STD-883." Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222. Or just circle reader service number 107.

TEXAS INSTRUMENTS
INCORPORATED

Sylvania Electronic Systems offers you everything to build a career with. At one time. In one company.



Over the past few years, you've watched the emerging of new electronic sciences, technologies, systems, entire industries.

New career directions have opened up to you that were virtually unknown when you started college — or when you started in your field. The choices were many then. Today, by comparison they seem limitless and far more complex.

In fact, they are. So the question is: what should it cost you to determine exactly where you ought to be heading? Years gambled on trying to fit yourself into one discipline? Jobs with two or three firms in quick succession, in an attempt to explore a handful of unrelated programs or products?

At Sylvania Electronic Systems, you don't have to do *either.* Why? Take a brief look at who we are . . .

We're an operating group within Sylvania Electric Products — a subsidiary of General Telephone & Electronics Corporation. We handle systems management for GT&E's major Government projects, and coordinate the defense systems work for other GT&E subsidiaries.

To do this, we have our own national network of 20 laboratories and 4 manufacturing plants. And we can muster men and facilities from the corporation's 150,000 people (including 6,500 engineers and scientists), 71 plants, 39 laboratories, 30 domestic and international operating companies. This makes us a focal point for the full scope of advanced GT&E electronics activity, from satellite communications systems to helicopter avionics to computer-controlled training systems.

Right now, with one company, you can evolve a direction for yourself through day-to-day, shirtsleeves contact with a mix of men, programs and objectives as broad as contemporary electronics itself.

We won't ask you to choose a career with Sylvania Electronic Systems. You don't have to. We simply offer you everything you need to find the *right* career . . . and everything to build it with.

For more information, please write to Manager, Professional Staffing, Dept. 1014, Sylvania Electronic Systems, Group Headquarters, 40 Sylvan Road, Waltham, Mass. 02154.

SYLVANIA

GENERAL TELEPHONE & ELECTRONICS

An Equal Opportunity Employer

At the outset of technical editing

Don't fight your technical editor. Work together with him from the beginning, and you will produce a paper well written and technically clear.

By Eldred E. Atkins, Engineering Writer, Laboratory Communications, IBM Systems Development Div., Rochester, Minn.

Have you ever wondered why a perfectly logical and straight-forward manuscript you submitted to "publications" five weeks (or five months) ago is returned—beautifully "laid out"—but:

- Topics are "transmogrified"!
- Illustrations don't show what they used to—or don't show anything!
- Text and conclusions aren't related—in fact, they don't even agree!
- Conclusions intended aren't mentioned!
- Once deathless prose is dead!

It is easy to blame the much-maligned technical editor for such transgressions. But he is there to help—not to botch your job. By following the suggestions below, you can make his (and your) job easier—and the results will be well worth the effort.

When you are ready to send a draft to the Publications Department, ask yourself these questions:

- What is the central theme of your report (paper, article, speech, etc.)? Does all of the text relate to the intended message?
- Have you covered your central theme, so that you don't have to recall your report—half through the reproduction process—to write a different conclusion, or even a conclusion?
- Are text and figures, as well as the various parts of complex figures, properly related? Do figures support rather than subvert the central message?

Your friendly technical editor

What's a technical editor, you might ask? Well—in some companies he's the guy who takes your often-handwritten, uncohesive, confusing inputs to technical reports, progress reports, proposals, papers—just about anything of importance that you write—and puts them all together in a form the reader (if there ever is one) can understand.

To him, and to all authors who work with him, is this article dedicated. If writing is part of your next project, we hope that the insights provided here will promote good will and timeliness throughout the publication process.

■ Have you verified the accuracy of all quoted material and cited references—as well as full titles and peculiar spellings—which the editor cannot check without extensive research?

■ Have you discussed your text with the editor so that the final version is compatible with your initial intent? The editor will refine whatever text he receives, but he needs some author's direction at the outset.

An early get-together

For best results, set up an engineer-editor conference as early as possible—ideally when the paper is still an idea. Such an early get-together is valuable for several reasons.

First, the engineer and editor can—from the beginning—establish a good working relationship. A much-edited text returned to an engineer sometimes sets off an explosive reaction. If you realize early that the editor wants only to improve *what* and *how* you write, a potentially strained relationship will become a friendly, mutually advantageous effort.

Second, your paper, if intended for a particular journal or audience, may need a different slant from that found in the first draft. Early recognition and agreement on the paper's style will prevent subsequent misunderstanding and duplication of effort.

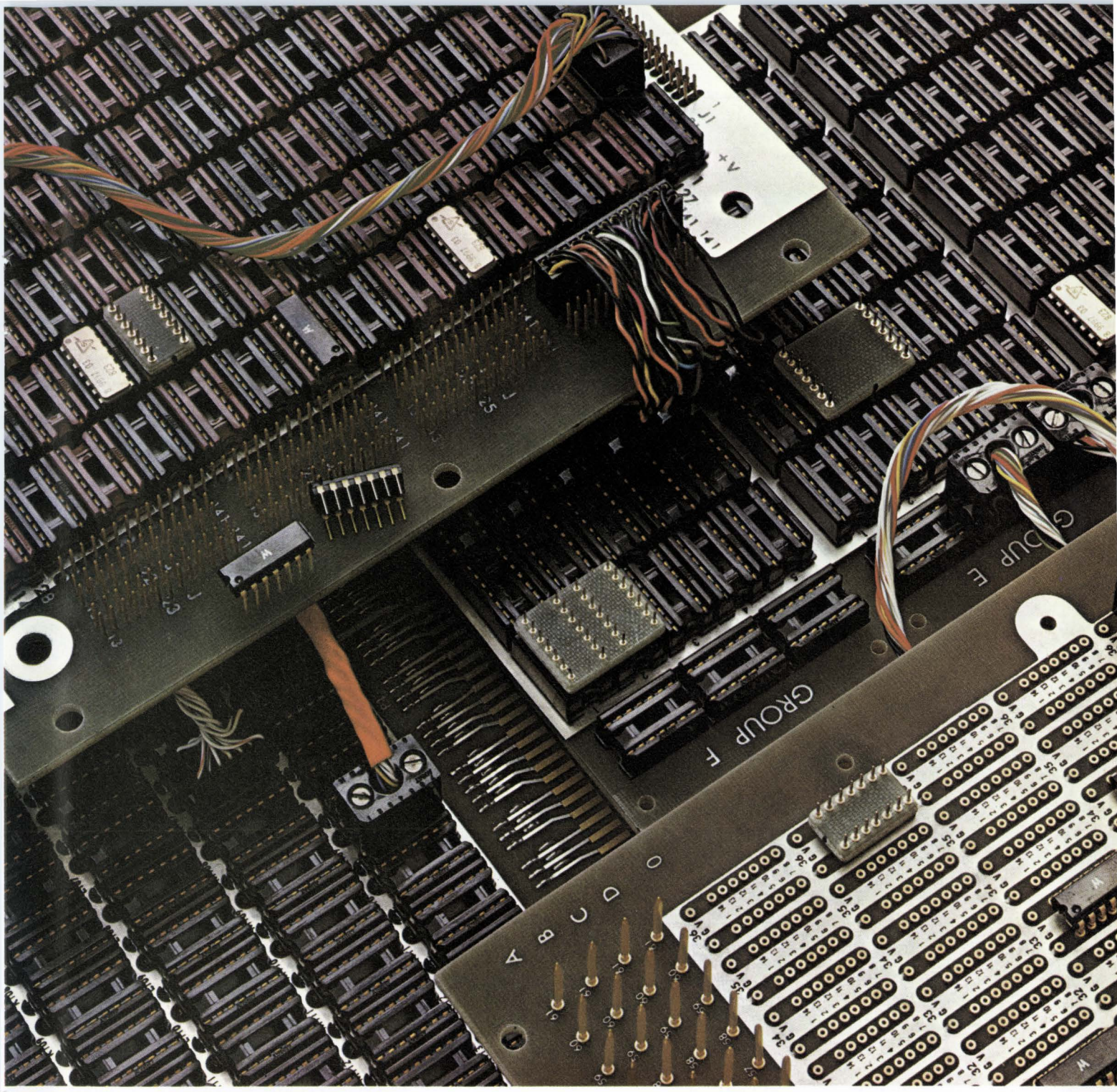
Third, if the editor has a brief outline of what you intend to say—before you say it—he can review this and perhaps suggest a reorganization or a shift in emphasis that will strengthen the paper.

Fourth, an *early* engineer-editor conference will let you set up a schedule for publication. Engineers often don't realize how much time it takes to rework retype, reviews, make all required changes, secure illustrations or photographs, prepare a bibliography, and print the document. If the paper must meet a deadline, substantial leadtime is mandatory.

Patience and prudence

When you seek editorial help, probably the most important asset you can have is **patience.** If you realize that you know much more about the subject than the editor does, the battle is half won. If you recognize that he knows more about the publishing process than you do, the other half is won. Finally, if you meet with the editor early, on equal terms, there will be no battle at all. Your teamwork will produce the highest quality document in the shortest possible time—all because a little extra effort was expended at the **outset** of technical editing.

INFORMATION RETRIEVAL
Careers



Innovation in IC packaging panels

Let Augat provide flexibility, reliability and fast turn around time you need

You can have increased flexibility — and save time, space and money — with Augat's unique 2-dimensional approach of packaging IC's on a point-to-point basis. And regardless of the size of package, Augat can design and produce the panels and peripheral hardware to solve your most difficult packaging problem.

In addition to standard panels, modifications can be made to your specification without premium charge: Standard sockets and connectors, providing excellent lead retention, low contact resistance, and long life reliability are used on all panels.

Illustrated are four methods of input-output connections. These are available on virtually any size or shape panel required to fit your existing cabinets, racks and drawers. Variations in contacts and materials permit unusual pricing flexibility.

Why wait. Call Augat for fast proposal and delivery. Tel: 617/222-2202 or write for our complete IC folder. Augat, Inc., 39 Perry Ave., Attleboro, Mass. 02703.

AUGAT INC.

Circle 26 on Inquiry Card

PRODUCT SEMINARS

This column lists product seminars that electronic companies offer to users of their products.

Operation and Maintenance 7600 Magnetic Tape System: Dec. 1-5, Denver, Colo., $180. To prepare the operator/technician for operation, calibration and repair of the complete tape system. The seminar requires a strong background in electronics repair with emphasis on solid state circuitry. Honeywell, Test Instrument Div., 4800 E. Dry Creek Rd., Denver, Colo. 80217.

Circle 415 on Inquiry Card

Resistance Welding and Reflow Soldering: Dec. 2, $5. Observations of various equipment operations to promote knowledge of procedures and techniques for implementing process control. The seminar covers welding fundamentals and techniques, metallurgical considerations, and soldering and packaging techniques. Unitek/Weldmatic Div., 1820 South Myrtle Ave., Monrovia, Calif. 91016.

Circle 416 on Inquiry Card

Real-Time Sound and Vibrations Measurements: Dec. 2-3. The real-time analyzer, its theory, operation, and applications; ancillary support equipment, analysis systems, and use of the instrumentation computer. General Radio Co., West Concord, Mass. 01781.

Circle 417 on Inquiry Card

Wideband Cable Transmission Systems: Dec. 3-5, Atlantic City, N. J., $3. Includes lectures and discussions on wire insulation systems, cable construction, shielding materials, and related developments for electronic use. Jack Spergel, co-chmn., U. S. Army Electronics Command, Fort Monmouth, N. J. 07703.

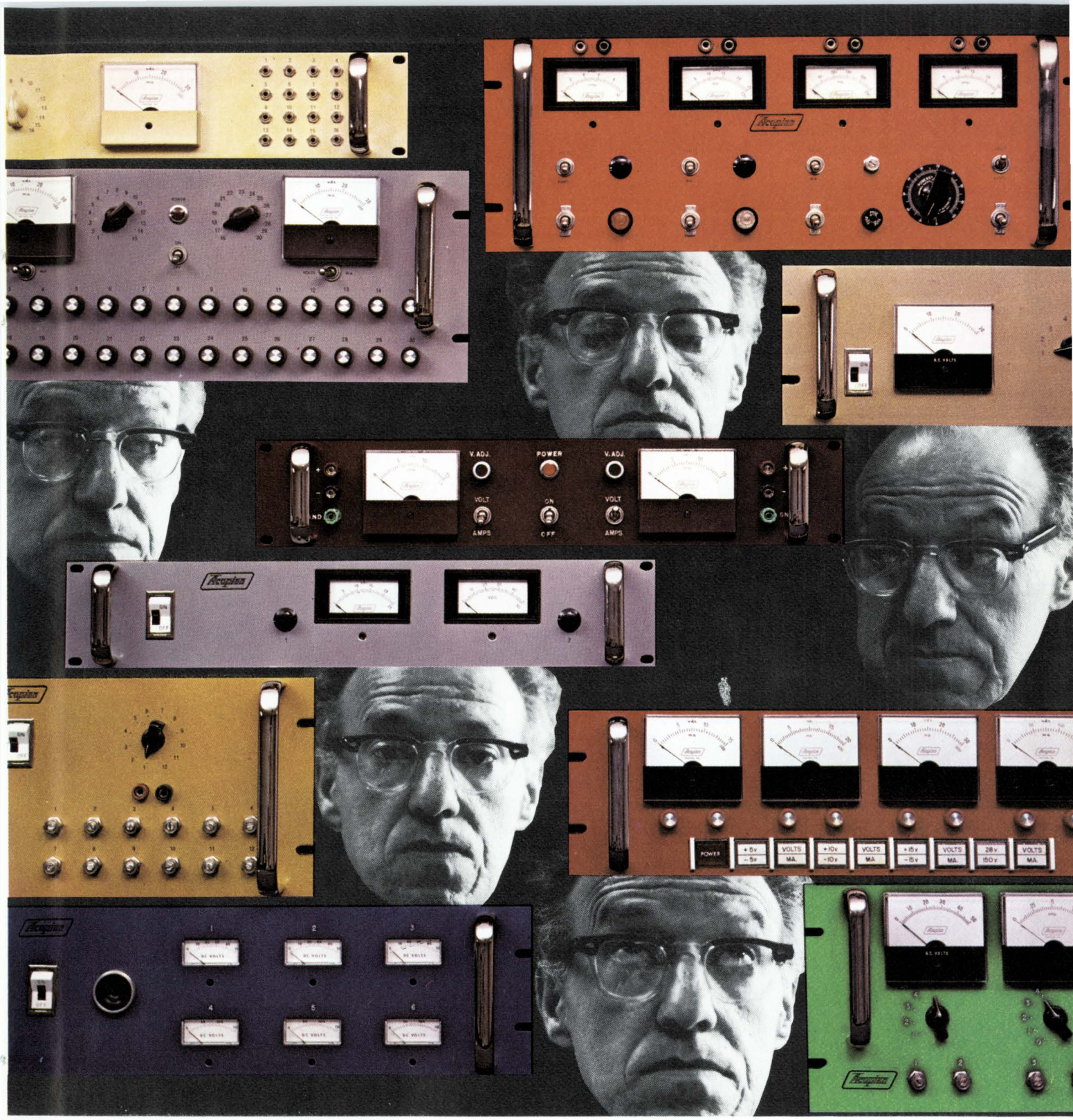
Circle 418 on Inquiry Card

Instrumentation for Industrial Measurement and Control: Dec. 8-19. The application, installation and maintenance of L&N products used for industrial measurement and control in the basic industries area. Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454.

Circle 419 on Inquiry Card

Communications ICs Application Seminar: Feb. 17, Phila., Pa. The day before the International Solid State Circuits Conference The Electronic Engineer magazine will sponsor a seminar highlighted in the morning by six papers on the new ICs for communication (i-f limiters, agc amplifiers, rf amps, etc.) and in the afternoon by a "hands on" workshop session. For information, price and registration forms

Circle 420 on Inquiry Card

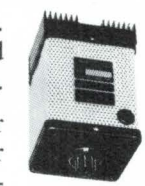


Looking for a special power supply system? Acopian will ship it in just 9 days!

When you're looking for a multiple-output power supply system, and you need it in a hurry, look no further. Acopian will design it, build it, test it, and ship it...fully wired...*in just 9 days!*

Call 'hot line' 215-258-5441. Simply tell us the DC voltages and currents you need. We'll discuss—on the phone—the power modules, the panel size, accessories such as meters, terminations, test jacks, rotary switches or any other feature you feel is important. Then—on the phone—we'll give you a firm price—and get the order going for guaranteed 9-day shipment.

Others make promises. Acopian makes power supplies. Power modules in 3 days, and now power systems in 9 days. For immediate service, call 215-258-5441. For literature, write Acopian Corporation, Easton, Pa. 18042.



Acopian

Circle 28 on Inquiry Card

HICKOK DMS 3200

DIGITAL MEASURING SYSTEM

(Fully solid state with IC's)

This all-solid-state precision measurement system offers unlimited expansion capability through plug-in additions, resulting in a specialized instrument for each type of measurement. New plug-ins now broaden the measurement capability of this field-proven unit. Over 10,000 are in use at present.

Scaling controls make possible resolution of up to seven digits on the three-digit display by utilizing the overrange capability of many of the plug-ins, thus providing high resolution and accuracy with minimum investment. Companion devices such as the PR 4900 Digital Printer and 1050 Digital Set-Point Controller further extend the utility of the DMS 3200 System.

DC VOLTMETER PLUG-IN DP 100 **$175**
00.1 mv to 999. volts
± 0.1% rdg ± 1 digit

DC MICROVOLTMETER PLUG-IN DP 110 **$475**
0.001 mv to 999.9 volts
± 0.05% rdg ± 1 digit
4-digit resolution

AC VOLTMETER PLUG-IN DP 130 **$395**
0.01 mv to 999. volts
± 0.1% rdg ± 1 digit
22 Hz to 1.0 MHz

EVENT COUNTER/SLAVE PLUG-IN DP 140 **$100**
Up to 1,000,000 counts/sec
Cascade with second DMS to obtain 6-digit display

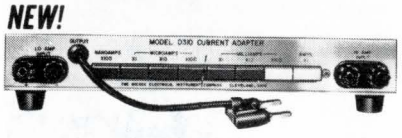
1 MHz COUNTER PLUG-IN DP 150A **$255**
00.1 Hz to 999. kHz
± 0.0005% rdg ± 1 digit
7-digit resolution

80 MHz COUNTER PLUG-IN DP 160 **$395**
00.1 Hz to 80.0 MHz
± 0.00005% rdg ± 1 digit
7-digit resolution

OHMMETER PLUG-IN DP 170 **$295**
.001 ohm to 999. megohms
± 0.1% rdg ± 1 digit
Microamp test current

CAPACITY METER PLUG-IN DP 200 **$295**
.001 picofarad to 9,999 mfd
± 0.1% rdg ± 1 digit
Low DC test voltage

TIME INTERVAL METER PLUG-IN DP 210 **$295**
0.01 ms to 999. seconds
± 0.0005% rdg ± 1 digit
Period or time interval



DC CURRENT METER ADAPTER D 310 **$100**
.0001 microamp to 9.99 amps
± 0.15% rdg ± 1 digit

HICKOK ELECTRICAL INSTRUMENT COMPANY, 10514 Dupont Ave., Cleveland, Ohio 44108

Here is your copy of a brand new reference chart

Guide to MICROWAVE SEMICONDUCTOR POWER GENERATORS

Tear it out, NOW . . . and mount it on your wall

If the chart has been removed, Circle Number 41 on the Inquiry Card for a copy.

READ THESE BOOKS

Electronics: BJTs, FETs, and Microcircuits

By E. James Angelo, Jr. Published 1969 by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036. Price $13.50. 630 pages.

Because electronics is such a fast changing field, textbooks must constantly be revised and updated. The relatively recent rise of MOSFETS, bipolar junction transistors, and integrated analog circuits have created a new need for a basic text explaining their operation and application. This book fills that need.

This book is meant primarily as an introductory text for a college course in electronics. However, it could very well serve as an up-to-date source of self-instruction for the practicing engineer who wants to acquire a basic analytical knowledge of modern electronics.

Condensed Computer Encyclopedia

By Philip B. Jordain. Published 1969 by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036. Price $14.50. 605 pages.

Forget how an Accumulator works? Want to know a little about PL/1? This book answers those questions and a thousand more.

Here is a perfect up-to-date guide for those who come in contact with a computer. It fills the gap between elementary computer dictionaries and complicated computer manuals. A fine reference for the business man, junior programmer, or student as well as for the experienced computer specialist. A complete index supplements the alphabetical arrangement of entries.

The Oscilloscope—New Third Addition

By George Zwick. Published 1969 by Tab Books, Blue Ridge Summit, Pa. 17214. Price $4.95 for paperback.

Introduction to the Theory of Linear Systems

By E. A. Faulkner. Published by Barnes and Noble Inc. 105 Fifth Ave., New York, NY 10003. Price $3.25. 89 pages.

Audio Systems Hand Book

By Norman H. Crowhurst. Published 1969 by Tab Books, Blue Ridge Summit, Pa. 17214. Price $4.95 paperbound. 192 pages.

17th Annual National Relay Conference Proceedings

By the National Association of Relay Manufacturers, P.O. Box 1649, Scottsdale, Arizona 85252. Price $5.

Computer-Aided Design of Magnetic Circuits

By Alexander Kusko and Theodore Wroblewski. Published 1969 by the MIT Press, 50 Ames Street, Cambridge, Mass. 02142. Price $6.95. 113 pages.

Electron Optics

By B. Paszkoski. Published 1969 by American Elsevier Publishing Co., Inc., 52 Vanderbilt Ave., New York, N. Y. 10017. Price $13. 305 pages.

WELCOME

This column welcomes new companies or new divisions in the electronics industry.

Microwave semiconductor source

Microwave Semiconductor Corp., headed by former engineers of RCA's Electronic Components, is presently offering high frequency power transistors and has recently begun production on a line of microwave solid state components. Its products include a 1-W, 2-GHz power transistor (with strip-line configuration), and a solid state noise source.

The MSC 2010, 10 W-2 GHz transistor is the highest power 2.0 GHz transistor presently available. The complete line of transistors is recommended for radar, ECM, communications, and telemetry applications.

This noise source has an octave bandwidth, from 2 to 4 GHz, and sells for $450 in quantities of 1-9. Other salient features include an excess noise ratio greater than 30 dB, temperature stability of 0.01 dB/°C. It needs a 28-V supply, and draws less than 30 mA.

While its production will center around the above devices, the new company will try to make power transistors with higher frequencies and power, step recovery diodes and eventually microwave ICs. It also thinks about supplying transistor chips to those involved in producing microwave ICs.

A spokesman for Microwave Semiconductor Corp. stated that major companies have sampled the new firm's wares. He feels that their strip-line ceramic package, which is hermetically sealed is both attractive and practical.

How did they fund the new semiconductor firm? From private investors —organized by the Wall Street Venture Capital Corp.

Circle 412 on Inquiry Card

Filling the custom ICs vacuum

Dionics, Inc., located in Westbury, L.I., is a new firm involved in supplying dielectric isolation material to IC manufacturers in addition to producing dielectric isolation components and ICs. Full operations began in July, 1969.

The company, financed by a closed investment group, was started by two former Industro Transistor Corp. employees with the hope of serving the needs of those requiring custom ICs. While trying to meet the up and coming needs of IC and semiconductor component manufacturers for radiation hardened materials, the OEM and equipment manufacturers are also being sought after.

The production of silicon slices, using the isolation geometry and material specs of a particular customer, is an area in which Dionics is greatly involved. The company does not grow its own silicon. Instead, involvement for Dionics begins with the ingot or slice phase and proceeds with the dielectric isolation process to arrive at a finished product. Custom slices, based on dielectric isolations, is a process finding expanded use in the development of radiation resistant microcircuits. The dielectric isolation process is said to impart 10 to 40 times more radiation immunity than pn junction isolation and effectively shields ICs and components from harmful effects of particle bombardment.

The founders of Dionics are aiming to fill the vacuum in the smaller specialty areas. They feel that the industry has progressed to the stage where OEMs are willing to buy processing rather than set up costly in-house operations. Eventual goal? To become the second materials source for firms now in the IC business.

Circle 413 on Inquiry Card

Miniaturized test equipment. Mini-Tron Co., Darby, Pa., is ready to market its first product—a miniature, hand-held, transistorized square wave generator which weighs less than 1 oz.

Priced at $9.95, the Mini-Probe Model 101 has been designed to meet the requirements of both the electronic engineer and technician alike. It can be used to test transistors and diodes without unsoldering, to provide transitions in logic circuits, or to debug audio and rf circuits.

The new company's second product will be a low-priced random pulse generator. Prime users of this device will be the research organizations that deal with the detection and measurement of random processes.

Circle 414 on Inquiry Card

You've seen the pictures...

Now read the book.

The perfect finish to our Great Digital Systems Kit new product program—over 170 pages of meaty description, specs, logic diagrams and schematics on our TTL and DTL modules; dozens of packaged analog/digital instruments like our MINIVERTER™ and other data acquisition equipment; hardware and accessories; wire-wrapping service and applications help. Write or call for yours today. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. Phone (714) 546-7160.

RAYTHEON

SPEAK UP

Practice what you preach

Sir:

I read your editorial "One Electronic World" in the May issue of **The Electronic Engineer** with particular interest. As an American working as a Sales Manager abroad I have become particularly aware of the American electronic industry's profound provincialism. "At last," I thought, "an American magazine is becoming aware of the world at large." I was, therefore, all the more disappointed to note that in an article in the same issue on small instrumentation computers you included only those of American manufacture.

Our company, Elbit Computers Ltd., Haifa, Israel, is the manufacturer of a low cost digital computer called the Elbit 100 which we have been delivering since January 1968.

The Elbit 100 is a low cost, special purpose digital computer, designed to be readily integrated into the user's system, instrument or control loop. A 12 bit, single address, fixed word length computer with typical add time of 7.2 μsec, the Elbit 100 is capable of operating with up to 256 channels of input-output equipment. Complete prices range from $4900 to $7000 based on memory size.

Leonard Dreyer
Sales Manager-Elbit 100
Elbit Computers Ltd.
Haifa, Israel

EDITOR's NOTE: Readers interested in the Elbit 100 can obtain more information by circling **205** in the Reader Service card.

On heckling and doing

Sir:

Re your editorial "On heckling and doing" [**The Electronic Engineer,** June 1969, p. 7].

Very good, man!

Harold G Lenz
Middleton, N.J.

More IC ideas

Sir:

Add more IC Ideas. The circuits are very helpful, particularly "Simple circuit speeds digital system checkout" [**The Electronic Engineer,** August 1969, p. 82], which saved me the $100.00 a similar probe would cost.

A. Tejeda
Computer Specialist
Computerized Testing
RCA - EC&D
Sommerville, N.J.

Find out now what NCR can do to further your career

NCR

Positions available in the following areas:

MOS/LSI

A MSEE or Physics degree required. Primary responsibilities include the following: mask making and photo-resist operations; oxidation and heat treatment; assembly and packing design automation and testing.

Military Circuit & Logic Design

Our Military Advanced Development area is presently reviewing applications for positions of senior circuit and logic design engineers. This department is concerned with government contracts of a highly sophisticated nature for both defense and non-defense programs. This department is presently engaged in highly technical programs that offer high level challenge for the senior engineer. Applicants should be capable of handling future projects.

Software Systems Engineers

These positions require creative individuals with proven leadership ability. A BS degree in engineering with 3-5 years' experience as Systems Engineer/Systems Analyst with hands-on experience with 360 systems software, related to teleprocessing, DOS, or OS is desired. Duties would include interfacing NCR terminals and communications systems with other computer equipment.

Engineering Design Evaluators

BS-MSEE minimum requirement. For detail design evaluation of product designs, before product is approved, for final stage of development or purchase of equipment from other sources is approved. Sound technical judgment as well as a good working relationship with others is essential.

Project Leader—Advanced Memory Development

Advanced degree preferred, or BS with considerable experience. Memory architecture, semiconductor memories, solid state devices, digital circuit design and logic implementation.

Display Device Engineer

MSEE or BSEE with related experience. Knowledge of solid state and electron physics, liquid crystals, optics experience desirable. Must be strong in logic circuit design.

Electro-Optics Engineer

MSEE or Physics or BS with related experience. Knowledge of geometric optics, electro-optic devices, control systems, digital circuit design and logic.

Senior Communications Systems Engineer

BS/MSEE. Modulation and coding theory, data communications, and development of high speed data modems for voice channels. Experience in data transmission and modern design desirable.

On-Line Systems Engineer

Design of commercial on-line systems involving terminals, communication networks, and central processing systems. Requires background in one or more of the following: design of computer systems preferably oriented to real-time applications, digital data transmission, systems software. Exposure to business system requirements helpful. Entails configuration analysis, trade-off analysis, optimization studies, systems modeling, subsystem requirement definition, design of interfaces, studies of reliability, maintainability, installability. Minimum of three years' pertinent experience. BS in engineering or sciences required. Advanced technical degree and/or MBA preferred.

Design Engineers

These positions are with our Industrial Products Division and are varied in their requirements. A BSME as well as five years' experience will qualify you for these positions. Duties would include a variety of assignments including design of moving mechanisms, testing and calibration as well as advisor to departmental supervision.

Terminal Hardware Design Engineers

A BSEE required. Primary responsibilities are varied but, include MOS-LSI, logic design, system transaction analysis, terminal unit design and electronic packaging.

Data Communications Engineer

Experience with switched telephone network and private lines, communication procedures, software implications at central processor, digital control, modems, signal transmission and modulation theory. Minimum requirements include BSEE plus three years' pertinent experience. Advanced EE degree desirable.

Electronic Design Engineer

BS/MSEE with experience in circuit and subsystem design. Duties would include circuit and subsystem design in frequency band up to 30 M.H.

Test Equipment Engineers

These positions involve the development of complex test systems for MOS-LSI arrays and array PC assemblies. Minimum requirements include three years' experience in logic assembly design of IC test systems.

Section Head—Test Equipment Engineer

BS/MSEE 5-7 years experience in test equipment design or EDP products. Duties include responsibility for design of equipment needed for test and inspection of EDP processing equipment, supervision of section (11-15 employees) and frequent contact with organizational section heads.

For confidential consideration, forward your resume to:

Mr. Vernon L. Mirre
Executive & Professional Placement
The National Cash Register Company
Main & K Streets
Dayton, Ohio 45409

An equal opportunity employer M/F

SPEAK UP

Don't buy test equipment without a good schematics

Sir:

The letter written by Mr. M. R. Barr of Redcor (The Electronic Engineer, February 1968, p. 22) was an excellent one, but was lacking in one additional item. In addition to inspection of instructions manual prior to sale, it is imperative that "inspection" include a look-see at the schematics. Take it from some one who learned the hard way, schematics are one thing you will learn to insist upon during your career in engineering. Often, a schematics that doesn't agree with actual wiring is sufficient reason to "refuse to accept", provided your purchasing department did not forget to provide that important clause in the contract.

Robert Wm. Lowe
Central Computer Corp.
Anaheim, Calif.

Cost, not price

Sir:

The article on "CAD Graphics" by Stephen A. Thompson, published in the August 1969 issue of **The Electronic Engineer**, was most interesting. We consider it, in general, to be most timely and well written. To clarify and expand your knowledge concerning the Mann Type 1600 Pattern Generator, the standard system of today includes the following features in addition to those described in the specifications.

(a) Four-inch motion in each axis, X and Y, in place of 2″ x 2″.

(b) Resolution of stage motion of 0.25 mil in place of 0.5 mil.

(c) A PDP-8L Computer in place of the PDP-8S.

(d) Rotation of the aperture.

The price of this system is $140,100 f. o. b. Burlington, Massachusetts, unpackaged (considerably less than the $250,000 stated in your article).

Aubrey C. Tobey
Director of Marketing
David W. Mann Co.
Burlington, Mass.

EDITOR's NOTE: The **cost** figure of a quarter million dollars, mentioned in the article, was for a system installed by a user. That figure includes the $140,100 **price** mentioned by Mr. Tobey, plus transportation (to the West Coast), installation, software and training.

Design contest on photosensitive FETs

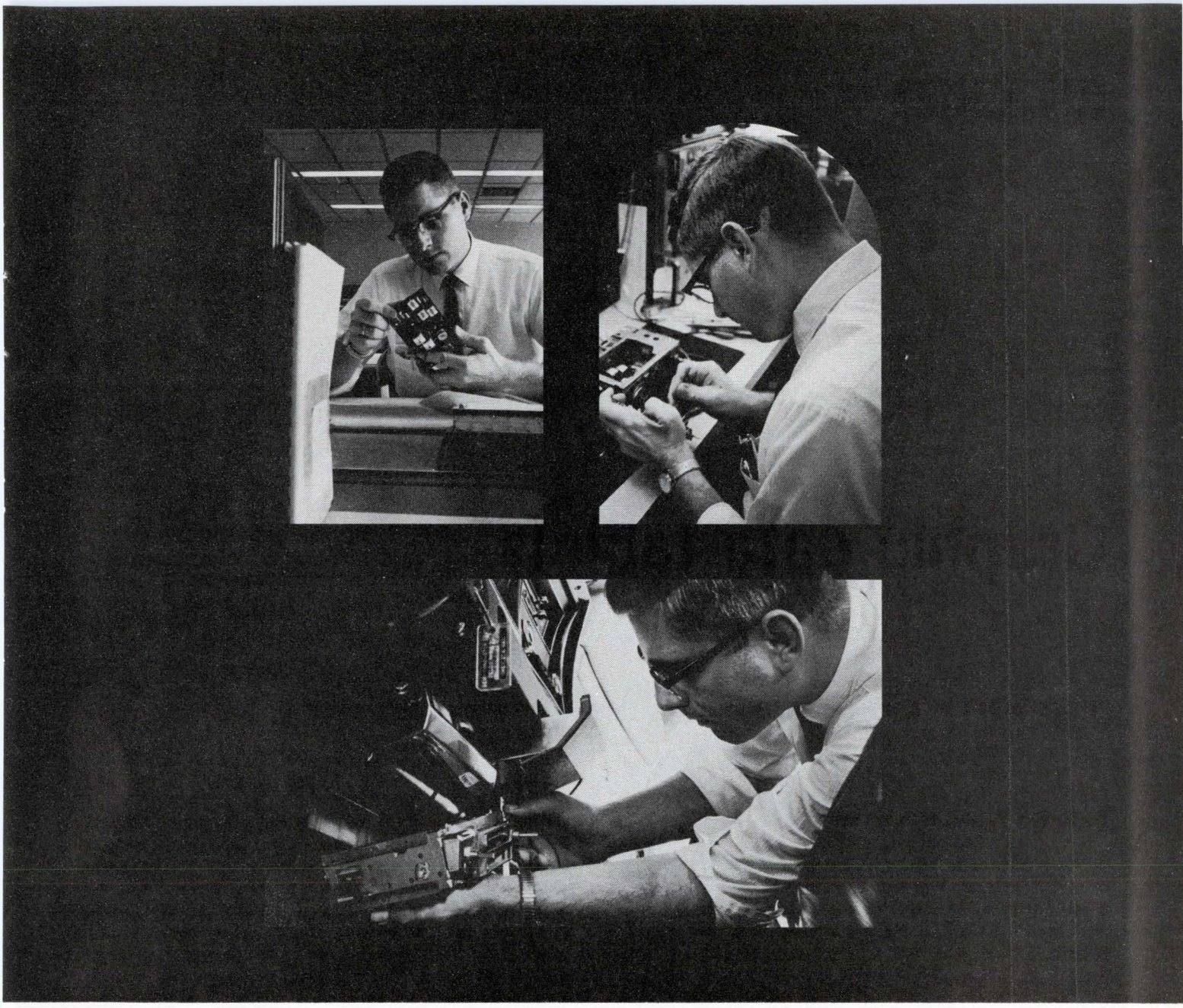
Do you use photosensitive field effect transistors? Then sharpen your pencil. Crystalonics, a Teledyne Company based in Cambridge, Mass., announces a design contest on their Fotofets®. To enter, you must submit an original design that uses photo FETS, complete with circuit schematics, description of circuit operation, and description of the application you intend it for.

From the entries, Crystalonics will choose ten semi-finalists who will each receive a Polaroid Color-Pack® camera. Then, from these ten semi-finalists, **The Electronic Engineer** magazine will select three top designs. First, second, and third prizes will be respectively $1000, $500, and $250 worth of amateur-radio gear and/or hi-fi equipment, selected by the winners from the following brand names:

- Ham gear: Drake, Swan, Galaxie, National, Collins, Hammarlund.
- Hi-fi equipment: Fisher, Scott, KLH, Acoustic Research, Sony, MacIntosh, Garrard, Dual, Pickering.

Entry forms together with necessary product and reference data will be mailed to all interested engineers. Entries must be postmarked no later than March 1, 1970. Crystalonics will select 10 semi-finalists by April 1, 1970, and **The Electronic Engineer** will pick the three top winners by May 1, 1970. In addition, we will publish the winning circuits (with their authors identified) in a subsequent issue.

For entry forms, literature on photo FETS, and contest rules, circle Number **321** on inquiry card.



