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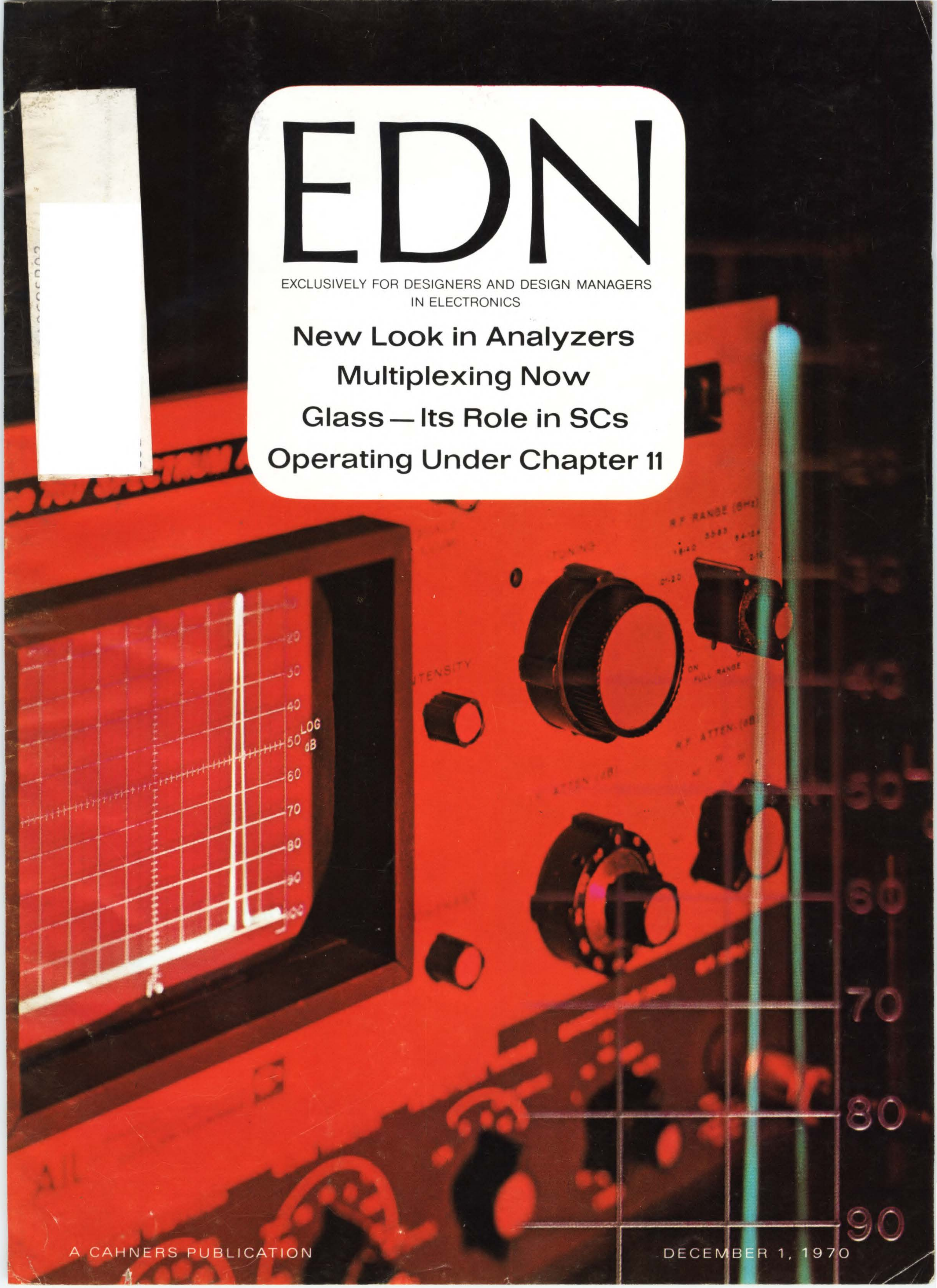

A CAHNERS PUBLICATION

DECEMBER 1, 1970

Trounce trimmer troubles

with Dale Industrial and Commercial T-Pots

RCA's widely-used Spectra 70 computer is a good example of Dale Trimmers' year-in, year-out dependability. The models shown here are from Dale's 2100 wirewound series...sealed to meet tough RCA immersion requirements. Used in a number of Spectra 70 control and voltage reference applications, they're part of Dale's workhorse line of industrial and commercial trimmers. Nothing fancy...but you get what you need, when you need it—and you can use all you receive. Dale trimmers have a record of less than 1% customer rejection for *all* causes. Join the growing number of trimmer users who've found there's less trouble when you specify Dale.

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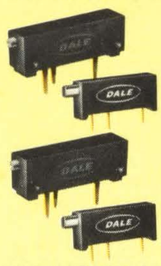
COMMERCIAL GRADE ECONO-TRIM T-POTS



WIREWOUND ELEMENT

2300 Series: Sealed/Unsealed; 10Ω to 50KΩ, ±10%; 0.5 watt at 25° C, derated to 0 at 105° C; .36 H x .28 W x 1.00 L.

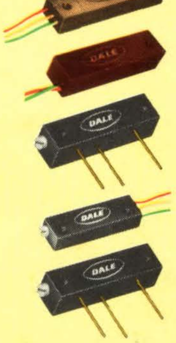
2400 Series: Sealed/Unsealed; 10Ω to 50KΩ, ±10%; 1 watt at 40° C, derated to 0 at 125° C; .31 H x .16 W x .75 L.

FILM ELEMENT

8300 Series: Sealed/Unsealed; 10Ω to 2 Meg., ±10% 100Ω thru 500K, ±20% all other values; .75 watt at 25° C, derated to 0 at 105° C; .36 H x .28 W x 1.00 L.

8400 Series: Sealed/Unsealed; 10Ω to 2 Meg., ±10% 100Ω thru 500K, ±20% all other values; .75 watt at 25° C, derated to 0 at 125° C; .31 H x .16 W x .75 L.

INDUSTRIAL GRADE T-POTS



WIREWOUND ELEMENT

100, 200, 300 Series: 10Ω to 100KΩ
100 Series: ±5%; 0.8 watt at 70° C, derated to 0 at 135° C
200 Series: ±10%; 0.5 watt at 70° C, derated to 0 at 105° C
300 Series: ±15%; .25 watt at 70° C, derated to 0 at 85° C
Dimensions: .22 H x .31 W x 1.25 L (also 1.32 L for 100, 200).

1100 Series: 10Ω to 100KΩ, ±10%; 1 watt at 70° C, derated to 0 at 175° C; .28 H x .31 W x 1.25 L.

2100 Series: Industrial counterpart RT-11; 10Ω to 100KΩ, ±10%; 1 watt at 70° C, derated to 0 at 125° C; .28 H x .31 W x 1.25 L.

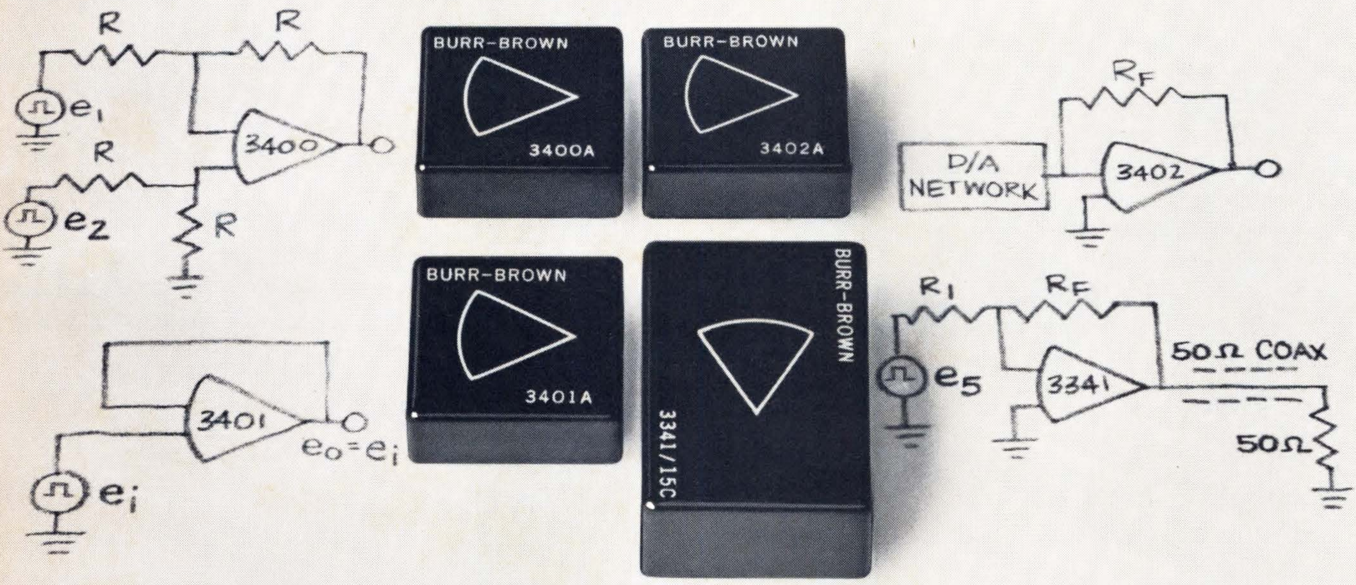
2200 Series: Industrial counterpart RT-10; 10Ω to 100KΩ, ±10%; 1 watt at 70° C, derated to 0 at 125° C; .18 H x .32 W x 1.00 L.

FILM ELEMENT

8100 Series: Industrial counterpart RJ-11; 10Ω to 2 Meg., ±10% 100Ω to 500K, ±20% other values; .75 watt at 70° C, derated to 0 at 125° C; .28 H x .31 W x 1.25 L.

CIRCLE NO. 1

Need a fast wideband op amp?



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This wideband bunch from Burr-Brown is the industry's most comprehensive line of high speed operational amplifiers. From 10 fast settling models, you can select the one that best meets the exact requirements for your specific application. The four illustrated models are representative of the performance range of the high-speed line. All units are available from stock.

For complete technical information on all 10 of our fast response, wideband op amps, contact your Burr-Brown Engineering Representative or use this publication's reader service card.

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3400A	Industry's fastest differential op amp. 100 MHz bandwidth. 1000 V/μsec slew rate. 1 μsec settling to .01%. FET input. Price (1-9) $55.00	Video and pulse amplification.
3401A	The industry's only fast settling op amp with guaranteed accuracy as a noninverting buffer. Gain accuracy better than .01%. 1 μsec settling to .01%. FET input. Price (1-9) $42.00	A/D, D/A converters . . . and multiplexers.
3402A	Fast settling, 1 μsec to .01%. Differential FET input. Low Cost, (1-9) $37.00	Ideal for high-speed precision D/A converters with monolithic quad switches.
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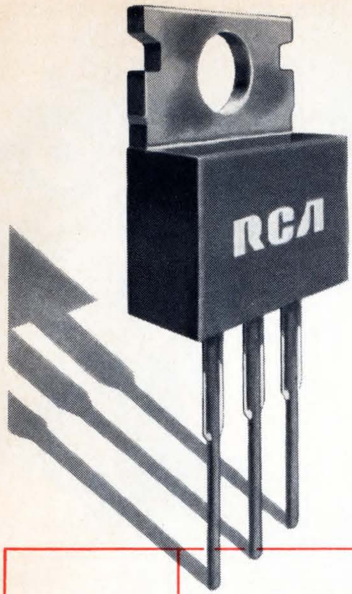
CIRCLE NO. 2



FOUR FOR FREE!

RCA offers you four plastic power transistors without charge.

RCA Type	Package	V_{CER} (sus) V	h_{FE}	I_C A	V_{CE} V
$f_T = 0.8$ MHz min; $P_T = 100$ W max					
2N5034	TO-3 equiv.	45	20-80	4	4
2N5035	Straight lead	45	20-80	4	4
2N5036	TO-3 equiv.	60	20-80	5	4
2N5037	Straight lead	60	20-80	5	4
$f_T = 0.8$ MHz min; $P_T = 36$ W max					
2N5293	TO-66 equiv.	75	30-120	0.5	4
2N5294	Straight lead	75	30-120	0.5	4
2N5295	TO-66 equiv.	50	30-120	1	4
2N5296	Straight lead	50	30-120	1	4
2N5297	TO-66 equiv.	70	20-80	1.5	4
2N5298	Straight lead	70	20-80	1.5	4
$f_T = 0.8$ MHz min; $P_T = 50$ W max					
2N5490	Straight lead	50	20-100	2	4
2N5491	TO-66 equiv.	50	20-100	2	4
2N5492	Straight lead	65	20-100	2.5	4
2N5493	TO-66 equiv.	65	20-100	2.5	4
2N5494	Straight lead	50	20-100	3	4
2N5495	TO-66 equiv.	50	20-100	3	4
2N5496	Straight lead	80	20-100	3.5	4
2N5497	TO-66 equiv.	80	20-100	3.5	4

Why? Because RCA has produced millions of plastic power transistors for automotive and audio applications, production techniques are proven, reliability is established, and prices are lower than hermetic counterparts. We're confident that you will design RCA plastic power into your circuits – once you've tried them!

Review the chart and select any four. They're ideal for applications such as voltage regulators, switching regulators, linear regulators, pulse amplifiers, linear amplifiers, power switching, solenoid relays, and many others.

Next, contact your *RCA Industrial Solid-State Distributor;* he is your source for the four free samples. This offer is good in the U.S.A., and expires December 31, 1970.

RCA | Electronic Components | Harrison, N.J. 07029

RCA

DECEMBER 1, 1970
VOLUME 15, NUMBER 23

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Cover

Cover by photographer Bill Megna shows a peak response on AIL's new spectrum analyzer, capable of 100 dB on-screen dynamic range. See lead news story "Modern Components Produce Competitive Analyzer", p. 14.

Design News

Surface Charge Transistor Chip Stores Million Bits/In^2 . . . Five-Year Effort Pays Off . . . Laser Guides Earth-Working Equipment . . . Design Briefs

Design Predictions

Six-inch-diameter silicon wafers with fewer impurities and improved surface characteristics in this decade – that's what Galamar Industries president foresees.

Design Features

Sophisticated multiplexing techniques are the key to modern data transmission. Here's a state-of-the-art overview of this accelerating technology.

Here's a "VCOS" circuit that you can readily implement, with gates from most IC logic families, especially high-speed TTL.

Not conventional hermeticity, but hermetic glass passivation directly on the junction is the secret of reduced semiconductor package cost and improved reliability.

Design Ideas

Systems approach and standard components produce a manufacturable laser document reader that can discriminate between 16 gray levels.

Two zeners *can* readily be tested simultaneously. That's the word from over 900 respondents to the July 15 Clinic appeal.

Design Interface

"A hell of a way to run a company," says a Kinetic Technology, Inc. executive, as his firm struggles toward the black under the shelter of Chapter 11.