Mondays never look the same to Bob Byse

When you're breaking ground on a new idea at Delco, you don't see a lot of your own desk. For Bob Byse, design engineering means work with two dozen solid professionals . . . people whose specialties range from microelectronics to model making to production. Wherever the project leads, Bob Byse is on his way. And every skill is at his disposal. Right through full production.
And beyond. If there's trouble shooting under dealer warranty three years from now, Bob Byse is still the man we'll call for. That's why no two Mondays ever look alike to Bob Byse and his colleagues at Delco.
The question is . . . can you say the same? Take a good hard look at how your responsibility shapes up, compared with Bob's. In fact, why not discuss it with us. By letter or telephone. Collect. Area Code 317/459-2808.
Contact: Mr. C. D. Longshore, Supervisor, Salaried Employment, Dept. 305, Delco Radio Division of General Motors, Kokomo, Indiana.

DELCO RADIO

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MARK OF EXCELLENCE

AN EQUAL OPPORTUNITY EMPLOYER
DIVISION OF GENERAL MOTORS
KOKOMO, INDIANA

Circle 36 on Inquiry Card (Please Use Home Address on the Card)

Graphic data tablets

A new breed of graphic input devices smooth the man-machine interface

By Robert Patton, Eastern Editor

■ In a Massachusetts laboratory, a designer doodles on a scratch pad. The ball-point pen in his hand draws a resistor symbol, some strange markings, more symbols, more markings. He glances up at a crt, then—impatiently—crosses out several symbols and replaces them with others. The crudely drawn symbols are followed by more of the seemingly meaningless markings. The result—on the scratchpad—is a mess. But on a scope screen in front of the designer, a complex mask layout for an integrated circuit begins to take shape.

■ In a New York design office, an engineer traces out a new circuit on an analysis pad. Three thousand miles away a ghostly hand retraces that circuit on a storage-scope in the office of a Los Angeles consulting firm.

The moving hand having writ

These exemplify just a few of the possible applications of a growing breed of graphic input devices that can take the motions of a stylus and display them on a storage scope, transmit them over telephone lines, or translate them into instructions for a computer. As a class, these graphic data tablets have the ability to convert the position of a stylus on a pad into Cartesian coordinates in digital or analog form.

Design approaches vary from tablet to tablet, but the external characteristics of all are the same. Each incorporates a stylus, a flat writing surface, and the all-important associated electronics that make it work. The operator uses the stylus like a pencil to draw or trace on the writing surface of the tablet, and the equipment furnishes a digital or analog output that is a function of the position of the stylus on the tablet. In some cases, certain positions on the writing surface may be assigned some special significance, and the stylus and tablet may then be used as a keyboard to input specific instructions into a computer. For example, a tablet may have various symbols inscribed on its surface—each representing a distinct command to a computer. When the operator presses the tip of his stylus against any one of these symbols, a contact switch in the probe tip closes, the digital equivalent of the coordinate position of the symbol is fed into the computer, and the command that it represents is executed.

Four contenders in the ring

There are now at least four graphic data tablets on the market. The best-known is the Rand tablet—now commercially manufactured by Bolt Beranek and Newman under the trade name, Grafacon. This is the Rolls Royce of the field, with prices starting at about $9000. The Sylvania data tablet is a somewhat lower priced contender that was introduced at the 1968 Spring Joint Computer Conference. Sales volume has not been particularly large for either of these units, perhaps because of price—or maybe it's the other way around. Whatever the case, prospective data tablet users can now get into the act for less than $3000—thanks to two recent entries into the field.

From Shintron Co., a Cambridge-based manufacturer of television equipment, comes the Ecricon, a remarkably compact, low-cost data tablet. Completely

self-contained in a single 15-lb package, the Ecricon features a data range of 2000 points per second, surpassed only by the much bulkier Grafacon. At $2000, the Ecricon is just a little more than a fifth of the cost of the Grafacon. (It should be added, however, that BB&N feels that the price of the Grafacon could be cut by as much as a factor of five if production levels were to reach a sufficiently high volume.)

The other low-priced entry comes from Science Accessories Corp., a Connecticut supplier of equipment for physics labs. The beauty of the SAC Graf/Pen is the simplicity of its operating principle. Two electrostatic capacitive microphones, constructed of aluminized mylar strips, are positioned along the X and Y axes of the writing surface. Built into the probe is a spark generator that develops fast risetime pulses that are picked up by the microphones. Since the arrival time of a signal at the microphones is a function of the proximity of the signal source in the probe, the tablet produces an output that is a function of the coordinates of the probe on the writing surface.

The SAC Graf/Pen is unique among currently manufactured graphic data tablets in that it does *not* use the stylus as the sensing element of the system. All the others, the Grafacon, the Ecricon, and the tablet made by Sylvania, apply some sort of voltage or signal to the tablet and use the stylus to pick up coordinate information from the writing surface.

CUTTING "HUMAN COSTS"

It all started some five years ago when the Grafacon, a commercial version of the Rand tablet, was described in a paper given at the 1964 Fall Joint Computer Conference. For the first time, a computer user could input graphic data as simply and naturally as using a pencil.

Dr. Michael Pilla of the Human Factors Group at the Bell Labs facility in Holmdel, N. J., is among those who have been intrigued by the possibilities inherent in this approach. For some time he has been examining graphic data tablets as a means of reducing what he calls "the cost to the human" in the man-machine interface.

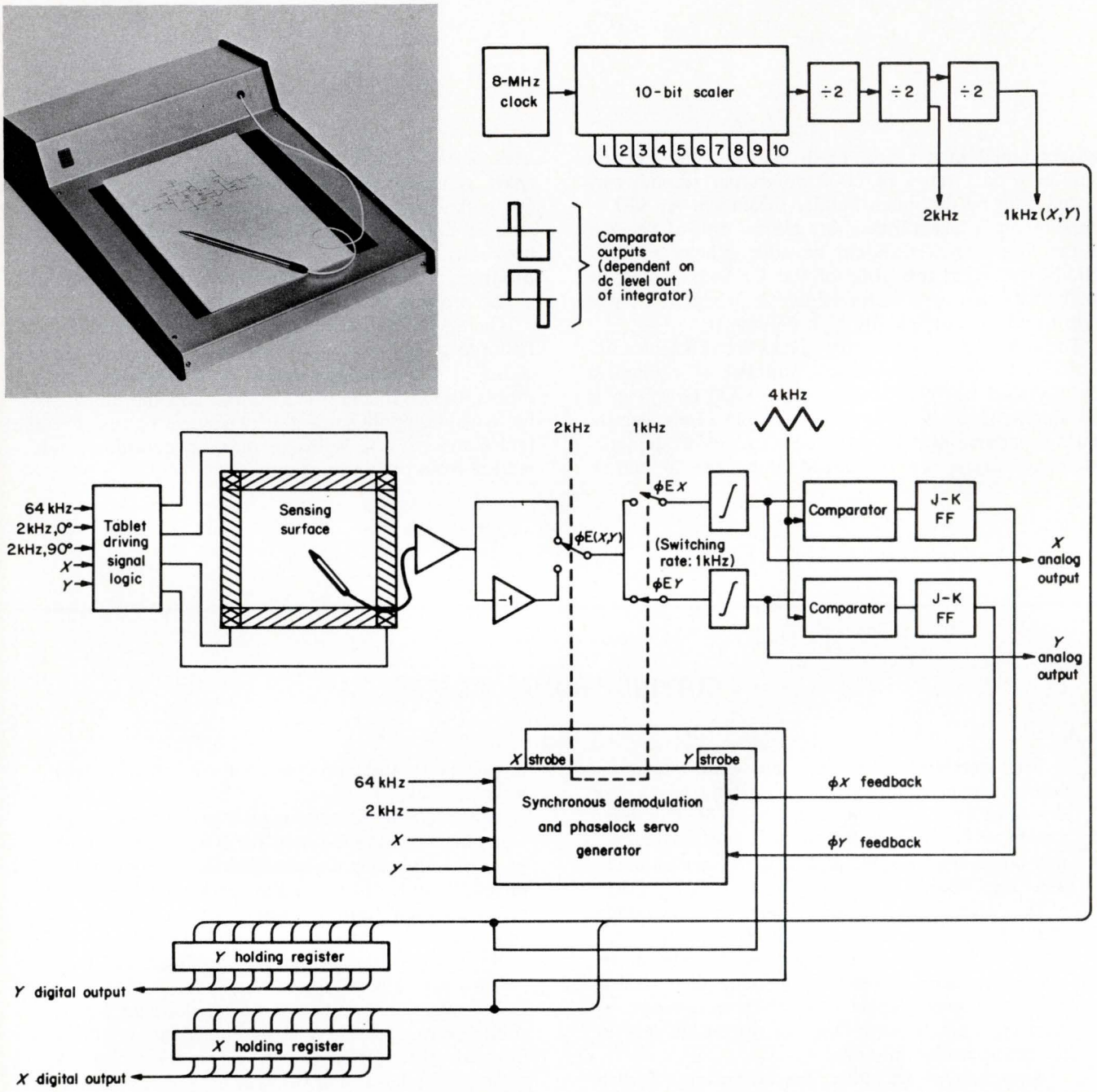
According to Dr. Pilla, the advantages of such tablets are many. They do not force the user to conform to the requirements of the machine. He sits as he would at his desk, holds the stylus as he would a pencil, and uses skills that are virtually second nature to him. The only drawback is that while he writes naturally on a tablet at desk height, the message that he inscribes appears at a remote position on an eye-level CRT display. Most users quickly accustom themselves to this and the handicap, if any, is slight. In addition, tablets can provide both hard copy and CRT display.

For computer-aided design the graphic data tablet is a natural. A designer can sit at a desk, sketch a circuit or logic diagram on the tablet, add a few symbols to represent component parameters, and get immediate feedback on theoretical performance from his computer.

The data tablet is more natural to use than a light pen, and eliminates the need for a light-pen tracking program. Also, only the tablet has the ability to trace directly from hard copy and to operate independently of, or remotely from, a display. A light pen cannot function with a storage-scope display and does not begin to offer the degree of positional accuracy possible with a data tablet.

For many applications, however, the light pen is still the way to go. Dr. William Sutherland of BB&N (formerly with MIT's Lincoln Laboratory) cautions against too quick a comparison of the two approaches. Having used both the Sylvania Data Tablet and the SAC Graft/Pen for computer-aided design of ICs, Dr. Sutherland is familiar with both the strengths and weaknesses of the tablet as an interactive computer input device. As he puts it, "If you just want to position a point, get a light pen, but if you need X-Y coordinate data, use a data tablet."

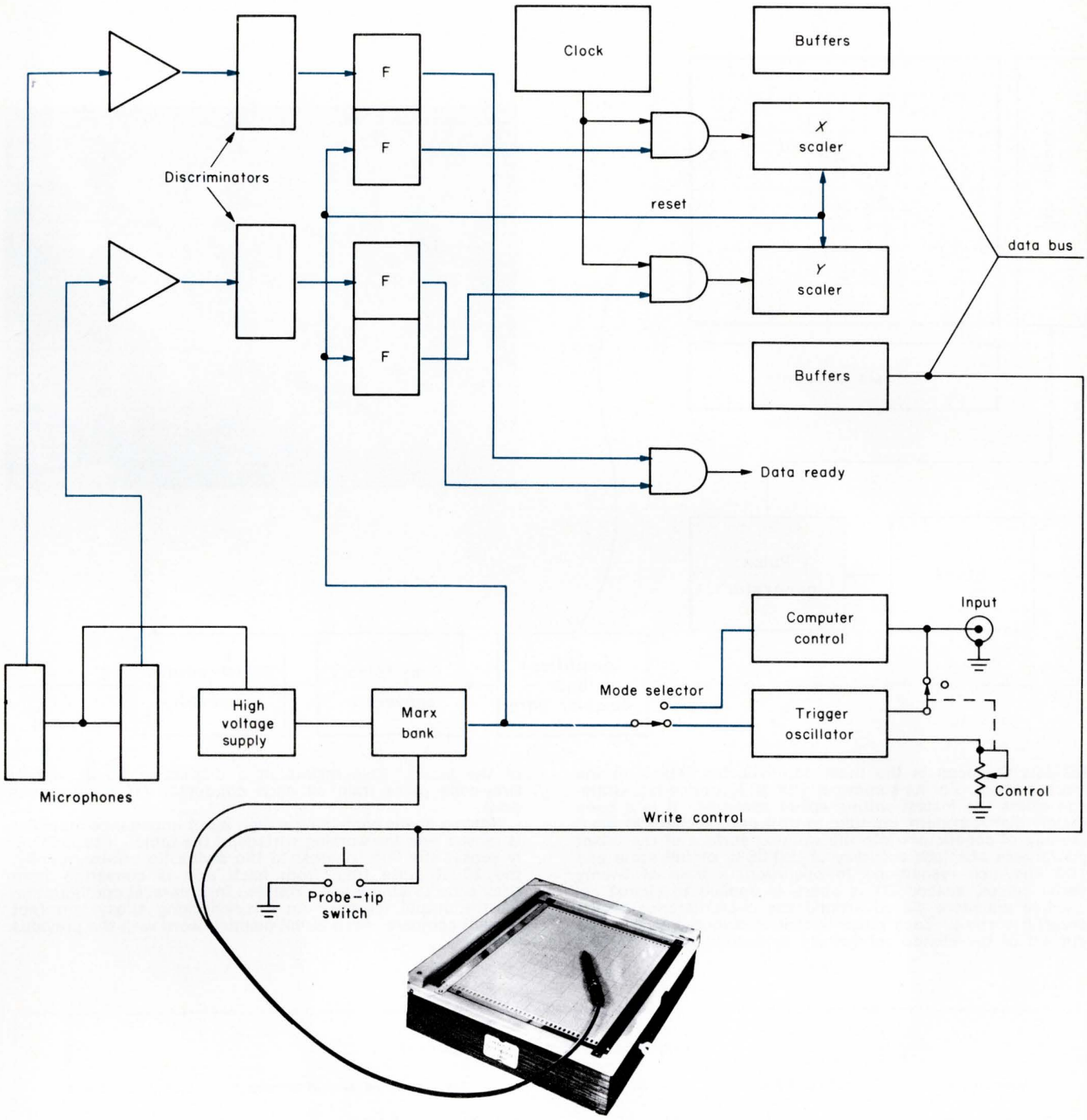
Perhaps the biggest advantage of the light pen is the body of software available from large computer manufacturers who offer light pens as part of many of their systems. For the graphic data tablet user, there is a software gap that may not be bridged for some time. But this is not a problem in digitizing applications and it is here that the data tablets offer a competitive advantage.



Shintron's Ecricon, at $2000, is the lowest priced data tablet available. Self-contained in a single 15-lb package, it is also the smallest. The Ecricon graphic tablet consists of the tablet itself, a drive circuit, and a detection circuit. The tablet has a vapor-deposited sensing surface with a resistivity of about 10 kΩ/sq. Around the borders of the tablet are strips with a much lower resistivity on the order of 10 Ω/sq and each corner is an ohmic contact.

To understand the operation, imagine that a voltage applied across the tablet creates a linear electric field parallel to the axes of the sensing surface. A handheld probe then picks up the dimensional coordinate information that is to be transformed into electrical signals. (Since both **X** and **Y** fields cannot be energized simultaneously, these coordinates are measured one at a time using a time sequential detection system.)

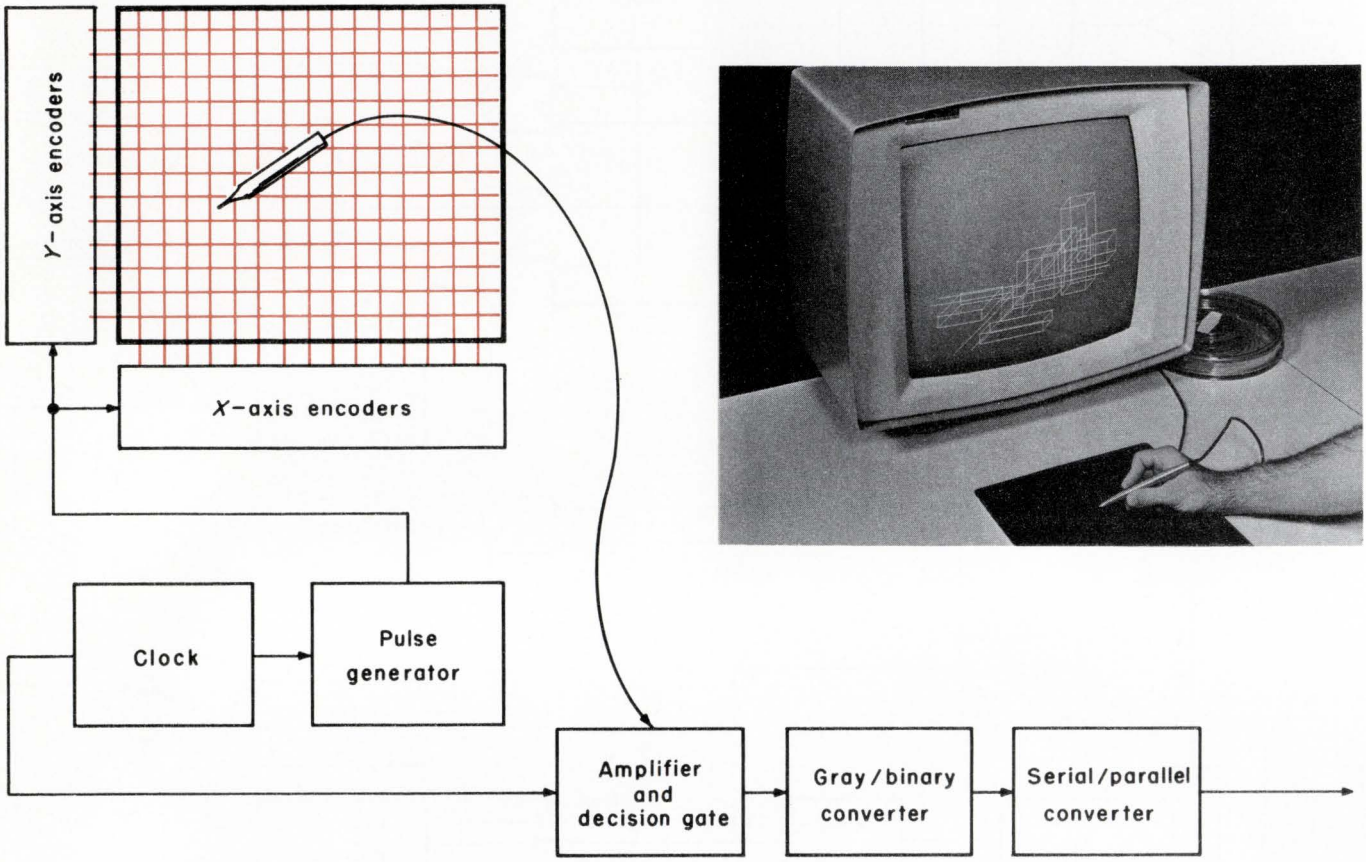
In actual practice, a 2-kHz square wave is applied alternately to the tablet from top to bottom and from right to left. Its phase varies from 0 to 90 degrees across the tablet in either the **X** or **Y** direction and is thus a function of position on the surface. This information modulates a 64-kHz carrier to permit capacitive pickup, efficient coupling, and effective filtering of power line noise. The probe capacitively picks up this high-frequency driving signal (modulated by the 2-kHz information) and feeds it through a length of cable into a preamplifier. After the preamp, an electronic switch synchronously demodulates the 64-kHz signal to obtain a 2-kHz signal that is phase dependent on the coordinates of the stylus. Gated by the **X** and **Y** switches, the signals pass through the integrators to produce dc outputs that vary between +5 and −5 volts as a function of stylus position. These voltage levels are then compared to a 4-kHz triangle to form a 4-kHz rectangular wave in which the width of the positive and negative pulses are dependent on stylus position. This comparator output feeds the trigger input of a J-K flipflop to form a 2-kHz square-wave that varies from 0 to 90 degrees in phase as a function of coordinate position. The rising edge of this square wave strobes a scaler into a holding register which then stores the binary value of the measured coordinate.



SAC Graf/Pen boasts a simple tablet that is nothing more than two strip mikes on a writing surface. The unit pictured, a prototype, appears bulky only because it accommodates a large roll of graph paper in its hollow base.

To operate, the Graf/Pen applies high voltage both to the electrostatic capacitive microphones and to the Marx bank (which supplies the voltage required to start a spark at the tip of the stylus). Controlled by the trigger oscillator or by an external computer, the Marx bank fires fast risetime pulses—up to 200 per second—into the spark pen. At the same time the initial trigger sets the binary gates into a 'one' state—or passing condition. This puts an enabling voltage on the AND gates, allowing clock pulses into the **X** and **Y** scalers. When the microphones receive a pulse, it undergoes amplification, passes through the discriminators (to eliminate spurious responses to ambient noise), returns the binary gates to the 'zero' state, and disables the AND gates, thus shutting off the flow of clock pulses into the scalers. The count accumulated by the scalers is now a function of the transit time of the pulse that was emitted by the spark pen and picked up by the microphones. Therefore, the **X** and **Y** counts are directly proportional to the **X** and **Y** coordinates respectively.

The big advantage of this approach is simplicity; the tablet is essentially nothing more than two strip microphones and a writing surface. In some applications, even the writing surface can be eliminated. For example, the strip mikes can easily be mounted on two sides of a CRT screen and—with the appropriate d-a converter to interface with the scope—the user can "write" directly on the face of the tube.

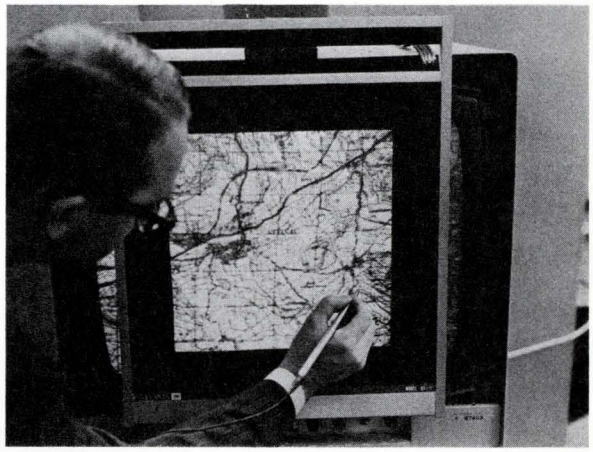


BB&N's Grafacon is the most sophisticated tablet on the market today. For its somewhat stiff $8950 price tag, Grafacon offers the fastest writing speed available. It is a completely digital system, immune to drift and mechanical wear. Etching of conductors into the working surface of the tablet guarantees absolute accuracy of ±0.05% of full scale and 100 line/inch resolution. In operation, a train of twenty serial pulses, spaced 20 μs apart, is applied to etched capacitive encoders placed around the circumference of the drawing surface. Each pulse is then distributed to a different set of the etched conductors embedded in the surface of the tablet. This results in a distinctive 10-bit, serial, Gray-code pulse train on each conductor (1024 lines per axis).

When a stylus containing a high input impedance amplifier is moved over the working surface of the tablet, it capacitively senses the lines nearest to the stylus tip. Subsequently, the 10-bit pulse train from each axis is converted from Gray code to binary and arranged in a parallel configuration for the output register. An error-checking subsystem (not shown) compares each 20-bit position word with the previous word.

GRAPHIC DATA TABLET COMPARISON CHART

Specifications	SAC Graf/Pen	Shintron Ecricon	Bolt Beranek and Newman Grafacon	Sylvania Data Tablet
Resolution, digital	10 or 11 bits, X and Y	10 bits, X and Y	10 bits, X and Y	12 bits, X and Y
Resolution, graphic	71 lines/in.	91 lines/in.	100 lines/in.	350 lines/in.
Accuracy	0.03 in.	0.2% pk-pk	±0.005 in.	0.1 in.
Data rate	200 points/s, variable	2000 points/s	4500 points/s	2000 points/s
Z-axis capability	2-position pressure switch	pen pressure switch: 1) no pressure 2) light pressure 3) writing pressure	pressure switch	three bits of height information up to 1 in. above tablet
Power requirements	105 to 125 V, 50/60 Hz, 40 W 210 to 250 V, 50/60 Hz, 40 W	117 V, 60 Hz, 20 W	105 to 125 V, 50/60 Hz, 40 W 210 to 240 V, 50/60 Hz, 40 W	105 to 125 V, 60 Hz, 100 W
Writing surface (in.)	14 x 14	11 x 11	10.24 x 10.24 (optional: 20.48 x 20.48)	11 x 11
Analog output	no	1 V pk-pk	optional	+2V to -2V
Weight (lb)	30: cabinet: 26 tablet: 4	15	42: cabinet: 35 tablet: 7	50: cabinet: 35 tablet: 15
Size (in.)	tablet: 16 x 16 x 1 cabinet: 19 x 3-1/2 x 12-5/8	20-13/16 x 15-1/4 x 2-5/8 at writing surface	tablet: 20-1/8 x 24-1/8 x 1-1/2 cabinet: 7 x 18 x 19	tablet: 16.5 x 20.5 x 3/4 cabinet: 17 x 18.5 x 7
Hard copy capability	ball-point cartridge in probe	ball-point cartridge in probe	no	ball-point cartridge in probe
Price ($)	2800	2000	8950	6875



Sylvania's Data Tablet, unlike the Grafacon, is an analog system. Its writing surface consists of a slice of thin, transparent, conductive film, sandwiched between two sheets of glass.

In operation a drive network applies signals at discrete points around the circumference of the writing surface. This establishes what may be considered as a travelling wave parallel to each axis. The phase of this wave is a linear function of its position on the writing surface.

A stylus with high input impedance capacitively couples to the film to pick up signals from the working surface of the tablet. Phase measurements on the signals from the stylus ultimately supply the **X-Y** positional information. The signals (about 100 kHz) are suppressed-carrier modulated by a 1-kHz sine wave.

A different carrier drives each axis so that signals picked up by the stylus may later be separated into **X** and **Y** channels to extract the phase information contained in the signal envelope.

The future of data tablets

The fullest potential of graphic data tablets has not yet been realized. For one thing, no body of computer software exists for data tablets to nearly the extent that it does for use with light pens. Until recently, at least one other factor conspiring against wider use of tablets has been their high price. With the introduction of the above-mentioned low-cost tablets, this picture may change. If it does, the expansion of the market may influence the established manufacturers to follow suit by cutting their prices somewhat. But be careful about comparing inexpensive systems like the SAC Graf/Pen or the Shintron Ecricon with a system such as the Grafacon. The Grafacon is a sophisticated instrument with a high level of performance and a wide variety of options. To expect it to be directly cost-competitive with the new, low-priced tablets is somewhat like comparing a Cadillac with a Chevrolet on the basis of price.

References

1. David N. Keast, "A survey of graphic input devices for computer-aided design," Machine Design, August 3, 1967.

2. James F. Texeira and Roy P. Sallen, "The Sylvania Data Tablet: a new approach to graphic data input," Proceedings of the 1967 Spring Joint Computer Conference.

3. M. R. Davis and T. O. Ellis, "The Rand tablet: a man-machine graphical interface," Proceedings of the 1964 Fall Joint Computer Conference.

For further information on the manufacturers and their products, circle the following numbers on the Inquiry Card:

Bolt Beranek and Newman	Circle number **201**
Science Accessories Corp	Circle number **202**
Shintron Company Inc	Circle number **203**
Sylvania Electronic Systems	Circle number **204**

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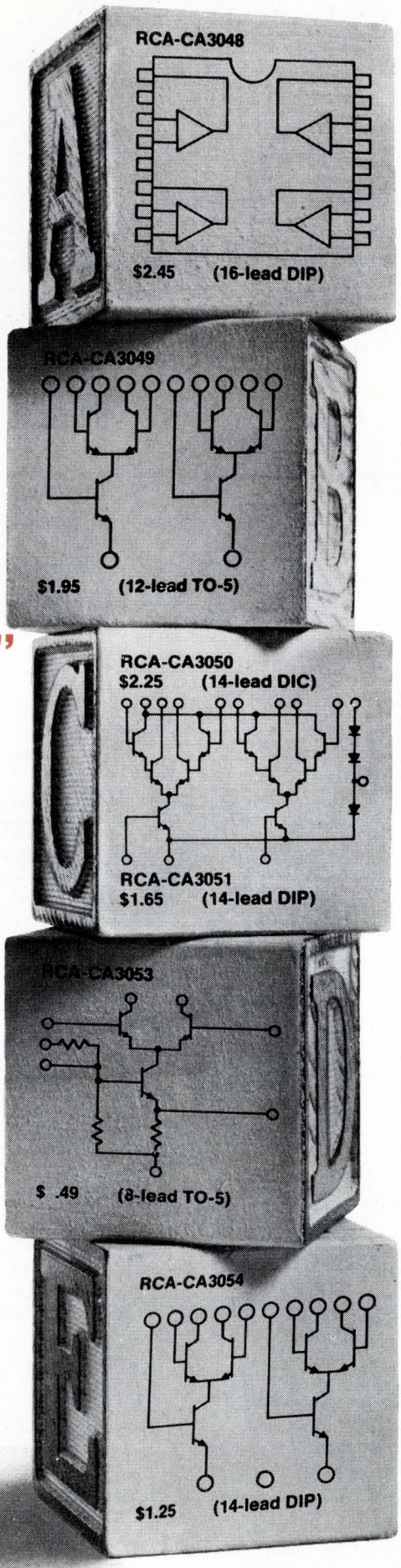

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Nomographs simplify phased array design

Here are three nomographs that can help you design phased antenna arrays with individual solid-state power generators.

By Chester W. Young, Program Planning Manager
Walter V. Sterling, Inc., Claremont, Calif.

In his article "Solid state designs for phased arrays" (**EE,** Sept. 1967, pp. 42-45), G. R. Brainerd set forth design guidelines for phased antenna arrays. This started me working on a set of nomographs that would simplify the application of those guidelines. The results of that work are the three nomographs presented here. Along with a description of each nomograph is an example of its use in a design. This sample problem is followed through all the nomographs.

Antenna half-power beamwidth nomograph

The physical constraints of wavelength, antenna beamwidth, and aperture size are usually the first considerations of the system designer. This nomograph combines these parameters using the equation:

$$\theta = \frac{51\,\lambda}{a}$$

where: θ = antenna beamwidth in degrees
λ = rf carrier wavelength
a = length of one side of a square aperture

The left-hand scale of the nomograph is calibrated in both half-power beamwidth degrees and aperture length in wavelengths, since these are inseparable. The center scale is dually calibrated in rf carrier frequency and wavelength in feet, since most arrays are usually measured in feet.

For example. Let's assume values of:

$$f = 1000 \text{ MHz}$$
$$a = 10 \text{ ft}$$

If we draw a straight line joining these two values and extend the line to the left, we find that the beamwidth will be 5.1°.

Power developed and radiated nomograph

This nomograph is actually three nomographs side-by-side. It determines the parameters which solid-state generators must meet to fulfill the total power requirements of the antenna.

The left three scales

The three left-hand scales solve the equation:

$$X = \frac{2a}{\lambda}$$

where: X = number of elements on the side of a square array
a = aperture length in feet
λ = rf wavelength in feet

Since each radiator will be a half wavelength, there will be twice as many radiating elements as the side is long in wavelengths.

Example. Assuming values consistent with the first example:

$$\lambda = 1 \text{ ft}$$
$$a = 10 \text{ ft}$$

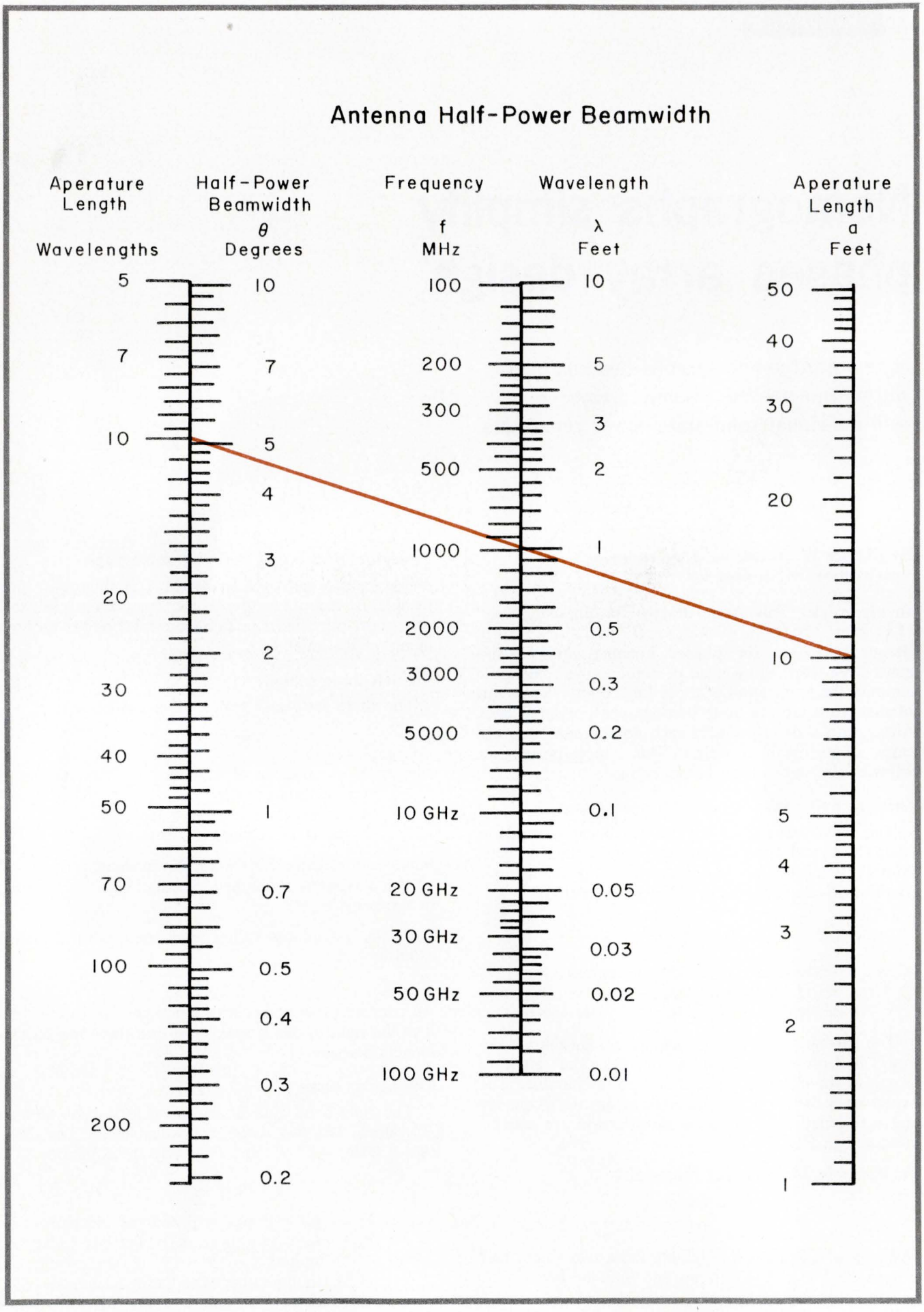
we connect these points with a straight line and extend it to the right to the X scale, and find there are 20 elements on a side.