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

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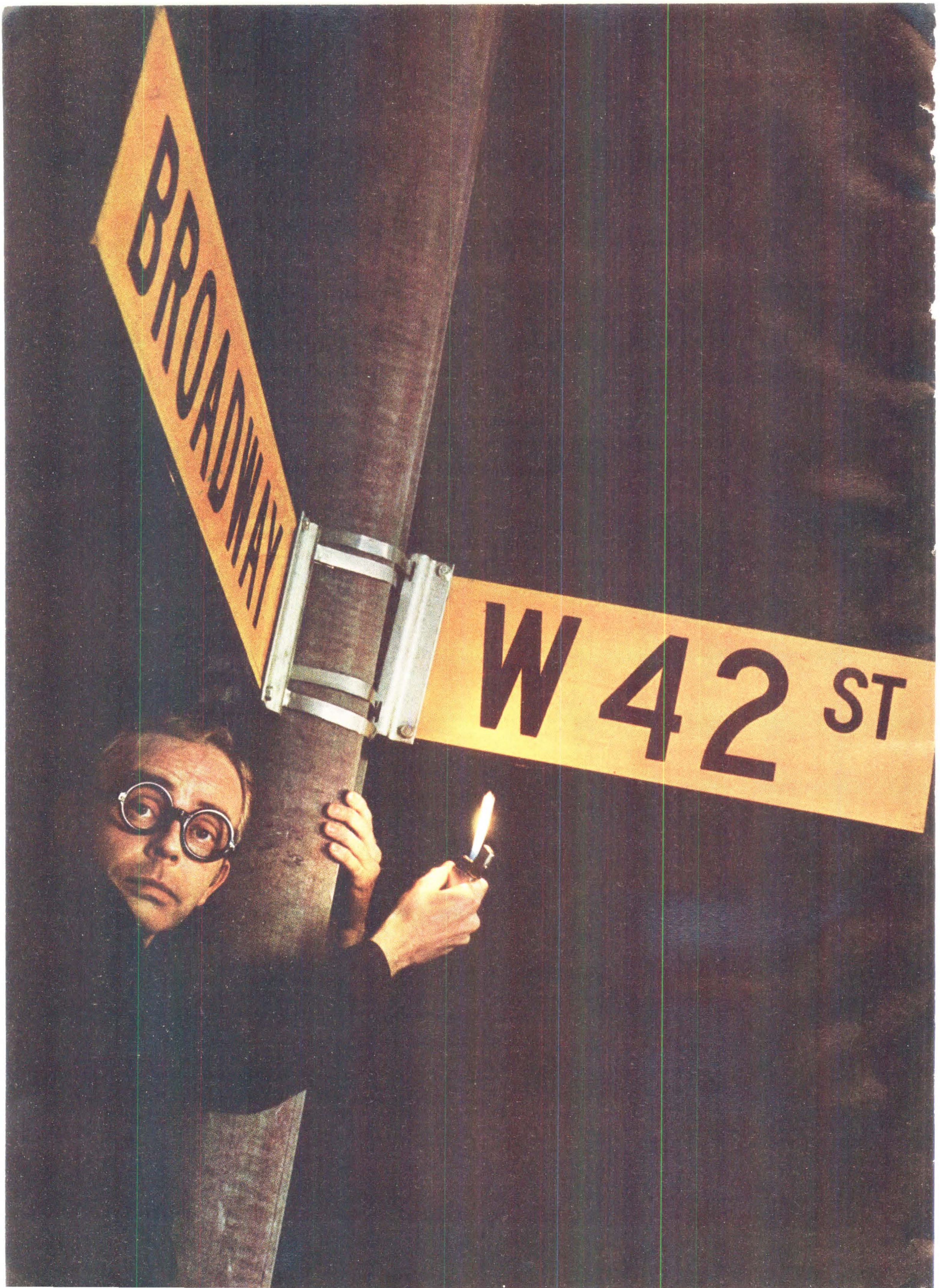
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We make components for guys who can't stand failures.

No one likes to be left in the dark. Especially by some "sophisticated" complex of control equipment that failed.

That's why we make our resistors and capacitors for guys who can't stand failures. Guys like your most important customers, guys like you.

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

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

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

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

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

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

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

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

At Corning we make components for guys who can't stand failures. Guys like your most important customers. Guys like you.

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

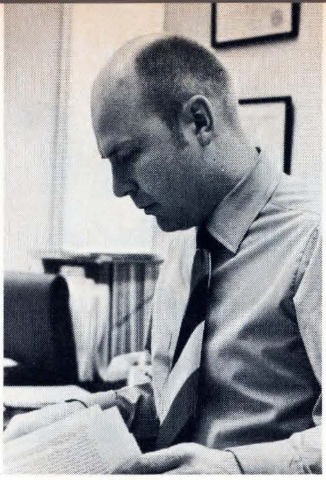
So the next time you're designing a system, design-in an extra measure of performance. Reach for your CORNING® resistor and capacitor catalogs or look us up in EEM. Or for in-depth technical information write us at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

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

CORNING
ELECTRONICS

CIRCLE NO. 5

Editorial Staff



Editorial

You CAN Do Something About It

1970 has been a rotten year for the electronics community. Unemployment has reached alarming proportions; profits have nosedived; salaries have been frozen and cut; work weeks and work days have been shortened; sales are sick.

At best, the future if "iffy." There is absolutely no promise of large government programs that might pick up the slack, and virtually no way that American industry can recapture the domestic consumer market.

So where can we go and what can we do?

One answer—maybe *the* answer—is to reorient our attitudes about world markets. Those companies that are holding their own or growing are doing so largely as the result of increased overseas business. It *can* be done.

But it cannot be done by remote control. Firsthand knowledge and experience is absolutely essential for effective action, no matter what or where the market is. And the time to acquire that knowledge and experience is at hand.

The Paris Components Show (Salon International des Composants Électroniques) will follow hard on the heels of the IEEE convention. EDN is arranging a tour that will take in the Paris exhibition and, in addition, will visit several major European electronics firms. Further, we're planning a seminar with British engineers on the problems of converting to metric.

Included in the price of the tour will be all transportation and accommodations, plus plant tours, the seminar and other fringes too numerous to mention. Two concurrent programs are being organized —one oriented to engineering, the other to marketing. So if the idea makes sense to you, maybe your marketing people will be interested too.

If you want full particulars, simply clip, complete and mail the coupon below. It could be the best thing you ever did for your company, your profession and your career.

G Boe

Editor

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A brief word about P.C. connector

No one connector supplier offers the variety of printed circuit types and configurations that AMP does. This fact translates in benefits to you of 1) greater design freedom, 2) selection of your own degree of reliability, and 3) a total termination capability that can fit the largest or smallest of your production needs. These benefits are what we call AMP **Economation.**

All three types of wiring techniques

We offer a choice of wiring techniques for crimp snap-in, point-to-point, and solder termination.

Crimp — AMP pioneered the *crimp snap-in* contact featuring the advantage of selective random wiring and partially filled housings. We still have the broadest selection for this type of application.

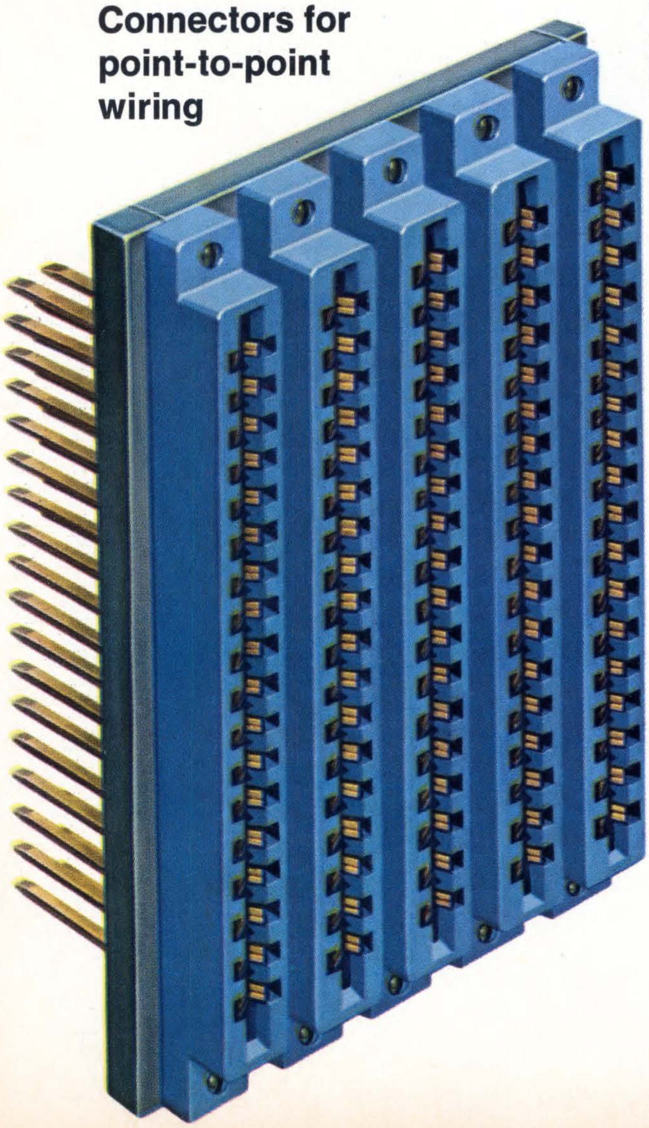
Point-to-Point — Our connectors for point-to-point wiring include both the A-MP TERMI-POINT★ clip-type and the wrap-type with .025 square posts. AMP terminating tooling includes manual, semi-automatic, and completely automatic X-Y wiring machines.

Solder—Most of our mother/daughter connector types and many of our board-to-wire connectors are available in solder tab or eyelet styles.

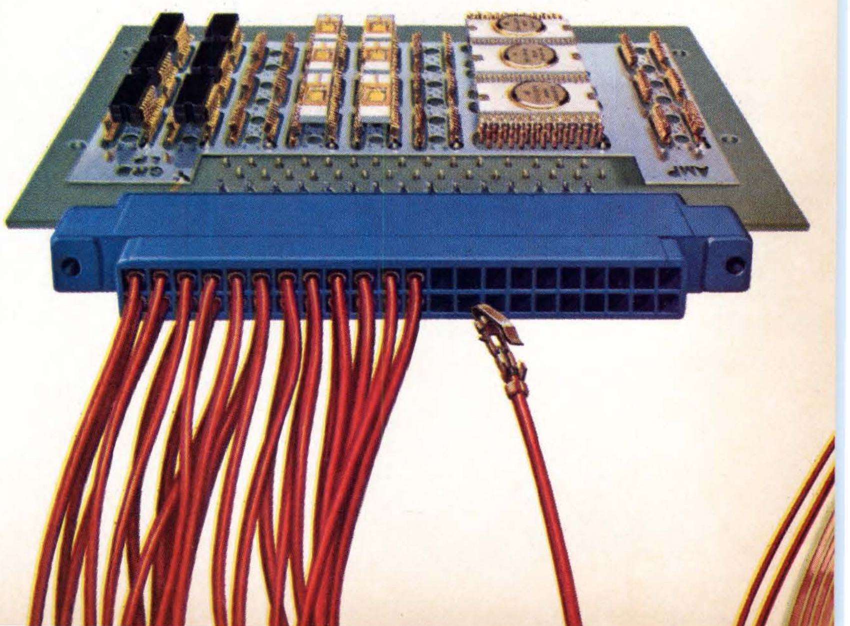
Biggest variety of contact types and plating

Because of your need to suit a variety of design parameters, AMP offers bifurcated contacts, leaf type, cantilever and

Connectors for point-to-point wiring



Random wiring with crimp snap-in contacts



the world's broadest line...AMP.

fork type. These contacts are available in a variety of platings to accommodate different degrees of reliability and economy.

Center line spacing and positions

Our commercial printed circuit connectors cover grid and staggered center-to-center spacings of .050 to .156 and positions variations—from 3 to 50 dual. The sheer variety of our P.C. connector types covers practically all your requirements. Our engineering staff will work with you on custom designs.

Variety of housing materials

Our plastic technology gives you a broad choice of housing materials in thermosetting and thermoplastic materials.

Flexible Flat Cable

AMP has the most reliable and quickest method for mechanically attaching contacts to flat cable — automatically by machine. And A-MP contacts can even be applied in the middle of the cable, or anywhere in between. Housings are available for cable-to-board or cable-to-cable applications. Round wire can also be used in combination with flat cable.

Substrate Connectors

AMP has a variety of designs for connecting various styles of substrates including zero-force and high density connectors for MSI and LSI circuitry. Talk to us about your requirements.

We'd like to enlarge upon this brief description of our P.C. line in person, or in printed form in our new printed circuit connector catalog. For more words and some fast action write: **AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105**

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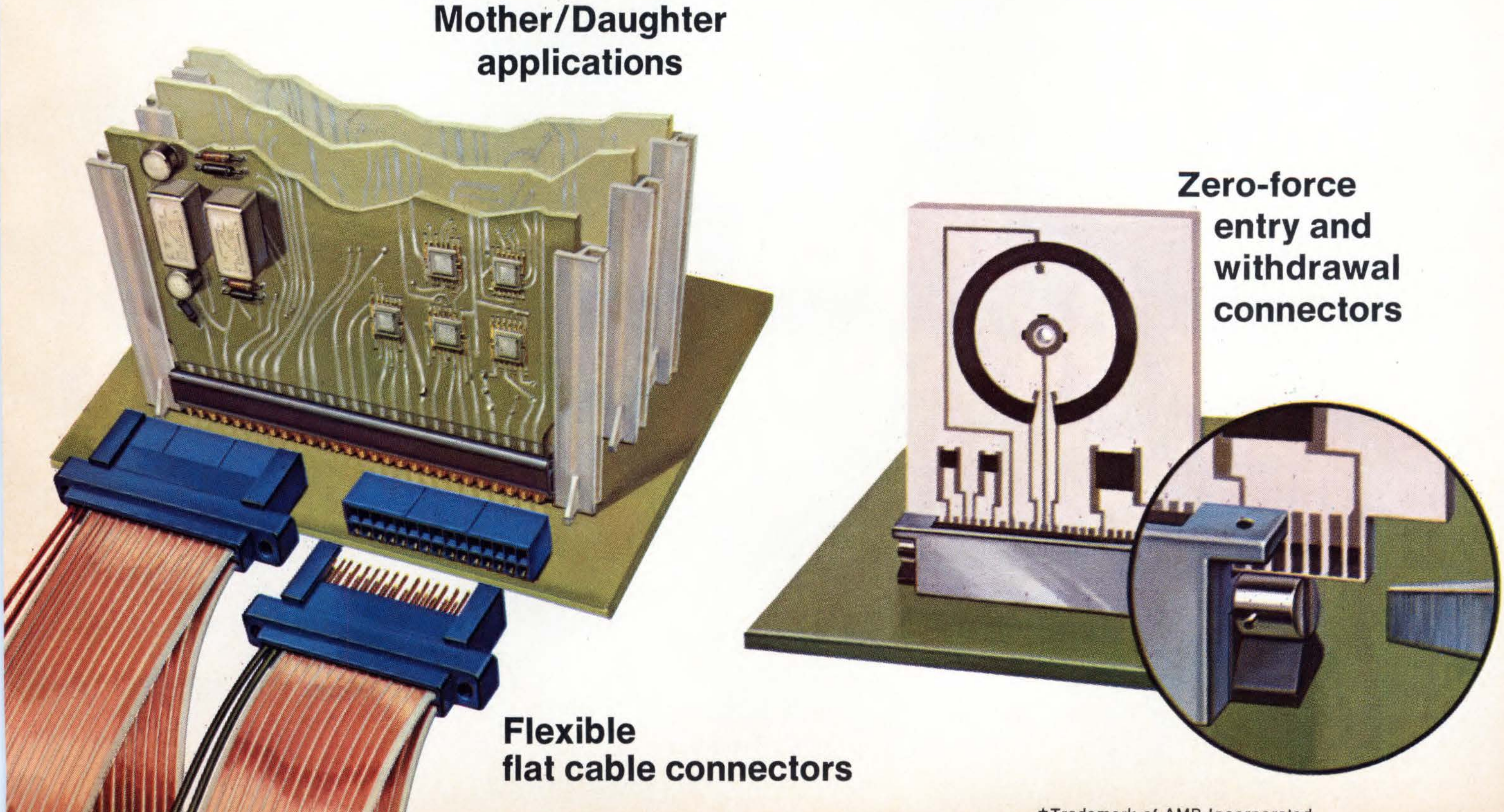
CIRCLE NO. 7