The center three

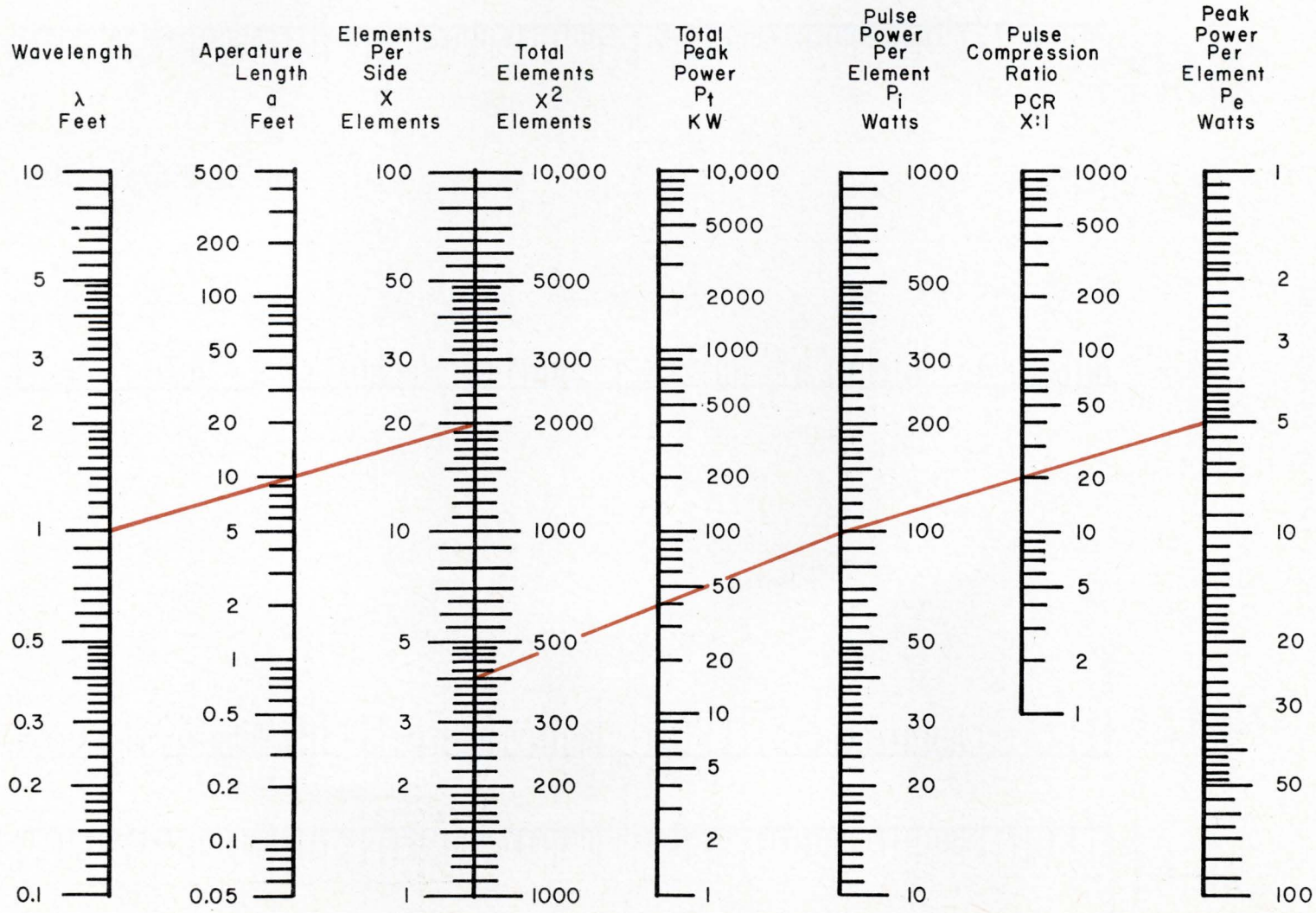
The right-hand side of the X scale is calibrated in X^2 values. *The two scales are independent.* The three center scales—X^2, P_t, and P_i—solve the equation:

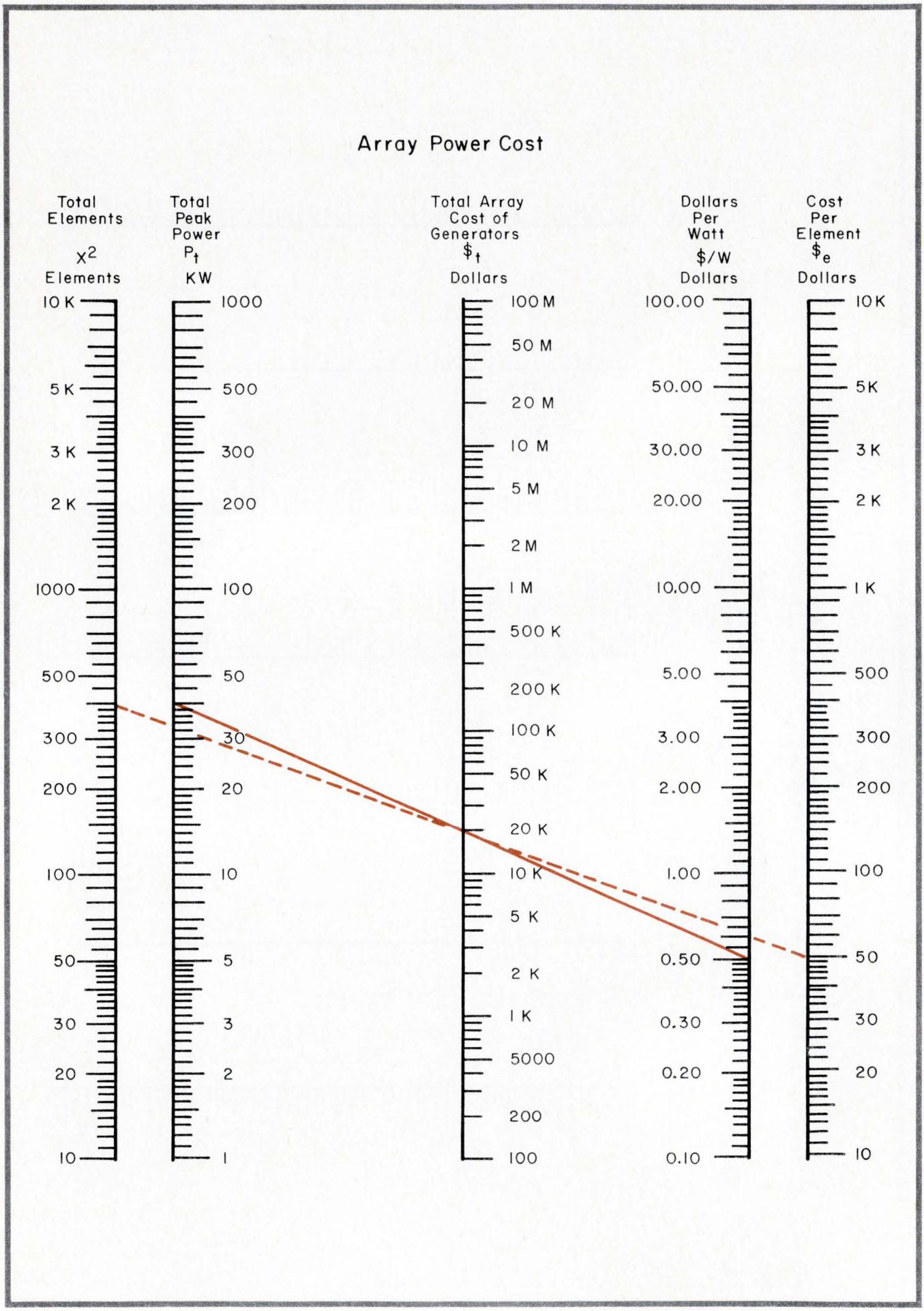
$$P_i = \frac{P_t}{X^2}$$

where: P_i = pulse power required per element
P_t = total output peak power per pulse required
X^2 = total number of radiating elements available


Antenna Half-Power Beamwidth
Aperature Length Wavelengths
Half-Power Beamwidth θ Degrees
Frequency f MHz
Wavelength λ Feet
Aperature Length a Feet
5
7
10
20
30
40
50
70
100
200
10
7
5
4
3
2
1
0.7
0.5
0.4
0.3
0.2
100
200
300
500
1000
2000
3000
5000
10 GHz
20 GHz
30 GHz
50 GHz
100 GHz
10
5
3
2
1
0.5
0.3
0.2
0.1
0.05
0.03
0.02
0.01
50
40
30
20
10
5
4
3
2
1

Power Developed and Radiated




Array Power Cost
Total Elements
X^2 Elements
Total Peak Power
P_t
KW
Total Array Cost of Generators
$\$_t$
Dollars
Dollars Per Watt
$/W
Dollars
Cost Per Element
$\$_e$
Dollars
10 K
5 K
3 K
2 K
1000
500
300
200
100
50
30
20
10
1000
500
300
200
100
50
30
20
10
5
3
2
1
100 M
50 M
20 M
10 M
5 M
2 M
1 M
500 K
200 K
100 K
50 K
20 K
10 K
5 K
2 K
1 K
5000
200
100
100.00
50.00
30.00
20.00
10.00
5.00
3.00
2.00
1.00
0.50
0.30
0.20
0.10
10K
5K
3K
2K
1K
500
300
200
100
50
30
20
10

Example. If we continue our problem where we found 20 elements on the side of our array, we calculate in our head or on a slide rule that $20^2 = 400$ and enter this value on the X^2 scale. Now, if we assume a 40-kW peak power output required for the array, we join these values on the X^2 and P_t scales and extend the line to the right—finding that the pulse power per element must be 100 W.

The right three

Since most power generators are peak power limited, these three scales determine the pulse compression ratio needed to accomplish the design. The scales cover the equation:

$$PCR = \frac{P_t}{P_e}$$

Example. Continuing our problem of 100 W/element and assuming a P_e or peak power per element of 5 W, we join these two values with a straight line and find that we need a pulse compression ratio of 20:1.

Array power cost nomograph

Of particular interest to the program manager or system designer are the cost tradeoffs in the proposed design. This nomograph is really two nomographs in one with the center scale common to the pair of *outside* scales and the pair of *inside* scales. The outside scales and the center scale solve the equation:

$$\$_e = \frac{\$_t}{X^2}$$

where: $\$_e$ = cost per solid state generating element
$\$_t$ = total cost of array generators
X^2 = total number of array elements

The inside scales and the center scale solve the equation:

$$\$/W = \frac{\$_t}{P_t}$$

where: $/W = normalized dollars per watt comparison figure of merit
$\$_t$ = total cost of array generators
P_t = peak power output required

Example concluded

Outer scales. If we try to meet a $20,000 per array cost for the solid state power generators and we have an X^2 of 400 elements, the cost per element must be $50 or less (dashed line).

Inner scales. Using our 40 kW of peak power and $20,000, we see that this averages $0.50 per watt (solid line). By reworking the problem with other assumed *PCRs* and element characteristics through all of the nomographs, we can minimize the cost per watt for a given state of the art.

INFORMATION RETRIEVAL
Microwaves and microwave products, Communications, Charts and nomographs

Tune in with a new N-path filter

By turning lowpass networks into bandpass filters the N-path principle finds itself in the middle of a new a-m/fm receiver.

By Erik Langer, Siemens Aktiengesellschaft, West Germany

Filter networks have been the nemesis of designers trying to integrate receiver circuits. The problems of tolerances and stability usually require solutions beyond technological and economic feasibility, hence attempts to use conventional N-path filters have been unsuccessful. They need a great many components to obtain transfer functions with more than two poles since this requires a lowpass filter with complex poles in each of the N paths. Moreover, the need for all paths to be identical imposes tight tolerances that cannot be easily satisfied.

As an alternative, a new type of N-path filter with two pairs of complex poles in the transfer function—one that has a simple configuration and is not critical with respect to tolerances—is described here.

The new filter

A second-order filter is, of course, the principal functional unit for the synthesis of selective networks for communications equipment. In this case let's start with an active lowpass RC filter network whose transfer function exhibits a single complex pair of poles (see Fig. 1). It includes two cascaded lowpass filters of first order arranged in the feedback loop of an operational amplifier. By replacing the capacitors with switched triplets of capacitors, you can convert this configuration into a variable-time filter of N-path character.

The transfer function $F_N(s)$ of the new N-path filter may be determined from the transfer function $F(s)$ of the lowpass filter shown in Fig. 1.

$$F(s) = \frac{V_4(s)}{E_1(s)} \approx \frac{-R_k}{\dfrac{R_s + R_k}{a_1 \cdot G_1(s) \cdot G_2(s)} + R_s} \qquad (1)$$

where

$$G_1(s) = \frac{V_2(s)}{V_1(s)} = \frac{1}{1 + sR_1C_1}, \quad G_2(s) = \frac{V_4(s)}{V_3(s)} = \frac{1}{1 + sR_2C_2}$$

This circuit differs from known active lowpass RC filter circuits[1] only in the addition of the buffer amplifier A_2 which allows the op amp A_1 to be inserted between the two RC networks R_1C_1 and R_2C_2.This measure improves the slope of the filter and is useful for the variable-time modification that now follows.

If, as already stated, the two RC networks with the transfer functions G_1 and G_2 are replaced by first-order parallel switch N-path filters (see boxed information), a lowpass to bandpass transformation will take place in line with the laws of N-path filter theory[2, 3].

Replacing

$$G(s) = \frac{1}{1 + sRC}$$

with

$$G(s \pm j\omega_o) = \frac{\sin^2\left(\frac{\pi}{N}\right)}{\left(\frac{\pi}{N}\right)^2}\left[\frac{1}{1 + (s - j\omega_o)\,NRC} + \frac{1}{1 + (s + j\omega_o)\,NRC}\right]$$

and entering two such functions in equation (1) we obtain, after a few transformations, the transfer function of a second-order bandpass filter shown in Fig. 2:

$$F_N(s) = \frac{V_4(s)}{E_1(s)} \approx \frac{-R_k}{\dfrac{R_s + R_k}{a_1k^2\left[\dfrac{1}{1 + (s - j\omega_o)\,NR_1C_1} \cdot \dfrac{1}{1 + (s - j\omega_o)\,NR_2C_2}\right]} + R_s}$$

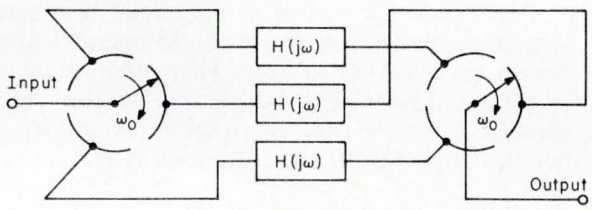
$$= \frac{-1}{\dfrac{R_s + R_k}{a_1R_kk^2}\left[1 + (s - j\omega_o)\,N\,(R_1C_1 + R_2C_2) + (s - j\omega_o)^2\,N^2R_1C_1R_2C_2\right] + \dfrac{R_s}{R_k}}$$

where

$$k = \frac{\sin^2(\pi/N)}{(\pi/N)^2}$$

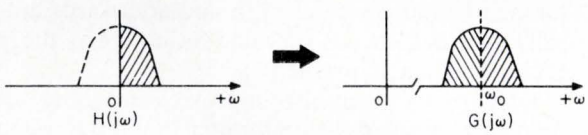
The facts about N-path filters

N-path filters are inductorless units that function on a time-division multiplex principle. This means that N successive identical channels or paths are cyclically cut into the signal path. Such networks are said to have a variable-time character. If a lowpass element with transfer function $H(j\omega)$ is present in each of these paths, the cyclical switching process causes a lowpass to bandpass transformation. The resulting transfer characteristic is symmetrical with respect to the switching frequency, ω_o.



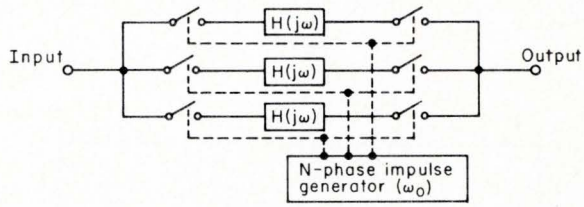
Underlying principle of N-path filter (N=3)

In particular, if each of the lowpass elements has only a single real pole point, then the corresponding bandpass element will have a single pair of complex conjugate poles. Analogously, each pair of complex conjugate poles in the lowpass elements will lead to a bandpass element with twice as many pairs of poles.



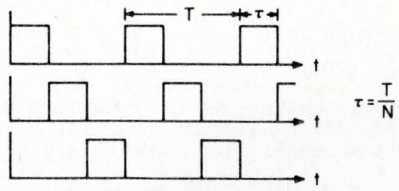
Lowpass-to-bandpass transformation

Networks in which the lowpass elements consist of only one resistor and one capacitor are of special practical interest. If commutating switches are replaced by electronic devices such as gate circuits with floating inputs and outputs, and the switching periods of these gates are mutually offset by the phase angle $2\pi/N$, a configuration composed of $2N$ gates and N lowpass elements is obtained.



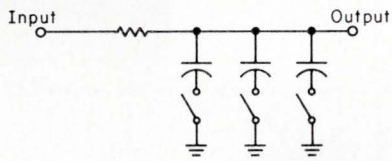
Serial-switch filter

For, say, $N = 3$, the trigger pulses controlling the gates exhibit the following characteristic vs time.



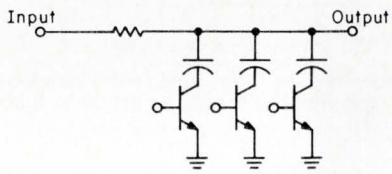
Pulse diagram of N-phase impulse generator

Rearranging the serial switch filter you get a parallel configuration with only N switches, N capacitors, and 1 resistor.



First-order, parallel-switch filter

This extremely simple network has the advantage that one end of the switches can be connected to ground. Thus they can be replaced by ordinary switching transistors.



First-order, parallel-switch filter in practice

The transfer function of this N-path filter then has the form

$$G(j\omega) = \frac{\sin^2\left[\frac{\pi}{N}\right]}{\left[\frac{\pi}{N}\right]} \left[H(j\omega - j\omega_o) + H(j\omega + j\omega_o)\right]$$

While the midband frequency, ω_o, depends solely on the switching frequency, the selectivity, like the bandwidth, of the N-path filter is determined by the lowpass elements $H(j\omega)$. As a result, N-path filters have a low sensitivity to tolerances.

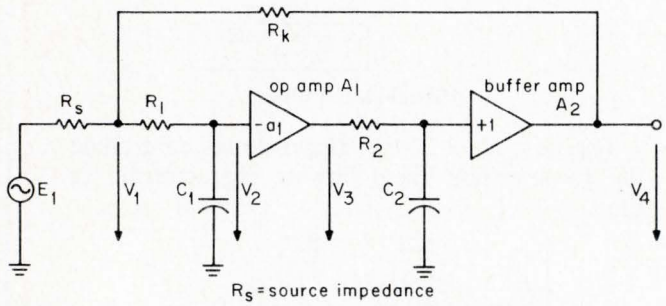


Fig. 1: Second-order lowpass filter. By replacing C_1 and C_2 with switched triplets of capacitors, this basic filter is converted to a parallel-switch, second-order N-path filter.

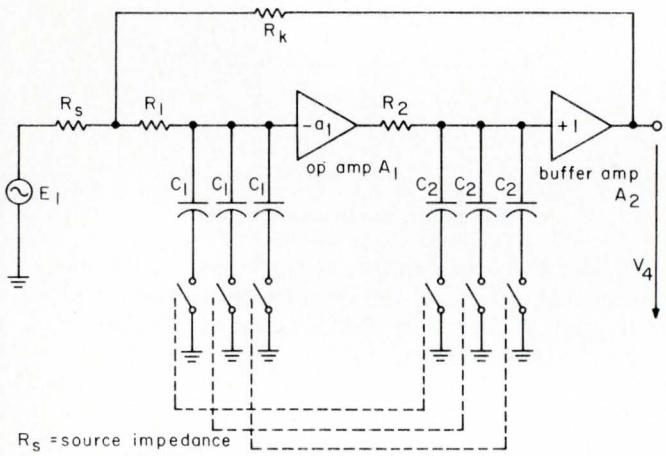


Fig. 2: Second-order N-path filter. This is the **bandpass filter** that comes from applying the N-path principle to the second-order lowpass filter.

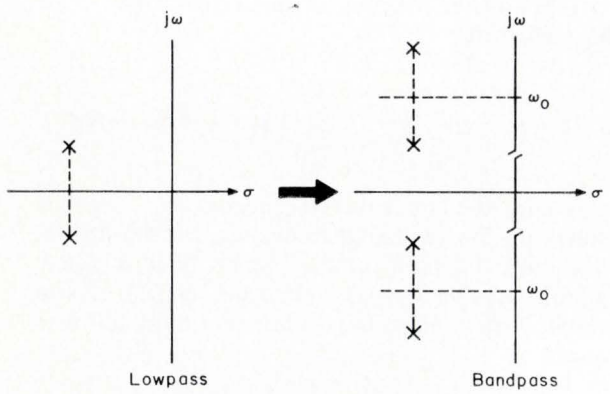


Fig. 3: Lowpass-to-bandpass transformation. Here is a representation in the complex plane of the transformation from the poles of the lowpass network to the poles of the N-path, bandpass network.

The denominator polynomial of this function has two conjugate complex roots as soon as the requirement

$$(s_v - j\omega_o)^2 N^2 R_1 C_1 R_2 C_2 + (s_v - j\omega_o) N (R_1 C_1 + R_2 C_2) + 1 + \frac{a_1 k^2 R_s}{R_s + R_k} = 0$$

is satisfied. Figure 3 shows the pole distribution in the complex plane of the transition from the lowpass filter network to the bandpass of second order.

The location of the poles of such a filter can be controlled by the gain a_1 and the ratio R_s/R_k. A quantitative analysis shows that a voltage gain of 20 to 40 dB suffices for practical requirements. This can be realized with relatively simple circuitry, but you must pay attention to the phase shift of the amplifier in the switching frequency band. Due to the variable-time character of the network, the amplifier must not have any delay or storage effects, or the rf response and overall gain will deteriorate.

If you cascade another simple N-path section as shown in Fig. 4, you get a third-order bandpass filter with a response curve that is flat in the middle.

Since the active portion of the circuit is common to all paths, parameter deviations in the operational amplifier do not affect the inherent filter noise or the center frequency. Also, placing the op amp between the keyed networks not only ensures a sharper selectivity curve, but also improves the signal-to-noise ratio.

Controlling the bandwidth

By varying R_1 and R_2 you can readily control the bandwidth of the filter and achieve a ratio of 1:10. For larger ratios, the capacitors must be switched as well. This feature may be used to advantage to fit the filter curve either manually or automatically to the given transfer requirements as in a receiver i-f section.

A suitable bandwidth switching circuit (See Fig. 5) may be used, for instance, to tune the receiver exactly to midband for fm. Since in an integrated receiver the otherwise conventional ratio detector is replaced by an inductorless demodulator circuit, there is no suitable tuning criterion. In the new N-path filter circuit, the transfer curve of the filter may first be adjusted during tuning to a narrow bandwidth and afterwards automatically switched to the specified value when the proper tuning position is reached.

Similarly, you can also improve a-m tuning accuracy by synchronizing the N-path filter in a practical manner with the desired signal. Since the locking range usually exceeds the pull-in range by a factor of 2 in flywheel synchronization circuits, the assurance of maintaining synchronism during temperature cycling and operating voltage fluctuations is seldom very great. However, if the bandwidth of the receiver is made narrow enough during tuning and increased to full channel width as soon as the switching pulse generator of the N-path filter is synchronized, a safety margin of from 3 to 5 results. This is shown in Fig. 6.

Another practical feature of the N-path filter is its converter function. The filter operates as a selective frequency converter if

$$f_{in} = n f_o \quad \text{where } f_o = \text{switching frequency}$$
$$\text{and } n = 1, 2, 3, \ldots$$
$$\text{but } n \neq N, 2N, 3N, \ldots$$

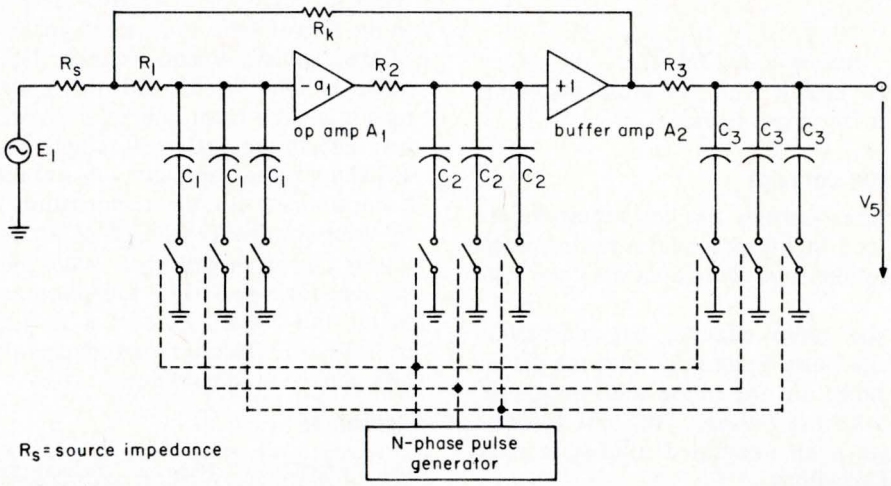


Fig. 4: Third-order N-path filter. This is the basis for a new i-f filter. The response curve for this filter is flatter than that of the second-order filter. All capacitors can be controlled by a single generator.

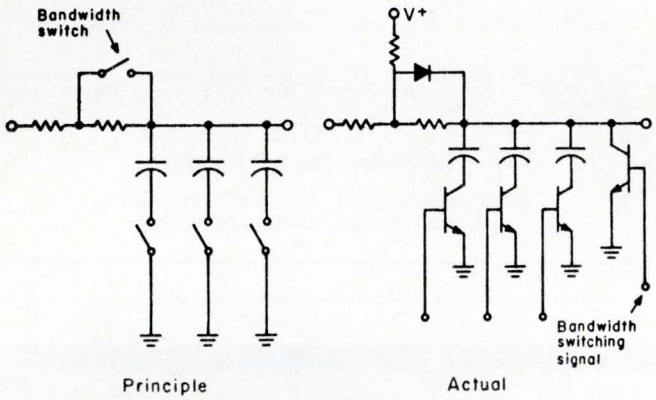


Fig. 5: By using this bandwidth switching circuit you can vary the filter bandwidth by 1:10. By switching the capacitors as well, larger ratios can be achieved.

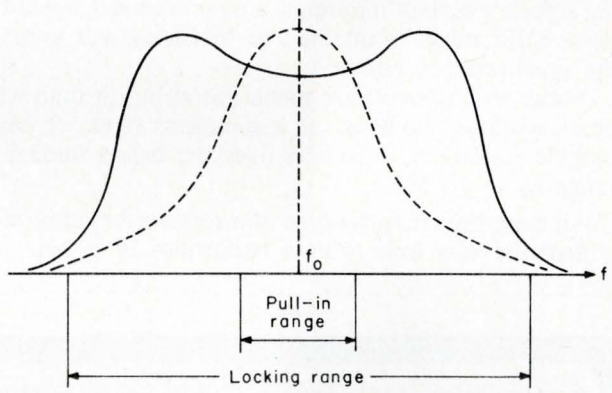


Fig. 6: Changing the bandwidth of the filter during tuning to **pull-in** a precise frequency allows synchronization of the switching pulse generator with the signal frequency. Then, the filter is switched to full channel bandwidth and remains **locked** at that frequency.

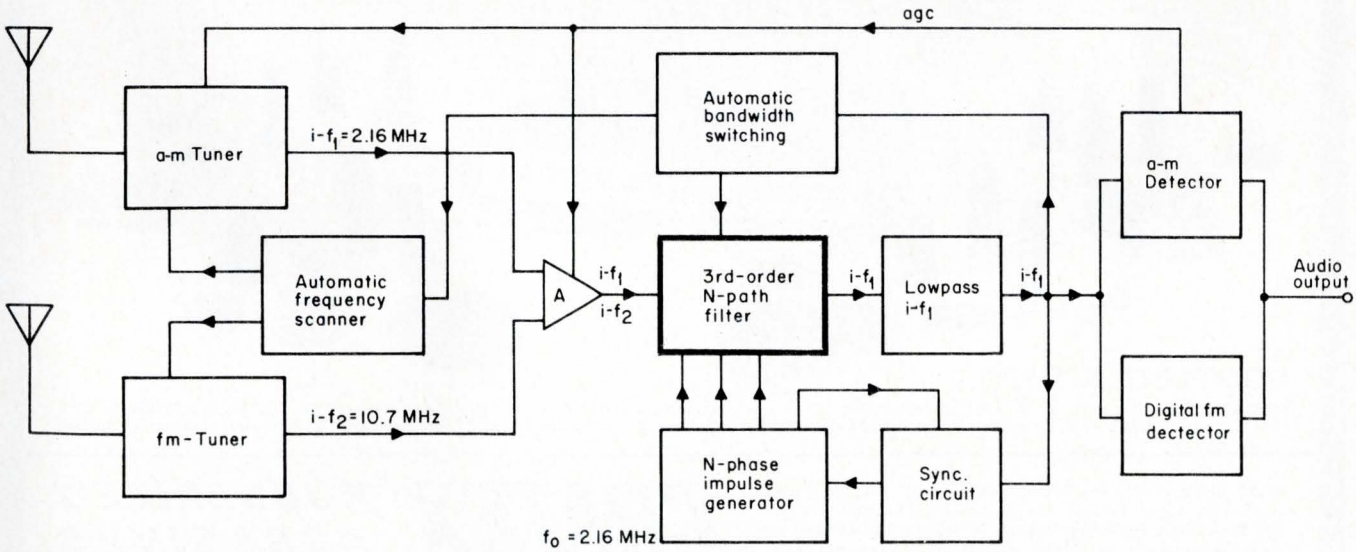


Fig. 7: This a-m/fm integrated receiver is built around a third-order N-path filter in the i-f section. Synchronization of the impulse generator with the i-f signal eliminates switching noise in a-m reception and assures precise automatic frequency control. Electronic bandwidth switching and frequency conversion allow the use of the same N-path filter for both a-m and fm without changing the switching frequency. The simple automatic bandwidth switching system supplies suitable stop signals for an automatic station seeker and improves afc stability.

The output frequency may then be chosen arbitrarily within the ranges

$$f_{out} = m f_o \quad \text{where } m = 1, 2, 3, \ldots$$
$$\text{but } m \neq N, 2N, 3N, \ldots$$

Thus, you can use the circuit with the same switching frequency for various frequency bands.

An integrated receiver concept

This inductorless filter satisfies the key requirements for designing a new and highly practical a-m/fm radio with integrated i-f amplifier and demodulators (see Fig. 7).

When designing the radio circuits, pay particular attention to the N-phase pulse generator, since the prime causes of switching noise are the phase and amplitude inequalities of the switching pulses. The best realization of this unit as yet is an integrated solid-state shift register composed of flip-flops.

Mathematical analysis[3] has shown that the signal-to-noise ratio cannot be improved by increasing the signal voltage; and although the switching noise can be eliminated by synchronizing the switching frequency with the signal, a certain minimum unsynchronized signal-to-noise ratio must be attained or problems will arise in the synchronizing circuit.

These requirements are much less stringent than with other synthesis methods for inductorless filters of comparable selectivity, especially over the broad frequency range up to 10 MHz.

An experimental prototype of a receiver based on this philosophy was built with a bandwidth of 6 kHz for a-m and 200 kHz for fm, and an adjacent-channel selectivity of better than 46 dB. The signal-to-noise ratio of the N-path filter in its non-synchronized state is about 30 dB. During synchronization, however, the switching noise is eliminated, and the channel noise depends mostly on the front end of the receiver. The temperature effects are extremely slight and mainly affect the switching pulse generator. A stability of ± 500 Hz has been attained (in the temperature range of 0°-50°C) by using a timer composed of RC oscillators and a regulated power supply unit. With diode-tuned front end sections for a-m and fm reception and a digital discriminator, this N-path filter leads to a completely new concept for radio receivers and makes possible an unusually high degree of integration.

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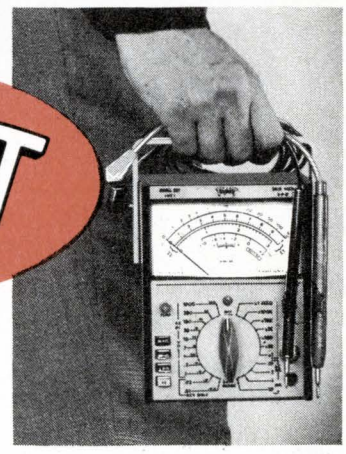

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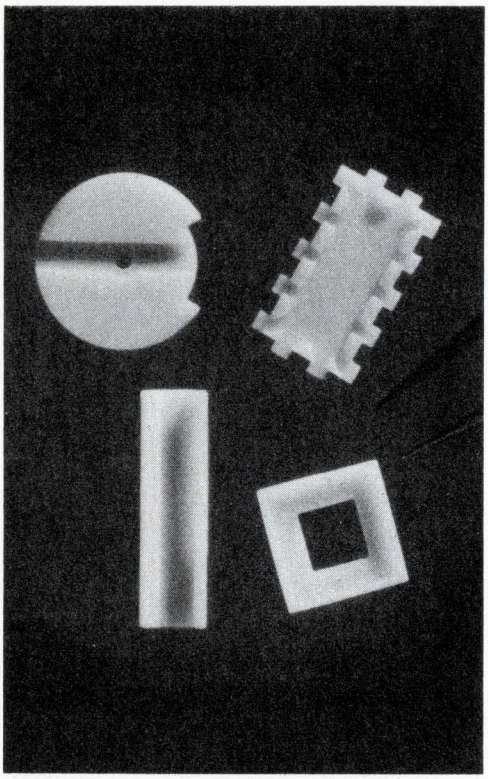

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DVM specs compared

Take a quick look, they change rapidly.

Stephen A. Thompson, Western Editor

Anyone who has tried to compare the specs of digital voltmeters lately knows what a difficult task it is.* The number of units available is large, as are the features to be compared.

The DVM is becoming a mature instrument, that is, extensions of performance are slow to evolve now. Most manufacturers are pushing the specs out to all the stops, and in many areas there are almost no differences worth mentioning.

The wide range of prices for DVMs tempts one to try to relate individual specs to cost. Often, however, several meters of various prices offer comparable performance. If one such spec was the sole basis for selection, the decision would be easy—buy the cheapest DVM.

Most applications, however, require some combination of specs, and the evaluation on that basis soon becomes a real problem. What is needed is an n-dimensional plot, so that each instrument could be compared in its totality to other instruments. Failing this, a handy formula that would weight the various specs and yield a DVM rating factor would be helpful. The difficulty is that no two users have the same needs, and each would assign different weighting factors for each spec.

Therefore, the first step in evaluating DVMs is to define the task it must perform. Then the user can make meaningful comparisons.

*See "Taking the mystery out of DVM specs," Kenneth Jessen, **"The Electronic Engineer,"** October 1969, pp. 46-52.

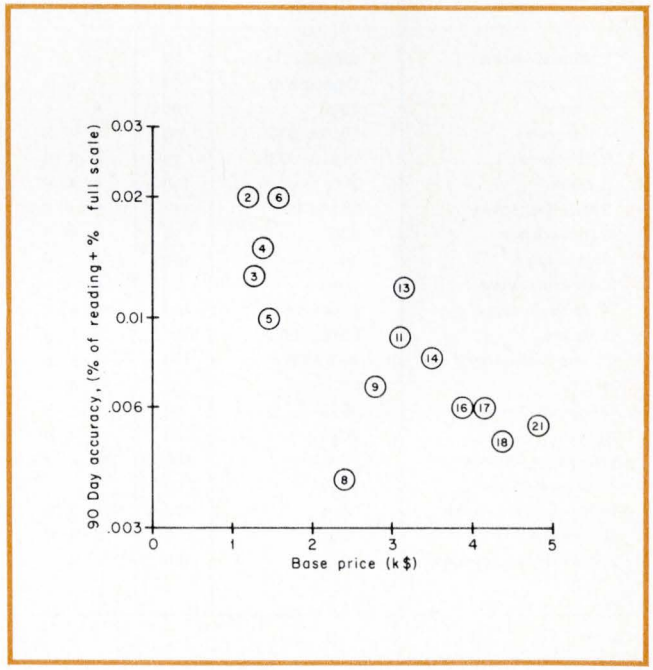


Fig. 1. Long term accuracy versus price for 5- and 6-digit DVMs. Each point is plotted at the base price of an instrument. The accuracy used is the sum of the percent-of-reading plus the percent-of-full-scale, yielding a full scale value. As the graph shows, better accuracy costs more money. The relationship of the numbers to the instruments they represent is given in the 5- and 6-digit DVM tabulation.

How to select a DVM

The DVM charts and tables on the following pages classify DVMs by the number of full digits. Since the user of a 3-digit DVM has different needs than one using a 5-digit DVM, we have listed those features that take on more importance as a function of the number of digits.

The tables include information on overrange capability, common-mode and normal-mode noise rejection near 60 Hz, dc and ac measuring speed, and sensitivity. Measuring speeds include amplifier settling times and worst case filtering when applicable. Measuring speed reflects the time for a response to a step input. Many of the instruments listed will sample at much higher rates,

3-digit DVMs

MANUFACTURER	MODEL NUMBER	Overrange (%)	NO. OF RANGES							FEATURES					PERFORMANCE					PRICE	
			DC Volts & mV	AC Volts	Ohms	Ratio	DC Current	AC Current	TOTAL	Autorange	Programmable	Recorder Output	Guarded Input	Battery Operated	CMR Near 60Hz (dB)	NMR Near 60Hz (dB)	DC Measuring[1] Speed (seconds)	AC Measuring[2] Speed (seconds)	Sensitivity (μV)	Basic Price ($)	With Options ($)
1 United Systems	Digitec 211	50	5						5			X			80	50	4.0	N/A	20	239	314
2 Honeywell	Digitest 500	100	5	5	5		1/41/4		25					X	100	30	2.0	5.0	100	250	320
3 Preston	722B	100	4		4				8			X			120	45	0.1	1.0	1000	295	355
4 Honeywell	Digitest 333	20	5	4	5		5	4	23						100	20	2.0	5.0	100	345	378
5 Honeywell	Digitest 333R	20	5	4	5		5	4	23						100	20	2.0	5.0	100	345	380
6 Digilin	340	100	4	4	5		5	5	23					X	100	ND	0.2	1.0	1000	345	425
7 Data Technology	361/361B	ND	5		5		5		15			X		X	ND	30	0.4	N/A	100	345	430
8 Dynasciences	330	20	4	4	5		5		18						100	40	0.1	2.0	1000	349	389
9 Eldorado	1810	100	5		6				11						80	40	0.1	N/A	100	350	N/A
10 Systron-Donner	7050	50	4		5		5		14					X	60	40	5.0	N/A	1000	354	394
11 United Systems	Digitec 262	100	5	4	5		5		19					X	100	35	0.7	2.0	100	375	450
12 Hickok	DMS 3200	1300	6	6	9		8		58[5]			X	X		120	60	1.0	1.0	1	375	2715
13 Data Technology	360/360B	100	5	5	5		5	5	25			X		X	60	30	0.4	2.0	100	385	470
14 Preston	722C	100	4	4	4				12			X			120	45	0.1	1.0	1000	395	455
15 Systron-Donner	9015	50	5		5		5		15					X	80	30	0.25	N/A	100	495	545
16 Systron-Donner	9025	50	4	4	5		5		18						80	30	0.25	3.0	1000	495	545
17 Practical Automation[3]	PDM-611	100	3/1		?		?		?						80	35	0.3	N/A	100	500	625
18 Hewlett-Packard	3430A	60	5			5			10					X	90	40	0.5	N/A	100	595	675
19 Non-Linear Systems	X3-A	100	6/2	3	9		9		29			X	X		106	60	0.3	1.0	10	765	840
20 Simpson	2701	0	6	6	7		9	9	37	X					120	ND	1.0	4.0	10	835	N/A
21 Pacific Measurements[4]	1010	100		4		1			5			X			N/A	N/A	N/A	1.0	300	1900	N/A

(1) Includes amplifier settling time.
(2) Includes amplifier settling time and full filtering, where applicable.
(3) A printer is included as part of the instrument.
(4) Display is in linear, dBm, or dB units.
(5) Includes 10 capacitance, 7 frequency, 6 period and 6 time interval ranges.

ND indicates no data is available N/A indicates not applicable Color indicates an option

which is very important in some systems applications.

The sensitivity spec tells you the lowest signal that can be measured on the lowest range of the meter. Most DVMs measure up to 1000 V on the highest scale. The fully loaded prices include at least those items that are listed as optional in the table. In many cases other features are also included, but a tabulation of all of them could fill this magazine.

The simple traits of 3-digit DVMs

Three-digit models are usually made as multimeters, and are used in the same way as analog multimeters. They have a large number of ranges included for the base price, and not many options. They are not systems

5-/6-digit DVMs

MANUFACTURER	MODEL NUMBER	NO. OF RANGES								PERFORMANCE									PRICE	
		# of Full Digits	Overrange (%)	DC Volts & mV	AC Volts	Ohms	Ratio	DC Current	AC Current	TOTAL	90 Day Accuracy (% of Range)	90 Day Accuracy (% of Full Scale)	90 Day Accuracy Conditions ($^0C \pm ^0C$)	Tempco (%/^0C)[1]	CMR Near 60Hz (dB)	NMR Near 60Hz (dB)	DC Measuring[2] Speed (seconds)	AC Measuring[3] Speed (seconds)	Sensitivity (μV)	Base Price ($)	With Options ($)
1 Heath	EU-805A	6	12	4						4	ND	ND	ND	0.05	ND	ND	0.1	ND	10	1250	N/A
2 Doric	DS-100-R3-K5	5	0	4			4	4		12	0.01	0.01	23±1	0.002	148	60	0.5	N/A	1	1290	1490
3 Fluke	8300A	5	20	3/2	4	5	5	6	6	31	0.01	0.003	25±5	0.001	140	60	0.025	0.5	1	1295	2995
4 Dana	5200	5	20	4	4	5	4	4		21	0.01	0.005	25±1	0.0007	120	100	0.05	2.0	10	1395	1990
5 Doric	DS-100-T2	5	0	1			2			3	0.005	0.005	23±1	0.005	160	100	1.0	N/A	1	1470	N/A
6 Doric	DS-100R5-K6	5	0	6			6	6		18	0.01	0.01	23±1	0.001	148	60	0.5	N/A	1	1490	1690
7 Vidar	501	5	300	4	1	7				12	0.017[5]	0.017[5]	23±1	0.006	110	ND	0.11	ND	100	1590	4140
8 Data Technology	370	5	20	5	4	6	1			16	0.003	0.001	ND	0.001	140	ND	0.25	ND	1	2400	3700
9 Non-Linear Systems	X-1	5	20	3/2	4	5	3			17	0.006	0.0008	31±19	0.0003	140	76	0.016	0.6	1	2785	5010
10 Cimron	6753	5	10	4/2	4	5	4			19	0.01[6]	0.002[6]	25±5	0.0003	120	90	0.05	0.7	0.1	2990	4015
11 Dana	5500	5	10	3/2	4	7	3			19	0.008	0.001	25±1	0.0004	120	80	0.05	0.3	1	3095	4480
12 Vidar	502	5	300	4	1	7				12	0.017[5]	0.017[5]	25±1	0.006	110	ND	0.025	ND	1	3140	5690
13 Hewlett-Packard	3450A	5	20	5	4	6	4			19	0.008	0.004	25±5	0.0007	130	26	0.065	2.7	10	3150	5150
14 Systron-Donner	7200	5	20	4	4	5	1			14	0.005	0.003	ND	0.001	120	50	0.1	0.3	1	3500	5635
15 Greibach	85	5	0	4/1	4	5	3			17	0.008[6]	0.009[6]	26±14	ND	130	60	0.01	0.5	1	3500	6000
16 Hewlett-Packard	3460B/3441A	5	20	4/1	4	5				14	0.004	0.002	25±5	0.0003	145	26	0.066	0.55	1	3950	5350
17 Cimron	6853	5	10	4/2	4	9	4			23	0.005	0.001	25±5	0.0001	140	100	0.035	0.6	0.1	4095	6185
18 Dana	5703	5	10	4/3	4	5	4			20	0.004	0.001	26±1	ND	120	80	0.11	0.1	0.1	4400	7695
19 Hewlett-Packard	2402A	5	30	5	4	5				14	0.01[6]	0.003[6]	25±1	0.0021	168	48	0.023	0.52	1	4800	6600
20 Vidar	520	6	300	6	1	7				20[4]	0.004[6]	0.01[6]	25±1	0.005	150	40	0.186	ND	0.1	4800	7350
21 Hewlett-Packard	3462A	6	20	4						4	0.005	0.0005	25±5	0.00022	165	45	1.1	N/A	1	4900	N/A
22 Vidar	521	6	300	6	1	7				20[4]	0.004[6]	0.01[6]	25±1	0.005	150	40	0.186	ND	0.1	5400	7950

(1) Sum of (% of reading + % of full scale).
(2) Includes amplifier settling time.
(3) Includes amplifier settling time and full filtering, where applicable.
(4) Includes 3 frequency and 3 period ranges.
(5) 30 day spec.
(6) 6 month spec.

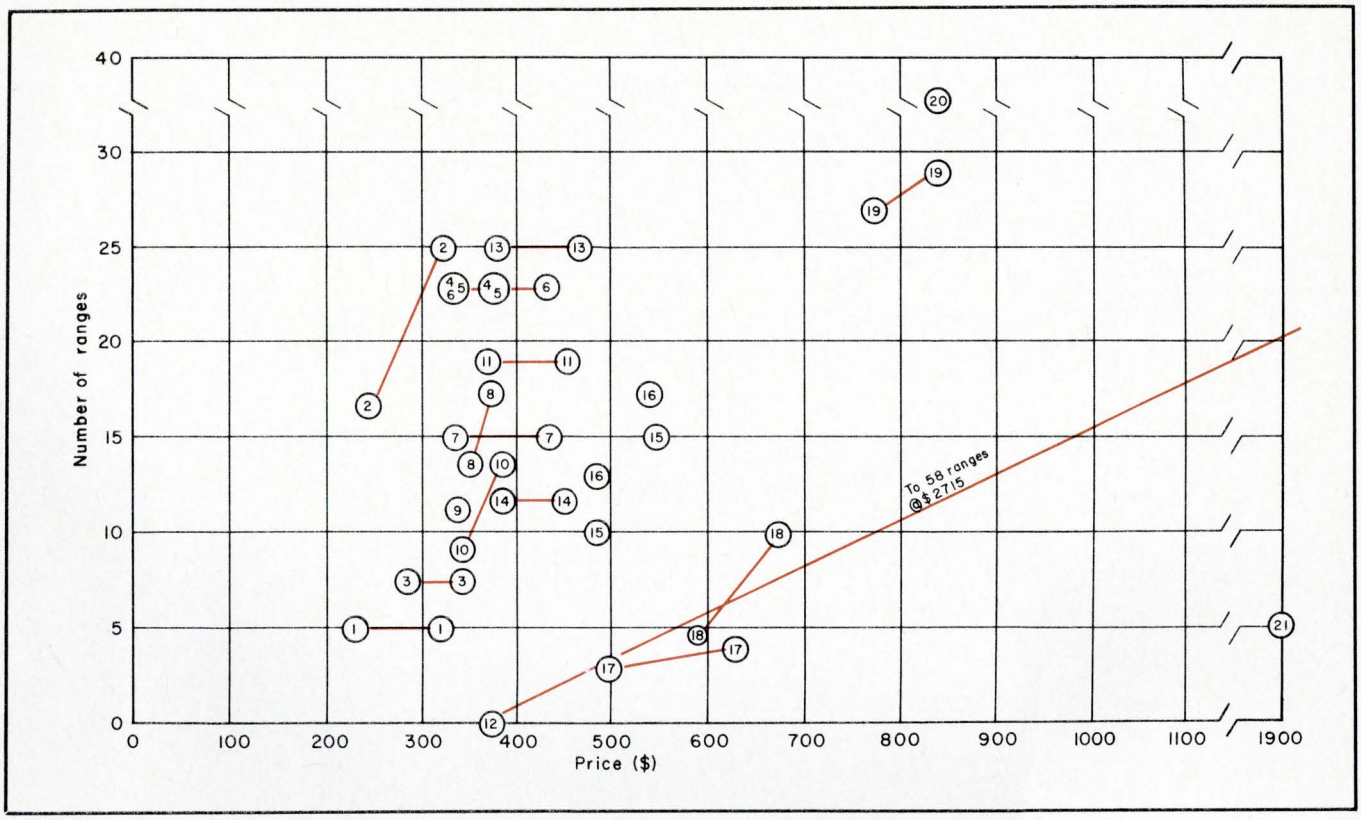
ND indicates no data available N/A indicates not applicable Color indicates option

4-digit DVMs

	MANUFACTURER	MODEL NUMBER	Overrange (%)	NO. OF RANGES: DC Volts & mV	AC Volts	Ohms	Ratio	DC Current	AC Current	TOTAL	FEATURES: Autorange	Programmable	Recorder Output	Guarded Input	Battery Operated	CMR Near 60Hz (dB)	PERFORMANCE: NMR Near 60Hz (dB)	DC Measuring[1] Speed (seconds)	AC Measuring[2] Speed (seconds)	Sensitivity (μV)	PRICE: Basic Price ($)	With Options ($)
1	Disa-S&B	55D30	2	3						3						50	ND	4.0	N/A	1000	420	N/A
2	Preston	723A	100	4						4			X			120	45	0.1	N/A	100	485	560
3	Denelcor	DV 101	20	4						4			X	X		100	ND	1.0	N/A	100	495	N/A
4	United Systems	Digitec 251/251-1	40	3						3		X	X			80	75	0.25	N/A	1000	595	N/A
5	Tycho	404	40	4						4			X			100	50	0.5	N/A	100	595	N/A
6	Simpson	2700	10	4		4		4		12		X	X			90	60	1.0	N/A	100	615	865
7	Preston	723B	100	5		7				12			X			120	45	0.1	N/A	100	645	720
8	Rohde & Schwarz	Digivolt 05-UGWD	50	5	5	5				15						120	54	0.33	0.33	100	660	N/A
9	Eldorado	1820	100	5		5		6		16		X	X			80	40	0.1	N/A	10	675	775
10	Trymetrics	DVM 4230	20	3						3			X			70	40	2.0	N/A	1000	695	755
11	Fluke	8100A	20	4	4	5		6	6	25				X	X	100	50	0.5	3.0	100	695	795
12	Data Technology	350	40	4/2	4	5	1			16	X	X	X	X		100	60	2.0	3.0	1	695	1570
13	United Systems	Digitec 251/251-3	40	2						2		X	X			80	70	0.25	N/A	10	740	N/A
14	Greibach	620B	20	3/3	4	5	2			17	X	X	X	X		140	66	0.25	0.2	1	745	1535
15	Trymetrics	DVM 4240	20	4						4			X			70	50	2.0	N/A	100	750	810
16	Doric	DS-101-K4	20	1			1	1		3			X	X		148	60	0.5	N/A	1000	790	990
17	United Systems	Digitec 251/251-4	40	4						4		X	X			80	40	0.6	N/A	100	795	N/A
18	Philips Elect. Inst.	PM-2421	21	6	6	9		9	9	39	X		X			80	ND	0.105	0.105	10	825	987
19	Trymetrics	DVM 4243	20	4	4	5				13		X	X			70	40	0.1	2.0	100	850	910
20	Cohu Electronics	514-122	20	4			4			8	X		X			100	ND	0.7	N/A	100	875	1205
21	Doric	DS-100-K3	20	1			1	1		3			X	X		148	60	0.5	N/A	100	890	1090
22	Monsanto	200A	20	4						4		X	X	X		120	70	0.25	N/A	100	895	N/A
23	Preston	723C	100	5	4	7				16			X			120	45	0.1	1.0	100	895	970
24	Doric	DS-100-K2	20	1			1	1		3			X	X		148	60	0.5	N/A	10	920	1120
25	Doric	DS-100-K5A	20	4			4	4		12			X	X		148	60	0.5	N/A	100	975	1475
26	Doric	DS-100-K1	20	1			1	1		3			X	X		148	60	0.5	N/A	1	990	1190
27	Trymetrics	DVM 4250A	20	5						5	X	X	X			110	40	0.1	N/A	10	995	1055
28	Dynasciences	440	20	4	4	5	1			14	X	X	X			140	60	0.1	2.0	1	995	1695
29	Doric	DS-100-K5	20	4			4	4		12			X	X		148	60	0.5	N/A	1	1090	1590
30	Non-Linear Systems	X-2	20	3/3	4	5	3	6		24	X	X	X	X		120	40	0.134	0.6	1	1115	2540
31	Cimron	6453	20	5	4	5				14	X	X	X	X	X	100	60	0.22	0.6	10	1125	1730
32	California Inst.	8300	20	5	5	5	5	5	5	34[3]			X	X		120	60	0.5	5.0	10	1145	1595
33	E.G. & G.	736A	200	5		14		11		36[4]		X	X	X		ND	50	0.4	N/A	10	1150	ND
34	Systron-Donner	9200	20	4			6			10	X		X			100	80	0.5	N/A	100	1175	1425
35	Systron-Donner	7000A	20	4/1	4	4		4		17	X		X			60	30	0.2	1.0	10	1175	2335
36	Hewlett-Packard	3440A/3445A	5	3	3					6	X	X	X			70	30	0.45	3.0	1000	1195	1795
37	Doric	DS-100-K6	20	6			6	6		18	X	X	X	X	X	148	60	0.5	N/A	1	1290	2090
38	Dana	4500/230	10	5	4	5	5			19	X		X	X		100	100	0.5	2.0	10	1295	1965
39	Systron-Donner	9210	20	5						5	X		X			100	80	0.5	N/A	100	1325	1525
40	Systron-Donner	9230	20	4		5				9	X		X			100	80	0.5	N/A	100	1325	1525
41	Doric	DS-100-T3D	100	1						3[5]		X	X	X		160	70	0.5	N/A	1	1390	1690
42	Systron-Donner	9220	20	4	4					8	X		X			100	80	0.5	2.0	100	1425	1625
43	California Inst.	8303	20			9				9			X	X		120	60	0.5	N/A	N/A	1495	N/A
44	Singer/Ballantine	3570/3572	25	5						5	X	X	X			130	100	0.075	N/A	10	1675	1855
45	Dana	5403	10	3/2	4	5	3			17	X	X	X	X		120	80	0.012	0.3	10	1695	3775
46	Systron-Donner	9240	20	5	4	5				14	X		X			100	80	0.5	2.0	100	1725	1925
47	Cimron	6653A	10	3/3	4	5	3			18	X	X	X	X		80	70	0.001	0.45	1	1740	2780
48	Rohde & Schwarz	UGZ	60	4						4		X	X			114	48	1.0	N/A	1000	1875	N/A
49	Singer/Ballantine	3570/3571	25		6					6	X	X	X			N/A	N/A	N/A	0.5	1	2000	2180
50	Systron-Donner	7100A	10	5	4	3	1			13	X	X	X	X		120	20	0.25	1.0	10	2175	2850
51	Fluke	9500	20		5					5	X	X	X			N/A	N/A	N/A	3.0	10	2485	2730

(1) Includes amplifier settling time.
(2) Includes amplifier settling time and full filtering, where applicable.
(3) Includes 4 frequency ranges.
(4) Includes 6 coulomb ranges.
(5) Includes 2 thermocouple temperature ranges.

ND indicates no date is available N/A indicates not applicable Color indicates option



Relationship between price and flexibility (number of ranges) available in 3-digit DVMs. Whenever the number of options affect the price, dashed lines connect the base price and the price that includes all options. Note that dollars do not always buy additional ranges, since they may account for improving other parameters. You can find the key to the circled numbers in the 3-digit DVM tabulation.

oriented, as evidenced by the fact that only one autoranges; none are programmable; and a recorder output is only available in a few models. They are general-purpose instruments, used in the lab for trouble-shooting. Several can be battery operated, giving them real portability.

Fours galore

The 4-digit classification is where the action is. Four-digit DVMs also have multimeter capabilities, but most of them get there via the option route. System compatibility is important, much more than with 3-digit models. Many of them autorange, can be externally programmed, and have a recorder output capability. Measurement speed is given for dc, and ac where available. Guarded inputs are common. Battery-operated models are rare, but should become more common as a method of improving CMR.

When comparing items such as short and long term accuracy, temperature coefficient, etc., we could not find any striking variations in performance—save for a few instances. Short and long term accuracy usually runs right at 0.01% of reading and 0.01% of full scale. Tempco usually runs very close to 0.001%/°C.

Top of the line

Five- and 6-digit DVMs are for the man who really cares about his readings. These DVMs have been considered as a group for two reasons. There are only a few of them, and while 6-digit models give better resolution, it is not with order-of-magnitude better accuracy.

The data tabulated for this class of meters is slightly different. Since virtually all of them offer system compatibility, features like programmability are ignored. Because most users of this type of instrument will demand long term accuracy and temperature coefficient data, the 90-day accuracy spec and tempco are listed.

If two instruments have the same accuracy spec, the one with the wider temperature tolerance will be superior. Sometimes data sheets separate tempco into a percent of reading and a percent of full scale. Our tabulation assumes that the instrument is at full scale. This allows us to add the two percentages and give a single, full scale value.

The CMR and NMR figures for 5- and 6-digit DVMs are excellent compared to most lesser digit models. Measuring speeds are also very good on the average.

Since many of these DVMs are expensive, a rigorous, in-depth evaluation must be made by the prospective user before he can choose wisely. Fortunately, in this category, a plot of accuracy (shown in Fig. 1) versus price is an aid to judgment. If you combine accuracy and tempco into a single sum, you get the same kind of a plot, giving some support to the theory that you really gain something for those extra dollars.

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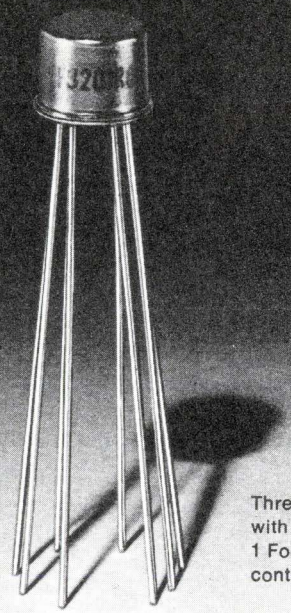

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Charts and Nomographs

***Nomographs simplify phased array design,** Chester W. Young, Walter V. Sterling Inc., "The Electronic Engineer," Vol. 28, No. 10, Nov. 1969, pp. 57-61. The author has developed three nomographs that simplify the design of phased antenna arrays. The articles include nomographs for antenna half-power beamwith, power developed and radiated, and array power cost.

Circuits

Hybrids move ahead in '69, James A. Rose, Consulting Ed., "EDN," Vol. 14, No. 17, Sept. 1, 1969, pp. 49-57. This report rambles through a number of areas of hybrid technology, in order to illustrate the author's two points: (1) hybrids today show a trend to get the job done in the most expeditious manner (that is, you never know what you'll find when you lift a hybrid's lid); and (2), more than a hundred companies make thousands of special, custom, and off-the-shelf hybrid devices, so don't expect any manufacturer's catalog to give you the full story on hybrids.

Feedback sharpens filter response, Roland J. Turner, General Atronics Corp., "Electronics," Vol. 42, No. 20, Sept. 29, 1969, pp. 102-103. Trying to cascade LC networks at very low frequencies to sharpen response is not practical because of the large capacitors and inductors. By using an active filter and an op amp you can achieve very low frequencies, in the order of 0.3 Hz.

Analyze Nonlinear Control Systems, John D. Markel, U.C. Santa Barbara, "Electronic Design," Vol. 17, No. 19, Sept. 13, 1969, pp. 84-89. In this meaty article the Method of Popov is hailed as being destined to become as important as the Bode and Nyquist criteria. It gives sufficient conditions for stability of nonlinear systems. A brief review of system stability is provided, as are computer programs for analyzing linear and nonlinear systems.

IC artwork profits from electroplating process, Roger H. McClurg, IBM, "EDN," Vol. 14, No. 18, pp. 63-64. The author describes a method to generate IC mask masters. His technique saves up to 80% of the time now needed to produce such artwork, by eliminating the cut-and-peel associated with the red, photographically opaque films now used.

A self-adjustable bandpass filter picks off weak signal despite noise, Basil Barber, Sperry Rand Corp., "Electronics," Vol. 42, No. 20, Sept. 29, 1969, pp. 104-107. Noise can make it difficult to pick out a signal. An active filter made in integrated form can solve this problem of noise masking a signal.

Circuit Design

Don't Just Fight Semiconductor Noise, Andrew S. Grove, Intel Corp., "Electronic Design," Vol. 17, No. 17, August 16, 1969, pp. 228-235. The author suggests that designers know their noise sources and design circuits that account for them. Models and methods of calculation are given. Thermal, shot, pseudoshot, and 1/f noises in semiconductors are treated.

***Tune in with a new N-path filter,** Erik Langer, Siemens Akliengesellschaft, "The Electronic Engineer," Vol. 28, No. 10, Nov. 1969, pp. 62-66. N-path filters are inductorless and operate on a time division multiplex principle. This article describes a second generation N-path filter which makes possible on am/fm receiver with integrated i-f amplifier and demodulators.

Communications

What's Delaying U.S. Satellite Communications?, C. D. LaFond & M. J. Riezenman, editorial staff, "Electronic Design," Vol. 17, No. 20, September 27, 1969, pp. 36-48. Everyone wants to see the U.S. develop a communication satellite system, but there is a multi-cornered battle between such giants as Comsat, AT&T, GE, the Ford Foundation, and the FCC over just how to do this. The topic of power for satellites and how to provide it or design around it is also treated.

Components

Reed relays — new applications/developments, Sidney C. Silver, Assoc. Ed., "Electronic Products," Vol. 12, No. 14, Sept. 1969, pp. 26-37. This is a survey of the reed relay field: what reed relays are; where they stand in comparison with crystal-can and semiconductor types; the proliferating applications for reed relays; and advantages and disadvantages.

How Tight a Tolerance is Really Needed?, P. Lee, The Marconi Co., Ltd., "Electronic Design," Vol. 17, No. 18, Sept. 1, 1969, pp. 82-83. Tight tolerances contribute to high costs. A method for calculating the effect of components on circuit performance is described. It enables the widest possible tolerances to be assigned, at the lowest possible cost.

Computers and Peripherals

Talk it out with your Computer, J. T. McAuley & P. D. Oyer, Professional Computer Services, Inc., "Electronic Design," Vol. 17, No. 18, Sept. 1, 1969, pp. 86-92. The authors hold that engineers and computers should be able to work together without a mysterious programmer/engineer interface. They advocate QUIKTRAN as a conversational language that solves the problem, and attempt to explain how to use it. Several examples accompany the text.

Magazine publishers and their addresses

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345 East 47th Street
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56th & Chestnut Streets
Philadelphia, Pa. 19139

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ABSTRACTS

Make Linear Models of Op-amps, John R. Greenbaum, General Electric Co., "Electronic Design," Vol. 17, No. 19, Sept. 13, 1969, pp. 92-96. The author shows how to make use of a manufacturer's gain-frequency curves to construct simple, accurate models of op-amps. These can then be incorporated into compute. aided design programs.

Memories Technology Series: "A choice for serial **memories,"** David C. Uimari, Corning Glass Works, **"Controlling creep and skew in thin-film memories,"** William M. Overn, Univac Federal Systems Division and **"Packing data tightly in thin-film memories,"** Judea Pearl, Electronic Memories and Magnetics Corp., "Electronics," Vol. 42, No. 19, Sept. 15, 1969, pp. 122-130. Here are three more articles in the Memories series. One of the articles looks at the tradeoffs betwen glass-delay line memories and MOS shift registers. The information given shows that each has its advantages for certain applications. The other two articles discuss the major problem of creep in thin films, and how to avoid the problem while getting higher package-density.

On the beam for sharp crt character displays, James W. Wolf, International Business Machines Corp., and James H. Williams, Lundy Electronics and Systems Inc., "Electronics," Vol. 42, No. 20, Sept. 29, 1969, pp. 108-111. A function generator delivering a complex waveform corrects for a CRTs tilt distortion in character displays.

Develop Useful General Models, Marvin E. Daniel, Sandia Laboratory, "Electronic Design," Vol. 17, No. 20, September 27, 1969, pp. 68-72. This article concerns itself with developing mathematical models of tunnel diodes for use in computer-aided design programs. An example illustrates the curve-fitting process that uses data sheet information and two measurements of the diodes to be characterized.

Integrated Circuits

Silicon-gate technology, L. L. Vadasz, A. S. Grove, T. A. Rowe, G. E. Moore, Intel Corp., "IEEE Spectrum," Vol. 6, No. 10, Oct. 1969, pp. 28-35. Despite the enthusiasm for them, MOS integrated circuits have advanced slowly. The use of polycrystalline sliicon for the gate electrode improves the MOS technology, particularly in the areas of increased component density and problems associated with bipolar interfacing. The authors review the technology and show its application to the construction of a 256-bit memory.

No West German 'creativity gap' where linear ICs are concerned, John Gosch, Assoc. Ed., **When it comes to color tv, the outlook is bright indeed,** Robert Surhmann and Eckhart Pech, **ICs enter the picture for automatic cameras,** Ernst L. Ginsberg, Engineer, **For noisy environments, why not low-speed logic?** Werner Hoehne and Ernst Wittenzellner, "Electronics," Vol. 42, No. 19, Sept. 15, 1969, pp. 105-117. This group of articles describes linear ICs made in Germany and their application in consumer electronic devices.

MOS: A Critical Review, Raymond Speer, Technical Editor, "Electronic Design," Vol 17, No. 18, Sept. 1, 1969, pp. 65-80. This is a special report consisting of the following four articles:

Problems for the Designer, S. Ralph Parris, Burroughs Corp., pp. 66-69. The designer must learn about MOS processing so that he can appraise what can be done in cooperation with his chosen vendor to get the best product. Considerations such as power, frequency, threshold voltage, and N or P channel devices are touched on.

TTL Compatibility is Here, J. Leland Seely, General Inst. Corp., pp. 70-73. Since MOS is always assumed to be responsible for problems at the MOS/bipolar interface, MOS processing is altered to achieve compatibility. Pros and cons of using either silicon nitride or 1-0-0 processing technology to achieve a threshold voltage of two volts are presented.

Partitioning is a Challenge, Glen Madland, Integrated Circuit Eng. Corp., pp. 74-77. Basic building blocks much larger than gates are possible using MOS. This leads to partitioning problems and the tradoffs for optimizing several interrelated considerations are discussed.

Single-sourcing Causes Changes, L. C. Drew & J. E. Sheahan, Viatron Computer Systems Corp., pp. 78-80. MOS design is becoming a team effort because of the interdependence at the vendor/user interface. Both parties must have a clear understanding of their responsibilities. A program manager must be set up to handle the myriad problems.

A faster generation of MOS devices with low thresholds is riding the crest of the new wave, silicon-gate IC's, Frederico Faggin and Thomas Klein, Fairchild Semiconductor, "Electronics," Vol. 42, No. 20, Sept. 29, 1969, pp. 88-94. This article describes a newer generation of "MOS" devices that use highly doped silicon instead of aluminum for the gate electrode. Because of this new technique, the devices can be made with bipolar processing. These new devices feature greater speed and lower threshold voltages.

Thick films or thin? Rudolf E. Thun, Raytheon Company, "IEEE Spectrum," Vol. 6, No. 10, Oct. 1969, pp. 73-79. Here is a discussion of the advantages of thick vs thin films in hybrid circuit technology. The article includes a tabulation of typical component values that you can presently get with the two techniques.

An up-to-date look at thick films, John J. Cox, Jr. and Donald T. DeCoursey, E. I. du Pont de Nemours, "EDN," Vol. 14, No. 18, Sept. 15, 1969, pp. 35-42. This article is a wide-ranging look at thick-film technology. Bonding of leads and closures, and device attachment, are described along with paste compositions, line widths and trimming, resistor tolerances and TCs, and so forth. Dielectrics for capacitors, encapsulants, and multilayer structures are also discussed.

Microwaves and Microwave Products

Acoustooptical approaches to radar signal processing, W. T. Maloney, Sperry Rand Research Ctr., "IEEE Spectrum," Vol. 6, No. 10, Oct. 1969, pp. 40-48. Acoustooptical processing is one method for improving the image received by a radar system. With this method, the echo is converted to an acoustic signal and used to modulate a light source. Dr. Maloney describes two such processors one for use below 150 MHz, the other, for higher frequencies.

Don't Be Fooled by Risetime Specs, J. T. Tymann, S. I. Rambo, & A. L. Quesinberry, Westinghouse Electric Corp., "Electronic Design," Vol. 17, No. 17, August 16, 1969, pp. 190-193. The rate of rise of voltage (RRV) specs on pulsed microwave tubes is held to be misleading. A case is made for observing RRV limitations while traversing the starting voltage range for establishing oscillations, but for ignoring them during other portions of the risetime interval. A darlington modulator is presented that gives the desired results.

Packaging

Reduce Stray Reactances of vhf and uhf, R. W. Hankins & H. W. Lamberty, Martin Marietta, "Electronic Design," Vol. 17, No. 19, Sept. 13, 1969, pp. 98-101. Stray reactances are responsible for the fact that rf circuits almost never work properly the first time. Physical circuit layout is one area where improvements can be made, and the boundary method is the key. Component selection and electrical circuit configuration are also discussed.

Power Supplies

Parametric transformer converts 10 to 30, Tom A. Finger, Wanlass Instr., "EDN," Vol. 14, No. 17, Sept. 1, 1969, pp. 61-64. The author describes a new connection to change single-phase to three-phase ac. The method combines an old concept—the Scott-T transformer—with Wanlass's "parametric" transformer, to solve the problem of providing a three-phase source for low-power systems.

Semiconductors

FETs — what's new, William I. Hillenbrand, Assoc. Ed., "Electronic Products," Vol. 12, No. 14, Sept. 1969, pp. 26-37. FETs are widely used today, although this wasn't always so. Advances in technology, accompanied by price reductions, have made these devices more attractive to potential users. The article describes the various classes of FETs available, and their general applications.

Test and Measurement

A quiet look at noise rejection, Barton Weitz and James Nelson, Dana Labs., "EDN," Vol. 14, No. 18, Sept. 15, 1969, pp. 45-47. This is a brief discussion of the normal-mode noise problem in digital voltmeters. Such noise is generally thought of as an undesired ac signal riding on top of the dc level to be measured. DVMs eliminate normal-mode noise by integration (single- or dual-slope) or by the use of multipole filters. The authors favor the use of filters, and explain their point of view.

Special report on x-y recorders, Irwin Sherry, Western Ed., "Electronic Products," Vol. 12, No. 14, Sept. 1969, pp. 118-125. This is a description of the important factors in the selection of an x-y analog recorder, as well as the use of such an instrument in data analysis. According to the author, these instruments are the most accurate and least expensive devices available for graphic presentation of raw data, functions, statistics, and so forth.

Teamwork streamlines differential amplifier tests, James Plumb, Hewlett-Packard Co., "Electronics," Vol. 42, No. 19, Sept. 15, 1969, pp. 132-135. Because of their wideband characteristics, a differential amplifier cannot be checked directly on an oscilloscope. Its bandwidth is wider than the scope's. With a new circuit using a mixer and a modified sweep generator you can use an oscilloscope to measure gain, phase shift, CMRR, and input and output impedance.

Using photocells for electro-optical potentiometer, George Brown and Walter Tomasulo, Hoke, Inc., "Electronic Products," Vol. 12, No. 14, Sept. 1969, pp. 150-151. A potentiometer is described that is noiseless, frictionless, operates at any speed, and produces any desired waveform output. The device uses two photocells behind a moving mask of a special pattern. Construction and use are shown.

Curve fitter aids the measure of rms by overruling square-law slowdowns, Gene Ochs, Dana Labs, Inc., and Peter Richman, Consulting Electronics engineer, "Electronics," Vol. 42, No. 20, Sept. 29, 1969, pp. 98-101. A new converter built with operational amplifiers allows you to make rms measurements in 300ms. In the past these rms measurements had to be made using a slow thermocouple device. This article gives information that permits you to construct such a device.

Digital vs deflection-type meters, Phil Wasserman, Darcy Industries, "Electronic Products," Vol. 12, No. 14, Sept. 1969, pp. 156-158. This article compares low-cost DMMs to deflection-type VOMs and VTVMs, in terms of readability, accuracy, resolution, measurement functions, portability, and so on.

Miscellaneous

***Graphic data tablets,** Staff report, "The Electronic Engineer, Vol. 28, No. 10, Nov. 1969, pp. 50-55. If it's true that engineers can only talk when they have a pencil in their hand, then graphic data tablets are a natural. These units can take your doodles and convert them to a form suitable for transmission over long distances or for communicating with a computer. Mr. Patton describes the four units that are on the market today.

***At the outset of technical editing,** Eldred E. Atkins, IBM, "The Electronic Engineer," Vol. 28, No. 10, Nov. 1969, pp. 29-30. The technical editor, despite what many authors think, really does try to improve your manuscript. Mr. Atkins outlines some steps to make the author-editor relationship more fruitful for both sides.

Make Systems Fail-operational, Paul M. Rostek, Interstate Electronics Corp., "Electronic Design," Vol. 17, No. 17, August 16, 1969, pp. 213-215. The use of automatic voters (selector circuits) is advocated for selecting the best signal from several sources. Diode gate, transistor, and op-amp voter techniques are discussed.

No Engineer Wants to be a Crybaby!, Bernard Daien, E. M. P. Electronics, "Electronic Design," Vol. 17, No. 18, Sept. 1, 1969, pp. 94-98. Six legitimate engineering gripes are listed and described wth vignettes. The reader can mail in a questionnaire outlining the management sins of his organization.

Join the "Experts"—Publish!, Roger M. D'Aprix, Xerox Corp., "Electronic Design," Vol. 17, No. 19, Sept. 13, 1969, pp. 104-106. This article encourages more engineers to publish articles. The author discusses the natural barrier to writing and the payoff if they can be overcome. The prospective author gets a good understanding of what to expect in his relationship with trade magazines and some insight into how the system works.

Production engineer: color him professional, Bill G. Kay, Hewlett-Packard, "EDN," Vol. 14, No. 17, Sept. 1, 1969, pp. 85-89. The author describes the term "production engineer," and the duties of such a man and why they are necessary, and shows how he is viewed by manufacturing, quality assurance, and marketing people. An important point is brought out: production engineers are required to be professional people today—degreed and capable.

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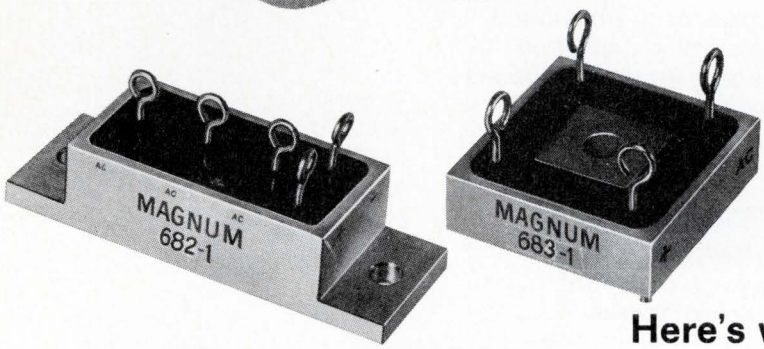

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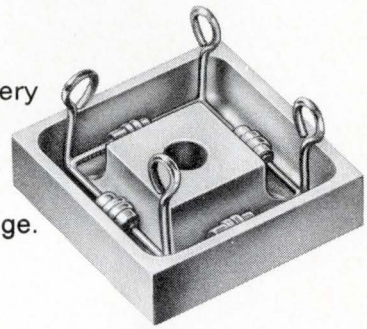

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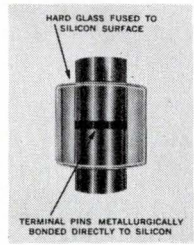

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Here's how you voted

The winning Idea for the June 1969 issue is, "Fault monitor checks for circulating logic bit."

Robert Serody, our prize-winning author, is a Task Manager in the Radar Systems Department of the Raytheon Company, at Bedford, Mass. Mr. Serody selected a Simpson Model 270 multitester.