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CIRCLE NO. 8

Modern Components Produce Competitive Analyzer

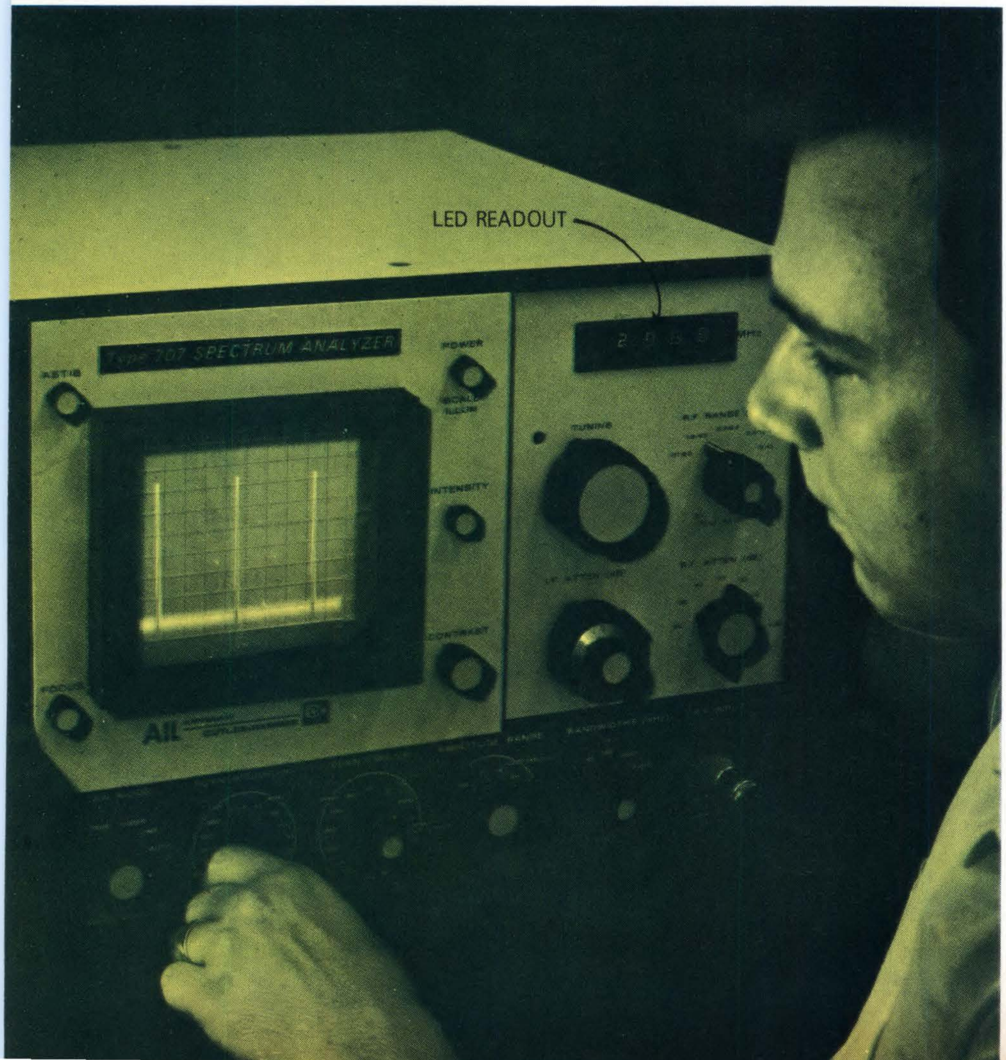
FARMINGDALE, N.Y.—A new spectrum analyzer, covering the 10-MHz to 12-GHz range (to 40 GHz with external mixer) demonstrates how designers can use the latest components to generate competitive new products despite the economic squeeze. The analyzer boasts as much as 100 dB on screen dynamic range. This compares to values 60 to 70 dB in previous instruments in this frequency range.

One can see very small signals next to large ones. The first CRT close-up photo (on opposite page) shows the instrument looking at a −60 dBm, approximately 2 GHz signal nesting within 35 kHz of a large 0-dBm signal. Previous analyzers would not be able to show this, says AIL, because the noise level (seen as "grass" along the bottom) would be up as much as 20 dB, masking any signals farther down than 40 dB from the large signal.

The second cathode ray tube photo shows the instrument sweeping over its 2-12-GHz upper band and looking at the spectral purity of a widely-used laboratory oscillator. It can be seen that when the oscillator is tuned to 2.7 GHz, its third harmonic (at 8.1 GHz) is quite high, only 30 dBm below the fundamental. Previous analyzers would not be able to show this, says AIL, because the 0 dBm input would overpower the analyzer's delicate front end, causing it to generate so many internal spurious harmonics that the test information would be hidden.

The sketched-in bars alongside the CRT displays show the relative dynamic range of this analyzer against previous analyzers.

The wide dynamic range comes from the analyzer's "rugged" front end. It will accept and process signals up to 0 dBm without generating spurious harmonics. Thus, with the same sensitivity for low-level signals as previous analyzers—110 dBm —the Model 707 has 100 dB of useable dynamic range (allowing 20 dB for noise).



The dynamic range decreases to 80 dB at the upper end of the 2-12-GHz frequency band (see second CRT close-up photo) for wide band sweeps because of the losses when harmonics of the 2-4-GHz VCO are employed. However, the 100 dB dynamic range can be recovered for narrow sweeping by narrowing the IF bandwidth.

The block diagram hints at how the AIL design handles high-level signals without generating spurious responses. The signal is made to pass through a YIG preselector filter before it reaches the critical mixers and amplifiers of the 200 MHz IF. The YIG preselector filter tracks the transistor VCO and only opens up a narrow window in the immediate vicinity of the frequency being swept. This shuts out broadband signals that might otherwise overload the mixers and IF amplifiers.

For the uninitiated, YIGs are spheres of material (yttrium-iron-garnet) used in the GHz region that undergo a shift in resonant frequency when a magnetic field is applied. The magnetic field is applied by a coil around the YIG. For sweep tuning, as in analyzers, a current ramp is fed the coil.

As the same current ramp drives the transistor VCO and the YIG filter, the two are automatically synchronized. Because of the inherent high linearity of the YIG and the VCO, the two track closely. AIL will not disclose the nature of the tuning element in the VCO, but typically varactors or YIGs are used in this GHz frequency range.

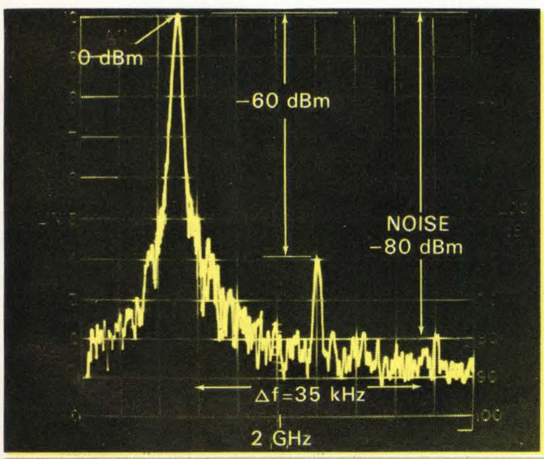
As the block diagram shows, the 2-12-GHz band goes directly into the YIG while the lower 10-MHz-2-GHz band is switched to a "pre-mixer". This "pre-mixer" is driven by the local oscillator and up converts the lower band into the 2-4-GHz range of the YIG preselector, allowing the YIG to be used on the low range also. A bonus derived from the YIG linearity is that AIL can digitize the ramp midpoint and display this as the center frequency on the front panel. It is accurate to within 0.2%. This readout uses seven segment LEDs.

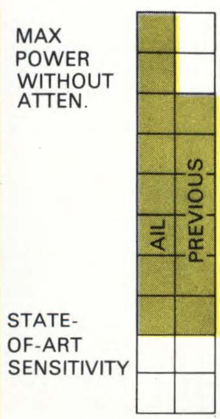
A second reason why AIL is able to provide spurious-free operation for inputs as large as 0 dBm is that the mixers and IF transistors for the 200 MHz IF are selected very carefully. AIL specs were: "free of intermodulation distortion in excess of 100 dB."

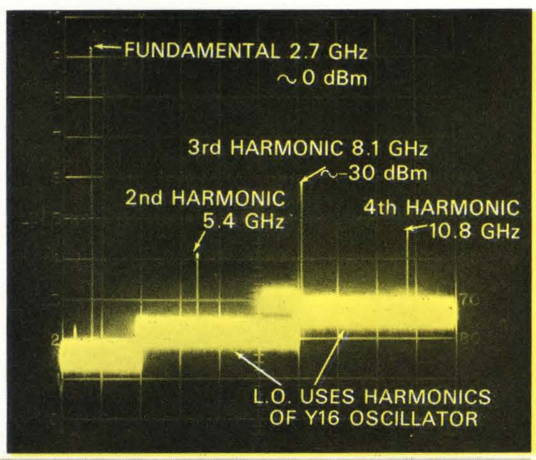
Ironically, the tight distortion spec on mixers forced AIL to use its own analyzer to inspect mixer candidates. They found that most mixer suppliers could not easily test mixers for the 100 dB spec because their spectrum analyzers were limited to dynamic ranges of about 60 dB. Therefore, the suppliers would send mixers to AIL to be checked on one of the 707 prototype breadboards. In a few cases, AIL and the supplier were pleasantly surprised to find that the supplier's mixer was significantly better than the 60 dB specified on his data sheet.

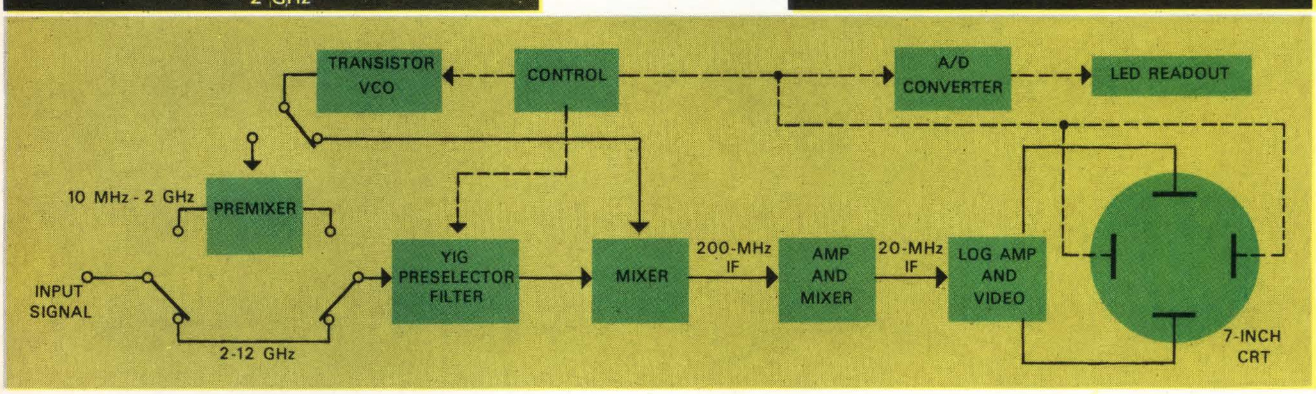
Another advantage of the preselector is that it prevents the 10 dBm power of the VCO from reradiating out the front end. Only nanowatts of power leak out and there is no danger of burning out detector diodes.

AIL's James Philbin predicts that the new analyzer will encourage improved mixer specifications.

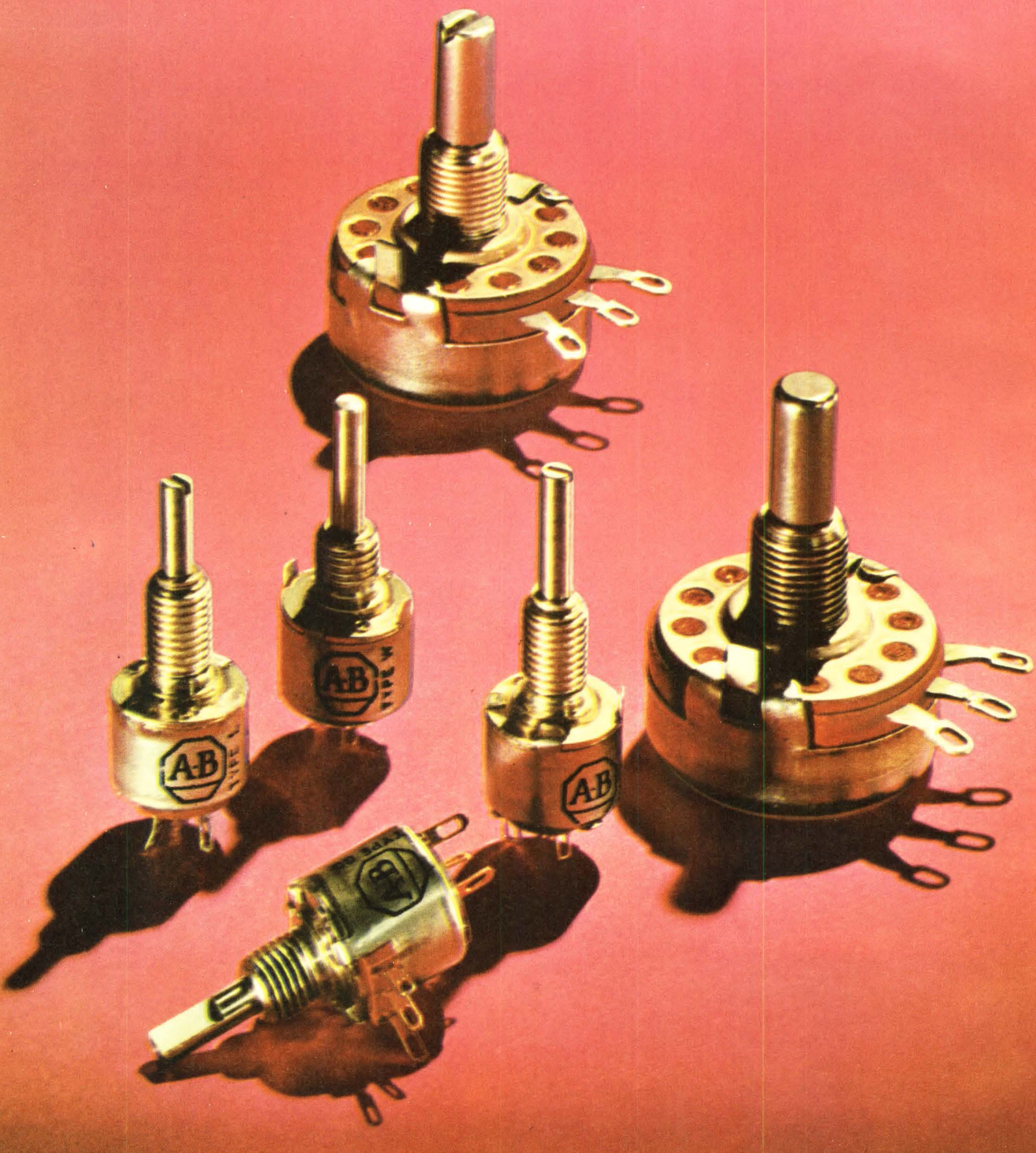








Fight noise pollution



with this quiet family.

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

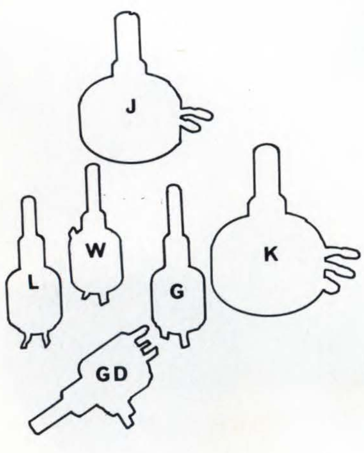
This important Allen-Bradley difference means better short-time overload capacity and a long operating life. Control is smooth, resolution almost infinite. These variable resistors are ideal for high frequency circuits. Why should you trust the performance of your designs or your reputation to anything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

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

SPECIFICATIONS

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

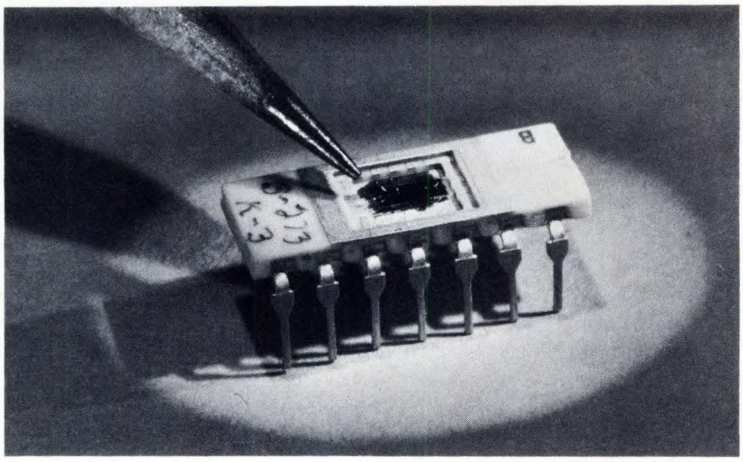
ALLEN-BRADLEY



NEW DIMENSION ELECTRONICS

Surface Charge Transistor Chip Stores Million Bits/In^2

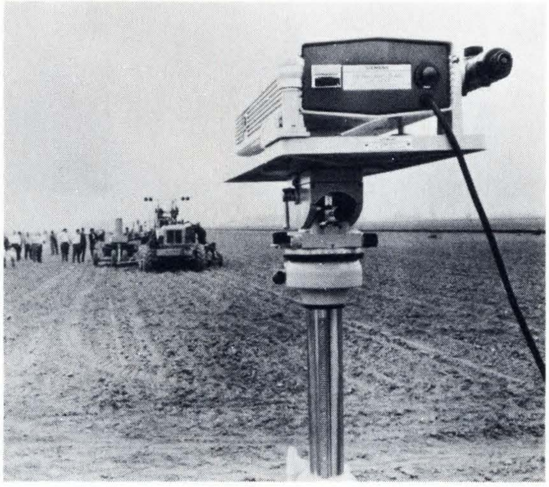
Researchers at GE's Schenectady R&D Center have developed a semiconductor circuit element that can store information at densities of a million bits/in^2. Called "surface charge transistor", its high speed and small size promise major increases in semiconductor memory storage capacity. Integrated circuit arrays of surface charge transistors are expected to find initial application in computer memories and readouts, television cameras and analog signal devices. Shift registers with high speeds are among the easiest to fabricate with surface charge transistors, since the receiver electrode of one unit serves as the source electrode for the next one.