964 External timing signals sync this crystal clock

M. R. Rawlings and A. L. Hall
Collins Radio, Dallas, Texas

The wide selection of crystal oscillator modules available today is a tremendous aid: you can select a module to fit your clock needs as simply as you can an MSI circuit to fit your logic needs.

However, a crystal oscillator's high Q means that it cannot respond to sudden phase changes, so you usually do not use such oscillators where you must synchronize a local clock to incoming data or timing signals. But here is a circuit which does let you incorporate a crystal oscillator into your design, and still lets you control the clock phase from external sync pulses.

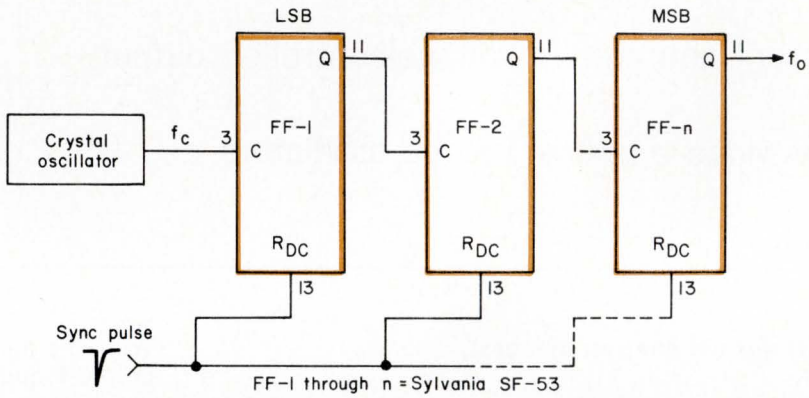
Here's how it works. A crystal oscillator drives a series of flip-flops which counts down to the desired clock frequency. The flip-flops form a ripple counter such that the crystal oscillator frequency, f_c, and and the clock frequency, f_o, are related by the equation, $f_c = 2^n f_o$, where n is the number of flip-flops.

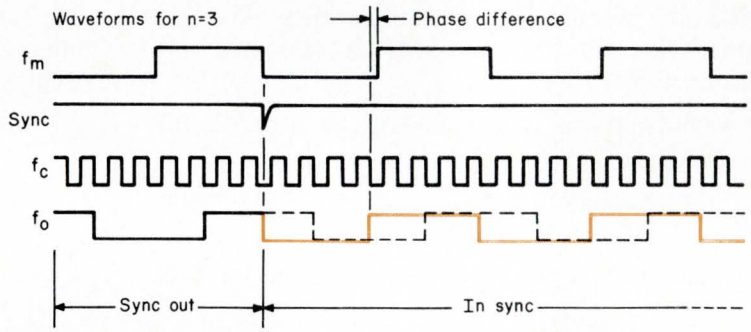
To determine the maximum phase shift introduced by the synchronizing counter, you must assume that f_o has exactly the same frequency as the remote clock, f_m, which generates the sync pulses.

If the sync pulse and the negative slope of f_c occur at the same time, the counter will reset to count *zero*; it will not step to count *one* until a full period of f_c has occurred. In such a case, there is no error in the count and f_o will be in phase with f_m. But a phase difference will occur if f_c clocks the counter prior to one period of delay after the sync pulse occurs. This phase difference is equal to the period of f_c, less the delay between the occurrence of the sync pulse and f_c's first negative transition.

The maximum possible phase difference is equal in time to the period of f_c, and you can control it by the number of flip-flops in the counter. In use, the frequency tolerance of the crystal oscillator may add to the maximum phase difference of the circuit, so you must consider not only the sync pulse rate, but also the tolerance of f_m.

Note that you can synchronize the circuit directly from the incoming data, simply by differentiating the incoming data.





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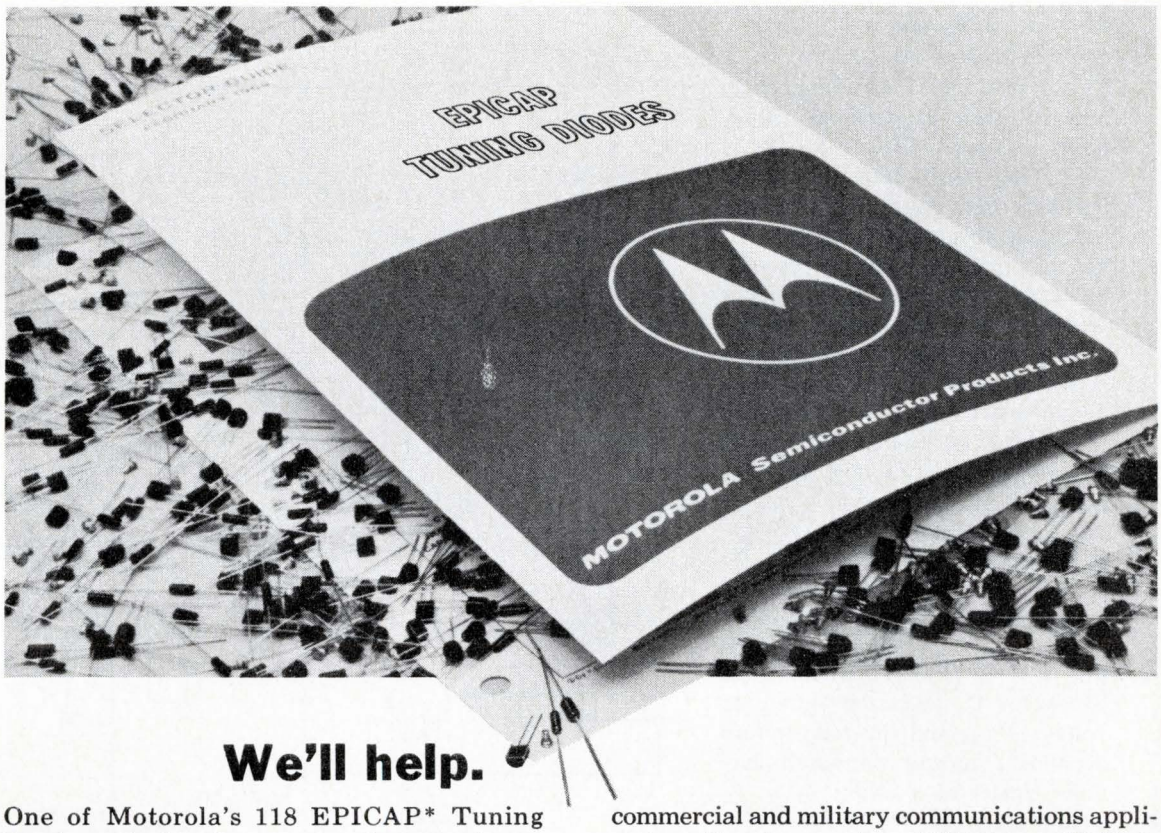

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Motorola EPICAP Tuning Diodes range from high-production-volume, low-cost plastic AFC diodes like the MV2201 to the epitome of quality and performance for the most exacting commercial and military communications applications like the premium 1N5461A or 1N5139. Most are abrupt junction diodes, but some, like MV1401, are the hyper-abrupt junction types needed for applications involving tuning over a wide frequency range. Nominal capacitance values from 1.0 pF to 550 pF are covered, and maximum working voltage ranges from 12 V to 60 V. Package variations include ceramic, plastic, and two different glass cases.

Motorola's tuning diode facilities are geared for volume production and quick turn-around to assure fast delivery on any quantity large or small. For information contact your Motorola Sales Office or Distributor. Or write: Motorola Semiconductor Products Inc. P. O. Box 20912, Phoenix, Arizona 85036.

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965 Current source has voltage-controlled output

Lawrence J. Rennie
Hughes Aircraft, Culver City, Calif.

This circuit gives an output current inversely proportional to an input control voltage. An RCA CA3018A quad transistor array performs both the log and antilog functions; this not only saves parts, but also minimizes the temperature differences which otherwise could cause errors in the output current.

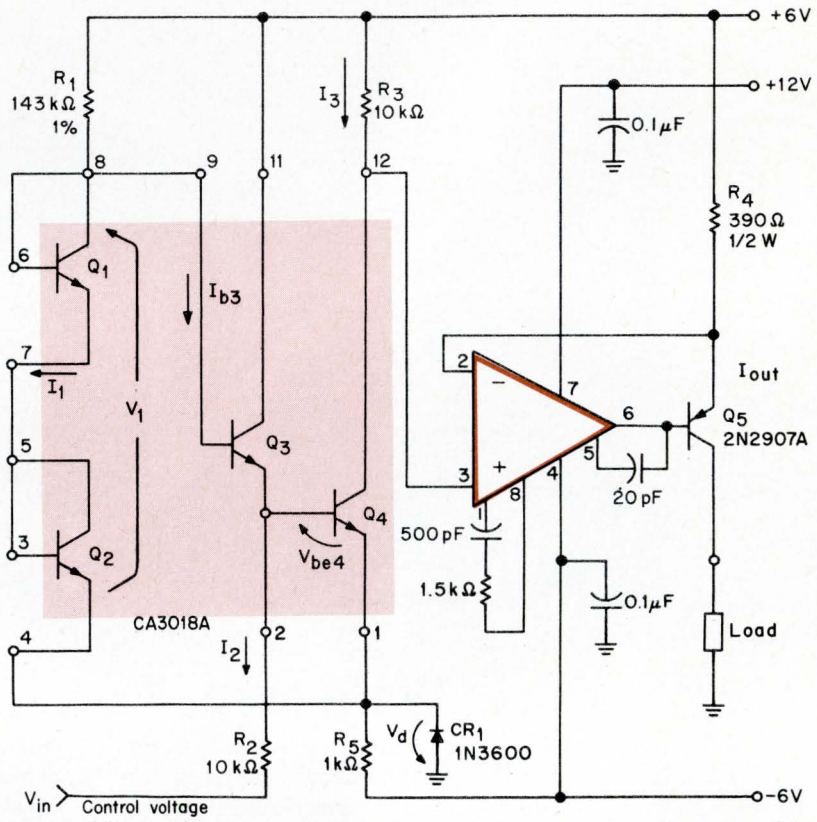
The circuit uses the logarithmic relationship between a transistor's emitter current and its base-to-emitter voltage. Transistors Q_1, Q_2, and Q_3 give the log functions, while Q_4 gives the antilog function.

Connected as diodes, Q_1 and Q_2 produce $V_1 = (kT/q)\ \text{ln}\ [I_1/I_R]^2$; I_R is reverse saturation current, and I_1 is a constant current.

Assuming $I_{b3} = 0$, you can show that $V_{be4} = (kT/q) \exp (I^2_1/I_R I_2)$. Transistor Q_4 takes the antilog of voltage V_{be4}, and the temperature dependent reverse saturation currents cancel each other: $I_3 = I_R \exp (qV_{be4}/kT) = I^2_1/I_2$, after substituting the previous expression for V_{be4}. Substituting $I_2 = (-V_d + V_{be4} - V_{in})/R_2$ into the previous expression for I_3 gives you $I_3 = (I^2_1 R_2)/(-V_d + V_{be4} - V_{in})$.

You use R_5 to adjust the current through CR_1 so that to a first-order cancellation, $(-V_d + V_{be4}) = 0$. The equation for I_3 now becomes $I_3 = (-I^2_1 R_2)/V_{in}$.

The μA709 op amp and Q_5 form a voltage follower that buffers the collector voltage of Q_4, and also gives a current gain $A_i = R_3/R_4$ for I_3. So the circuit's output current is $I_{out} = (-R_3/R_4)(I^2_1 R_2/V_{in}) = K/V_{in}$. Measured output currents match the calculated output currents to within ±10% over a range of 0.038 mA (at −9 V) to 3.8 mA (at −90 mV).



Circuit limitations are due to non-zero base currents and the first-order diode cancellation of V_{be4}. Base current I_{b3} increases with input voltage and causes the "constant" current, I_1, to decrease. This in turn causes the actual I_{out} to be less than its theoretical value at high input voltages.

Because $V_d = V_{be4}$ at only one value of I_3, the actual value of I_{out} depends on $(-V_d + V_{be4})$. This causes I_{out} to be again less than its predicted value at low inputs and, in fact, to roll off where $(-V_d + V_{be4})$ is significant compared to the input control voltage.

966 One video amplifier: three oscillators

Michael English
Fairchild Semiconductor, Mountain View, Calif.

The three oscillators shown here use an IC video amplifier as their active element. Oscillation frequencies range from several Hz to more than 10 MHz, and the output signals can directly drive DTL or TTL circuits. Output rise times and fall-times are less than 10 ns.

The Fairchild μA733 has differential inputs and outputs, and a 120-MHz, 3-dB bandwidth when operated at 20-dB voltage gain. It needs no external frequency-compensation. Gain-adjustment terminals let you continuously vary the IC's gain from 10 to 400 with an external resistor; without external components, you can still select fixed gains of 10, 100, or 400.

The basic oscillator is an *RC* relaxation circuit, with the other two being variations upon it. In this basic circuit, capacitor C and the voltage divider formed by R_1 and R_2 supply positive feedback. The period of oscillation, T, is

$$T \approx 2C\,(R_1 + R_2)\cdot \ln\,[A_v R_1/(R_1 + R_2)] \geq 2.$$

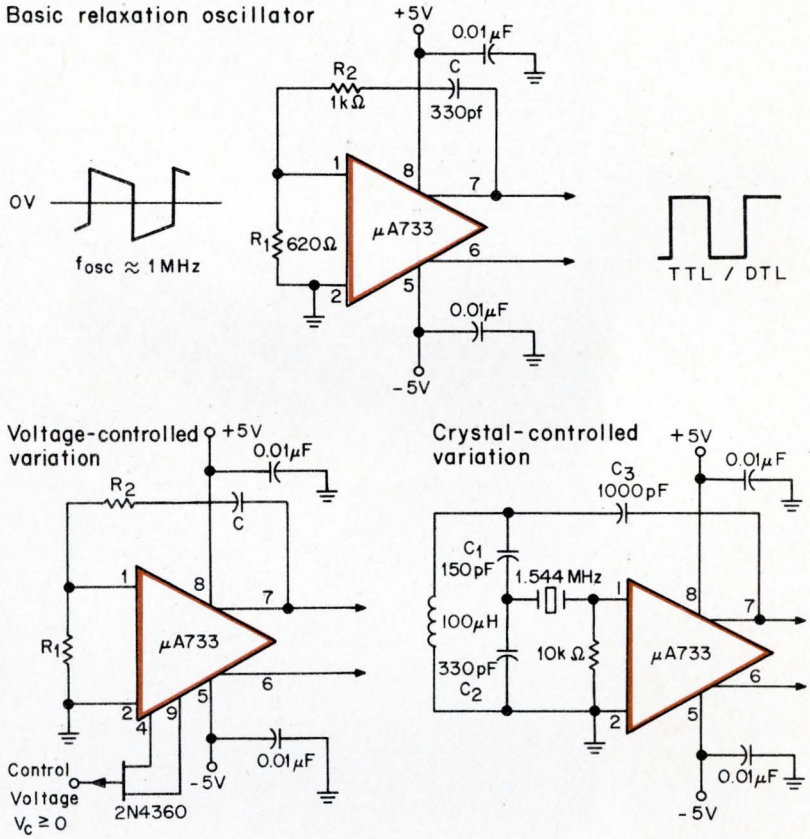
The approximation is due to the fact that the IC draws input bias current when the input signal is positive, but none when the input is negative. This means that the duty factor of the oscillation differs slightly from the ideal value of 50%, and thus the coefficient of the equation is not exactly two.

A voltage gain (A_v) of ten holds the division ratio R_1/R_2 to values between 0.2 and 0.4. The equation for T sets the lower limit, because the inequality $A_v R_1/(R_1 + R_2) \geq 2$ must hold for practical solutions. The single-ended output swing, and the input range of the device (±1 V), set the upper limit.

You can control the oscillation frequency in two ways, both of which give rise to the voltage-control variant of the basic circuit. In one method, you shunt an FET across R_1, and vary the FET's drain resistance by its gate voltage. Take care that you still satisfy the division ratio restrictions for the combination of R_1, R_2, and the FET.

A second method of frequency control uses the fact that the period, T, is proportional to the natural log of the gain. So, to control the gain, connect an FET across the gain-adjustment terminals of the device, as shown. A junction FET as the gain control element gives about a 3:1 frequency variation: the higher the gain, the lower the oscillation frequency.

Another variant of the basic relaxation circuit comes about because, in principle, you can replace capacitor C with a crystal of the desired frequency. To prevent excitation of the crystal's overtone modes, put a tuned circuit in the feedback loop. This tank favors oscillations at its own resonant frequency, but suppresses other, spurious modes. To sustain oscillations, the voltage division ratio, C_1/C_2, must be greater than the reciprocal of the amplifier gain.



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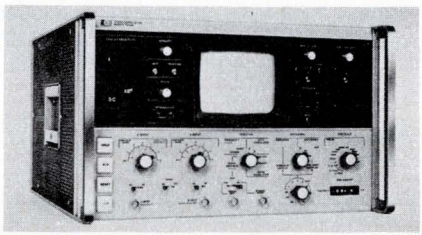
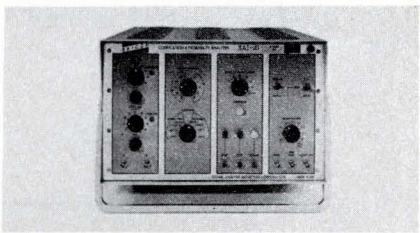
Both instruments compute the cross-correlation of two signals—or the auto-correlation of a signal with itself—for 100 values of the time shift between the signals. The Saicor SAI-41 gives you the data in the form of outputs to an oscilloscope and an x-y plotter. The Hewlett-Packard 3712A, in addition to scope and plotter outputs, displays the data on its own CRT.



Hewlett-Packard's Model 3712A



Saicor's Model SAI-41

Bandwidth limitations

You can adjust the time shift between inputs (time shift is the time between input samples) on both units; on the SAI-41 from 25μs to 50 ms, and on the 3712A, from 1μs to 1 s. For the sake of comparison, let's assume you need 4 points to define a function. This gives you an upper frequency response of 250 kHz on the HP unit and 10 kHz on the Saicor unit. Because the units use digital techniques, their low frequency limit is dc. The 3712A gives you the option to use an external clock to set the input sampling rate, so you can make the time between samples as long as you wish.

An optional delay offset feature on HP's processor lets you enlarge a portion of the display. With a front panel control, you can select an offset as long as 900 times the time between samples. Thus, by decreasing the time between samples and selecting the appropriate offset, you can increase the resolution of the display in a particular area.

Both instruments also compute the probability density function and its integral, the probability distribution function for a waveform.

Signal recovery

HP's 3712A lets you recover periodic signals hidden in noise, through the use of its averaging mode. This mode needs a synchronizing signal at the start of each period of the signal of interest. The sync signal can be an external trigger, or you can derive it from the instrument's internal clock. The 3712A then samples the input at fixed intervals for a predetermined number of repetitions, and stores the information in a memory. Each time it takes a sample, the 3712A algebraically adds the new value to its memory. Each sample thus enhances the signal portion of the input, while the noise, which is random with respect to the synchronizing signal, tends to cancel.

Sample averaging

Both units use summation averaging to compute the 100 values of a particular function. With this method, each value is composed of equal parts of all samples of the value up to that time. Front panel controls on both instruments let you select the number of samples you want. The 3712A has a range of 128 (2^7) to 131,072 (2^{17}); the SAI-41's range is 500 to 100,000. Both units compute for the number of samples you select and then stop automatically.

Saicor's correlator gives you a continuing integration mode. Here, there is no preselected number of samples. The instrument continuously computes the 100 values of the function and stops only when you exceed the capacity of the memory.

Exponential averaging

Besides summation averaging, HP's 3712A lets you use an exponential averaging technique. Here, the unit gives more weight to the most recent sample of a value. This mode is useful for the analysis of time-varying signals, because the unit recognizes changes more quickly than in the summation averaging mode.

The exponential mode has switch-selectable time constants from 36 ms to 10^7 s. And with an external clock, you can make the time constant as long as you need it to be.

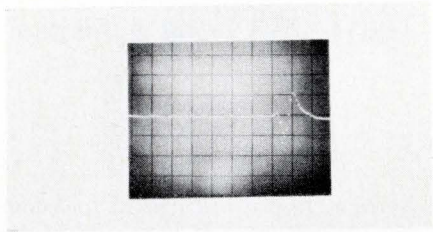
Exponential averaging on the 3712A gives you another advantage. Because of the particular algorithm used, the time constant at the beginning of an experiment is short and builds up to the value that you select. This means that the 3712A can give you a rough average in the early stages of low frequency or long time-constant applications. With this, you can uncover errors in your test setup without waiting for the experiment to run its course.

The Saicor Model SAI-41 comes in either a bench or rack-mounting unit. Its price is about $8000 with a four-month delivery. Signal Analysis Industries Corp., 595 Old Willets Path, Hauppauge, N.Y. 11787. (516) 234-5700.

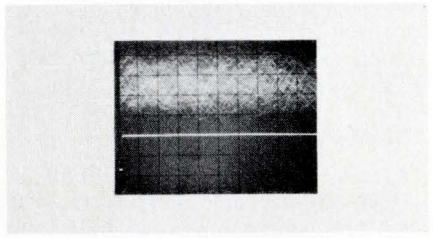
A lighted panel on HP's instrument gives you display sensitivity (mean square volts/div.) at a glance, making the unit very easy to use. The 3712A costs $8350 and deliveries are scheduled to start in January. Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

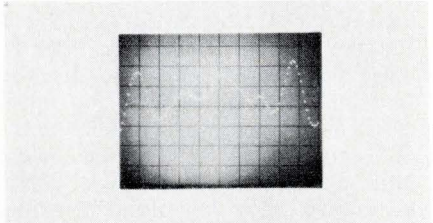
For more information on these units, please use the reader service card:

Hewlett-Packard: Circle 206
Saicor: Circle 207



Correlation in flow measurement performed by the HP 3712A. A noise signal with a BW of 150 Hz was applied to the head of a tape recorder. The output from a second head located 9/16 in. downstream is cross-correlated with the input. Time scale 1 ms/mm. Tape speed 7.5 in./s.





Signal Recovery. Top photograph is a repetitive waveform buried in noise (S/N = −20 dB). Bottom trace on photograph shows sync pulse that identifies the start of each repetition. The lower photograph shows the signal as recovered by HP's instrument after averaging 32,768 repetitions.

Correlation is the measure of the similarity of two signals. Suppose you take two waveforms, multiply them together ordinate by ordinate, and find the average of all the products. Now, insert some time delay between the two signals and perform the same operations again. Do this a number of times, plot the averages as a function of the time delay, and you have the correlation function of the two waveforms. And this is what the HP and Saicor instruments do.

You can use correlation to detect periodic signals hidden in noise; to establish coherence between otherwise random-appearing signals; to find the transmission time and locate the source of a signal, and so on.

Correlation lets you analyze the behavior of large, complex, non-electrical or electromechanical systems (with appropriate transducers, of course). You apply a low-level, broadband stimulus to the system's input, and correlate its output with that input. This gives you the impulse response of the system, and you've gotten it without disturbing the system's normal operation.

Autocorrelation — the correlation of a waveform with itself—gives you the Fourier transform of the waveform's power spectrum or, in the case of random signals, their power-density spectrum.

The correlation function does not give you any information about signal amplitude variations with time. A statistic that does give you such waveshape information is the **probability density function.** The area under the probability density curve between any two amplitudes is the probability that the signal will be between those amplitudes at any arbitrary time. The most familiar pdf is the bell-shaped Gaussian curve of distribution.

The integral of the probability density function is the probability distribution of a signal. This gives you the probability that a measurement will not exceed a particular value.

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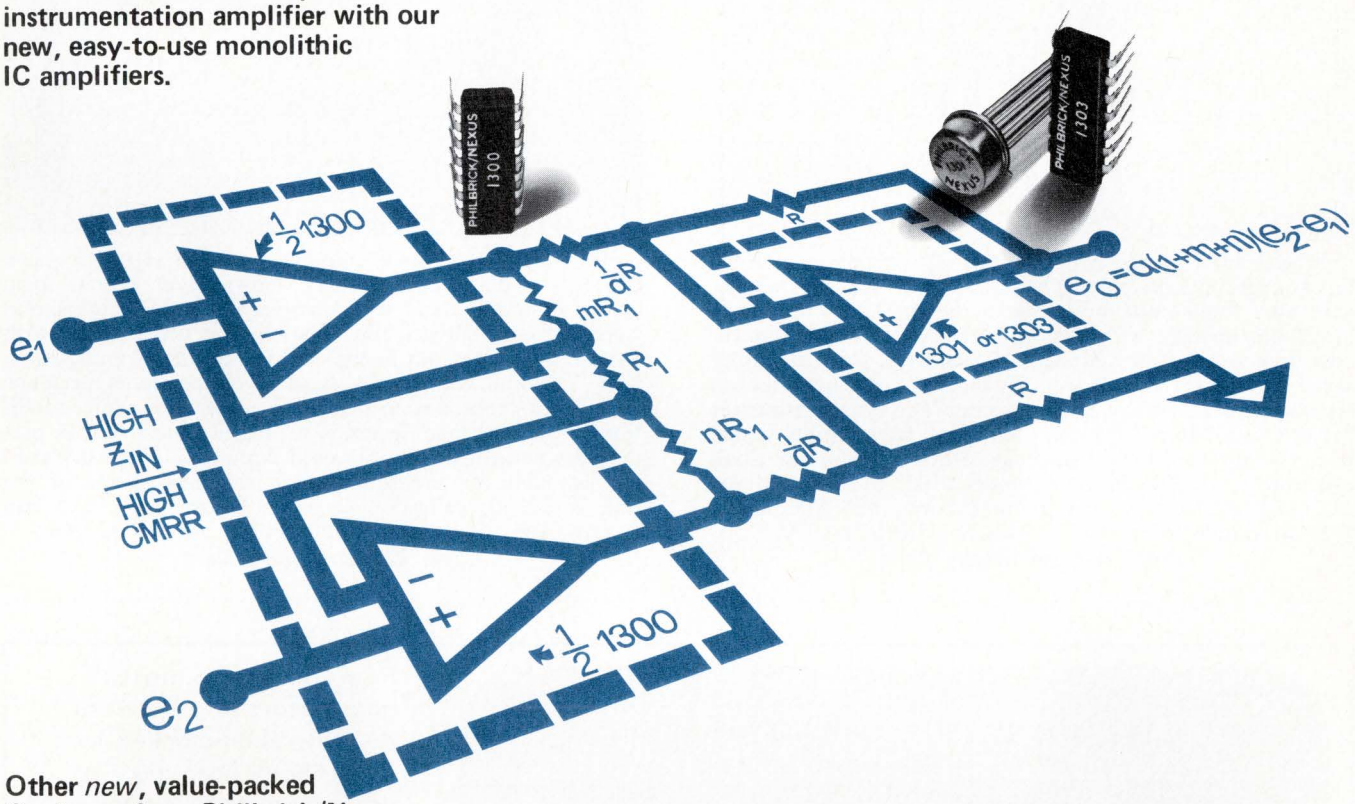

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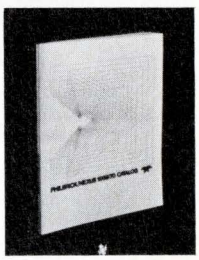

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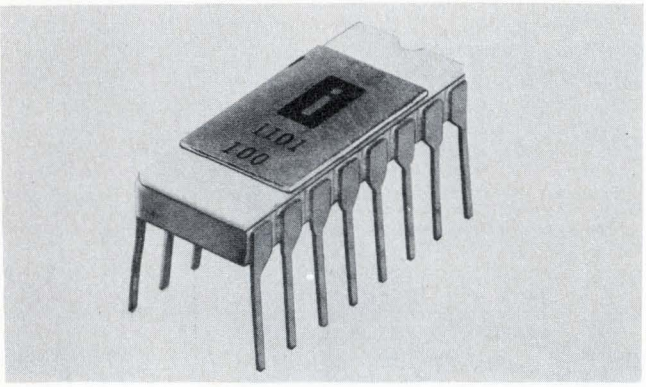
STATIC RANDOM-ACCESS MEMORY

Uses large-scale integration.

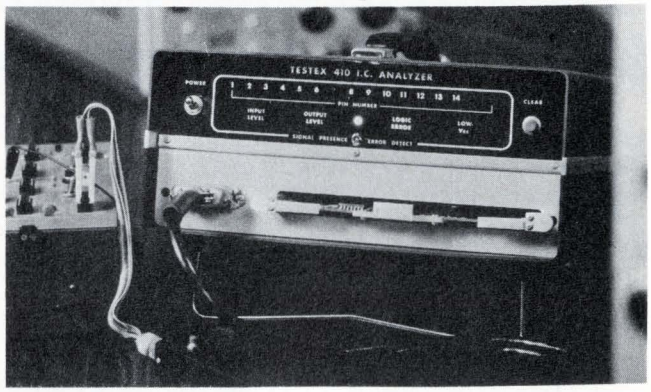


Model 1101 stores 256 bits and all decoding circuitry on a single silicon chip. The memory is the first silicon gate MOS semiconductor to reach the market. The device interfaces directly with TTL and DTL logic. Maximum access time is 1.5 μs for Model 1101 and 1μs for the slightly faster Model 11011. Power dissipation is 50 μW/bit on standby and 2 mW/bit during access. The device organizes the bits in a 256 x 1 format, and comes hermetically sealed in a 16-lead dual in-line package. Stock delivery for small quantities; to 1000, 30 days. Model 1101, $150 ea., Model 11011, $187.50 ea., 1-9 pcs. Intel Corp., 365 Middlefield Rd., Mountain View, Calif. 94040. (415) 969-1670.

Circle 225 on Inquiry Card

INTEGRATED CIRCUIT ANALYZER

Checks all pins without removing device from circuit.

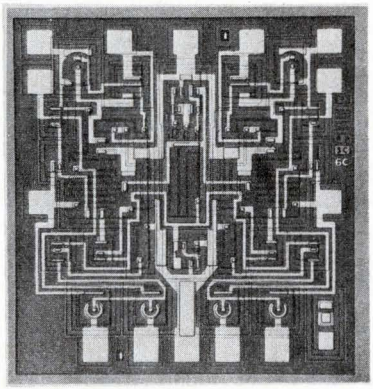


The Model 410 uses a snap-on, multi-pin probe to check digital ICs. The visual display shows level errors, logic errors, or low V_{cc} and you can select a mode which shows signal presence at each pin. You can use the analyzer with RTL, DTL, and TTL ICs in the dual-in-line or flat-pack packages. The unit compares voltage levels or signal presence with a reference device operating under the same conditions. The reference device is a plug-in board that is preprogrammed for commonly used circuits. Universal blanks are available for programming in the field. Price of the unit is $2500, delivery, 30 days. Testex, Inc., 154 San Lazaro Ave., Sunnyvale, Calif. 94086. (408) 732-0461.

Circle 226 on Inquiry Card

DUAL WIDEBAND OP AMP

Unit has channel separation of 140 dB.

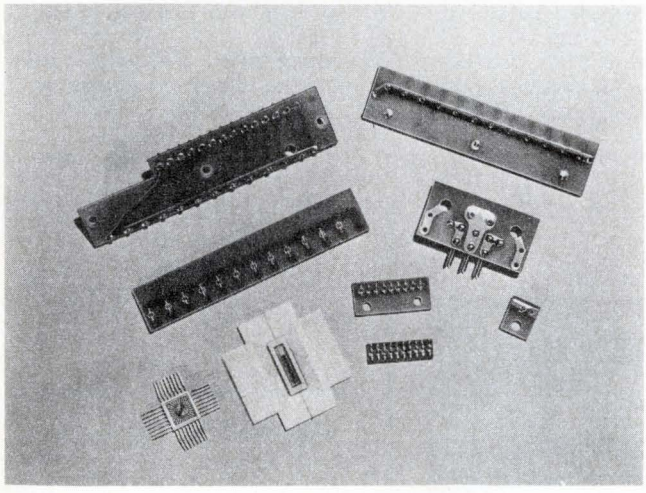


The μA749 has a gain of 20,000 and input impedance of 150 kΩ. The device is latch-up proof and short circuit protected, and it has a 20 MHz unity gain bandwidth. It is constructed from a single silicon chip and contains two identical three stage op amps. Each op amp has differential inputs and an uncommitted pnp output stage. This output approach gives you a variety of load configurations for applications from dc to 10 MHz. The device comes in a hermetically sealed ceramic dual-in-line package. $5.95 ea. (ind.), $17.95 (mil), in quantities of 1-24 pcs. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040. (415) 962-3563.

Circle 227 on Inquiry Card

MONOLITHIC OPTOELECTRONIC ARRAYS

Typical array has 31 photodiodes on 0.005 in. centers.



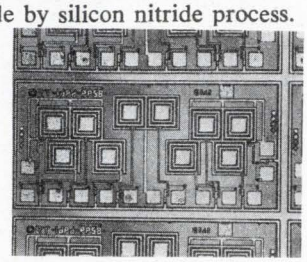
You can consider these monolithic arrays as the opto-electronic equivalent of integrated circuits. They offer advantages over discrete arrays of better resolution, better and easier alignment of array elements, space savings and potentially lower cost per element. Because the parameters vary with the application, present arrays are custom made to meet customer requirements. The manufacturer supplies these arrays in various packages and has developed special packages for large arrays, including a 100-pin ceramic flat pack. Technical Information Center, Motorola, Semiconductor Products, Inc., Box 20924, Phoenix, Ariz. 85036. (602) 273-6900.

Circle 228 on Inquiry Card

NEW MICROWORLD PRODUCTS

TEN-CHANNEL MULTIPLEXER

Made by silicon nitride process.

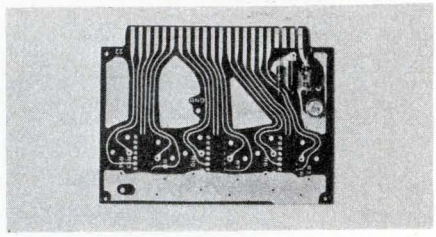


The MU-6-2281 has ten insulated field effect transistors. You get a 10^{10} Ω R_{in}, integrated zener clamp protection, and a low on resistance with this device. In a 24-lead DIL package, the price is $21.20 ea., in quantities of 100. General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11802. (516) 733-3333.

Circle 274 on Inquiry Card

IC LOGIC CARDS

Additions to DTL series.

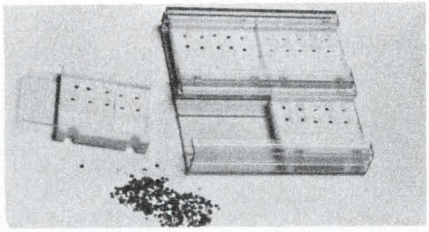


The module 273 is a 2 input OR gate and the 275 is a 2 input AND gate. Both modules have the manufacturer's "dynamic decoupling" which eliminates both high and low frequency noise in large systems. Both are $29, delivery, two weeks. Datascan, Inc., 1111 Paulison Ave., Clifton, N.J. 07013. (201) 478-2800.

Circle 277 on Inquiry Card

THIN-FILM RESISTOR KIT

RETMA valves; 33Ω to 470 kΩ.

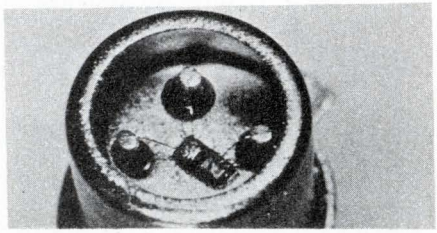


These resistors have a symmetrical center tap with an insulation resistance of 10^{10} Ω min. TC is ±50 ppm from −55 to 125°C. Substrate material is oxidized silicon 25 mils square by 10 mils thick max. Price is $187, delivery 2 weeks. Dickson Electronics Corp., Box 1390, Scottsdale, Ariz. 85252. (602) 947-2231.

Circle 275 on Inquiry Card

INTEGRATED LIGHT SWITCH

Has output current of 4 mA.

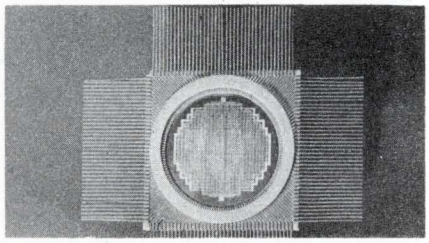


The Type IPL 11 has a silicon planar photodiode, and integrated circuitry on a single substrate. It's in a TO 18 can with glass window. Light of a pre-selected intensity activates the photodiode. Switching speed is about 1 ms in normal operation. Teknis Inc., Plainville, Mass. 02672. (617) 695-3591.

Circle 278 on Inquiry Card

LSI DDA

Special purpose computer.

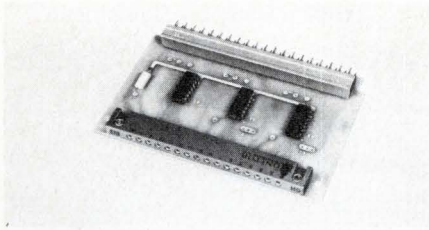


This Digital Differential Analyzer on a single slice of silicon uses discretionary LSI routing. The DDA is an incremental computer for solving differential equations. Interconnecting two of them will provide the incremental solution to the sine and cosine functions. Texas Instruments, Incorporated, Box 5012, Dallas, Tex. 75222. (214) 238-2011.