Laser Guides Earth-Working

Reduction of surveying time and manpower and increased accuracy for trenching, grading and paving are among the benefits claimed for the new Siemens Corp. automatic, laser-directed control system.

It uses a photoelectric receiver tuned to the 17.7 kHz frequency modulation of the laser that serves as a reference plane. The laser's output is a fan-shaped beam with a power output of 1 mW and a range up to 1/2 mile. Position of the reference plane is detected by vertical and horizontal columns of photocells on the receiver, as accurately as 0.1 in. Set-up time for the laser is 3 to 5 min.

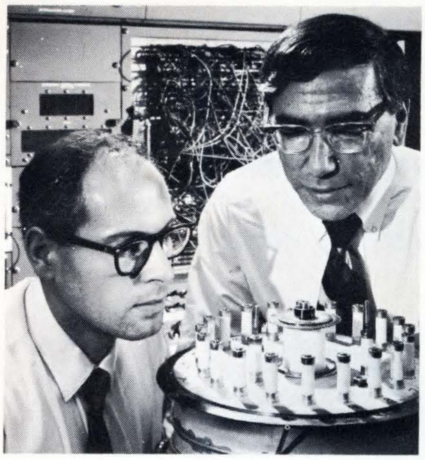


Five-Year Effort Pays Off

As MIL-C-81511 becomes America's first tri-service coordinated specification for connectors, Amphenol Connector Div. of Bunker-Ramo Corp. is in a hard-earned position to take advantage of it. The spec has also been recommended as the connector standard for all NATO countries' military electronic equipment.

Amphenol's enviable position dates from 1966, when the Naval Air Development Center recommended to a tri-service conference that the company's Astro/348 connector design (photo) be adopted as the military services' standard. With its further product development based on this reassuring recommendation, Amphenol has announced a major expansion of the Astro/348 line, to include 20, 22 and 24 shell sizes, in 12 new circular connector insert configurations.

20% More Efficient



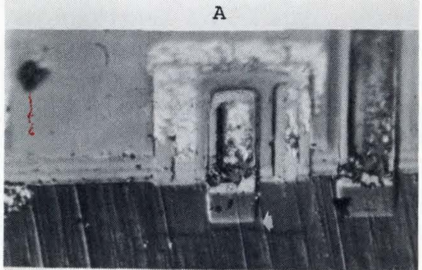
Big step toward practical high-power transmitter satellites is General Electric's newly-developed electrostatic depressed collector that jumps efficiency of klystron broadcast tubes more than 20%. As a result, the tube's heat rejection system and the satellite's solar cells can be drastically reduced in size. GE spokesmen say "The savings in satellite launch costs alone could be noteworthy."

New Problems— Old Solutions

For immediate, low-cost relief of small-aircraft collision problems, Emerson and Cuming, Canton, Mass., make the "Ecco" Reflector®. It's a spherical Lunenberg lens that augments radar return from a small aircraft by focusing a plane wave entering on one side to a point on the opposite side. A metallic coating over the surface on the focus side reflects the original plane wave toward its source, thus producing the most efficient and broadest reflection viewing angle available among all types of microwave reflectors. Typically this 12-inch diam "Ecco" Reflector® produces a steady radar cross-section of over 5 inch^2 at S-band over a conical viewing angle of 140°, while a typical small aircraft presents the same cross-section in its most favorable aspect over a viewing angle of only 0.5°. The 12-inch "Ecco" Reflector® represents an apparent radar cross section magnification of over 5.5, thus making small aircraft readily visible among much larger commercial flights.

Arsenic Is Better

A



B

Searching for an emitter impurity superior to phosphorus in gold-doped transistors, IBM engineers have demonstrated that arsenic eliminates base push-out effect (A) and gives excellent control of base width (B). Because of improved emitter injection efficiency, the resulting profile gives higher current gain and cutoff frequency in high-performance npn bipolar transistors.

Soften Blow

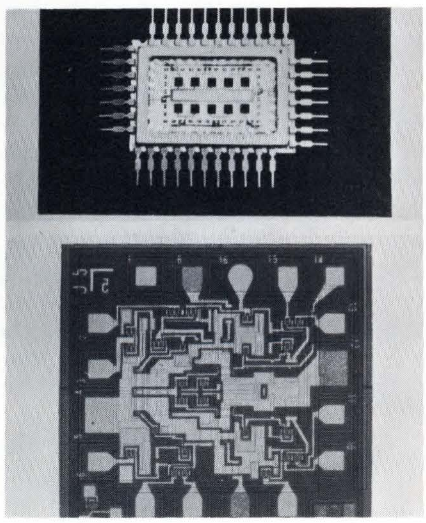
Government is moving, albeit slowly, to cushion the impact of 65,000-plus engineers and scientists out of work late this year.

U.S. Dept. of Labor has set up a central file of engineering job opportunities and applicants in Sacramento, Calif. (near the distressed aerospace and defense industry centers), with cooperation of the NSPE. The registry is nationwide, and unemployed engineers can get forms from their state employment service or professional engineering society.

Keep an eye on Senate Bill 4241, Senator Edward Kennedy's "Conversion Research, Education and Assistance Act of 1970". It calls for National Science Foundation studies to show industry how to convert from defense-related to commercial R&D, would provide $450 million for a 3-year retraining program for scientists, technicians, engineers and management.

Meanwhile, Deutsch, Shea and Evans' engineer demand index showed a point gain of 4.8 for August and noted a plateau near the current 49.0 point level for the remainder of the year.

Faster ECL



Propagation delay time of 1.1 ns is claimed for gates in Hitachi's new ECL large-scale integrated circuits. Key component in a new Japanese high-speed computer, 10 IC chips are sonically bonded face down to a multilayer printed substrate insulated with sputtered glass film. They will also be used in Nippon Telephone Corp. information processing systems.

SILICON'S SILENT PROGRESS

Though unheralded, the progress in silicon-crystal technology steadily continues. Dr. J. Trevor Law, president of Galamar Industries, envisions 6-inch-diameter wafers with significant improvements in crystal perfection and purity.

Ever since the invention of the silicon transistor in 1950, various other materials have been proposed as potential replacements for silicon as the starting material for device fabrication. These have ranged from totally different materials, such as gallium arsenide, to modified silicon systems (for example, the deposition of silicon on a foreign substrate such as sapphire). Single crystal silicon technology however, has the advantages of low cost and, currently, an extremely well-developed technology.

There are only two reasons for any significant switch in starting material: cost and device performance. With the current state of technology, silicon wafers are probably the least expensive material available to the device manufacturer.

One way of achieving lower costs has been to use larger diameter starting wafers. Typical wafer diameter was 0.75 inch in 1960, 1.25 inch in 1963 and 2.0 inch in 1969. This has meant that for a 10- by 15-mil chip (such as a high frequency amplifier or switch), the potential number of devices per wafer has increased from 3000 to 20,000. Presently, several manufacturers are looking at 3-inch-diameter material which would produce some 50,000 10- by 15-mil chips per wafer. Other advantages derive from lower capital equipment costs, since fewer wafers of larger size need to be processed for a given output of devices. By 1973, 3-inch-diameter material should be the industry standard, and during the next decade 4- and 6-inch material may be available and in use. An alternative approach to large circular wafers is the use of rectangular slabs (for example, 2 by 6 inch) such as those currently used at Motorola. This approach obviates the need for much retooling in a wafer fabrication area, but is, we feel, just an interim solution.

In addition to increased size as a method of cost reduction, device manufacturers are now insisting on better crystal quality and surface perfection to improve fabrication yields. Dislocation densities in silicon crystals which have in the past been as high as 10,000 cm^{-2} are rapidly approaching zero, and more emphasis is being placed on the elimination of trace impurities such as oxygen and carbon. Complete elimination of trace elements will call for a new generation of crystal growing equipment which can compete on a cost basis with the existing Czochralski method, while at the same time permitting 2- to 6-inch-diameter material to be produced.

For the next 10 years, I feel that we will continue the past trend of silicon material usage, increasing at a rate of more than 20% per year, with wafer diameters steadily approaching 6 inches.

Other materials, such as gallium arsenide and gallium-arsenide phosphide, will not reduce the growth rate of silicon usage but will complement it in such areas as light-sensing and light-emitting devices. At the same time, we are just entering a period when the use of silicon chips as memory devices is becoming feasible. Potential size of this business, together with the introduction of more and more silicon devices into the automotive industry, may make even our bullish projections of silicon usage in the next decade conservative.

MULTIPLEXING—
TODAY'S CIRCUITS AND SYSTEMS

Designers multiplex, not because they want to, but because they have to. With the amount of information being transmitted today, it's just not practical to provide a separate circuit for every transmission.

HARRY HOWARD, Technical Editor

Back when life was simple, a communication channel was a pair of wires, such as the first transcontinental telegraph line. The principle was elementary: single messages transmitted over a single channel one at a time. This blissful situation didn't last long.

We're now in an era of large-scale automation in accounting, manufacturing, process control, transportation, education, medicine and government. We are leap-frogging from interchange between man and computer to interchange between computers. This expansion could not have taken place without reliable data communication. One solution is the technique of multiplexing—transmitting more than one channel of information over a single wire.

Aircraft has become one well-known application of multiplexing. Instrument Systems Corp. (ISC) developed the passenger entertainment systems for the Boeing 747 and L-1101 aircraft. These systems eliminate approximately 25 miles of cable and save close to 500 pounds of weight. Both ISC and Radiation Systems Div. are investigating the use of multiplexing in military aircraft, not only for audio intercom functions but also to eliminate the hundreds of cables now required for instruments and controls.

The AEC's National Accelerator Lab. of Batavia, Ill. uses multiplexing systems developed by Dynamic System Electronics for acquiring proton beam profile data in the booster section of their proton accelerator, now under construction. A solid-state voice response unit, developed by Phonplex Corp. (subsidiary of ISC), enables computers to talk by electronically storing "phonemes" or the smallest meaningful sound. They are reconstructed into words on command. Another development by Phonplex is the multiplexing of telephone terminals to permit up to eight simultaneous

(Continued)

conversations on a single dedicated wire. These instances exemplify typical applications for multiplexing.

IC Multiplexing

Because of the recent trend toward MSI and LSI devices, the majority of major IC manufacturers now produce at least one type of multiplexer. These devices fall into one of two categories—analog or digital. By definition, "analog" units provide a direct resistive connection between input and output, and "digital" units are circuits in which signal transmission is unidirectional. Digital devices also have some digital logic in the input/output path, and they may have other labels, such as data selector or code converter.

Ten configurations of digital multiplexers are offered by Signetics. Three are 1-bit and seven are multiple-bit units. A 1-bit multiplexer presents the data from a selected input. All handle 8 inputs, but provide different output capabilities. Five multiple-bit units are variations of a 4-bit multiplexer with totem-pole outputs and two non-inverting channels. Two Signetics multiplexers are analogous to a 4-pole, 3-position switch. That is, any one of three 4-bit words can be selected by an appropriate 2-bit code.

Propagation delay can be the critical factor that dictates the system response. For example, in time division multiplexing (TDM) a multiplexer may be required to have faster switching speeds than other circuits in the system. Recently, Fairchild Semiconductor introduced an 8-channel multiplexer (9581) with MSI complexity that has a 3 ns throughput.

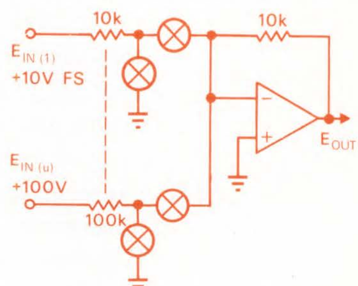
Let's Not Forget Analog

In the past, analog multiplexers were limited in use because their control circuitry was incompatible with digital ICs. Now, manufacturers are providing units with DTL/TTL compatibility. With MOS technology, analog multiplexing is a natural because the structure does not exhibit a pn junction voltage effect.

Motorola entered the MOS IC business with their introduction of an 8-channel multiplexer (MC1150) and a 2-of-8 channel multiplex switch (MC1151). Both devices are characterized by very large changes in conductance between ON and OFF states. At 25°C, the maximum ON resistance is 500Ω, while the minimum OFF is 1000MΩ.

Early this year, National Semiconductor introduced a four-channel analog commutator, MM454/MM554,

Ordinarily, multiplexers are used in conjunction with A/D converters. Depending upon system requirements, a multiplexer may be high level (5 to 10V full scale) or low level (10 mV to 1V full scale). It may be single ended (common signal return) or differential. It may be of the high impedance or constant-impedance type.



CONSTANT IMPEDANCE MULTIPLEXER

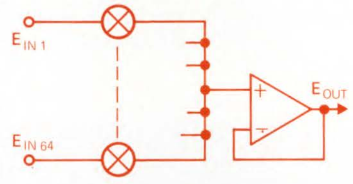
In the constant-impedance multiplexer, input signals are connected to resistors, the other end of which switches directly to ground (OFF) or to the virtual ground point of an operational amplifier (ON). Therefore the input load is constant, regardless of whether or not the input is selected. This type is useful for multiplexing inductive loads such as the output of "Scott-T" transformers used in synchro-to-digital converters. If the multiplexer draws any transient current from the source, a large voltage will be induced. This voltage then has to settle down to its normal value, with the inductive source establishing the time constant which could be in the millisecond range. A second use for the constant impedance, multiplexer is for scaling inputs of different full-scale values.

In a single-level, high-impedance multiplexer, all channels are tied to a common node that is con-

Design Parameters for Consideration

JAMES V. DIROCCO, Analogic Corp.

nected to the high-impedance input of a buffer amplifier. When a channel is selected, the impedance of the switch connecting the source of the amplifier is relatively low, while the impedances of the non-selected switches are extremely high. Thus the selected channel source sees the input impedance of the amplifier plus any load effect of the nonselected channels connected to the common node. In a typical amplifier this input impedance may be on the order of 1000 MΩ with picoamp bias current. Therefore, the amplifier presents an extremely light or insignificant load to the source.



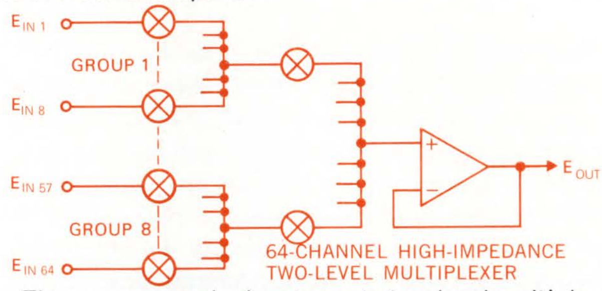
64-CHANNEL HIGH-IMPEDANCE ONE-LEVEL MULTIPLEXER

In a well-designed system, typical off-channel leakage represents a load of about 0.5 nA or less per channel—typical leakage current of a FET switch at room temperature. Although this current is low at room temperature, it will double with every 10°C rise in temperature and must be considered when calculating system inaccuracies. As an example, for a 64-channel multiplexer using single level, a total of 63 times 0.5 nA or about 32 nA would be presented by the off-channels. This leakage current must be supplied by the source. Thus, if the source impedance is 10KΩ, the error voltage will be 320 μV.

If 10V full scale signals were being multiplexed into a 12-bit converter, this error would be about 1/8 of the least significant bit (LSB) and therefore would appear to be unimportant at room temperature. However, if the temperature goes to 65°C, this leakage component increases by a factor of 16, causing an error of close to 5 mV which is not insignificant and must be considered.

A second type of error is dynamic. This is caused by tying many channels to a common point. Typical capacitance of an off-channel is 7 pF. For a 64-channel unit, total capacitance will be approximately 450 pF. Working with a 10 KΩ source, the resultant time constant is roughly 4.5 μs. Since it takes approximately 9 time constants to settle within 0.01 percent of final value, capacitance of this size is obviously a serious hindrance to system throughput capabilities.

A better scheme uses two level multiplexing. In this approach, a signal passes through two switches prior to the connection to the buffer amplifier. A useful configuration for a 64-channel multiplexer is an 8 by 8 two-level multiplexer array. In this approach, one channel in each input group of 8 is turned on simultaneously. However, only one of the eight second-level switches is on to allow only one input to be connected to the buffer amplifier.



64-CHANNEL HIGH-IMPEDANCE TWO-LEVEL MULTIPLEXER

There are several advantages to two-level multiplexing. In a 64-channel array, the selected source "sees" only 14 OFF channels—seven of its own group plus seven in second level switches. This reduces the total leakage at room temperature to about 7 n_s—more than a factor of four less than the one-level multiplexer.

In addition, the total effective capacitance seen by the source impedance is reduced by the same ratio. Relating this with the previous example, the time constant with a 10 KΩ source impedance is about 1 μs, allowing settling to 0.01 percent in about 9 μs. Obviously, this compares favorably with the 40 μs settling time needed in the one level, 64-channel design.

Multiplexing System

The most common configuration used in instrumentation today is the high-level, high-speed system. A typical system may have up to 32 single-ended input channels with expansion capability to 256 channels. Full scale ranges are usually ±5V or ±10V. Typical applications include scientific spectroscopic instruments where a single channel system may be used for monitoring the output of a photo-multiplier tube in an infrared spectrometer. A multichannel system may be used for measuring the triggering and hold levels of MOS FET memory cells in an automated test system for a production line. Obviously, there are hundreds of applications for a multiplexer.

(Continued)

capable of switching four analog input channels sequentially onto an output line. Commutating rate of this device is 500 kHz. In addition, this commutator can be used for submultiplexing, because a 4:1 clock countdown signal is provided that can drive the clock input of subsequent MM454/MM554 units.

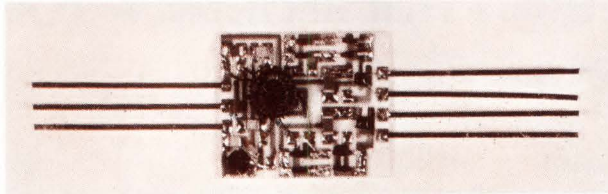
Using n-channel JFETs, Siliconix offers a variety of devices capable of switching analog signals at frequencies up to 10 MHz. These circuits contain two channels in one package, each channel consisting of a driver that controls single-pole, single-throw or double-pole, single-throw JFET switches. The driver interfaces with DTL, TTL or RTL logic signals for multiplexing, commutating and D/A converter applications.

Silicon-gate technology, now used by Intel and Fairchild Semiconductor, offers lower threshold voltage and faster switching than the conventional aluminum-gate MOS. Because this technique is compatible with conventional bipolar processing, transistors and MOS switches can be combined on a single chip for greater circuit density. Ion-implanted MOS is being used by Hughes Aircraft Company in an experimental multiplexer to achieve higher switching speeds.

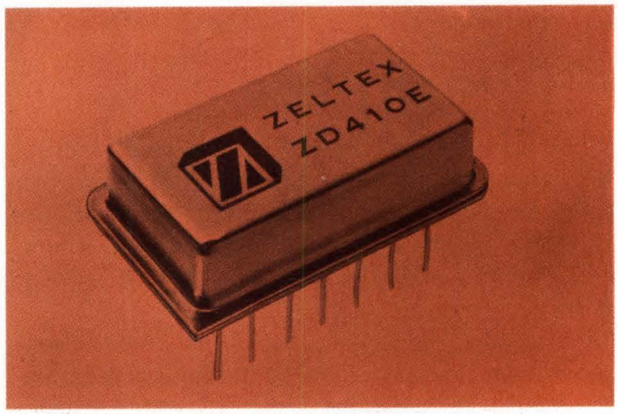
General Instrument developed their products using nitride-passivated insulated gate FETs, referred to as MTNS. In 1969, they introduced a 10-channel multiplexer (MU-62281) and this year a 16-channel random/sequential access multiplexer designated AY-6-4016. The AY-6-4016 is a 40-lead unit that contains a programmable four-stage binary counter, a 4 by 16 decoding matrix and 16 single-pole, double-throw switches. Maximum operating frequency is 2 MHz.

Complementary MOS or COS/MOS has been primarily used by RCA in experimental multiplexers. For example, the TA5460 is an experimental analog switch that passes both analog and digital signals reliably. Unlike devices using p-channel enhancement technology, the COS/MOS multiplexer accepts peak signal voltages approaching full supply voltage.

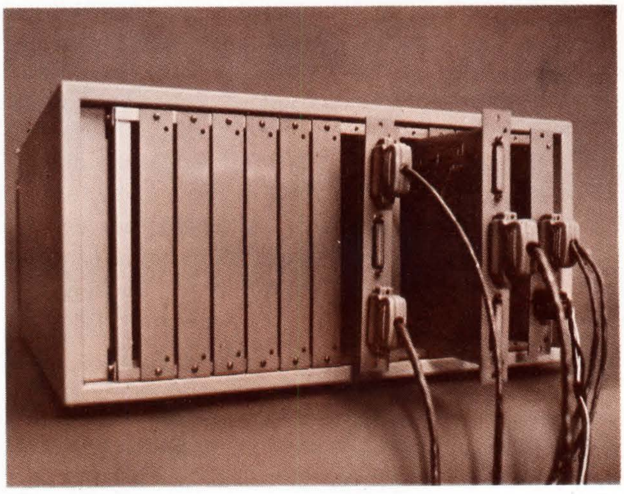
Unusual among the IC analog multiplexers is the Harris Semiconductor (formerly Radiation) type HS-1000. This device contains 16 JFET switches plus bipolar TTL compatible decoding circuitry on a single dielectrically isolated silicon chip. The switching elements provide very low leakage and minimal crosstalk over the operating temperature range of −55 to 125°C. Also, there is a constant ON resistance,



A low-level hybrid multiplex switch, developed by Spacetac measures, 0.75 by 0.75 by 0.1 in and will accept up to 12 Vac pk-pk or ±6 Vdc. Designated MC-37, this unit operates from dc to 100 kHz and has >50 MΩ input/output isolation.



Four-channel analog multiplexer, offered by Zeltex, Inc., features patent-pending short-circuit protection. When dc is removed, each channel assumes and maintains at least 10 MΩ isolation from ground and other channels regardless of input level within specified input range.



Multiplexing equipment offered by Computer Transmission Corporation intermixes high and low speed terminal equipment. Designated MULTITRAN, these units interface directly with data sets that operate at 19.2, 40.8, 50 or 230.5 Kbps.

regardless of the analog signal level. By means of a mode select digital input, the device will switch either 16 single-wire lines or 8 two-wire lines. This device is packaged in a 28-lead flat package.

Daniel Lubarsky and Charles Botchek convey the real potential of the MOS/LSI technology in the box below. The devices discussed were developed at Larse Corporation for data transmission in process and supervisory control systems and they operate in all standard communications modes including FSK, AM, DC and EIA RS-232-B with universal input/output interfaces. They operate in full duplex, half duplex or simplex configurations. Party-line operation is possible with up to 64 stations.

MOS/LSI Impact

DANIEL LUBARSKY, CHARLES BOTCHEK, AND RON RIEGERT, Larse Corp.

Modern industrial facilities require remote alarm supervision, data acquisition and central control to achieve precise operational control and to reduce costly downtime due to undetected malfunctions. One technique, FDM, uses one frequency in a given spectrum (generally between 300 and 3000 Hz to be compatible with voice grade circuits available through normal telephone service) to represent either a status or an alarm point or to provide a control function. Some systems use Frequency Shift Keying (FSK) to minimize the possibility that noise introduced into the communication circuit can cause or issue a false command. The FSK channel uses one frequency (MARK) to generate a control function and another (SPACE) to indicate that the channel is operating and no control action should be performed. Obviously, there is a practical limit to the number of tone channels that can be used. When this limit is reached, a more economical approach is TDM.

The TDM system operating over voice grade circuits uses a single FSK tone channel for communication. With this approach, the communication channel is time shared between the digital data generated at the remote points. This system requires two units. One unit scans data inputs at a constant rate, multiplexes, and generates a serial code containing data plus check and timing bits—Larse Corp. refers to this device as the "SEN" unit (Scanner-ENcoder-transmitter). The other unit, called "REDE" (REceiver-DEcoder-demultiplexer) receives the transmission, decodes the data word, checks the integrity of the work and demultiplexes the data onto the output lines.

For this system MOS/LSI is ideally suited because:

—MOS logic functions require fewer components than bipolar technology.

—Resulting device containing 4000 MOS components can be batch fabricated with high packing densities.

—Having one MOS/LSI chip per subsystem reduces interface connections nearly 98 percent over other approaches.

—Reducing separate part count by 90 percent reduces system size nearly 2000 times.

—MOS devices, being voltage controlled, inherently exhibit greater noise immunity than bipolar.

—Supply voltage regulation is not critical for low-speed MOS circuitry.

—System speed is not critical for low-speed MOS circuitry, thus allowing low development cost amortization. These potentially significant advantages can be realized only if production yields are reasonably high and if complete system function is not jeopardized in the MOS/LSI design.

Partitioning a System

Main objective of system partitioning is to select the die complexity that will give optimum process and assembly yields. Normally, this means reduced gate and p-diffused region area thus achieving high-process yields for low-cost systems. Also, the number of package pins is reduced, improving assembly yield and reliability.

The SEN chip, containing approximately 1500 active devices, could have been partitioned into three 60 by 90 mil dies and a 30 by 40 mil die. These chips would include a 16-channel multiplexer, a hold memory, a transmission controller and an oscillator. This partitioning approach would increase individual die yield to between 50 and 90%, but would increase assembly time by 250 percent and package count by four. Component count would increase at least 10 percent, and redundant pin-reduction-logic and interface buffers would increase the total active area. These latter factors also increase power consumption.

The decision to use one chip for SEN and another for REDE was based on careful analysis of the above factors. Other factors that weighed heavily are:

—curves for projection of future MOS/LSI yields
—simplified inventory problems
—reduced number of different test programs
—simplified assembly instruction with less chance for errors
—fewer printed-circuit board solder joints
—reduced system size

Partitioning decisions included several calculated risks because each chip contains an untried MOS circuit technique. For example, the SEN chip contains an on-chip oscillator driven directly from a crystal. Careful device modeling was required for this circuit.

REDE chip contains resettable single shot multivibrators with a carefully defined time delay range operable over the full supply and temperature ranges.

(Continued)

Multiplexing (Cont'd)

Universal System

Serious studies began more than a year ago at the Systems Division of Radiation Inc. to develop a Versatile Interior Multiplex System (VIMS). The VIMS analysis was directed at the general problem of information transfer accommodating many signals within the broad classification of digital, analog and video. Specific analyses of both total signal and routing requirements were performed for several modern systems such as bombers, fighters, space bases and submarines. Despite environment differences, the signal transfer problems were strikingly similar. **Table I** lists typical signals found in these applications, all of which can be accommodated by the VIMS concepts.

CLASS	SIGNAL	INFORMATION BANDWIDTH	MULTIPLEXING METHOD
Video	Scan converter Television Radar Sonar	40 MHz 10 MHz 5 MHz 20 kHz	Baseband or FDM Baseband or FDM Baseband or FDM Baseband or FDM
Analog	Audio Synchro High level Low level	300-6000 Hz 400 Hz DC-100 Hz DC-100 Hz	Baseband or FDM Baseband or FDM TDM TDM
Digital	Computer serial digital Control	20k-500 bps DC-20 bps	Baseband or FDM TDM

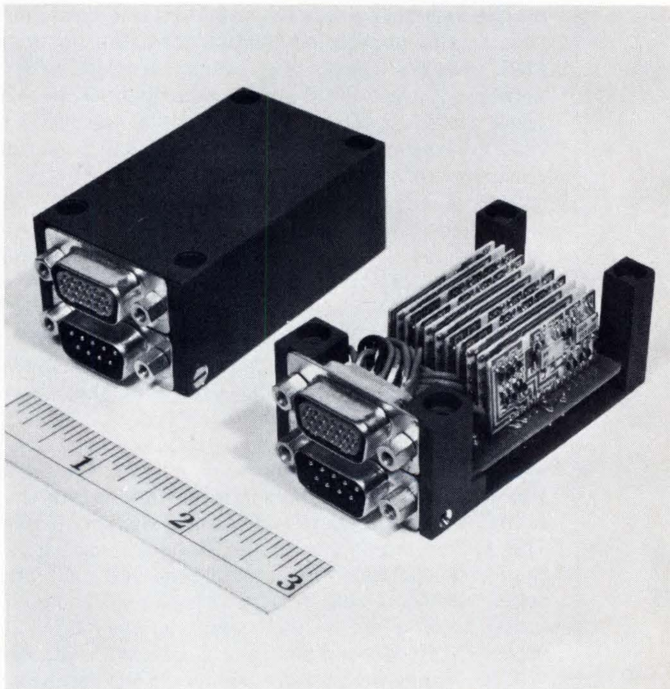
Table 1—Typical signals accommodated by VIMS

Through these investigations, it became apparent that there is no standard building-block answer that is the same for two system problems. Ideally, every signal within a craft can be multiplexed directly onto a single common bus or "party line". Unfortunately, this is only possible in the simplest systems.

Data Processing

By its own nature, data processing generally implies that source material collects at remote points and is brought into a central processor. In June of 1970, IBM introduced System/370 Models 155 and 165 which feature an increased number of channels or data paths linking the memory and all system devices to the control processor. A technique called "block multiplexing" allows simultaneous execution of multiple high-speed channel programs, thereby increasing system throughput. As many as 11 block-multiplexer channels can be used, each handling up to 64 concurrent requests. In the same systems, IBM used a byte-multiplexer channel for sharing low-speed devices. The byte-multiplexer channel lets several low-speed devices operate concurrently or in burst mode, permitting interface with one high-speed device to function. For a system with 524,288 bytes or more of storage, up to 256 channels are standard.

Varian Data Machines offers the 520/DC time-multiplexing system as a communication preprocessor for a major computer. This system samples each of 64 lines once every 59.5 μs. If less than 64 lines are in the system, blank intervals are inserted so that the interval for return to each line remains at 59.5 μs.