Circle 276 on Inquiry Card

LOGIC LINE

For low-speed, high-noise uses.

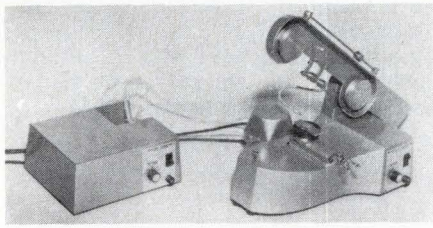


The Monilogic H Series has over 25 types of cards. The series uses 15 V ICs in the DIL package. The threshold level is 7.5 V versus the 1.5 V for normal DTL logic, and the propagation delay is typically 110 ns. Monitor Systems, 401 Commerce Dr., Ft. Washington, Pa. 19034. (215) 646-8100.

Circle 280 on Inquiry Card

SLICING AND DICING UNIT

Has kerf loss of 0.005 in.

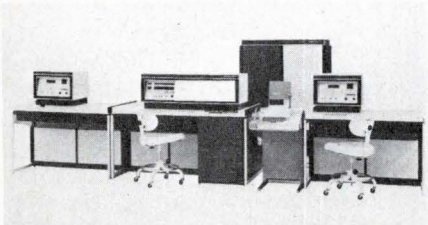


Model 850 can cut large samples of brittle materials with little operator attention. You can use the instrument to cut materials such as semiconductor crystals, ceramics, thin film substrates, ferrites and glass. South Bay Technology, Inc., 4900 Santa Anita Ave., El Monte, Calif. 91731.

Circle 281 on Inquiry Card

IC TEST SYSTEM

Computer controlled.



Series 5000C system, can greatly increase throughput rates. This is due to a high-speed, A/D converter, use of computer control, and a complete software package. Basic 5000C system performs static parameter measurement of digital ICs. A complete system tests both digital and linear ICs, performs static and dynamic measurement and high speed functional testing. Fairchild Systems Technology, 974 E. Arques Ave., Sunnyvale, Calif. 94086.

Circle 282 on Inquiry Card

NEW LAB INSTRUMENTS

DIGITAL PULSE GENERATOR

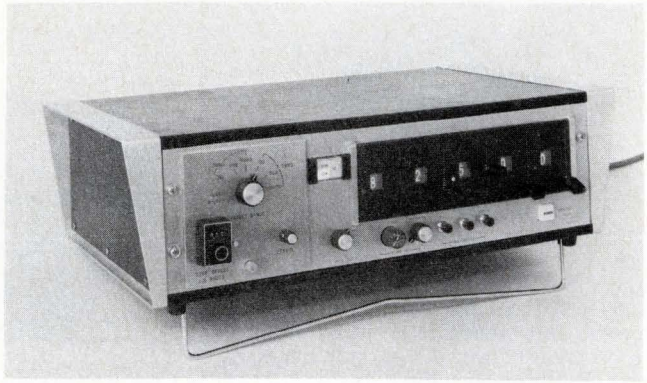
Has both high and low power outputs.

The PG-100 gives synchronized pulse chains on two separate outputs. You can adjust pulse width from 2 ns to 20 ms. One output, for use with bipolar circuits, provides 5 V at 120 mA. This output has 1 ns rise and fall times and you can adjust the repetition rate from less than 1 Hz to 150 MHz. The other output gives you −28 V at 600 mA and is useful in testing MOS FETs. This ouput has rise and fall times of 7 ns and a repetition rate of up to 30 MHz. The unit also gives you the logical inverse of both outputs. Price is $2,450 with four-week delivery. Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852. (617) 458-6871.

Circle 208 on Inquiry Card

PRECISION RESISTOR TESTER

Can monitor and control resistor trimming equipment.

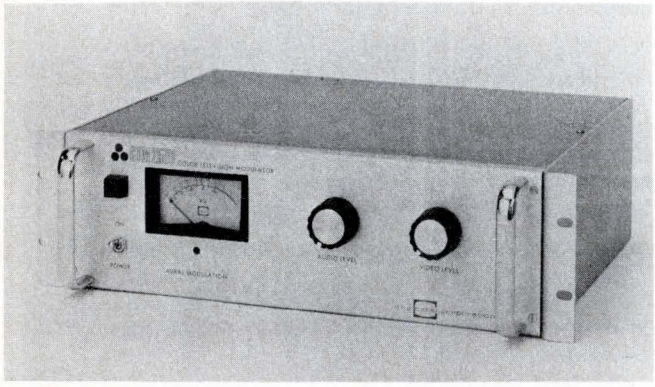


Model 603 uses ratio and voltage-current techniques to measure resistance, instead of the conventional resistance bridge circuit. You can use this instrument to control air abrasive or laser equipment to trim resistors to absolute values or to specific ratios. You can also use it to trim active networks by monitoring voltage ratios. Typical accuracies are 60 ppm of the reading for absolute values and 20 ppm for ratio measurements. A front panel switch gives you six resistance ranges from 100Ω to 10 MΩ. Maximum dissipation during testing is 11 mW on the 100Ω range. James G. Biddle Co., Plymouth Meeting, Pa. 19462.

Circle 210 on Inquiry Card

COLOR TV MODULATOR

Unit accepts either local or microwave input.

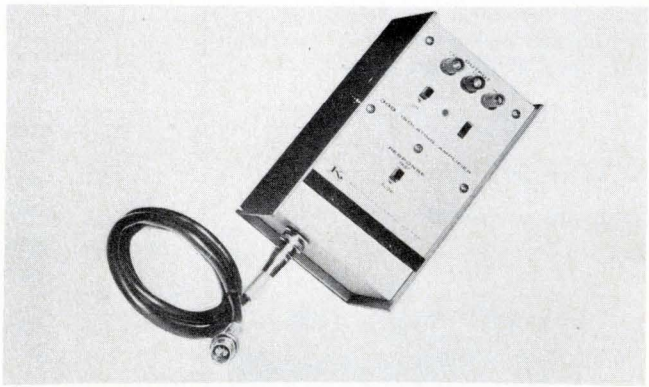


The CTM-2500 gives you phase equalized color video signals that exceed NTSC standards. The unit has an envelope delay equalizing network and produces broadcast-quality transmission signals in any closed-circuit, film, local-origination, or microwave system. The audio input to the unit is either 600 to 10,000Ω or an inter-carrier 4.5 MHz signal. The unit controls the audio carrier frequency to assure a maximum drift of 2 kHz. The video carrier frequency is crystal controlled and maintains a stability of 0.001%. Price of the unit is $1,050 with immediate delivery. Catel Corp., 517 Marine View Ave., Belmont, Calif. 94002. (415) 592-3776.

Circle 209 on Inquiry Card

ISOLATION AMPLIFIER

Linearity is ±3%; stability, ±3%/day.



Model 399 lets you make measurements at up to ±1500 V off ground. The instrument is a unity-gain amplifier with a full scale input of ±1 V. With the input floating, you can ground the output or it can float up to 100 V from ground. Gain accuracy is ±0.2%. The unit has two modes of operation to give you a choice between response and noise. The fast mode has a frequency response of 100 Hz and a noise level of 5 mV pk to pk. The slow mode gives you a response of 0.3 Hz and has a noise level of 0.5 mV pk to pk. Price of the instrument is $175, delivery in 30 days. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio, 44139. (216) 248-0400.

Circle 211 on Inquiry Card

One diode. One cavity. One watt.

Now Varian delivers the highest power single-diode oscillators on the market. These Impatt-mode devices put out 1 watt CW in C or X band, operate at 6% typical efficiencies and require only 160 mA at 95 Vdc for X band or 110 mA at 150 Vdc nominal for C band.

Operating frequency range is from 6 to 10 GHz. Two versions are offered: a ±250 MHz tunable model and a fixed-frequency model. Delivery is 60 days or less.

These Varian oscillators are available with optional current regulators and power supplies, operating from 115 Vac, 60-400 Hz, or 28 Vdc. Or you can order the high power Impatt diode alone.

Only from Varian. What you need in Microwave Solid State. Contact our more than 30 Electron Tube and Device Group Sales Offices around the world, or call our Solid State Microwave Operation, Salem Road, Beverly, Massachusetts.

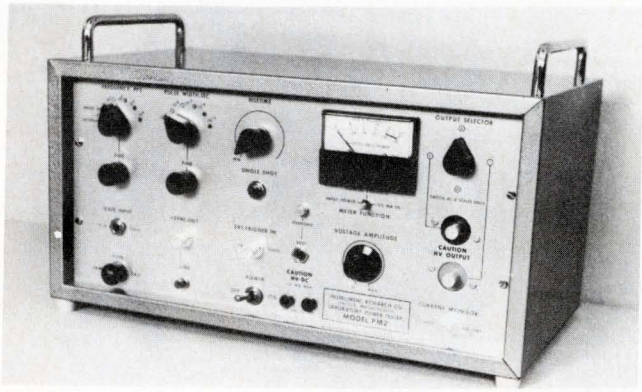
varian
solid state microwave

Circle Reader Service No. 40.

NEW LAB INSTRUMENTS

POWER PULSER

Output is adjustable from 0 to 2 kV.

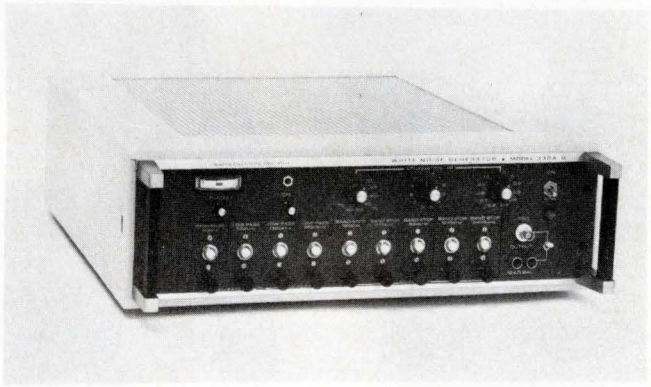


The PM-2 gives you output pulses of up to 1 A at 2 kV. The unit has a frequency range of 1 pps to over 20,000 pps and you can adjust the pulse width from ½ μs to 1 ms. An active discharge circuit gives good fall times even when operating into high-C loads. You can also use the unit as a 100 W dc power supply with an adjustable output of 0 to 2 kV, 0 to 50 mA. In this mode the unit gives you a rms ripple of less than 0.4% at full load, and a regulation of 0.12%/mA. The meter lets you read both voltage and current. The PM-2 is priced at $1175 with delivery within four weeks. Instrument Research Co., Box 231, Lincoln, Mass. 01773. (617) 897-7647.

Circle 212 on Inquiry Card

NOISE-LOADING TEST SET

For multiplex networks of from 12 to 2700 channels.

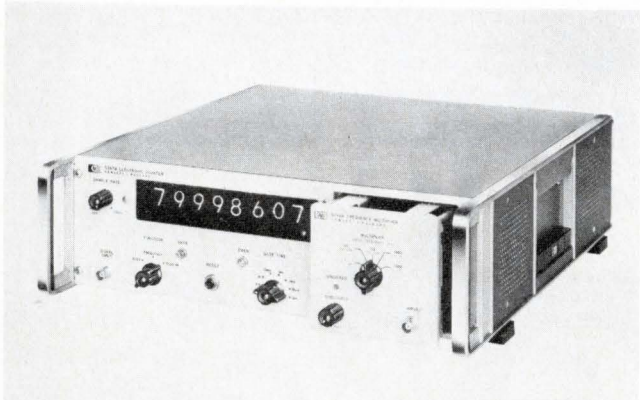


The Model 330A test set consists of a white noise generator (illustrated above), a receiver, and appropriate filters. The set loads all channels with noise and measures the mean noise level in one or more selected channels. A filter blocks the noise in the selected channel and the set measures the noise due to intermodulation distortion at the output of the network. You get the noise power ratio, a measure of network performance under maximum design-load conditions, by comparing the two measurements. Price is $2,950 with filters extra. Sierra Electronic Operation, Philco-Ford Corp., 3885 Bohannon Dr., Menlo Park, Calif. 94025. (415) 322-7222.

Circle 214 on Inquiry Card

PLUG-IN MULTIPLIER

Improves counter resolution at low frequencies.

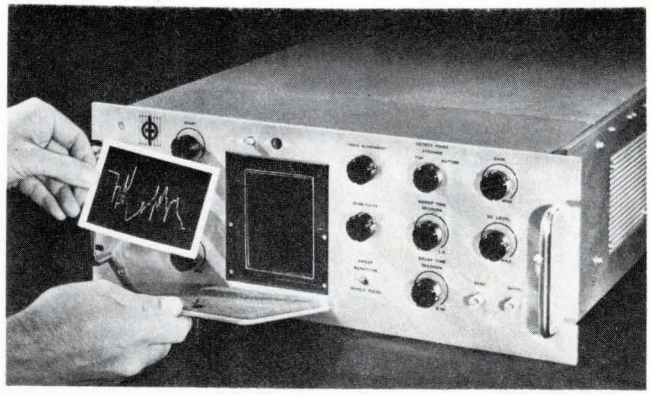


Model 5268A multiplies the frequency of an input signal by 10, 100, or 1000, depending on the setting of a front panel switch, and then applies the multiplied frequency to the counter. You can increase the counter resolution for a given gate time, or, for the same resolution, you can divide the gate time by the multiplying factor. The instrument measures sine-wave signals as small as 100 mV rms or positive or negative pulses as small as 500 mV peak. The pulse duty factor can be as low as 5%. Price of the 5268A is $650. Delivery from stock. Inquiries Mgr., Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 213 on Inquiry Card

WAVEFORM REPRODUCER

Gives output from optically scanned waveform.



The Model 47A can reproduce waveforms for computer analysis, or you can use its output to drive shock or vibration test equipment. The input to this instrument can be a photograph from an oscilloscope camera or you can use a drawing of a waveform that has a white line on a black background. A front panel control adjusts the scan rate from 0.1 to 150 s to make the unit compatible with other equipment. You can also vary the time between scans from 0.01 to 30 s and adjust the amplitude of the output. The instrument is priced at less than $6,000; delivery within 30 days. Physi Tech, Inc., 645 Davisville Rd., Willow Grove, Pa. 19090. (215) 657-2900.

Circle 215 on Inquiry Card

At 12.4 GHz, forget about crosstalk.

This new switch gives 60 db of isolation at 12.4 GHz. You can forget about crosstalk at high frequencies because it's held to an absolute minimum.

Besides excellent isolation across its entire operating range (zero to 12.4 GHz), electrical characteristics are well suited to high-frequency applications. VSWR at 12.4 GHz is 1.5 max. Insertion loss is only 0.5 db max.

Mechanical characteristics make Amphenol's high-isolation switch easy to use. Switches come with standard N or TNC connectors. They measure a small $2\frac{1}{8}''$ x $2\frac{3}{16}''$ x 1″ and can be easily stacked. Temperature range is from −55° to 85°C. Altitude range goes from zero to 70,000 feet. Shock and vibration performance meets MIL-S-3928B.

For high-isolation, high-frequency switches, talk to Amphenol RF Division, 33 E. Franklin St., Danbury, Conn. 06810.

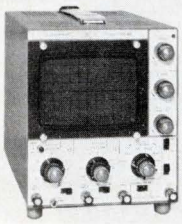
AMPHENOL
THE BUNKER-RAMO CORPORATION

Circle 51 on Inquiry Card

NEW LAB INSTRUMENTS

DUAL-BEAM OSCILLOSCOPE

Has 6- x 10-cm CRT.

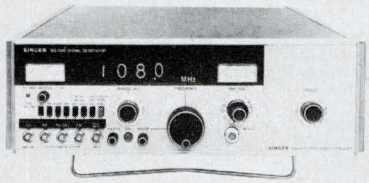


The D51 has a dc- to 6-MHz bandwidth for Channel 1, and a dc- to 3-MHz bandwidth for Channel 2. The unit has deflection factors from 100 mV/cm to 50 V/cm for both channels, and sweep rates from 1 μs/cm to 100 ms/cm in 6 steps. Price, $345. Tektronix, Inc., Box 500, Beaverton, Ore. 97005 (503) 644-0161.

Circle 216 on Inquiry Card

SIGNAL GENERATOR

From 61 kHz to 512 MHz.



Model SG-1000 gives a choice of modulation; AM, FM, pulse, video or combinations such as AM/FM, FM/pulse, etc. You can also use it as a counter for signals between 100 Hz and 2 MHz. $3,790. Availability 90 days. Singer Co., Instrumentation Div., 915 Pembroke St., Bridgeport, Conn. 06608. (203) 366-3201.

Circle 219 on Inquiry Card

WATTHOUR STANDARDS METER

Has internal rf shielding.

Model 2002 has a digital readout for direct reading of power consumption, power comparison correction factor and meter constant. You can use this unit in all fields of dc power consumption and also for calibrating dc watthour meters. Applied Electronics, 877 Cowan Rd., Burlingame, Calif. 94010. (415) 697-2701.

Circle 222 on Inquiry Card

DECADE RESISTOR BOXES

Have accuracy of 0.02%.

The DR-100 Series give you six decade selection with two concentric dials. Four models offer a choice of resistances from 12.22 kΩ to 12.22 MΩ. Prices, $210 to $260. You can get 0.0025% accuracy as an option. Julie Research Laboratories, Inc., 211 W. 61 St., New York, N. Y. 10023. (212) 245-2727.

Circle 217 on Inquiry Card

PORTABLE RELAY ANALYZER

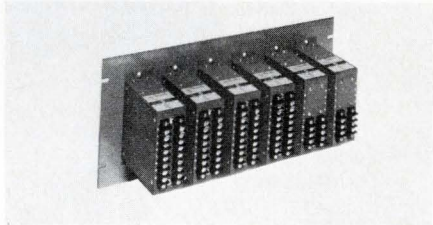
Measures contact performance.

This instrument checks the operate time, release time and bounce of reed relays, mercury-wetted relays and crystal can relays. The only other equipment you need is a relay power supply. $650. New Product Engineering, Inc., Sub. of Wabash Magnetics, First & Webster Sts., Wabash, Ind. 46992. (219) 563-2191.

Circle 220 on Inquiry Card

POWER SYSTEMS TRANSDUCER

For use with dc instruments.

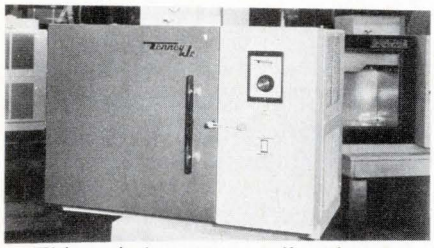


Series S-2000 includes watt, var, voltage, current and frequency transducers. These units will measure single phase or three phase (both 3- and 4-wire) systems. A standard 2 in. wide package gives you high density mounting. F. W. Bell, Inc., 4949 Freeway Dr., East, Columbus, Ohio 43229. (614) 294-4906.

Circle 223 on Inquiry Card

TEST CHAMBER

Has range of −120 to 350°F.

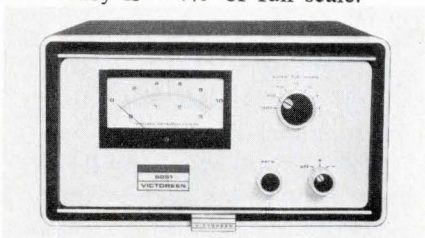


This unit has a controller that uses zero-voltage switching to eliminate any rf interference. Its accuracy is ±¼ °F throughout the range. The refrigeration system has no expendable refrigerant and gives you an operating cost of about 2¢/h. Tenney Engineering, Inc., 1090 Springfield Rd., Union, N. J. 07083 (201) 686-7870.

Circle 218 on Inquiry Card

PROXIMITY VOLTMETER

Accuracy is ±4% of full scale.

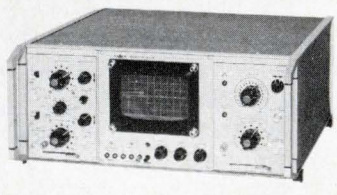


Model 5051 measures potentials on electrically charged surfaces without loading or physical contact. The instrument gives you seven switch-selectable ranges from ±1 to ±1000 V. Victoreen Instrument, Div., Victoreen Leece Neville, Inc., 10101 Woodland Ave., Cleveland, Ohio 44104. (216) 795-8000.

Circle 221 on Inquiry Card

OSCILLOSCOPE

Has bandwidth > 25 MHz.

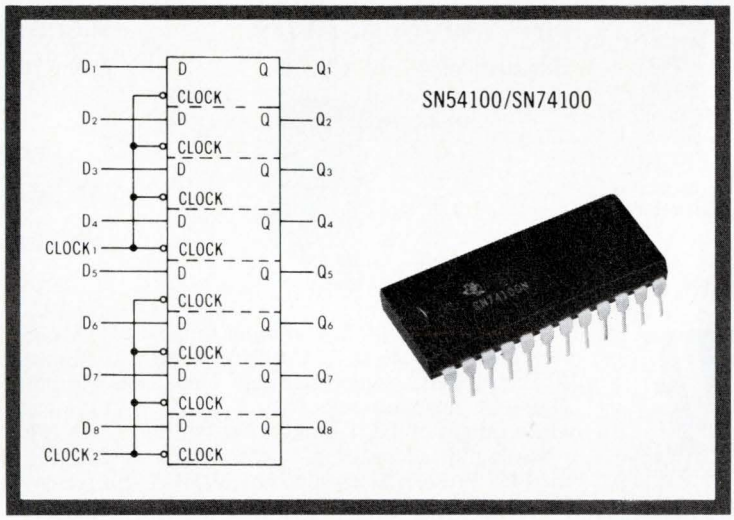


Model OS2000R has a maximum sensitivity of 10 mV/cm (1mV/cm at 5 MHz). You have a choice of single or dual trace and standard or delayed time-base plug-ins. Price is $775 for the single trace version and $895 for the dual trace model. Marconi Instruments, 111 Cedar Lane, Englewood, N. J. 07631. (201) 567-0607.

Circle 224 on Inquiry Card

The Choice is TTL.

Now, an MSI dual quad latch that won't break the bank...

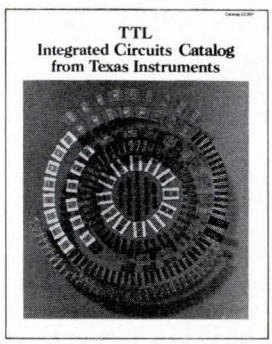


$7.42 from TI—your first source for TTL.

If the cost of temporarily storing 8 bits is more than you really like to pay, then TI's new MSI dual quad latches (SN54100/SN74100) will please you.

For example, the SN74100N, in 100-999 quantities, is a cost-conscious $7.42.

These new MSI functions combine two independent quadruple latches in a single, 24-pin dual-in-line plastic package. Typical power dissipation is 40 mW per latch. And the SN54100/SN74100 are fully compatible with TI's other TTL and DTL integrated circuits.



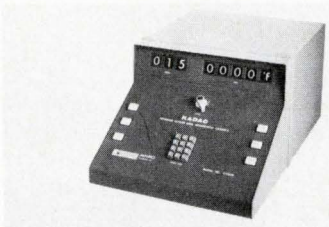
As attractive as the price is, you'll want more details before you buy. Our new 424-page TTL catalog contains a data sheet on these dual quad latches as well as sheets on all TI Series 54/74 circuits. Circle 110 on the Reader Service Card, or write Texas Instruments Incorporated, P. O. Box 5012, M.S. 308, Dallas, Texas 75222. Or call your authorized TI Distributor.

TEXAS INSTRUMENTS
INCORPORATED

NEW LAB INSTRUMENTS

DIGITAL DATA CONSOLE

Accepts up to 100 inputs.

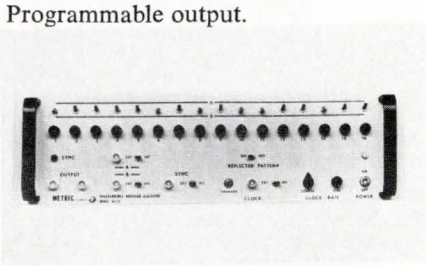


Inputs to the Kadac unit can include thermocouples, RTD's pressure transducers, strain gates, or other analog sensors. This unit will scan all points, continuously, or update a single point every five seconds. Electronic Modules Corp., Box 141, Timonium, Md. 21093. (301) 666-3300.

Circle 232 on Inquiry Card

WAVEFORM GENERATOR

Programmable output.

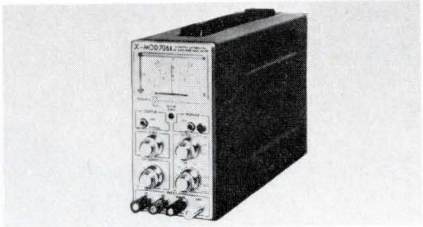


Model 8272 can simulate sonar and radar signals, antenna and transducer patterns, video signals, response curves, analog and digital test patterns, and various other signals. Price of the unit is $1700., availability 45 days. Metric Systems Corp., Ft. Walton Beach, Fla. 32548. (904) 242-2111.

Circle 235 on Inquiry Card

DIFF. AMP/NULL METER

Has drift of $< 0.1\ \mu V/°C$.

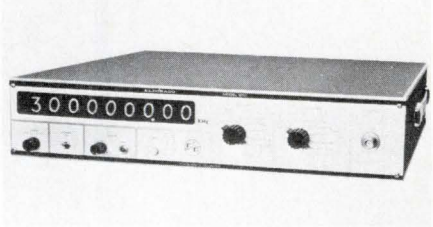


The X-MOD 706 has an input range of 1 μV full scale to 1 V full scale in 20 calibrated, switch-selected steps. The unit lets you select three bandwidth ranges of 10, 1 and 0.1 Hz, with a bandwidth accuracy of ±5%. Price is $445. Preston Scientific Inc., 805 E. Cerritos Ave., Anaheim, Calif. 92805. (714) 776-6400.

Circle 233 on Inquiry Card

MICROWAVE COUNTER

From 20 Hz to 3.0 GHz.



Model 970 is designed for the new communication and telemetry bands. The unit has a 9-digit readout, a resolution of 0.1 Hz, and a sensitivity of −7 dBm. Price of the instrument is $2,250; delivery 2 weeks. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. 94520. (415) 686-4200.

Circle 236 on Inquiry Card

DIGITAL CURRENT METER

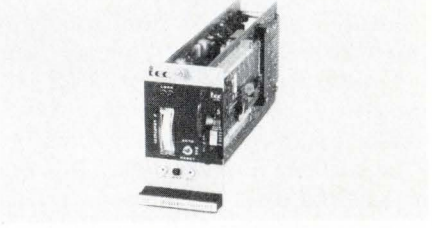
Measures from 10 mA to 1 A.

Model 801A displays the peak magnitude of pulse currents as short as 7 ns. The unit has a built-in calibrator which lets you calibrate the instrument and current probe at levels of 10, 50, 100, 250 or 500 mA. Scientific Measurement Systems, 351 New Albany Rd., Moorestown, N. J. 08057. (609) 234-0200.

Circle 234 on Inquiry Card

FREQUENCY PROCESSOR

Unit has selectable bandwidth.



Model 251/Type B recovers frequency and phase of a signal. The output is a high level square wave that is frequency coherent and phase locked with the input. The unit covers a range of 1 to 240 kHz in six steps. Price, $1945. Interstate Electronics Corp., Box 3117, Anaheim, Calif. 92803. (714) 772-2811.

Circle 237 on Inquiry Card

Ferroxcube is ±1% intolerant about pot cores

Ferroxcube is extremely intolerant of wide tolerances in pot core inductance.

As one example out of dozens, our 3B9 material 1408 size pot cores with 100 A_L maintain ±1% tolerances. No one else in the industry holds to better than ±3%. Maybe they could. But then maybe they couldn't match our competitive prices.

Ferroxcube's ability to beat down pot core tolerances means that you get better stability (because you have a smaller tuning range). And it isn't just A_L values. We keep our specs strict in every parameter.

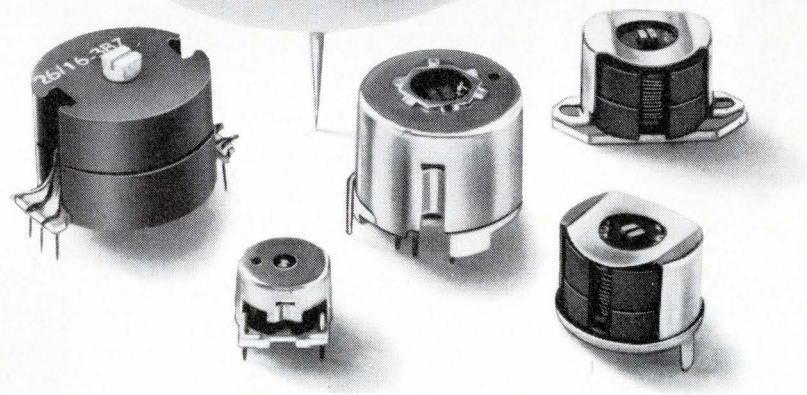
We also deliver faster. No one else has eight Stocking Centers nationwide . . . loaded for immediate local shelf-to-you deliveries.

And no one else gives you such a wide choice of bobbins and hardware accessories. Not to mention an unbeatable variety of pot cores in sizes from 9 mm to 42 mm and in five materials.

If you were harder on your pot core supplier, maybe you could be easier on yourself . . . in design, in costs. Write to Ferroxcube for Bulletin 220-C. When you study the pot cores there, you won't tolerate any other kind.

Ferroxcube
Saugerties, New York
A NORTH AMERICAN PHILIPS COMPANY.

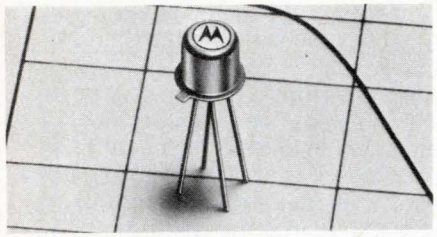
BEAT POT CORE TOLERANCES



Atlanta—Cartwright & Bean, (404) 237-2273; **Baltimore**—Eastern Components, (301) 322-1412; ***Burbank, Calif.**—(213) 849-6631; **Cedar Rapids**—Thomas & Modricin, (319) 377-6261; **Columbus, Ohio**—Mulligan & Mathias, (614) 486-2976; ***Dallas**—Gillett Industries, (214) 363-0107; **Fayetteville, N.Y.**—R. P. Kennedy Co., (315) 637-9531; **Hazelwood, Mo.**—Thomas & Modricin, (314) 838-6446; **Huntsville, Ala.**—Cartwright & Bean, (205) 852-7670; **Hyde Park, N.Y.**—R. P. Kennedy Co., (914) 229-2269; **Indianapolis**—Thomas & Sukup, (317) 251-4574; **Kansas City**—Thomas & Modricin, (913) 432-2131; **Littleton, Col.**—Wm. J. Purdy Agents, (303) 794-4283; **Marion, Ia.**—Thomas & Modricin, (319) 377-6261; **Minneapolis**—(612) 920-1830; ***New York**—Kahgan Sales, (516) 538-2300; ***Northlake, Ill.**—(312) 261-7800; **No. Miami Beach**—Cartwright & Bean, (305) 945-2962; **Orlando**—Cartwright & Bean, (305) 425-8284; **Ormond Beach, Fla.**—Cartwright & Bean, (904) 677-3480; ***Philadelphia**—Eastern Components, (215) 927-6262; **Phoenix**—(602) 264-3129; **Rochester, N.Y.**—R. P. Kennedy Co., (716) 271-6322; ***San Francisco**—Wm. J. Purdy Agents, (415) 347-7701; **Saugerties, N.Y.**—(914) 246-2811; **Shawnee Mission, Kans.**—Thomas & Modricin, (913) 432-2131; **St. Louis**—Thomas & Modricin, (314) 338-6446; **Union, N.J.**—(201) 964-1844; ***Waltham, Mass.**—(617) 899-3110; ***Woodstock, N.Y.**—Elna Ferrite Labs, (914) 679-2497; ***Toronto, Ont.**—Philips Electron Devices, Ltd., (416) 425-5161. *Denotes stocking distributor.

SWITCHING TRANSISTOR

Radiation-resistant.

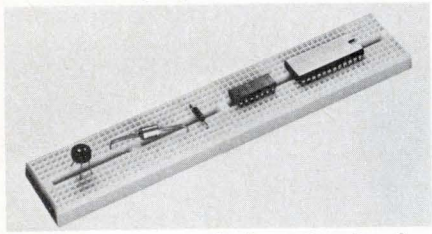


The pnp Si switching transistor, Type MM4261H, retains more than 50% of its specified dc current gain after exposure to a fluence of 3 x 10^{14} neutrons/cm^2 at a neutron energy level of 1 MeV, or 1 x 10^{15} neutrons/cm^2 at > 10 keV. It has a high current-gain BW product of 3.5 GHz typ. Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

Circle 238 on Inquiry Card

TERMINAL STRIPS

For instant plug-in connections.

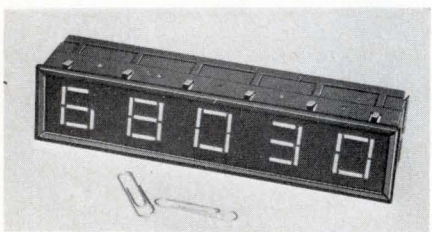


Solderless terminal strip is for breadboarding with even the largest DIPs as well as TO-5s. It also accepts all discrete components with lead diameters from 0.010 to 0.032 in. Any solid wire can be used. Typical contact res. after 1000 insertions is < 5 x 10^{-4} Ω at 1 A at 25°C. AP Inc., 72 Corwin Dr., Painesville, Ohio 44077. (216) 357-5597.

Circle 239 on Inquiry Card

NUMERIC READOUTS

With std. T 1¾ flange based lamps.

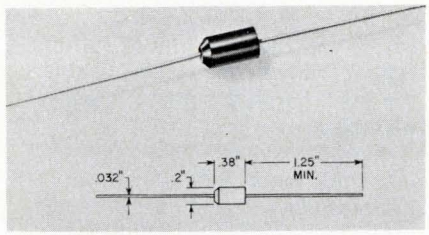


Series 68030 seven bar readouts with character ht. of 0.7 in. come completely enclosed and ready for mounting into a rectangular panel cut out. They can be supplied with matching BCD to 7 bar decoder-drivers. Info-Lite Div. of Cartelli Technology, Inc, 55 Jericho Tpk., Jericho, N. Y. 11753.

Circle 240 on Inquiry Card

SILICON RECTIFIER

2 kV to 5 kV.

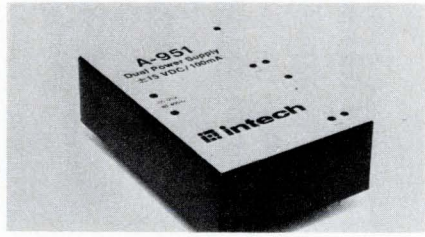


New BH series of up to 5 kV PIV, 250 mA rectifiers comes in a 0.2 in. dia. x 0.38 in. long DO-27 package. Easily mounted on a PC board, they are suitable for use in TWT amplifiers, medical instruments, lasers, transmitters, screen supplies, and Xenon flash power supplies. Electronic Devices, Inc., 21 Gray Oak Ave., Yonkers, N.Y. 10710. (914) 965-4400.

Circle 241 on Inquiry Card

DUAL POWER SUPPLY

For op amps and related devices.

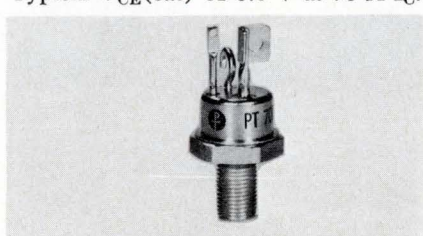


The A-951 supply furnishes ±15 V at 100 mA and features separate positive and negative sections to eliminate interaction. It provides two 15 V at ±0.3 V outputs, and guarantees line reg. 0.02% max., load reg. 0.02% max., and rms noise 0.5 mV max. Price $55.00. Intech Inc., 1220 Coleman Ave., Santa Clara, Calif. 95050. (408) 244-0500.

Circle 242 on Inquiry Card

POWER TRANSISTORS

Typical V_{CE}(sat) of 0.6 V at 70 A I_C.

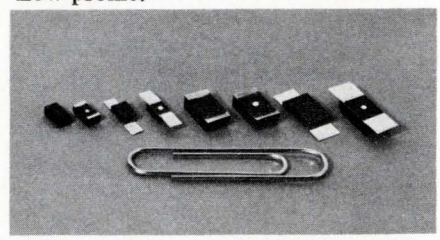


MiniSat series is for Mil type high current switching applications. Packaged in a JEDEC TO-114 double ended stud, the series offers minimum H_{FE} of 10 at collector currents to 100 A and V_{CEO} to 150 V. Price range is $220 to $325. PowerTech Inc., 9 Baker Court, Clifton, N.J. 07011. (201) 478-6205.

Circle 243 on Inquiry Card

TANTALUM CAPACITOR

Low-profile.

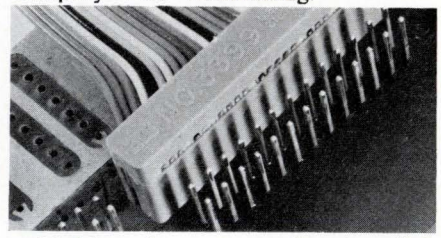


Type 193 D Domino® rectangular-block solid tantalum capacitors are for use on hybrid substrates and PC boards. They come in six working voltages from 3 to 35 Vdc and in 10% and 20% tol. from 0.1μ F to 47 μF for the 3 V units to a range of 0.1 μF to 3.3 μF for the 35 V units. Sprague Electric Co., Marshall St., North Adams, Mass. 01247. (413) 664-4411.