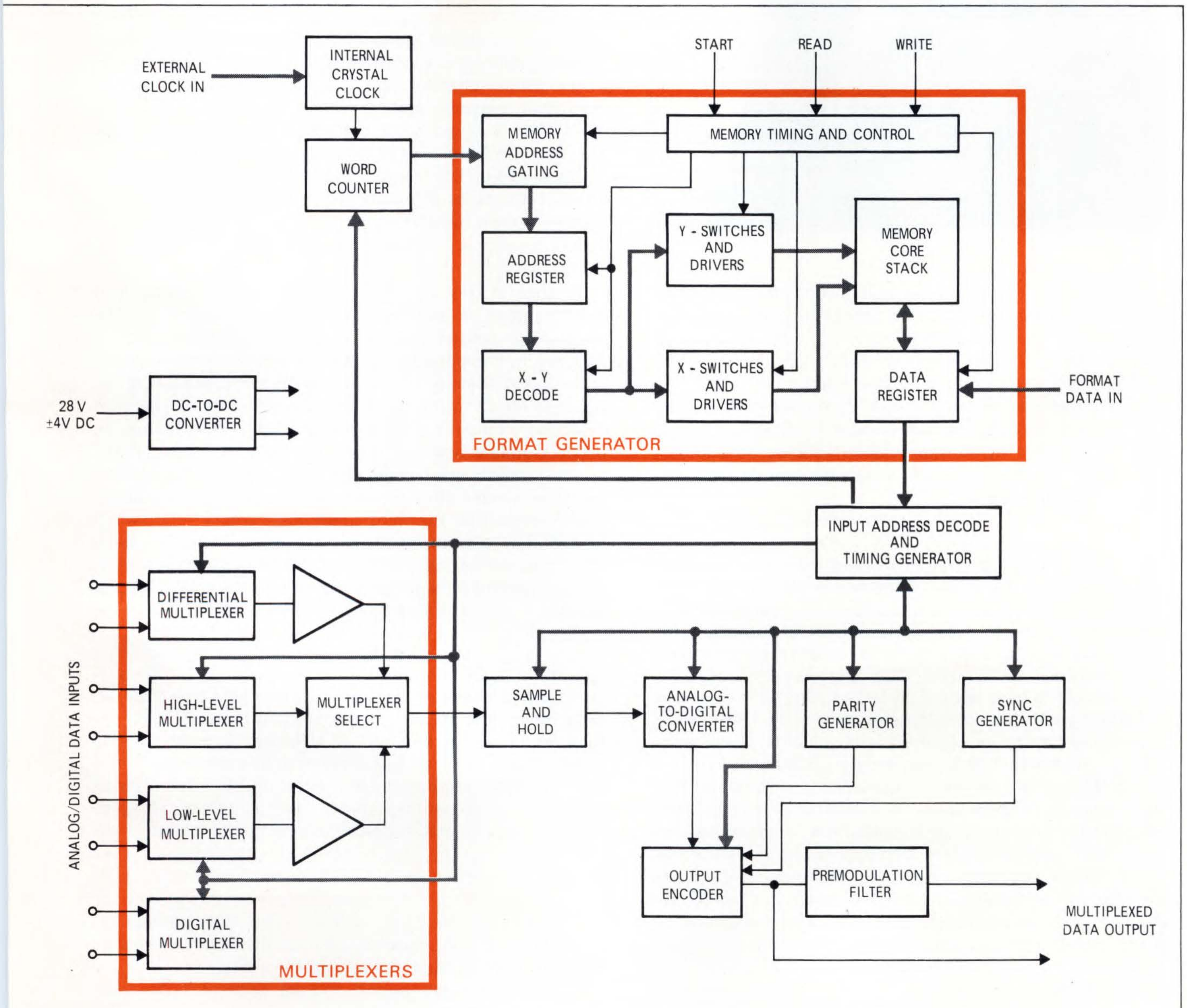
Multiplexing scheme developed by Spacetac, incorporates a 21 kilobit read/write memory for PCM format control. With this scheme, PCM format is changed remotely by simply loading a new format into memory via telemetry link. Applications include unmanned satellites, rockets, and drones where onboard data acquisition can be controlled from ground.

General Electric's DigiNet concept is a set of building blocks that can be combined to meet various communication needs. The 150 Series, for example, permits up to 17 duplex channels to be multiplexed onto four-wire telephone lines. Available exchange rates for transmitting data are 110, 150 or 300 bits/s per data channel. A companion to the 150 Series is the 160 Series. This is a private line multiplexer that provides multichannel and multipoint data transmission use of leased or private four-wire voice grade circuits. Like the 150, it has up to 17 full duplex channels on a four-wire telephone line, and the channel speeds are up to 110, 150 and 300 bits/s.

Electromechanical Is Still Here

The simplest form of multiplexing is the sampling switch of a mechanical commutator—a rotating brush that makes contact with a relatively large number of contact pins in a specific sequence. Such switches have been constructed with up to 500 contacts and have several synchronized poles. However, the most general requirement is 100 channels or less, with from two to four poles.

Electromechanical multiplexers are primarily used for aerospace telemetry applications where lowest cost per data point is the primary objective, and long life and high speed are of lesser importance. Both



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Elements of Computer Multiplexing

DONALD E. MURPHY, Digital Equipment Corporation

To a certain extent, "computer multiplexing" has been given such a wide meaning that it is in danger of becoming almost meaningless. Computer multiplexing can mean using a computer to act as a message concentrator; it can mean something akin to time sharing; or it can mean a combination of both. For this discussion, the term "computer multiplexing" will be used to cover a single computer servicing multiple terminals located at an appreciable distance. In addition, parameters for designing this sort of multiplexing arrangement will be considered.

Basically there are two types of multiplexing—"time division multiplexing" (TDM) and "frequency division multiplexing" (FDM). Each has strengths where the other has weaknesses. Perhaps the easier of the two is FDM. In this technique, the data channel is subdivided by frequency bandwidths (analogous to dividing the broadcast spectrum into individual radio stations) and one bandwidth region is assigned to each user or terminal. Thus, along a given data path, it is possible to have several non-interfacing terminals communicating with the computer simultaneously. This is especially important for multiplexed arrangements where terminals are scattered over a large geographical region.

In TDM, a period of time is established for a computer-support device to cycle through. This period of time is subdivided between the various terminals in the multiplex system.

To clarify, assume a clock with a sweep-second hand that is conductive and whose end actually makes contact with the clock face. Further assume that there are conductive circular arcs, each covering just less than 5 seconds on the clock face, and that they are insulated from each other. If each arc is connected to a separate input source and the second hand is connected to an output wire, each input would be sampled for 5 seconds if the second hand runs at normal speed. Increasing the speed will increase the sampling rate. If one of the circular arcs carried a reference signal (such as an endlessly repeating number), it would be possible to keep track of all channels—in this case, the remaining 11 data channels. This, in essence, is TDM.

One great weakness of the FDM system is its inefficiency as regards to its overall data handling capabilities. Each terminal is assigned a specific frequency and that band is open whether or not information is present. In addition, to insure proper channel isolation, there must be frequency separation between adjacent channels. This causes communication wastage, since the separating frequency bands are "dead" with respect to transmitted information.

Unlike FDM, TDM insures that the whole communication channel is used as a link between each terminal, permitting maximum data transfer. In effect, this arrangement "dedicates" the computer to serving each TDM terminal totally during the allotted time period.

Because of this, the TDM approach is more efficient in data transfer. In addition, TDM systems seldom use the mechanical method that was used to introduce the concept. As a result, it is possible to alter the widths of the individual time slots if some of the terminals are not communicating. Again referring to the clock face analogy; suppose the first 5-second interval is a synchronizing signal, the second an active terminal and the third an unused terminal. If the fourth terminal was active also in a sophisticated system, the time divider after passing the second 5-second space could detect that the third space was "empty" and switch immediately over to the fourth and linger there for nearly 10s—thus permitting additional data to flow. In really sophisticated systems, it is possible to divide up the extra time proportionally among the remaining active terminals.

The ultimate end-point of this philosophy is to have a "first-in" TDM system. It works this way: Let the computer operate in short time intervals (corresponding to the chopped time intervals of the initial commutator-type TDM arrangement), but have each signal identify itself. Then the first terminal that has data is serviced for a time period rather than a terminal arbitrarily assigned a number. Since each terminal identifies itself, there is no question of mixing data. This is sometimes called "asynchronous" TDM. By contrast, the commutator-type is called "synchronous" TDM.

In addition to terminals with direct access to the computer, it is possible to have "buffered" terminals which store information that is transmitted to the computer at a fast rate when the terminal has access. This method has several advantages, permitting a more efficient rate of data transfer between the terminal and the computer.

Buffered terminals permit another form of TDM—"polling". In this method, each terminal stores its data for the computer and transmits the information when the computer queries it. This is used when a whole message or its equivalent is being sent from a terminal. Perhaps a typical example would be an airline reservation counter where each reservation terminal has to be able to send a complex routine query for a specific passenger.

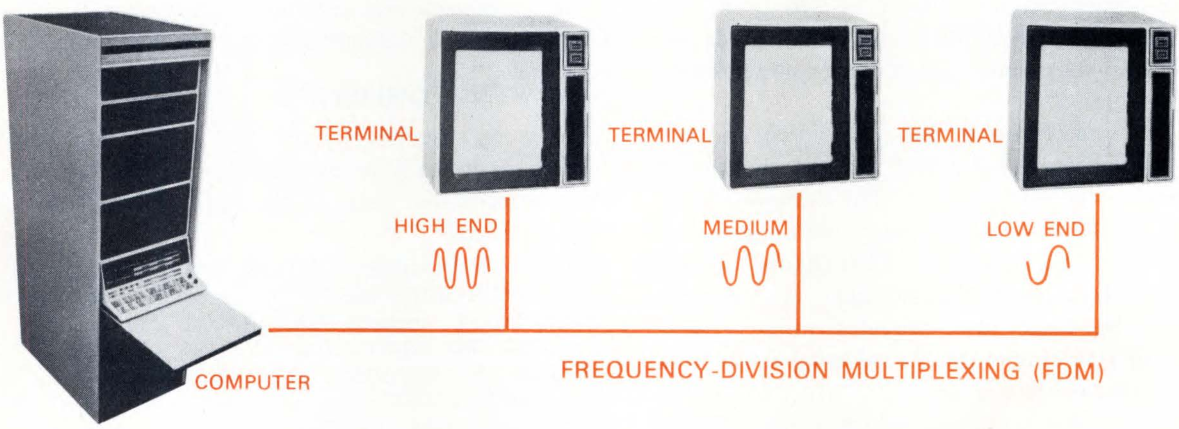
Time division multiplexing does not lend itself to terminals along a communication line with a large geographical extent, due to the difficulty of dropping lines to terminals from the main communication line. With a polling scheme, this restriction does not apply. This form of asynchronous TDM works very well in such circumstances.

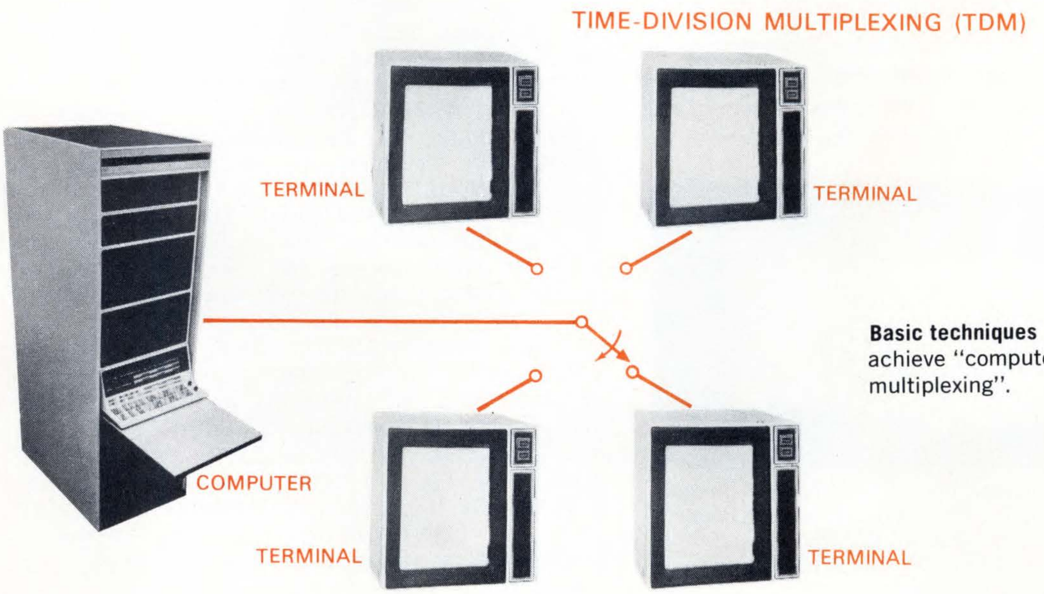
A question that a person interested in computers and data communication is bound to ask is "Which is best?".

The answer is, there is no "best" approach—that is why all the different techniques have been developed. The polling method, for instance, is the most efficient for transferring data if there is no immediacy about receiving the answer. For someone using a multiplexed computer to control a device or process, however, a polling system would be virtually useless. A timeshared computer service bureau, too, would require a computer input that would guarantee virtually instantaneous responses.

As a result, the only way to determine the best approach is to relate it analytically to the job to be accomplished. The job, in effect, defines the best multiplexing scheme.

Multiplexing of computer data is a growing field. If it does not affect your daily routine now, it is just a matter of time before it will. You can judge the efficiency of your multiplexing arrangement by comparing its application with the items that have been discussed.





Basic techniques achieve "computer multiplexing".

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General Devices Inc. and Fifth Dimension Inc. provide mechanical units. General Devices offers a 60 channel per pole unit that is 3 in^3 in size, weighs <1 oz and consumes approximately 1W. Fifth Dimension Inc. has a two pole unit of 90 data points for low level signal sampling, that weighs <0.1 oz per low level channel. Both companies offer solid-state units that are used primarily in larger missile programs, aircraft flight testing satellites and man-rated space programs.

Relay Scanners

Collecting analog data from numerous sources requires either measuring each source manually or switching large numbers of wired inputs to the instrument making the measurement. In its simplest form, this can be achieved by rotary or push button switches, hard-wired from input to output—a long and tedious job where large numbers of signals are involved. Obviously, some means of automatic switching is desirable.

Analog Digital Systems, Inc. offers two systems. One system carries a maximum scanner capacity of 100 channels; the other goes to 1000 channels. Scanning rate of these systems is up to 500 channels/s. Recently, they introduced a 1000-channel access switching system specifically designed for computer interface. The basic unit provides random-access control in BCD or binary code for selecting and routing a specific input to one output.

Control Equipment Corp. developed a data coupler unit around self-contained relay scanner cards. One card contains the relay control logic and the other holds the relays and drive circuits. Each card contains 20 relays that can be connected for either one-pole or two-pole operation. Two types of relays are used—mercury film and reed. In the mercury film, contact resistance is stable and <50 MΩ during the relay's life span. There is no contact bounce, and dry circuit switching life extends to billions of operations.

Hewlett-Packard multiplexer, Model 2930A, handles up to 64 analog channels and up to eight units can be used to multiplex 512 channels. A choice of 11 different ranges from ±10 mV to ±10V is available with programmable gains, in binary increments, from 1 to 1024.

Wrap Up

Multiplexers decrease equipment weight and improve reliability in aircraft. Multiplexing is an ideal transmission method for systems requiring video, audio and control functions. Multiplexing also plays an important role in the field of medicine through the use of TDM for transmitting data on a patient's condition and for providing necessary communication throughout the hospital.

System and component technologists are continually searching for ways to provide designers with improved and economical multiplexing techniques. In turn, multiplexing techniques can and will significantly improve and enhance our everyday living. ▭

ACKNOWLEDGMENTS

EDN greatly appreciates the information and other help given by each of the listed companies. Without their cooperation much of the story would have remained untold.

AMERICAN MULTIPLEX SYSTEMS, INC., Anaheim, CA; AMERICAN REGITEL CORP., San Carlos, CA; ANACONDA ELECTRONICS, Anaheim, CA; ANALOG DEVICES, INC., Cambridge, MA; ANALOG DIGITAL DATA SYSTEMS, INC., Rochester, NY; ANALOGIC CORP., Wakefield, MA; BECKMAN INSTRUMENTS INC., Richmond CA; CONTROL EQUIPMENT CORP., Needham Heights, MA; DDC, Hicksville, NY; DATAMETRICS CORP., Van Nuys, CA; DATOTEK, INC. Dallas, TX; DYNAMIC SYSTEM ELECTRONICS, Tempe, AZ; FAIRCHILD SEMICONDUCTOR, Mountain View, CA; FIFTH DIMENSION, INC., Princeton, NJ; GENERAL ELECTRIC CO., Lynchburg, VA; GENERAL DEVICES, INC., Princeton, NJ; GENERAL INSTRUMENT CORP., Hicksville, NY; GENERAL RADIO CO., West Concord, MA; HARRIS SEMICONDUCTOR, Melbourne, FL; HEWLETT-PACKARD, Palo Alto, CA; INDUSTRIAL COMMUNICATIONS ASSOCIATES, New York, NY; INTERNATIONAL DATA SCIENCES, INC., Providence, RI; IBM Corp., White Plains, NY; INSTRUMENT SYSTEMS CORP., Jericho, NY; LARSE CORP., Palo Alto CA; LENKURT ELECTRIC CO., INC., San Carlos, CA; MOTOROLA SEMICONDUCTOR PRODUCTS, INC., Phoenix, AZ; NATIONAL SEMICONDUCTOR CORP., Santa Clara, CA; NORTH AMERICAN ROCKWELL AUTONETICS, Anaheim, CA; RADIATION, INC., Melbourne, FL; SIGNETICS CORP., Sunnyvale, CA; SILICONIX INC., Santa Clara, CA; SPACETAC, INC., Bedford, MA; SYLVANIA ELECTRIC PRODUCTS, INC., Waltham, MA; TEL TECH CORP., Rockville, MD; COMPUTER TECHNOLOGY, INC., Dallas, TX; VARIAN DATA MACHINES, Irvine, CA; COMPUDYNE CONTROLS, INC., Hatboro, PA; XEROX DATA SYSTEMS, Los Angeles, CA; ZELTEX, INC., Concord, CA;

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VOLTAGE-CONTROLLED ONE-SHOTS FROM STANDARD ICs

Few systems exist that could not use electronically-adjustable time delays. Here is a design with a high-speed TTL example.

KENNETH C. WAINE, Honeywell, Inc.

One-shots whose delay can be electronically adjusted over almost a 2:1 range (can be increased for slower circuits) can be constructed from a number of standard logic gates. The circuit used to illustrate the approach (**Fig. 1a**) uses AND/OR/INVERT integrated circuits from the HLTTL families of Fairchild (9005), Transitron (4211), TI (SN5450), Motorola (946G) and others. However, the concept should work with any dual input AND/OR/INVERT for the first gate (IC-1 in **Fig. 1a**) and any compatible inverter for the second gate.

The steps in the one-shot's operation are, referring to **Fig. 1b** for timing points:

Time 0—Normally, the signal and feedback inputs to IC-1 are low; thus IC-1's output is high. IC-2's output is low because its input is being held high by R1.

Time 1—Trigger pulse at signal input of IC-1 causes

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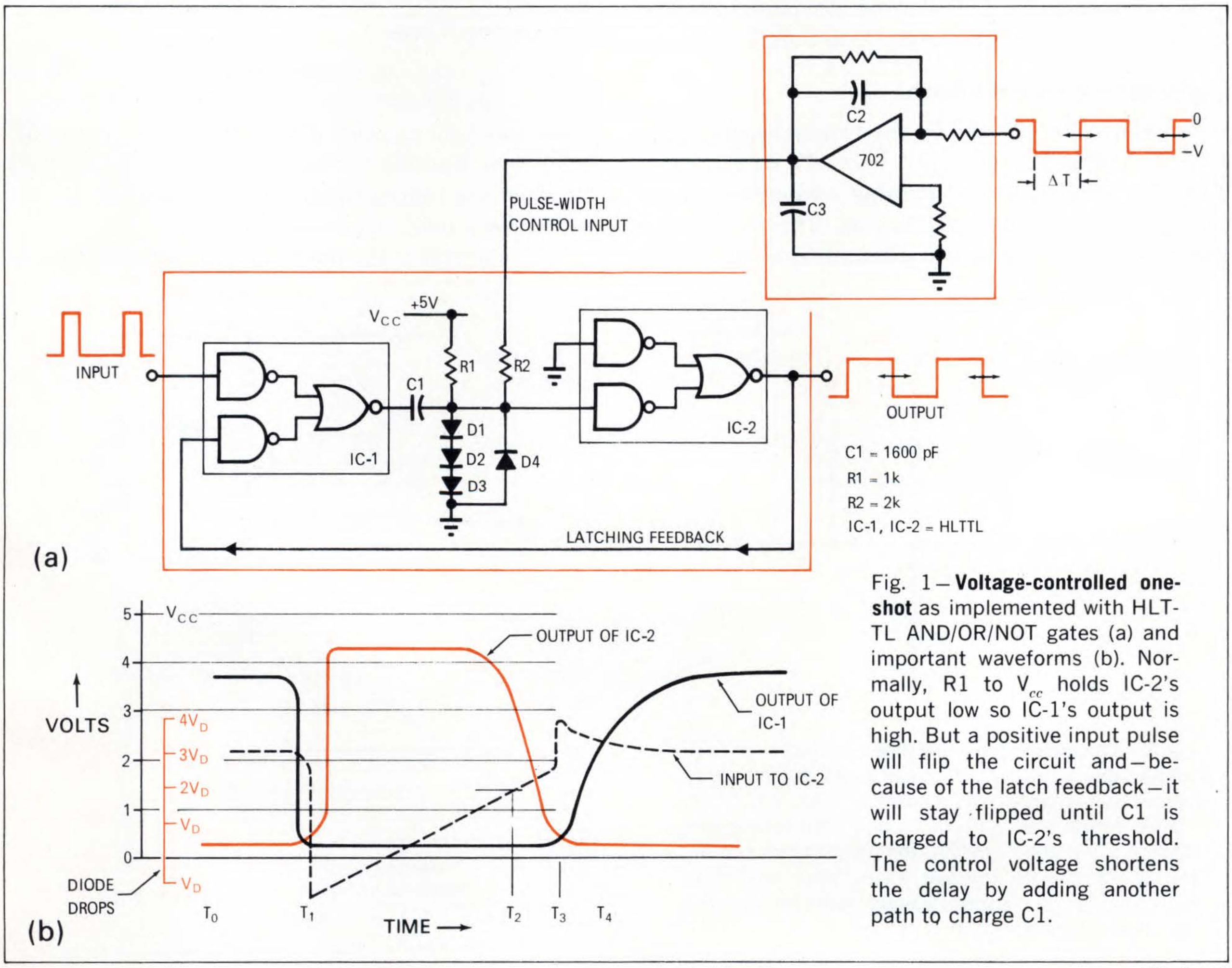


Fig. 1—**Voltage-controlled one-shot** as implemented with HLTTL AND/OR/NOT gates (a) and important waveforms (b). Normally, R1 to V_{cc} holds IC-2's output low so IC-1's output is high. But a positive input pulse will flip the circuit and—because of the latch feedback—it will stay flipped until C1 is charged to IC-2's threshold. The control voltage shortens the delay by adding another path to charge C1.

(Continued)

One Shots (Cont'd)

IC-1's output to go low. Voltage on C1 causes input to IC-2 to go below ground, but diode D4 clamps it to a safe $-0.7V$ (safe for the gates used whose inputs can stand as much as $-1.5V$). Falling input voltage causes IC-2's output to go high. This is fed back to other "OR" input of IC-1 to keep one-shot latched after trigger pulse has passed.

Time 2—C1 is being charged via R1 and control voltage circuit. When the IC-2 side of C1 reaches IC-2's threshold (1.4V), IC-2's output switches low again. This releases the latch-up feedback to IC-1, and circuit starts to return to initial state.

The pulse width is controlled by varying the current available for charging C1 from time T_1 to T_2. This is done by varying the voltage fed through a second resistor, R2. Resistor R2 serves both to isolate the control voltage from the rest of the circuit and to supply an additional controlled current source to charge C1.

The diode string D1-D3 clamps the positive voltage at IC-2's input to 2.1V. The string also helps to reduce the reverse recovery time (time T_3 to time T_4).

Calculating Pulse Width

Between times T_1 and T_2, the timing capacitor C1 must be charged from $-0.7V$ to $+1.4V$ or a total of 2.1V. The expression for charging a capacitor can be set equal to this and solved for time. This is shown in **Fig. 2** along with the circuit elements that apply. The solution given applies only for the simpler case when there is no control voltage and the unit is being used as a fixed delay one-shot. However, it does show that the IC's own input resistance must usually be included.

The control voltage adds another charging current path and its equivalent resistance and voltage must be worked into the single Thevenin equivalents for voltage V_{EQ} and resistance R_{EQ}. (Of course, a voltage-controlled resistance, such as a FET, could be used in place of R2, with this being connected to a fixed voltage, say V_{cc}.)

Actually, this computation will fall short of the true delay time, for—as can be seen from the waveforms of **Fig. 1b**, and the scope photos of **Fig. 3**—there is an additional delay between the time T_2 that the IC-2's input threshold has been reached and time T_3 where the one-shot's output has fallen to 1.5V. However, for fast TTL, this error is small. The propagation delay time of IC-2 should be added to the basic formula derived in **Fig. 2.**

Recovery Time

Recovery time can be a problem, especially if slower types of circuits are used, such as DTL. It is the duration from time T_3 when IC-2's output falls to the 1.5V level (removing the latching feedback to IC-1) to time T_4 when the timing circuit between the two ICs has settled back into its quiescent state.

The first part of the duration T_3-T_4 is caused by the

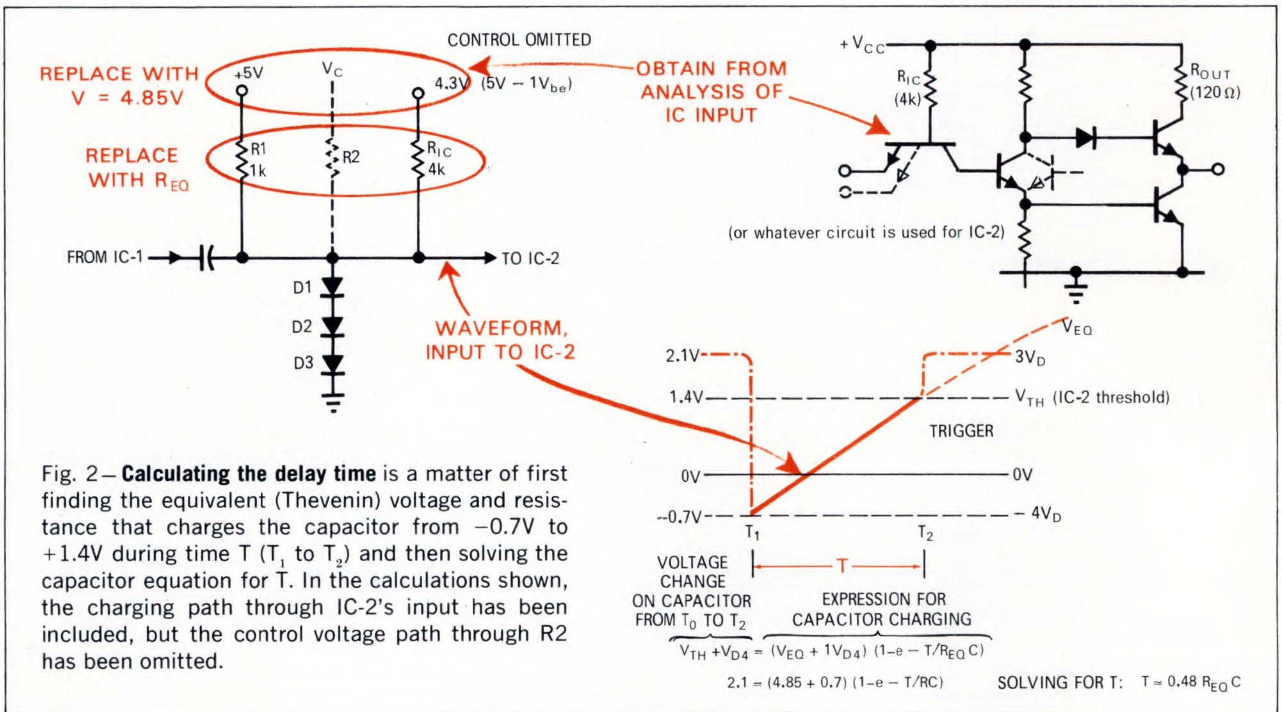


Fig. 2—**Calculating the delay time** is a matter of first finding the equivalent (Thevenin) voltage and resistance that charges the capacitor from $-0.7V$ to $+1.4V$ during time T (T_1 to T_2) and then solving the capacitor equation for T. In the calculations shown, the charging path through IC-2's input has been included, but the control voltage path through R2 has been omitted.

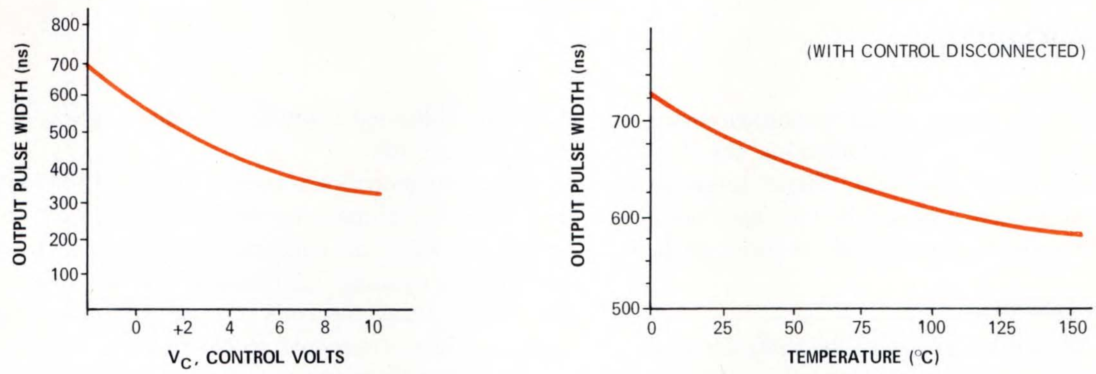


Fig. 3 – **Performance curves** for the HLTTL one-shot shown in **Fig. 1a**.

turn-off delay of IC-1. The remainder – and the longer part – is determined by the time it takes the output of IC-1 to rise from 1.5V to four diode drops, or about 2.8V. This latter part rises exponentially, as can be seen by the waveforms, and is governed by the time constants formed by C1 and the various resistances on either side. These are the output impedance of IC-1, the value of R1, the resistances of the bias diodes as they begin to conduct, and the control resistance R2.

The recovery time of TTL gates in this application will usually be many times faster than DTL gates. The TTL gates typically have active pull-ups while the DTL gates often have rather large, 2K, passive pull-ups. However, even with fast TTL gates such as those shown in the example, the recovery time may be too long. If so, the designer may want to consider adding active components to speed recovery by lowering the resistance of the charge paths to C1 during times T_3 to T_4.

Temperature Compensation

As the temperature increases, the threshold of the IC drops by $2\triangle V_{be}$-$\triangle V_{sat}$ and the bias voltage decreases by $3\triangle V_{be}$. Although the bias and input thresholds do not track each other, the circuit can be operated over a wide range of temperatures, as shown on **Fig. 3**. If, however, it is to operate over 100°C, it may be wise to add a fourth diode to the string, D1-D3. This will raise the bias voltage to $4V_D$.

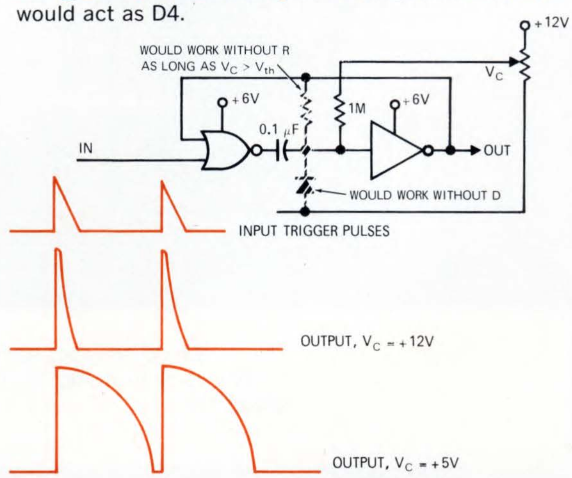
The main causes of pulse-width variations with temperature are the changes with temperature of IC-2's threshold voltage and the various diode forward drops. These decrease with increasing tempera-

A C-MOS Voltage-Controlled One Shot

EDN implemented author Waine's one-shot with complementary MOS gates. The high input impedance of MOS permits it to work well with RC timing arrangements, and it was found that a circuit as simple as the one shown would give up to 5:1 pulse-width variations.

Author Waine agreed that all one really needs is a two-input NOR for IC-1 and a compatible inverter for IC-2. However, he pointed out that the recovery time will be much longer for those logic gates that don't have the low-output impedance of TTL with its active bipolar pull-ups.

Waine also said that, while the clamping diodes could be eliminated as shown, they do help stabilize the timing. He suggested a single zener connected with the same polarity as D4. When the signal was positive, the reversed-biased zener would act as diode string D1-D3. When the signal was negative, the zener would act as D4.