Circle 244 on Inquiry Card

WRAP POST CONNECTORS

Simplify wire terminating.

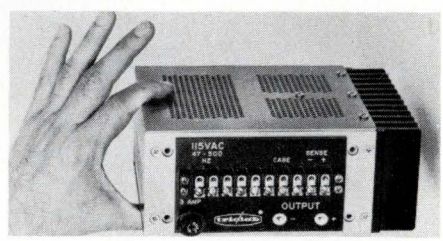


Multi-conductor round wire flat cable, twisted pairs or individual hook-up wires are simultaneouly terminated to wrap posts with these two connectors. "Scotchflex" No. 3399 (26 pos.) and No. 3414 (34 pos.) transition flat cable directly to 0.025 in.^{2} posts on 0.100 in.^{2} grid without soldering or stripping insulation. 3M Co., 3M Center, St. Paul, Minn. 55101.

Circle 245 on Inquiry Card

POWER SUPPLIES

For ICs.

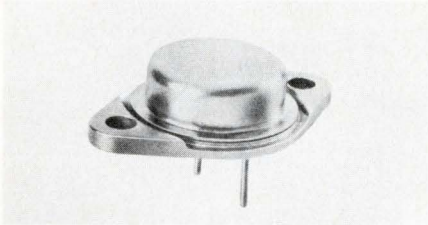


New series of 100 W supplies allow full-load operation for a minimum of 30 ms after the loss of ac input. Noise and ripple, including spikes, is held to a max. of 50 mV pk-to-pk. Line and load reg. is < 0.5%, and TC is 0.02%/°C. Trio Laboratories, Inc., 80 Dupont St., Plainview, L.I., N.Y. 11803. (516) 601-0400.

Circle 246 on Inquiry Card

EPITAXIAL TRANSISTOR

Fast switching, HV, high current.



Double epitaxial transistor has a typ. speed (f_t) of 30 MHz at voltages ($V_{CEO(SUS)}$) up to 375 V and a peak current (I_C) of 30 A. Type 1843 is for use in power supplies, voltage regulators, dc to dc inverters, linear amps, dc to ac converters, control circuitry and other basic industrial applications. Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230. (412) 255-3693.

Circle 247 on Inquiry Card

ROTARY SELECTOR SWITCH

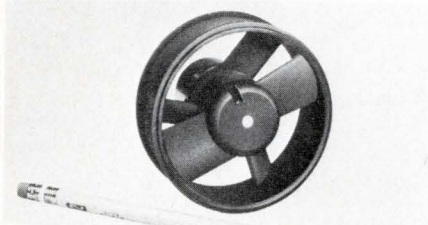
For PC board mounting.

Model SW62S, single pole, miniature switch is only 0.570 in. in dia. It features positive detent action at 36° intervals up to 10 factory-set positive stop positions, and environmental sealing. Gold contacts provide low resistance of 0.050 Ω max. Contact rating is 0.25 A at 28 Vdc max, Minelco, 600 South St., Holbrook, Mass. 02343.

Circle 248 on Inquiry Card

DC TUBEAXIAL FAN

Produces 80 cfm at 0 in. H_2O.



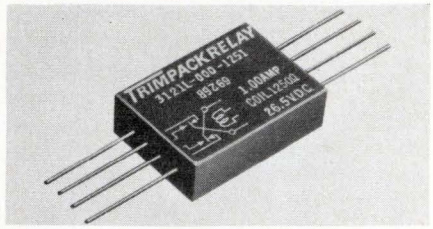
New dc fan mounts in 3⅛ in. dia. holes. It meets MIL-E-5272. Housing and dynamically balanced propeller are black anodized aluminum die castings. Weight is 6.5 oz. Prototype price is $85. Globe Industries Div., of TRW, Inc., 2275 Stanley Ave., Dayton, Ohio 45404. (513) 228-3171.

Circle 249 on Inquiry Card

NEW PRODUCTS

RELAYS

Only ¼ in. high.

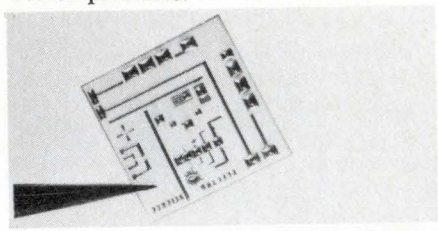


Model 3120 spdt and 3121 dpdt Trimpack™ subminiature relays have a 1.0 A rating at 26.5 Vdc, and are only 0.80 long x 0.56 wide x 0.25 in. high. Operating temp. range is −65 to +125°C and both models meet Mil-R-5757D. Operating life is 100,000 cycles. Bourns, Inc., Trimpot Products Div., 1200 Columbia Ave., Riverside, Calif. 92507. (714) 684-1700.

Circle 259 on Inquiry Card

CERMET CONDUCTIVE PASTE

Screen-printable.

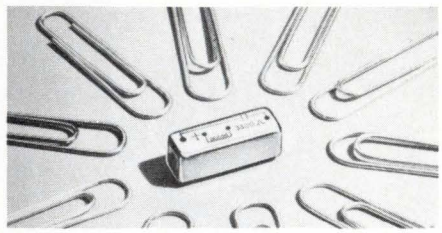


ESL #6831 palladium/gold composition has good ultrasonic wire bonding char., may be eutectically bonded with Si ICs without preform and readily accepts all tin-lead solders or various gold alloys. Thermo compression bonding and parallel-gap welding may also be used. Electro-Science Laboratories, Inc., 1133 Arch St., Philadelphia, Pa. 19107. (215) 563-1360.

Circle 260 on Inquiry Card

REED RELAYS

Have built-in diodes.

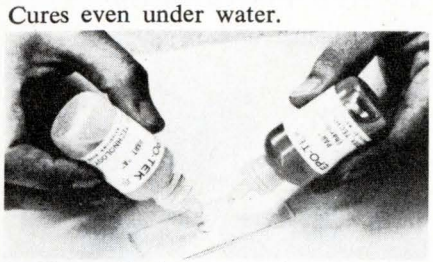


New 442DS series of ss relays have a blocking or arc depression diode within a 0.04 in.³ package. Forty two-pole relays can be mounted on a 5½ x 4½ in. PC board. Height is only 0.25 in. Relays are available in 2, 3, and 4 pole models. Contacts are rated at a full 7 W. Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N.J. 07740. (201) 222-6880.

Circle 261 on Inquiry Card

FAST SETTING EPOXY

Cures even under water.

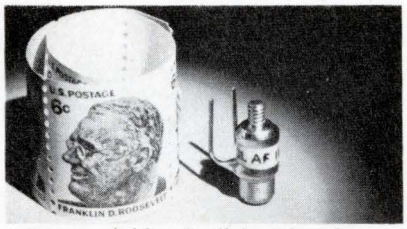


New adhesive cures at room temp. and bonds to a wide variety of materials. Thin films of the two-component, clear Epo-Tek 201 compound will set up to handling strength in five to 10 min. Successful applications have included bonding delaminated PC land areas, optical encoders, and in fiber optics. Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. 02172.

Circle 262 on Inquiry Card

AIR TRIMMER CAPACITOR

For PC or panel installations.

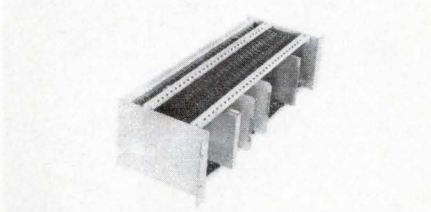


Two variable air dielectric trimmers are available in two ratings each—from below 0.8 pF to above 10 pF and from below 0.8 pF to above 14 pF. Quality factor (Q) is guaranteed to exceed 4000 at 100 MHz. Panel mount units are the AT10N and AT14N (shown); the vertical PCB units are the AF10N and AF14N. Voltronics Corp., West St., Hanover, N.J. 07936. (201) 887-1517.

Circle 263 on Inquiry Card

PC CARD RACK

Easily assembled.

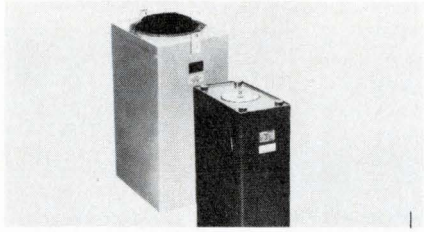


All you need to assemble Versa-Cage® is a screw driver. Side rails are drilled to hold snap-in, one piece molded polycarbonate PC card guides. Rack is 19 in. long and will hold 32 cards 4½ in. wide and up to 6½ in. long (on ½ in. centers). Unitrack® Div. of Calabro Plastics, Inc. 8738 West Chester Pike, Upper Darby, Pa. 19082.

Circle 264 on Inquiry Card

HV CAPACITORS

For low inductance energy discharge.

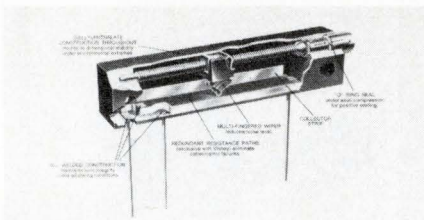


Series C capacitors include voltage ratings from 5 kV to 75 kV, with peak discharge currents up to 150 kA and rep. rates to 4 ppm at 85% voltage reversal. They are for capacitor bank applications where fast current rise times, HV reversals, long life expectancy and low cost/joule are required. Maxwell Laboratories, Inc., 9244 Balboa Ave., San Diego, Calif. 92123. (714) 279-5100.

Circle 265 on Inquiry Card

METAL FILM TRIMMER

TC of ±10 ppm.

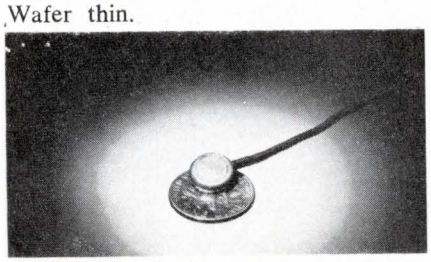


New trimmer is non-inductive and has no offset, no thermal noise, <2 Ω end res. for all res. values, and max. noise of 10 Ω ENR. Multi-fingered wipers on redundant resistance paths eliminate catastrophic failure mode of wirewound trimmers. Trimmer meets or exceeds all requirements of Mil-R-27208 and Mil-R-22097 Characteristic C. Vishay Resistor Products, 63 Lincoln Hwy, Malvern, Pa. 19355.

Circle 266 on Inquiry Card

FORCE CELLS

Wafer thin.



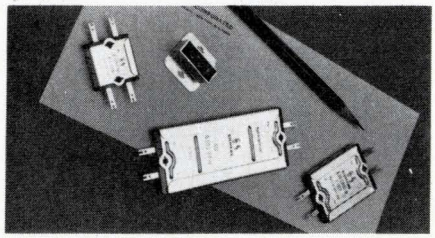
Model LP load cells measure loads and forces as high as 500 lbs., and as low as a few grams. The cells are for applications where accurate, dynamic subminiature force or load cells are needed and a total system accuracy of 1% is required. Typical linearity and hysteresis is 0.5%. Sensotec Div., of Comtel Corp., 1400 Holly Ave., Columbus, Ohio 43212.

Circle 267 on Inquiry Card

NEW PRODUCTS

SELENIUM RECTIFIERS

Replace some silicon types.

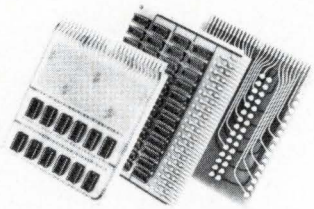


These selenium rectifiers are for many applications where silicon rectifiers are now used. The selenium types offer greater resistance to transients. They come in flat and block type configurations with a wide range of power ratings, sizes and designs to meet specific requirements. Siemens America Inc., Box 1268, Union, N.J. 07083.

Circle 268 on Inquiry Card

PC BOARDS

Eight varieties offered.



New standardized "Compuboards" all have std. IC attachments and fittings, and may be inserted into std. PCB connectors. They allow quick circuit assembly by either solderless-wrapping or point-to-point soldering methods. Silicon Systems, Inc., 1555 Placentia, Newport Beach, Calif. 92660. (714) 548-1881.

Circle 269 on Inquiry Card

DC-DC REGULATORS

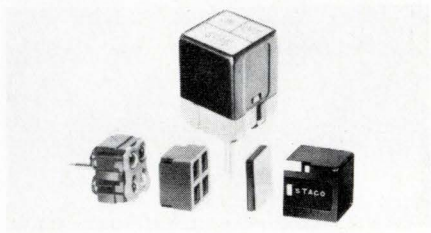
Only 2-13/16 x 1⅜ x 19/32 in.

CX 95 Series dc-dc, positive or negative "point-of-load" regulators come in 14 models. Outputs are from 3 to 24 Vdc at 4 A; inputs from 7-35 Vdc, depending on model. Flat-pack units provide ±0.5% "point-of-load" regulation for line or load changes. Technipower, Inc., Benrus Ctr., Ridgefield, Conn. 06877. (203) 438-0333.

Circle 270 on Inquiry Card

LIGHTED DISPLAY MODULE

Self-contained assembly.

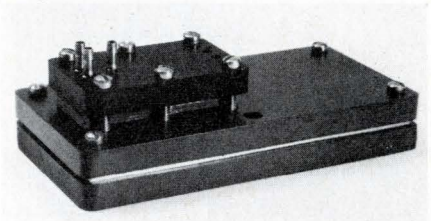


New 4-lamp display module is for use as a lighted switch actuator or integral indicator display with the Series 40 pushbutton switch and Series 1M matrix system. A total of 384 easily changeable standard options are available. Display area measures 0.60 in. square. Stacoswitch, 1139 Baker St., Costa Mesa, Calif. 92626. (714) 549-3041.

Circle 271 on Inquiry Card

FLUIDIC SENSOR

High S/N ratio.

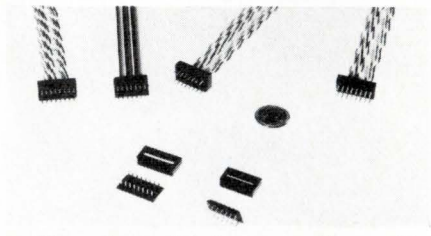


Model 24AS13A, Angular Rate Sensor is a laminar jet type sensor with an inherently high S/N ratio. It has an integral amplifier to provide scale factors as high as 0.25 psi/radian/s. A typical range of the sensor is ±20 radians/s, with a threshold of 2°/s ($p = 10^{-3}$ psi). General Electric Co., Schenectady, N.Y. 12305.

Circle 272 on Inquiry Card

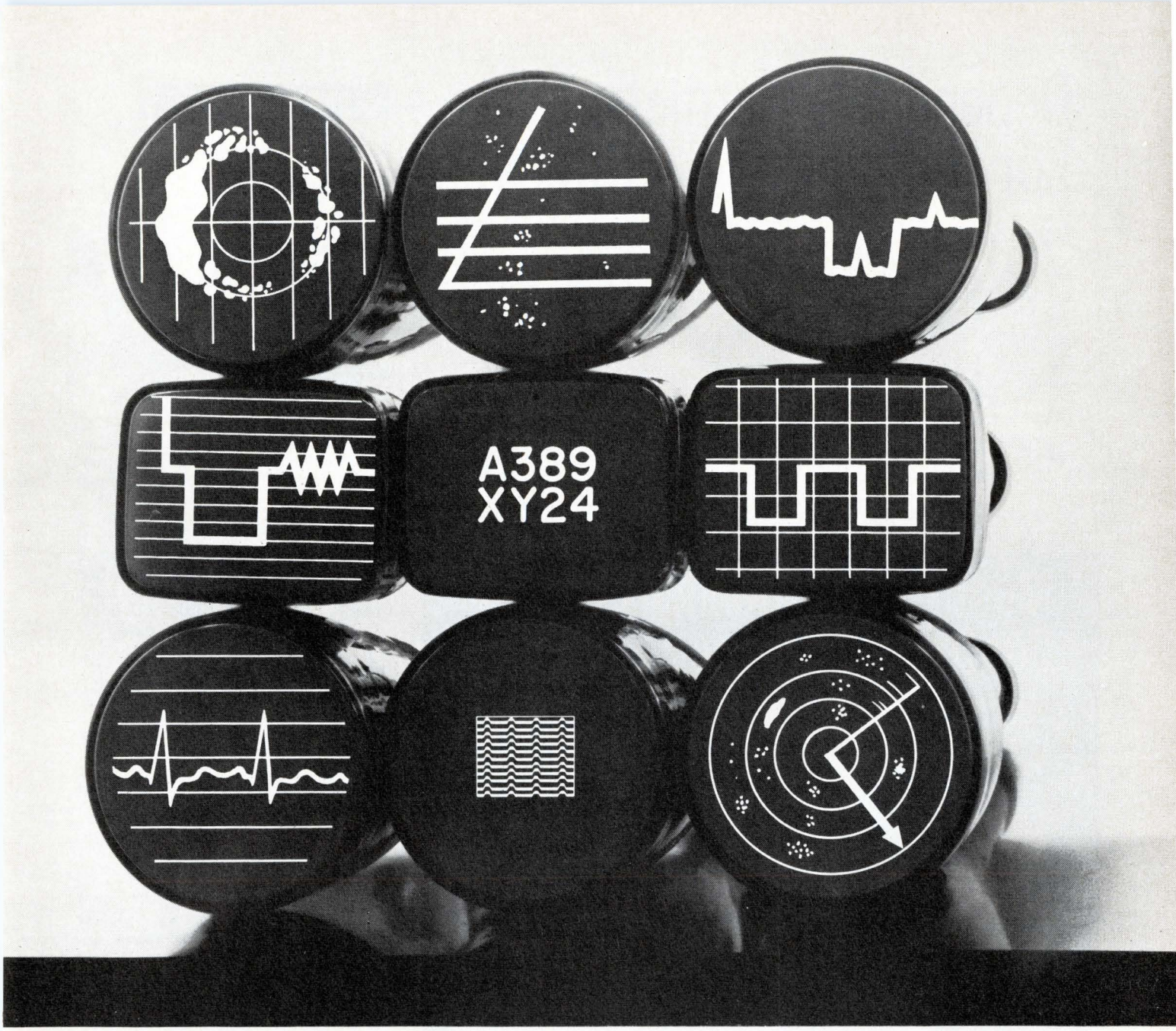
MINIATURE CONNECTORS

And interconnecting assemblies.



New line of interconnecting cable assemblies and jumpers has both 14- and 16-pin, dual, in-line connectors. The miniature 14- and 16-pin connectors have gold-plated pins measuring 0.015 x 0.025 x 0.190 in. arranged in a dual line for a 0.300 x 0.100 in. grid pattern. Circuit Assembly Corp., 3023 S. Kilson Dr., Santa Ana, Calif. 92707.

Circle 273 on Inquiry Card



We offer over 200 talking pictures. Pick one that speaks your language.

Our CRT's have been articulate right from the start. Our first, thirty years ago, told us we were onto a good thing. Some people didn't believe it, but that one spoke our language.

Since then we've gone on to develop and produce CRT's that make up an electronic United Nations.

One speaks to the weatherman. Another to a heart specialist. There's one that sits on a desk and talks to bookkeepers or accountants. And one that communicates with aircraft control tower personnel. One that strikes up a conversation with geologists. And even one that displays nuclear explosion data to anyone who cares.

That's asking a lot from a CRT. But then we've always done that. And we'll go right on doing it. Because even as our customers tell us, there's almost no limit to what a CRT can talk about.

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Electronic Tube Division, ETD. General Atronics, Philadelphia, Pennsylvania 19118

GENERAL ATRONICS

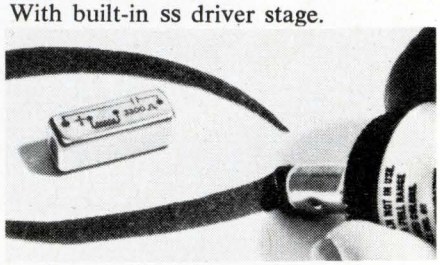
GENERAL ATRONICS

Circle 59 on Inquiry Card

EE NEW PRODUCTS

REED RELAYS

With built-in ss driver stage.

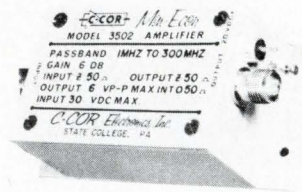


These ultra-miniature Series 442SS relays occupy only 0.05 in.^{3} including the transistor driving stage. They need only microwatts of power. Contact for the 442SS series is rated at a full 7 W and has been tested to a 10^7 MCFF (Mean Cycle to First Failure) at this load. They come in 2 to 4 pole models. Wheelock Signals, 273 Branchport Ave., Long Branch, N.J. 07740. (201) 222-6880.

Circle 256 on Inquiry Card

WIDEBAND POWER AMP

Measures only 1 ½ x 2 x 3 in.

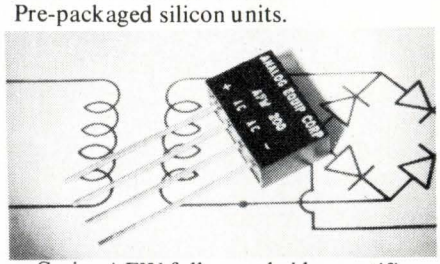


Min-Econ Model 3502, linear power amplifier is for laboratory use, for "bread-boarding," and for actual system amplification. It has a typical 3 dB bandpass from 0.5 to 325 MHz and a gain of 6 dB. Model 3502 sells for $130. C-COR Electronics, Inc., State College, Pa. 16801. (814) 238-2461.

Circle 257 on Inquiry Card

BRIDGE RECTIFIERS

Pre-packaged silicon units.



Series AFW full wave bridge rectifiers are for commercial and industrial applications. They directly replace individual units in multi-rectifier circuits. Units come in PRV ranges of: 50, 100, 200, 300, 400, 500, 600, 800, and 1000 V all with dc output current of 2.0 A at 50°C. Analog Equipment Corp., 18 Granite St., Haverhill, Mass. 01830. (617) 373-1501.

Circle 258 on Inquiry Card

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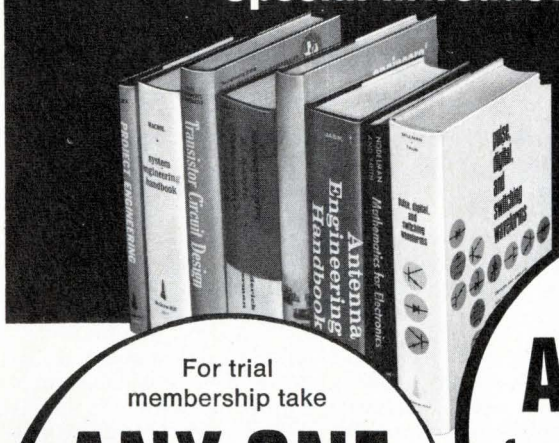

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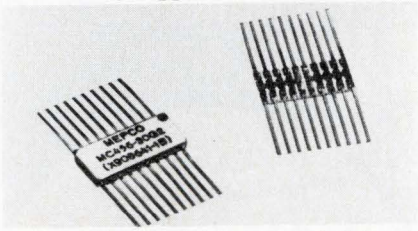
NEW PRODUCTS

RESISTOR FLATPACKS

With many applications.

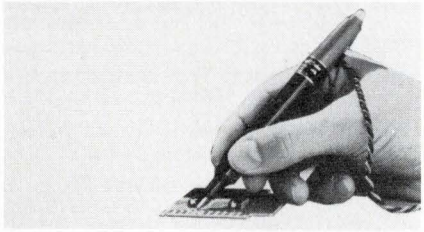


Ceramic sandwich resistor flatpack comes in three sizes: ¼ x ¼, ¼ x ⅜, and ¼ x ½ in. These thick-film networks may be used as voltage dividers, miniature attenuators, matching networks, 4-bit ladders, and as precision feedback resistors for amps. They meet all environmental requirements of Mil-Std-202. Mepco Inc., Morristown, N.J. 07960.

Circle 283 on Inquiry Card

PROBE

For logic circuitry.

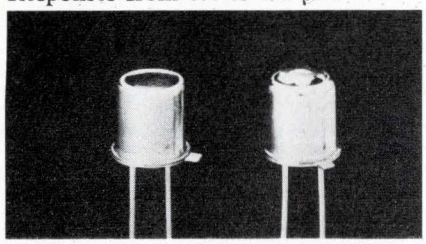


Model 401A LogicProbe is for high noise immunity circuitry, 12V Vcc ±15%. It visually displays quiescent states, single pulses as narrow as 50 ns and rep. rates to 10 MHz. Lamp on end of probe indicates and identifies quiescent logic levels, single pulses and continuous pulse trains regardless of rise and fall times. Automated Control Technology Inc., 3452 Kenneth Dr., Palo Alto, Calif. 94303. (415) 328-6080.

Circle 284 on Inquiry Card

PHOTODIODE DETECTORS

Responses from 0.4 to 1.1 μm.



MD1 and MD2 Si pin photodiodes match emission characteristics of the company's IR GaAs light-emitting diodes and are most sensitive at a wavelength of 0.9 μm. Some applications are in high-speed optical switching, laser detecting, optical encoding, and process and industrial control. Monsanto Electronic Special Products, 10131 Bubb Rd., Cupertino, Calif. 95014. (408) 257-2140.

Circle 285 on Inquiry Card

VOLTAGE SOURCE

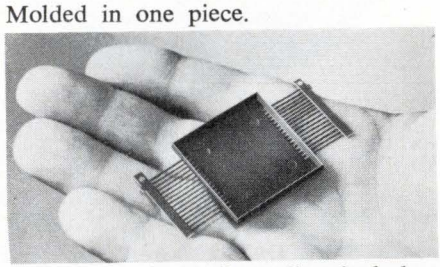
Dialable from 1-999 V in 1 V steps.

Output on this multi-tapped transformer is shown in three windows. Accuracy at 10 mA is guar. ½% and is normally > ¼%. Larger currents may be drawn. Input is settable to a single ref. point on an expanded scale meter. Input volt. range is 105-125 V. Input freq. range is 50-1000 Hz. Idalee Electronics Corp., 891 Fulton St., Valley Stream, N.Y. 11580. (516) 825-8955.

Circle 286 on Inquiry Card

PLASTIC HYBRID PACKAGES

Molded in one piece.

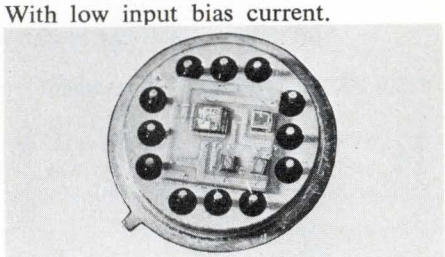


Epoxy resin package line includes std. DIP's, ¼ x ¾, ½ x ¾ in. with 0.600 and 0.300 plug-in; flat packs with substrate areas of 0.100 in., 0.500 in. and 1.00 in.². Modules contain all necessary metal leads and ext. connections molded in place ready for placement of chips and bonding of interconnections. U. S. Electronic Services Corp., Holgar Ind. Park, Clifton Heights, Pa. 19018. (215) 626-5200.

Circle 287 on Inquiry Card

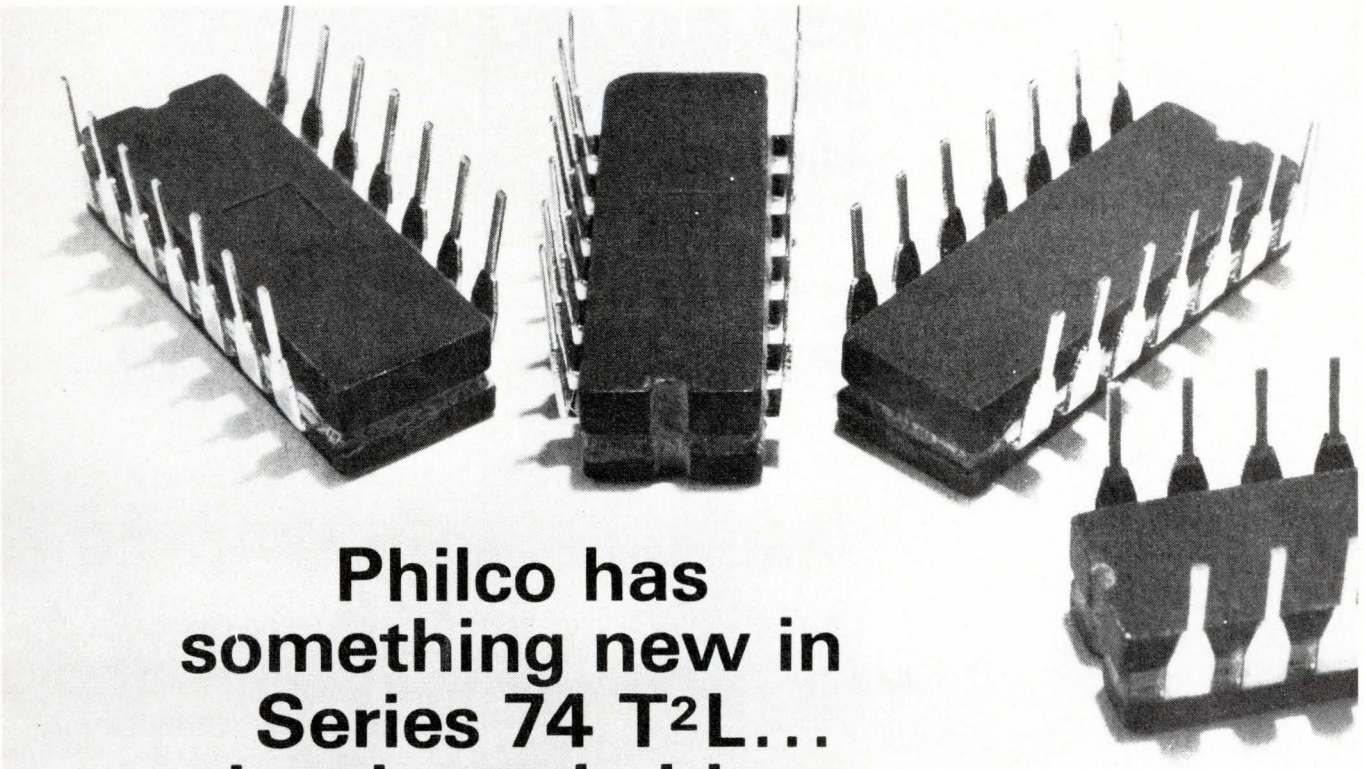
HYBRID OP AMP

With low input bias current.



The 2741 amplifier is for use in sample and hold applications, as integrators, and as high impedance filters. It provides low input bias current of 40pA, low input offset current of 15pA, low power dissipation of 50 mW and a high input impedance of 100 GΩ. Amelco Semiconductor, A Teletyne Co., 1300 Terra Bella Ave., Mountain View, Calif. 94042. (415) 968-9241.

Circle 288 on Inquiry Card



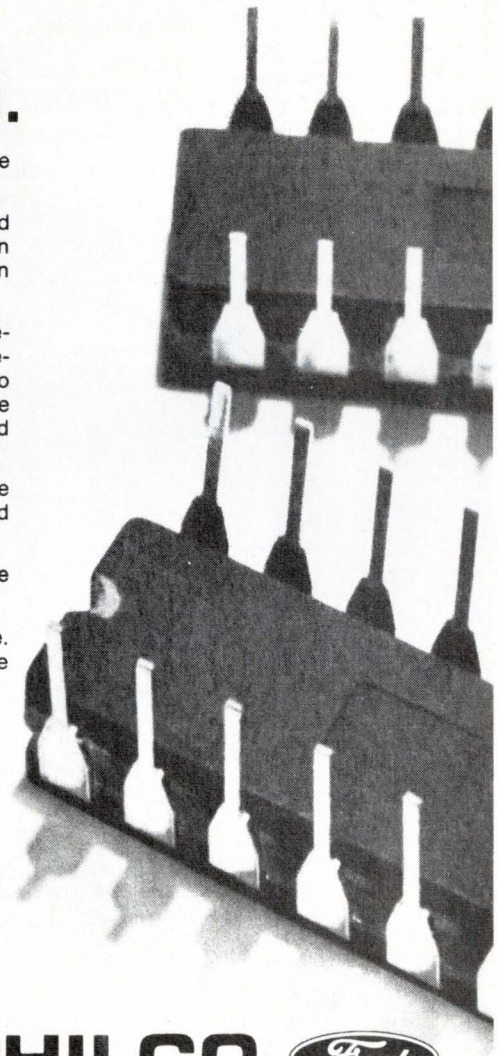
Philco has something new in Series 74 T²L... glassivated chips in cerdip packages.

Why consider another source for Series 74 T²L? Here are three good reasons from Philco-Ford.

- RELIABILITY—as a final production step, we put an added layer of glass over the completed chip. This glassivation process protects the circuit against damage, and gives an extra measure of reliability.
- HERMETIC DUAL IN-LINE PACKAGES—All Philco-Ford Series 74 circuits are manufactured in hermetically sealed ceramic dual in-line packages . . . AND at prices comparable to plastic. Your assurance of quality is the experience we have gained in manufacturing many millions of cerdip DTL and T²L circuits.
- CLAMP DIODES — All Philco-Ford Series 74 circuits have been designed with clamp diodes input to reduce ringing and improve system noise immunity.

All popular Series 74 circuits are now available from our Lansdale facility, one of the country's largest IC manufacturing plants.

For complete data and prices, contact your nearest sales office. Or write Philco-Ford Corporation, Microelectronics Division, Blue Bell, Pa. 19422.



Contact the nearest Philco-Ford Sales office:

Suite 714, 9841 Airport Blvd.
Los Angeles, Calif. 90045
(213) 641-8105

3939 Fabian Way
Palo Alto, Calif. 94303
(415) 321-8740

2225 West North Ave.
Melrose Park, Ill. 60160
(312) 345-1000

Northwest Industrial Park
Second Avenue
Burlington, Mass. 01803
(617) 272-1600

Blue Bell, Pa. 19422
(214) 646-9100

20000 Rotunda Drive
Eng. Bldg. 3, Room 2060
Dearborn, Mich. 48121
(313) 323-3797

609 Saw Mill River Road
Ardsley, N.Y. 10502
(914) 693-3700

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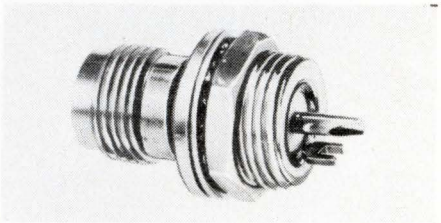
Room 428, State Tower Bldg.
Syracuse, N.Y. 13202
(315) 422-3154 or 3155

the better idea people in bipolar IC's **PHILCO** Ford

NEW PRODUCTS

TNC RECEPTACLE

Isolate rf.

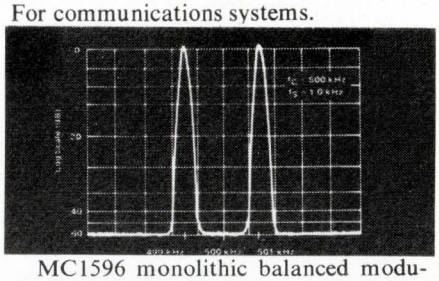


Known as the KA79-59, this TNC receptacle has a Teflon insulated ground lug to isolate rf from the equipment panel. It mounts in a ½ in. dia. hole, on a $\frac{3}{16}$ in. thick panel. Its rigid fastening insures low noise level. Kings Electronics Co., Inc., 40 Marbledale Rd., Tuckahoe, N.Y. 10707.

Circle 229 on Inquiry Card

MODULATOR/DEMODULATOR

For communications systems.

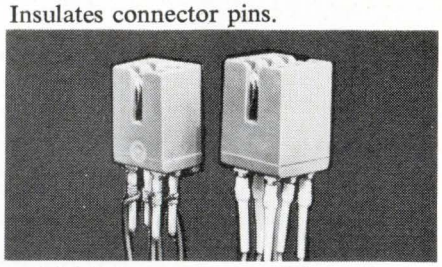


MC1596 monolithic balanced modulator/demodulator generates a double-sideband suppressed carrier signal. Unit features adjustable gain, good carrier suppression (60 dB typ. at 0.5 MHz), carrier feedthrough of 40 μV rms typ. at 1 kHz, and high CMR ratio of 85 dB typ. Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036. (602) 273-3466.

Circle 230 on Inquiry Card

HEAT-SHRINKABLE TUBING

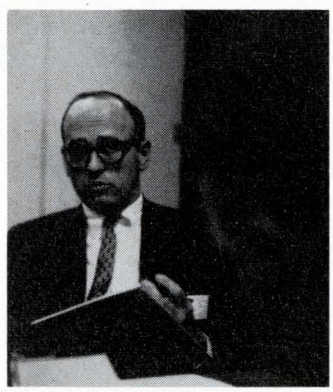
Insulates connector pins.



Mojo™ connectors (Elco Corp.) are shown before and after application of TLT™ shrink-tubing. The tubing shrinks to cylindrical or odd shapes in seconds from any source of 200°F heat such as a heat lamp or hot air. Applications include wire and cable termination and insulation, cable marking and splice jacketing. The Zippertubing Co., 13000 S. Broadway, Los Angeles, Calif. 90061.

Circle 231 on Inquiry Card

SWITCH CRAFT FORUM



on Pushbutton Switches

The only hang-up I've encountered on pushbutton switches is the abnormal amount of engineering time spent on finally selecting a switch. Maybe your Forum can clear up some of the mystery.

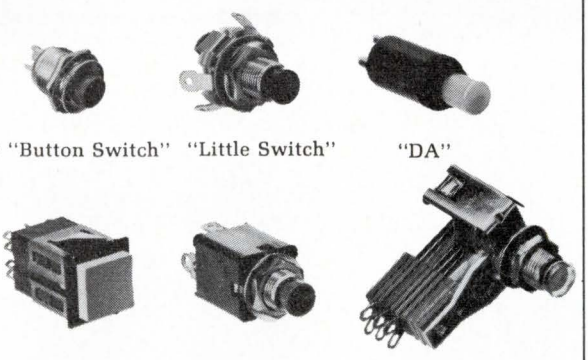
Here's what may be happening. You're breadboarding or prototyping a new circuit. Proving-out the circuit is the big problem so why worry about a simple pushbutton switch . . . in fact, a Fahnstock clip and a shorting wire will do for now . . . need another circuit path, just add another wire. Little by little, you're building up requirements for the switch without treating it as a component with characteristics that must be functionally acceptable to your overall circuit.

Maybe so. But, you can't expect us to project our exact requirements for a pushbutton switch in the prototype state.

Granted. But, based on your preliminary specs you can select a switch **series** that will probably provide the range of switching desired. The important thing is to interject the overall switch characteristics into the prototype stage as soon as possible. For instance, the Switchcraft "Box Switch" series offers a variety of circuits, contact materials, spring plating, etc. Final selection of these variables poses no problem as long as the basic "Box Switch" parameters are acceptable to the circuit operation.

Fig. 1 shows other series of Switchcraft pushbutton switches such as compact "Littel Switches," miniature 903 "Button Switches," "NF-LITE" illuminated switches,

Fig. 1

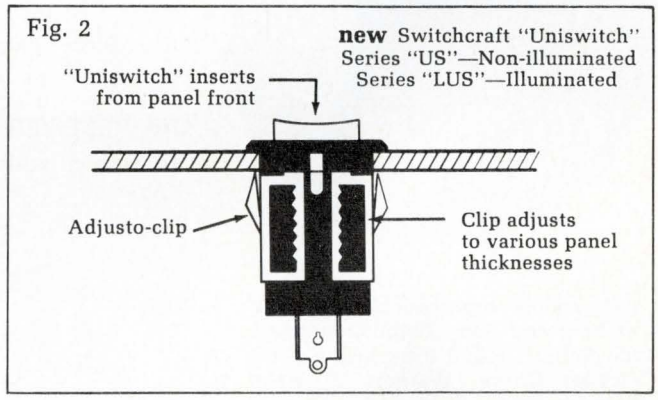


computer type "DA" switch and the compact "HI-D" switches. Each series has a range of functions and characteristics that may be selected for prototyping early in the circuit design stage. Just circle the reader service number of complete information on Switchcraft pushbutton switches.

What characteristics are you talking about? I'm not so sure it's all that difficult.

Operating forces, contact bounce, insulation resistance, contact resistance, etc. And, don't forget other considerations such as, mounting space, method of mounting, pushbutton colors, cost, etc. The difficulty usually occurs when the production switch is substituted for the "spare parts" variety used in the prototype.

Fig. 2



I'll buy that. Especially on mounting specs where the engineering conference time and drafting changes on cutout dimensions can kill you.

Not to mention the cost of actually assembling the units on the production line. Switchcraft took a hard look at these costs and developed a unique "Adjusto-clip" feature for the "Box Switch" and "Uniswitch" switches. Fig. 2 shows how the switch snap-locks into the panel cutout from the front for split-second assembly.

The same kind of engineering know-how applies to our entire line of pushbutton switches. Which, incidentally, is the most comprehensive on the market.

And, you'll be glad to ship prototypes anytime. That's natural, but how about shipping complete info on your pushbutton line to my staff, first?

Talking about prototypes, we'll be glad to send them an illuminated or non-illuminated "Uniswitch" sample.

All we need is their name on your company letterhead.

They'll also receive our "FORUM FACTS on Pushbutton Switches" handbook and TECH-TOPICS every other month. This engineering-application magazine is read by over 10,000 design engineers who find the technically oriented application stories extremely interesting and helpful.

SWITCHCRAFT® INC.

5539 North Elston Avenue

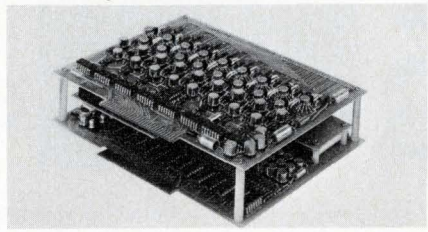
Chicago, Illinois 60630

Circle 66 on Inquiry Card

SYSTEMS EQUIPMENT

CORE MEMORY SYSTEM

Has a 2 μs access time.

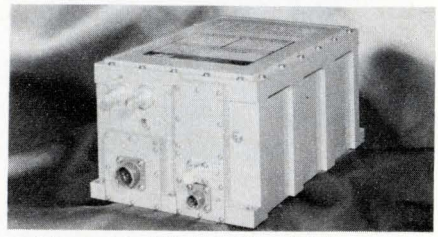


New FI-23 plug-in random access system has capacities of 80 or 160 words with up to 17 bits/word. This 8 μs full cycle system has an interface line to insure that stored data isn't lost during power turn-on or turn-off. Power required is +5 V at 3 A max. and —5 V at 0.6 A max. Ferroxcube Corp., Systems Div., Englewood, Colo.

Circle 250 on Inquiry Card

L-BAND TRANSMITTER

For fm/fm, PCM/fm telemetry data.

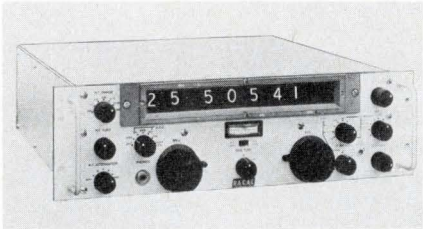


New 20 W hybrid uhf-fm transmitter can transmit telemetry data from 1435 to 1540 MHz (L-band). The Model 3670 features rf power output > 20 W under all environmental conditions, an efficiency exceeding 15% and true fm freq. response from zero to > 500 kHz EMR-Telemetry, Box 3041, Sarasota, Fla.

Circle 253 on Inquiry Card

HF RECEIVER

Has digital readout to 10 Hz.

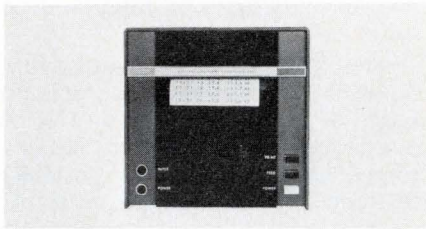


An electronic counter with a 7 digit display, locked to a built-in crystal freq. source, lets you read received tuned freq. to within 10 Hz, Model RA6218 has demodulation facilities for am, fm, ssb, (upper and lower), cw and mcw reception, over a freq. of 1-30 MHz. Racal Communications, Inc., 8440 Second Ave., Silver Spring, Md. 20910. (301) 587-8515.

Circle 251 on Inquiry Card

DRUM PRINTER

Parallel, positive true BCD input.

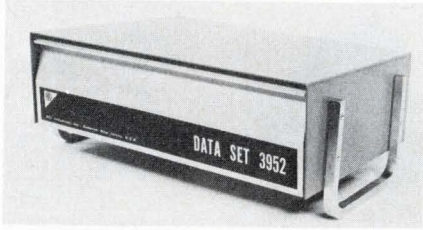


Model 691 is a 3 line/s, printer expandable from 4 to 21 columns. Nineteen columns contain digital characters 0 through 9 and 6 symbols. A "floating" decimal point may be programmed in any of these columns. Two columns may be used to print 38 symbols. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403.

Circle 254 on Inquiry Card

HIGH SPEED DATA SET

For digital data communications.

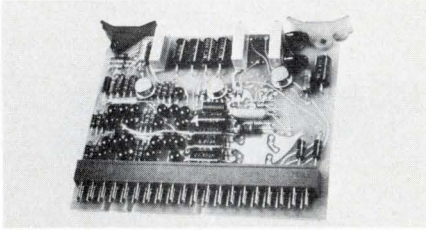


Model 3952 transmits and receives serial binary data over a voice bandwidth at a synchronous rate of 2400 bits/s. It can be used with all present-day transmission equipment including conventional and dedicated telephone lines, power lines, microwave and radio. RFL Industries, Inc., Boonton, N.J. 07005. (201) 334-3100.

Circle 252 on Inquiry Card

D/A CONVERTER

On a 3.5 x 4.3 in. card.

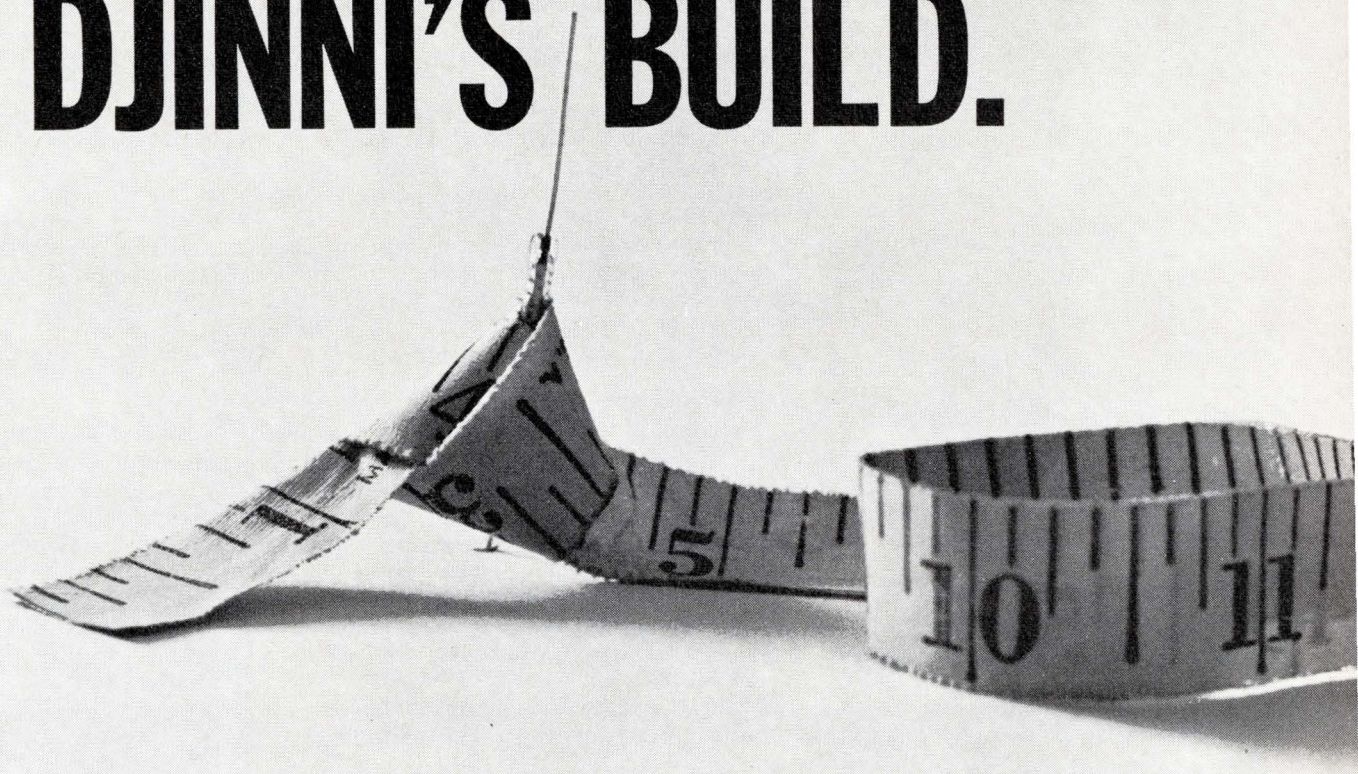


New 8 bit D/A converter with operational amplifier output, adjustable gain and precision voltage reference has up to 12 bit resolution, 4 μs settling time, 0° to 70°C operation and DTL / TTL compatibility. Costs $85.00 each in single quantity. Standard Logic Inc., 1630 S. Lyon St., Santa Ana, Calif. 92705.

Circle 255 on Inquiry Card

Circle 119 on Inquiry Card→

CHECK OUR DJINNI'S BUILD.



Low profile.

Which means you can build a complete relay only .187″ high to fit dual in-line spacing using Hamlin's new Mini-2 reed switch. It has a sensitivity range of 7.5 to 32.5 ampere turns which will rate your relay at 100 milliwatts with an operate time of 200 microseconds.

Like all Hamlin Djinnis, it's built to last longer whatever your application. That's why we're asked to build more types of reed switches for more people than any other manufacturer.

For instance, our Micro-miniature Djinni is the world's smallest. Then, there's the Tiny, Subminiature, Miniature, Compact and Standard sizes just to make sure you won't have any packaging problems.

If your application calls for RF switching, we have a Djinni that will switch frequencies from 30-100 MHz with low resistive losses and an impedance level of 52 ohms. The tiny MTRF-2 measures only .092″ glass diameter by .635″ glass length.

Ultra-high voltage applications call for the type DRTV that will switch voltages up to 20,000 VDC. Life expectancy is 1 million operations at full load and practically infinite life at lower voltage levels.

Work a little magic of your own the next time you have a control problem. As a starter, send for our free "Switch Lab" kit. Just write to Hamlin, Inc., "Baghdad on the Lake," Lake Mills, Wisconsin 53551.

HAMLIN INC

Check 119

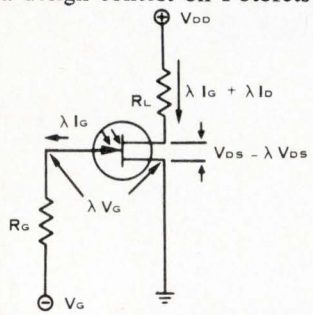
MAGNETIC REED SWITCHES • ASSOCIATED SWITCH PRODUCTS

How's that for low-cal magic?

LITERATURE

Photoelectric FETs

An 8-page brochure contains an introduction to Crystalonics' Fotofets® plus electrical data and characteristics. Incidentally, Crystalonics is sponsoring a design contest on Fotofets® featuring many attractive prizes. And this brochure is sure to help! For more information on this contest and for a copy of this brochure, turn to page 48 of this issue and



Circle 321 on Inquiry Card

1969/70 complete catalog

A 100-page illustrated catalog features operational amplifiers, modules, instruments, boosters, power supplies, regulators and accessories, including up-to-date specs and prices. Information on company research, sales and customer services is provided. Indexing is the key to the usefulness of this catalog. Products are indexed by function/title with applications and are indexed numerically by series and model numbers. The company provides new specifications as new products become available. Philbrick/Nexus Research, 3 Allied Dr., Dedham, Mass. 02026.

Circle 322 on Inquiry Card

Power servo actuators

Power servo actuators for guidance and control systems are described in a 4-page folder. Those featured are in service on AN/APQ-113 Attack Radar on the F-111 series aircraft. Complete specs are given showing electrical and mechanical performance. Weston-Transicoil, Worcester, Pa. 19490.

Circle 323 on Inquiry Card

Power grid tubes

A fully-illustrated 50-page catalog provides information on current power grid tubes for new equipment design. A brief description accompanies each tube as does a chart providing characteristics and applications. EIMAC division of Varian, 301 Industrial Way, San Carlos, Calif. 94070.

Circle 324 on Inquiry Card

Monsanto metricist

The seventh issue of this 8-page publication presents two major articles, "Understanding and Using Counter/Timer Specs" and "Model 501A Programmer Simplifies Repetitive Sequences of Test Procedures." The first deals with clock stability and aging rate, concluding that there are no standards for writing counter specs, and the second with the simplification of simple or semi-automated sequential test procedures. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006.

Circle 325 on Inquiry Card

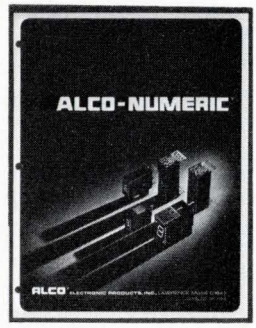
Micro-miniature trimmer pots

This 2-page technical bulletin (P-67) contains specifications, schematics and actual size photos of micro-miniature trimmer pots. The wire-wound, single-turn trimmers, with standard resistance values ranging from 20 to 25,000 Ω, offer a wide variety of mounting, connecting, and adjusting styles. Additional material includes applications, Mil spec references and ordering information. Minelco, 600 South St. Holbrook, Mass. 02343.

Circle 326 on Inquiry Card

Neon and incandescent readouts

Miniature readout indicators and decoder-drivers are the subject of this 8-page illustrated catalog. Detailed specs, code tables, dimensional drawings, and prices are included in each description. Listed among the incandescent types are the metal-encased MS-4000 series numerical and symbol indicators. Ten types of readouts are listed as well as logic modules and special mounting kits. Additional information includes wiring instructions, schematic drawings, quantity pricing and accessories. Robert E. Laffey, Alco Electronic Products, Inc., Box 1348, Lawrence, Mass. 01842.



Circle 327 on Inquiry Card

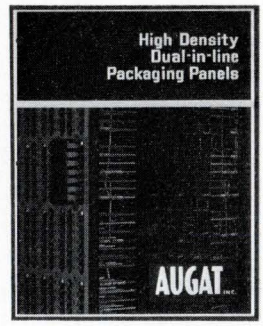
Miniature circular connectors

A 36-page catalog describes intermediate size miniature circular connectors and provides information and illustrations for the complete line, including Mil-C-26500, Mil-C-38300 and Mil-C-5015. The connectors come in a variety of configurations. Each of the seven sections of the catalog is devoted to providing you with complete information on a specific line of miniature circular connectors. Amphenol Connector Div., The Bunker-Ramo Corp., 2801 S. 25th Ave., Broadview, Ill. 60153.

Circle 328 on Inquiry Card

Packaging panels

This 16-page catalog (#266) describes a two-dimensional concept and design features of packaging panels for DIL integrated circuits and accessories. Technical and dimensional information for the 8150 series and



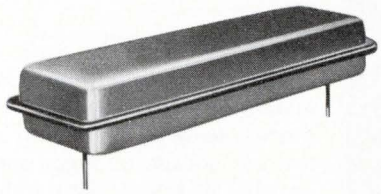
8136 series IC packaging panels is included along with test data and information on the firm's new service for complete automatically wire-wrapped panels from one source. Augat Inc., 33 Perry Ave, Attleboro, Mass. 02703.

Circle 329 on Inquiry Card

Power supply catalog

As with all good catalogs on dc power supplies, this one does not limit itself to a description of the company's products. It starts with 16 pages of background on dc power supplies, including a glossary of terms, a description of the operating principles of basic regulators, and explanation of the typical applications problems, such as remote sensing, programming, testing, and so forth. The product description includes all Sorensen lines—lab supplies, overvoltage protectors, programmable supplies, modular, h-v supplies, and many others. Raytheon Co., Sorensen Operation, Richards Ave., Norwalk, Conn. 06856.

Circle 330 on Inquiry Card

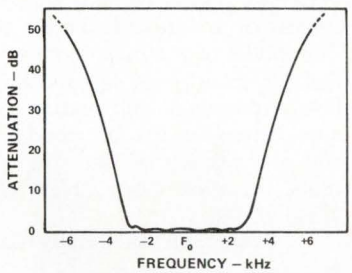


CRYSTAL FILTERS
State-of-the-Art-minus-1

Reeves-Hoffman can and does design discrete component and monolithic crystal filters that range from the economically prosaic to the state-of-the-art. Many of them are somewhat sophisticated (sort of "state-of-the-art-minus-1"). What we promise in capability and reliability, we deliver; what we promise in delivery, we fulfill.

The four filters shown below were manufactured to meet user requirements. For further information on these filters, or for crystal filters, crystals and oscillators designed to your specifications, call or write today.

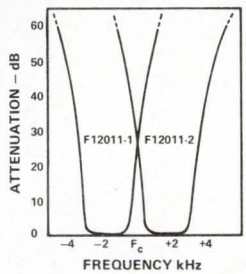
MONOLITHIC BANDPASS FILTER



Model F12257-1 A. M. Filter

Center Frequency	9 MHz
Bandwidth @ 6 dB	6000 Hz min.
Bandwidth @ 50 dB	13000 Hz max.
Ripple	2 dB max.
Insertion Loss	4 dB max.
Impedance	470 ohms, input and output
Size*	1.5 x .730 x .360 in.

MONOLITHIC SIDEBAND FILTERS

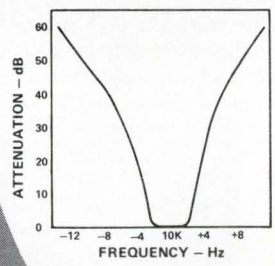


Model F12011-1, Lower Sideband
Model F12011-2, Upper Sideband

Carrier Frequency	9 MHz
Bandwidth @ 6dB	2500 Hz min.
Bandwidth @ 60 dB	7000 Hz max.
Carrier Rejection	20 dB min.
Insertion Loss	3 dB max.
Impedance	470 ohms, input and output
Size*	1.5 x .730 x .360 in.

*E2 Coldweld package shown above actual size

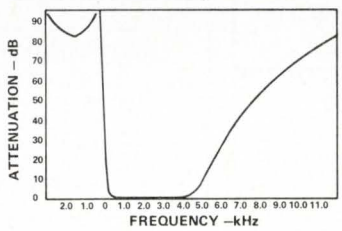
BANDPASS FILTER



Model F15481

Center Frequency	10 kHz
Bandwidth @ 3dB	5 Hz
Bandwidth @ 60 dB	20 Hz
Insertion Loss	4 dB max.
Impedance	10K ohms, input and output
Size	3.5 x 1.5 x 2.5 in.

SINGLE SIDEBAND FILTER



Model F12635

Carrier Frequency	100 kHz
Bandwidth @ .2 dB	f_c +250 to +4150 Hz
Bandwidth @ 60 dB	f_c –100 to +8800 Hz
Insertion Loss	6 dB max.
Impedance	36K ohms, input and output
Size	3.5 x 2 x 1 in.

craft-masters in crystal controls

REEVES-HOFFMAN

DIVISION, DYNAMICS CORPORATION OF AMERICA

440 W. NORTH ST., CARLISLE, PA. 17103 • 717/243-5929 • TWX: 510-650-3510

LITERATURE

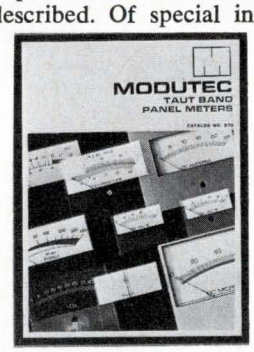
Dip socket boards

RN Catalog 0969 provides information on high density DIP socket boards using a method of mounting the DIP socket through, rather than on, the PC board. This technique allows for economy and flexibility without an increase in overall height. Mounting information is provided in the brochure as well as information on available material. Robinson-Nugent Inc., 800 East Eighth, New Albany, Ind. 47150.

Circle 346 on Inquiry Card

Panel meters

Catalog 870 lists over 3000 types of panel meters. A complete line of Windo-Mount meters is included and many options and modifications are fully described. Of special interest is

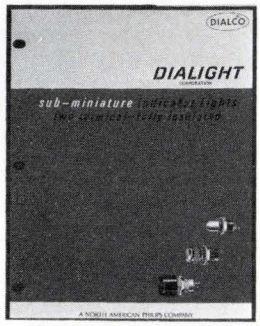


the availability of all styles and sizes in Mil-Spec versions, with ruggedized movements and cases and covers of Lexan. Modutec Inc., 18 Marshall St., Norwalk, Conn. 06854.

Circle 347 on Inquiry Card

Indicator lights

Two-terminal subminiature indicator lights are the subject of this 12-page catalog (L-178D). Each indicator is illustrated and described, and diagrams provide mounting information.



Indicator assemblies are included in the catalog, and information is complete for dimming and non-dimming units. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237.

Circle 348 on Inquiry Card

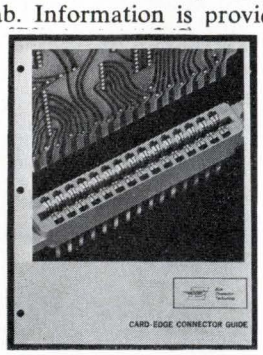
Energy discharge capacitors

Energy discharge capacitors are the subject of a 4-page technical bulletin. The bulletin provides curves, charts and formulae to aid in capacitor selection. Additional information includes applications, a list of standard units and a check list of data for ordering units. Aerovox Corp., New Bedford, Mass. 02741.

Circle 349 on Inquiry Card

Card-edge connectors

Mil-C-21097, modular and metal-plate designs are among 18 connector series included in a 32-page guide to connectors. The 27 sizes range from 4 to 84 contacts and include connectors compatible with terminating techniques such as solderless, solder and taper tab. Information is provided on

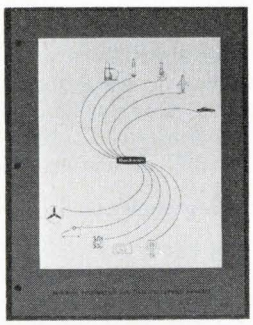


single- and dual-readout contacts, insulator materials and contact materials. A 3-page illustrated index, complete drawings, detailed specs and connector descriptions are provided for your convenience. Elco Corp., Willow Grove, Pa. 19090.

Circle 350 on Inquiry Card

Information systems

Bulletin 2470 provides specifications, illustrations and descriptions of 15 products including the Model 3700 ANSCAN Subsystem and the Model 3701 Universal Output Coupler. The 12-page bulletin also describes the Model 816 Digital Data Processor



and devotes two pages to a block diagram indicating options available with the data processing systems. Electronic Instruments Div., Beckman Instruments, Inc., 2400 Harbor Blvd., Fullerton, Calif. 92634.

Circle 351 on Inquiry Card

Film reader/recorder

A 2-page spec sheet describes the functional capabilities of the PFR-3 programmable film reader, its principles of operation, the signal processing and logic unit and peripheral equipment. Its ability to differentiate between wanted and unwanted data is a primary feature. Additional information includes a wide list of applications. Information International, 12435 West Olympic Blvd., Los Angeles, Calif. 90064.

Circle 352 on Inquiry Card

Electronic switches

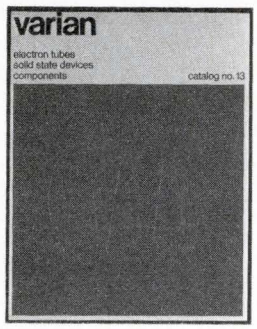
Complete technical information is provided on electronic switches in an illustrated 2-page data sheet (catalog ES-697). The bulletin describes principles of operation, special features, typical applications and detailed specs for all models. It includes quantitative data on dynamic range and intermodulation distortion performance. Lorch Electronics, 105 Cedar La., Englewood, N.J. 07631.

Circle 353 on Inquiry Card

LITERATURE

Oscillators and amplifiers

Oscillators, amplifiers and components are among the materials presented in a 95-page catalog. A concise resumé of each subject provides practical information for the reader and is followed by charts or diagrams providing thorough information on specifications and applications. Included with catalog no. 13 are a table of contents and a product index making it practical and easy to use. Varian Assoc., Electron Tube & Devices Group, 611 Hansen Way, Palo Alto, Calif. 94303.



Circle 354 on Inquiry Card

Communications testing

The new R127 Capacitance Bridge and the K946 Generator and Detector are the subject of this 4-page bulletin. Both instruments are used for quality control testing of communications components to 1 MHz. Additional information includes specifications, application data and notes on accessories and optional equipment. A circuit diagram and illustrations of the R127 are provided. Telecommunications Div., Siemens America Inc., 350 Fifth Ave., New York, N.Y. 10001.

Circle 355 on Inquiry Card

Time-sharing services

A 4-page bulletin (DB 24-350) informs engineers and scientists of interactive time-sharing computer services which give them direct access to two RCA Spectra 70/46 systems through terminals in their plants or offices. The service accommodates the Basic, Fortran, and Cobol languages and provides an extensive library of programs. Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230.

Circle 356 on Inquiry Card

Test socket/carriers

A 6-page catalog describes test sockets and carriers for integrated and hybrid circuits, MSI and LSI, rectifiers and other semiconductors. Information on configurations, applications and special features is provided for each unit. Additional information on a variety of related products is available. Textool Products Inc., 1410 Pioneer Dr., Irving, Texas. 75060.

Circle 357 on Inquiry Card

Flexible laminates

Descriptions, characteristics and suggested applications for a variety of laminated combinations of papers, films and foils make up this new 8-page brochure. Included in the line of flexible laminates and coated products are more than two dozen items such as Spauldo paper with aluminum foil, kraft paper with polyester film and glass cloth with steel foil. Solvent or water base adhesives are available. Natt Burke, Spaulding Fibre Co. Inc., North Rochester, N.H. 03867.

Circle 358 on Inquiry Card

Panel meters and voltmeters

A 36-page catalog describes in detail a complete line of digital panel meters and voltmeters. Included is a family of six compact, low-cost digital panel meters, two 3-digit multimeters and sophisticated 4- and 5-digit multimeters. The catalog has illustrations of each instrument as well as a general description, technical highlights, detailed specs, available options and price list. Data Technology Corp., 1050 East Meadow Circle, Palo Alto, Calif. 94303.

Circle 359 on Inquiry Card

Multiplexers

A 4-page brochure provides information on the MULT6 MOS P-Channel IC 6-channel Multiplexer. Applications information, maximum ratings and guaranteed electrical characteristics are provided in addition to a circuit diagram, mechanical data and a test circuit for switching time detail. Union Carbide Corp., Semiconductor Dept., Box 23017, 8888 Balboa Ave., San Diego, Calif. 92123.

Circle 360 on Inquiry Card

LITERATURE

Components and resistors for coupling, decoupling, filtering, timing, switching or computer circuits—EPD DSF-1, (4-pager). Corning Glass Works, Corning, N.Y.

Circle 331 on Inquiry Card

Wrap kits for modular direct entry packaging of ICs and discrete components—catalog 5814-16 (4-pages). Interdyne, 2217 Purdue Ave., Los Angeles, Calif. 90064

Circle 332 on Inquiry Card

Vehicle detector which consists of 1 to 6 sensing heads per amp detects the presence of a passing vehicle up to 120 mph—4 pages. Card Key Systems, 5930 W. Jefferson Blvd., Los Angeles, Calif. 90016.

Circle 333 on Inquiry Card

Energy discharge capacitors designed to permit the flow of large currents by discharging stored energy—4-pages. Aerovox Corp, EDC Dept., New Bedford, Mass. 02741.

Circle 334 on Inquiry Card

Power supplies with strip terminals, with outputs ranging from 4 to 1000 volts. Acopian Corp., Easton, Pa. 18042.

Circle 335 on Inquiry Card

Ground plane tape (pressure sensitive) for use in computer and color TV delay lines—data sheet GPF-219. Tapecon, Inc., Box 4741, Rochester, N.Y. 14612.

Circle 336 on Inquiry Card

Ceramic filters for 2-way communication sets, combine ladder network of ceramic resonators with a tuned transformer-bulletin 94026. Clevite Corp., 232 Forbes Rd., Bedford, Ohio 44146.

Circle 337 on Inquiry Card

Antenna system and accessories for antenna switching matrices for military and ship-borne applications, 8 pages. Delta Electronics, Inc., 4206 Wheeler Ave., Alexandria, Va. 22304.

Circle 338 on Inquiry Card

PC plug-in relay with terminals on 0.1 grid spacing for standard PC boards—bulletin #B-8. Guardian Electric Mfrg. Co., 1550 W. Carroll Ave., Chicago, Ill. 60607.

Circle 339 on Inquiry Card

Connectors, protectors and extractors, including circular and rectangular connectors of the high density, military and aerospace types. Bean-Protolab, 326 Town & Country Village, Palo Alto, Calif. 94301.

Circle 340 on Inquiry Card

Spacers, posts and standoffs for electronic and electro-mechanical trade. Technical Accessories Co., 789 Jersey Ave., New Brunswick, N.J.

Circle 341 on Inquiry Card

Microwave water loads, offering low VSWR, including high power miniature loads of the ceramic block type, 16 pages. Varian, 611 Hansen Way, Palo Alto, Calif. 94303.

Circle 342 on Inquiry Card

Trends in transformers, including design techniques with emphasis on insulating materials, article reprint GER-2026 (4-pages). General Electric Co., Bldg. 705, Corporation Park, Scotia, N.Y. 12302.

Circle 343 on Inquiry Card

Gridded cross-field amp, S-band, for use in airborne or pod-mounted applications—data sheet RW-617 (4-pages). Warnecke Electron Tubes, Inc., 175 W. Oakton St., Des Plaines, Ill. 60018.

Circle 344 on Inquiry Card

Sockets for op-amps, designed for production testing, aging, and burn-in, bulletin PB-1011. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050.

Circle 345 on Inquiry Card

Advertisers—November 1969

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Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.

Nomex®. The best thing next to electricity.

No matter what the class, you want the most reliable insulation you can get. NOMEX* nylon gives Class H performance and better for Class A through H motors, generators, transformers and wrapped wire. As a result, one insulation—NOMEX—can efficiently satisfy all of your insulation needs.

NOMEX has high overload capacity. UL-rated at 220 C., it also conforms to MIL-1-24204. It will not melt or support combustion.

NOMEX is tough enough to withstand the rigors of automated production. It's available in a variety of forms and can be easily creased, formed or punched. NOMEX is compatible with all major resins, varnishes and enamels. And its resistance to moisture and chemicals is outstanding.

For more facts, write: Du Pont Company, NOMEX Marketing, Wilmington, Delaware 19898. In Canada, write Du Pont of Canada Ltd. In Europe, Du Pont de Nemours Int. S.A., 81, Route de l'Aire, Geneva, Switzerland.

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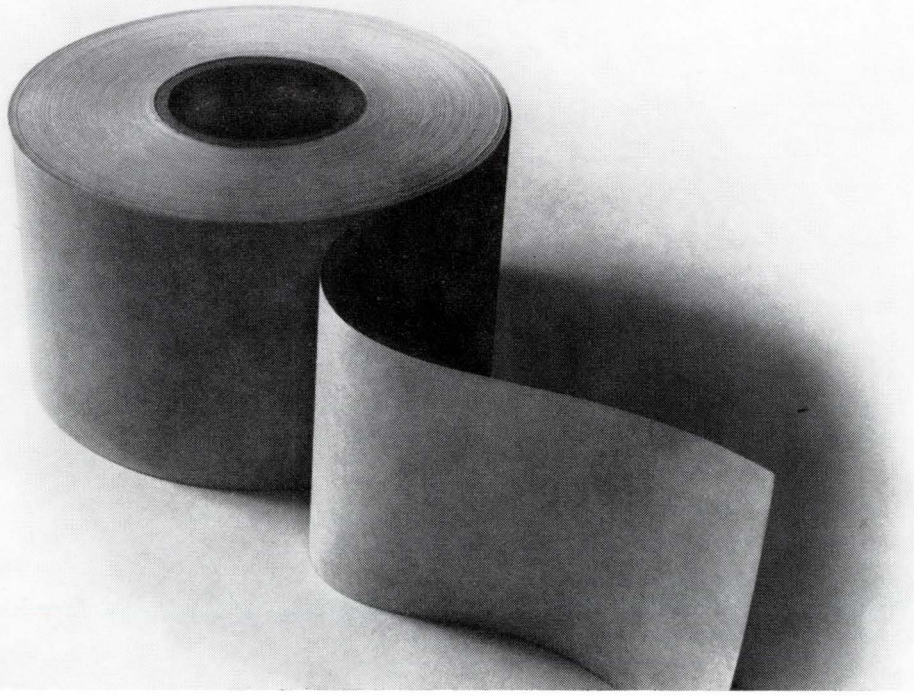

Circle 2 on Inquiry Card

Measure...
the little pencil tube oscillator that's big in aircraft transponder systems

This pencil tube and cavity oscillator, RCA-4068, is 3″ long, weighs 4 oz., and costs less than $50 in quantity. Ideal, you see, for general aviation use.

What's more, its reliability is so impressive that it's warranted for 1000 hours.

The RCA-4068 is an integral device adjusted at the factory. Hence, it is easily replaceable at the factory where the whole device can be reoptimized—and, in fact, go back to the user adjusted to original specs. The device features low power drain with a dc supply voltage of 1,400 volts or less and a 500 W useful power output at peak of pulse. Note these other practical data:

Tuning range . . . . . ±15 MHz
Maximum output VSWR
(all phase angles) 1.3:1
Operating temperature . . . −46°C to +71°C
Altitude . . . . . up to 35,000′
Duty factor . . . . . up to 0.01

For further information, see your local RCA representative. For technical data on the RCA-4068 and other pencil tubes and cavities, write: RCA Electronic Components, Commercial Engineering, Section K50Q, Harrison, N. J. 07029.

RCA