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ture, lowering the initial negative voltage swing at IC-2's input at time T_1 and hastening the T_1-to-T_2 rise to IC-2's lower threshold. These temperature variations can be compensated by putting a positive-temperature-coefficient thermistor in series with R1.

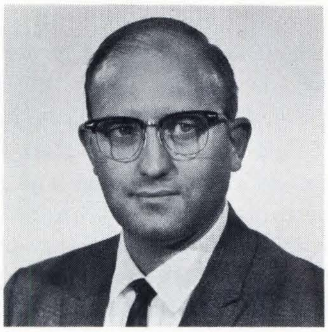
Control Circuits

The simplest way to generate the control voltage is just to tap it off a potentiometer across the supply. This might be desirable in situations where one wanted to have a manual control knob on a remote panel but did not want to carry high-frequency signal lines away from the circuit—as would be the case if a potentiometer were used to vary R1.

The more elaborate method shown in **Fig. 1a** indicates how the capabilities of the one-shot can be exploited in an all-electronic feedback loop. In this case, the one-shot's output pulses, after subsequent signal manipulations, are monitored and their widths converted to a feedback regulating signal for the one-shot. Capacitor C2 is the op amp's integrating capacitor, and C3 is an additional filtering capacitor to prevent feedback through R2.

This arrangement was used at Honeywell to produce controlled test-signals in a piece of IC checkout equipment. The wider the negative-polarity feedback pulses fed into the op amp, the more positive the control voltage. Thus, if the one-shot's manipulated pulses started to grow wider, the op amp would alter the control voltage to narrow them again, and vice versa for narrowing pulses. ☐

Kenneth C. Waine is a circuit design engineer in Honeywell's EDP Product line where he has been 5-1/2 years. He was previously a field engineer with Raytheon Co., ESO Div.



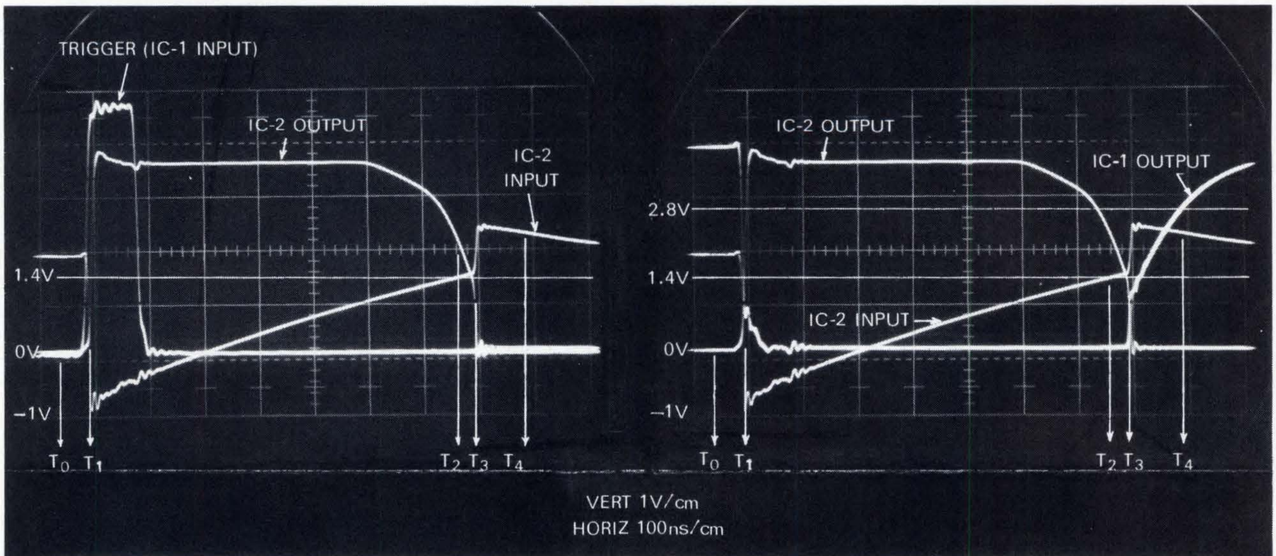


Fig. 4—**Actual one-shot waveforms** show more ringing than artist's version in **Fig. 1b**. This can be expected with high speed TTL.

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GLASS

ITS VITAL ROLE IN SEMICONDUCTOR PACKAGING

From the dawn of the semiconductor era, glass has played a prominent part in device packaging. In the search for reliable yet economical hermetic packages, glass promises to assume even greater importance.

SEYMOUR MERRIN, Innotech Corp.

As glass-sealed hermetic semiconductor packages evolved, history shows that both reliability and cost improve as the glass approaches the active semiconductor junction. In the limit, this trend suggests that the ultimate package is glass, bonded directly to the active chip, leaving pads for interconnection. Although this seems an obvious solution to many packaging problems, the semiconductor industry is still "making do" with techniques based on old vacuum tube technology—"Kovar" and 7052 glass. For example, it took many years to get the price (and reliability) of the TO-5 package to come even close to that of the semiconductor die packaged in it. Indeed, except for specialized or high-power devices, the packages still cost more than the chips.

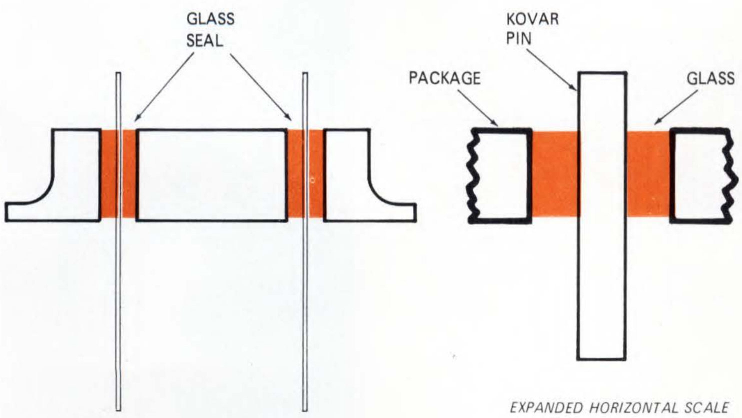
Rather than rely on old technology and standard off-the-shelf glasses, some companies developed their own glass technology and were extremely successful. Prime examples are IBM, whose SLT technology required a glass-passivated chip to achieve the necessary level of automation, and Unitrode, who built a successful diode business through a unique glass.

How Far Have We Come?

Unfortunately, package technology has not kept pace with the highly sophisticated semiconductor industry. Most semiconductor packages are made of "Kovar" or a similar metal. Leads are sealed with glass and lids are either welded or soldered on (**Fig. 1**). Similarly, the DO-7 diode package consists of a glass sleeve sweated on to glass beads which, in turn, are sealed to dumet leads (**Fig. 2**).

With the advent of the integrated circuit, a new package configuration was needed. Initially, the glass flat pack was offered (**Fig. 3**), but it suited neither the 14-lead requirement nor the production convenience of high-volume users. Eventually the dual in-line package (DIP), having 100-mil lead centers and 300 mils between rows, became the industry standard.

Reflecting a definite departure from standard package technology, Fairchild's "CERDIP" (**Fig. 4**) is the most successful of the hermetic DIPs. Package piece parts are assembled, together with the chip, in-house as opposed to prior packages where the chip was merely bonded to a prefabricated header. A key feature of the



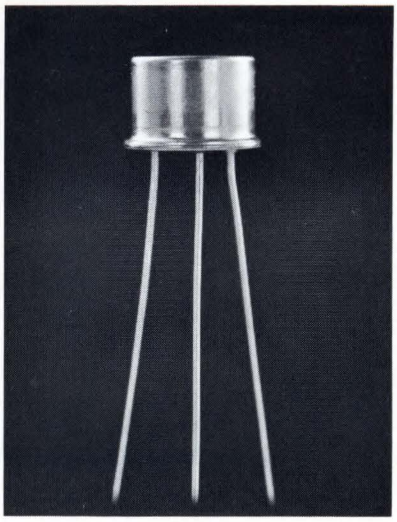


Fig. 1—**Typical TO-5 hermetic package** requires glass seal between pins and package. Lids are welded or soldered. (*FAIRCHILD SEMICONDUCTOR*)

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(Continued)

Glass (Cont'd)

"CERDIP" is that the glass used for sealing is a solder glass of the devitrifiable type. Having the property of controlled crystallization, this glass will, when properly fired, become a ceramic-like material. The result is a package that exhibits most of the strength and dielectric properties of ceramic and a very low thermal expansion coefficient.

With large-scale integration (LSI) on the scene and costs becoming critical to profitability, new approaches are necessary. Although the monolithic ceramic package can be very reliable, cost and turnaround time are significantly limiting factors.

The direction that industry will take will be the one that moves the hermetic seal closer to the chip and allows for in-house, one-step "integrated" packaging, rather than the multistep labor-laden approach that generally prevails. This being the case, a review of the history of glass passivation is in order.

History of Glass Passivation

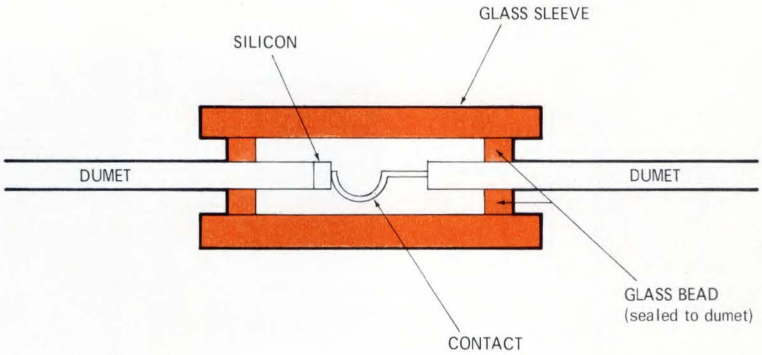
Hermetic glass passivation in semiconductors differs markedly from oxide passivation, both in detail and purpose. Hermetic passivation is used to seal the device hermetically at the chip level and to stabilize the surface. Oxide passivation is used primarily to mask the device during fabrication and to protect the exposed junctions. Oxide passivation is needed to *manufacture* the semiconductor device. Hermetic glass passivation is needed to lower device costs and improve the *packaging* of the device.

In order to be used properly, glass must be applied over the oxide, after removal of the oxide, or—in mesa type devices—after etching and/or dicing. Hermetic glass passivation is an extra step which can reduce cost and improve yield. Interestingly, in successful applications, the presence of boron or phosphorus in the glass did not affect its ability to passivate the device hermetically.

The first commercially successful hermetic glass-passivated device was Unitrode's double-stud diode. In this package (**Fig. 5**), a diode is bonded to two studs (for example, silver-plated molybdenum) with a glass sleeve shrunk onto the structure. *The glass bonds directly to the junction,* sealing and stabilizing the device. Even though the glass contains approximately 30% B_2O_3, it is highly effective for passivation.

IBM followed suit in its SLT (solid-logic technology) for the series 360 computers. Remarkably, the philosophy has not been copied by the rest of the industry. IBM decided that automation was critical, but hermetic packaging, *per se*, was too expensive. Consequently, it hermetically sealed the chip with glass and thereby allowed new metallization and packaging techniques to be used. With this technology IBM met its cost goals.

In essence, IBM made planar, oxide-masked transistors and diodes, metallized them with aluminum, covered the oxide and aluminum with glass and finally etched through the glass only for external contact. Reliability, a key factor, was equal to or better than hermetically packaged units, even though the glass



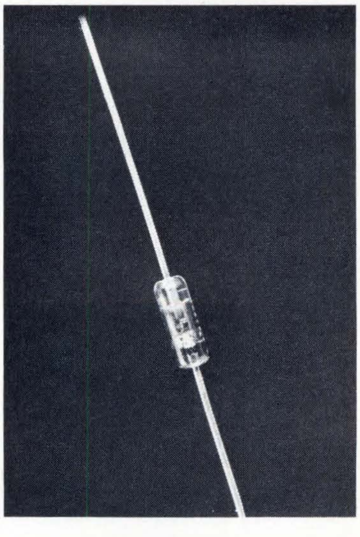


Fig. 2—**DO-7 diode package** combines glass beads, sleeve and dumet leads. (*FAIRCHILD SEMICONDUCTOR*)

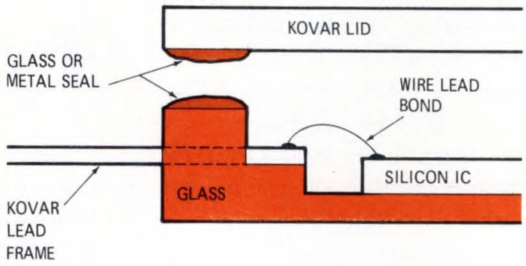


Fig. 3—**Glass flat pack** incorporates wire bonds, Kovar lead frame and separately-attached lid.

being used contained approximately 1% Na_2O by design!

The next meaningful attempt at commercial glass passivation was in rectifier production at Texas Instruments Incorporated. TI's approach, at least initially, was ultrahigh-purity glass (a *lead*-alumino-silicate) applied in valleys between mesas while the rectifiers were still in wafer form.

With the advent of integrated circuits, mechanical protection of the intricate aluminum interconnection pattern became a major concern. Motorola attacked the problem by coating the devices with a pyrolytic film formed by the decomposition of silane and other gases. Because of in-house familiarity with the general process and low capital investment, pyrolitic glasses were rapidly accepted. These glasses, however, do not protect chips from mechanical damage or surface impurities as well as fired-on glasses.

A similar technique consists of applying silicon nitride directly on the junction or over oxide before metallizing. This method created a major impact in 1965–1966 when Sperry-Rand announced silicon nitride as *the* new material. Many other companies followed with announcements of new products based on its properties.

Silicon nitride can be evaporated or pyrolytically deposited at temperatures in excess of 575°C (the silicon-aluminum eutectic range). It has been difficult to etch, but it very successfully blocks the migration of impurity ions. However, it cannot be deposited directly on silicon or used alone as an MOS gate, because it does *not* block the migration of electrons. Consequently, it must be, and is used *over* an oxide and *under* the contact metallurgy. More recently, RF sputtering has been tried on specialized devices and in the laboratories with varied success.

Types and Results of Hermetic Passivation

There are two basic types of hermetic semiconductor passivation—over the oxide and on the junction. Each has its own critical parameters and characteristics. Each must be treated independently, and consideration must be given to why something does or does not hermetically passivate.

Regardless of device power rating, the electrostatic field in the immediate vicinity of the semiconductor junction is very high. A 5V diode, for instance, has a field gradient of 2.5×10^6V/meter over a 2-μm junction width. From this simple calculation, it is obvious why impurities migrate directly to the junction. Passivation materials, therefore, (1) must be able to withstand high voltage gradients, (2) must *prevent the migration* of impurities, and (3) must be compatible with other production processes.

Over-the-Oxide Passivation

Silicon dioxide misses the second criterion; it cannot prevent the migration of impurities. In all surface-state-critical and high-power devices, oxides can be used only when ultraclean oxides are grown, and the units are hermetically sealed. The best examples of this requirement are the MOS devices.

IBM and others who used similar fired-over-oxide glasses found distinct lifetime reliability benefits. Leakage currents after 2000 hours of 125°C back-bias stress are consistently less than initial values. However, there is initially a small (dependent on the device) increase in leakage, with a peak around 1000 hours (**Fig. 6**).

An explanation of this phenomenon that agrees with the observed effects also tells us much about hermetic passivations. The initial leakage increase, comparable to that of unglassed hermetically sealed devices, is caused by the previously existing surface impurities migrating through the oxide to the junction. But the junction can accumulate impurities only from a *limited* area, because the glass absorbs impurities coming from greater distances. With the device in the dynamic state, there is a net loss of impurities from the junction with

(Continued)

Glass (*Cont'd*)

time, and a net increase in the glass where they are harmless.

This phenomenon is based on the fact that impurities are infinitely more soluble in glass than in the oxide. Indeed, the right glass, properly fired on, generally will harden the knee of a junction breakdown curve. This occurs even with the "IBM glass" containing Na_2O. The glass fired on over the oxide prevents ion migration and is physically compatible with the device.

When glass is fired over both oxide and aluminum, the maximum firing temperature must be lower than that of the silicon-aluminum eutectic (578°C). Also, the glass must have a coefficient of expansion close to that of silicon, or it will peel. Unfortunately, no glass absolutely meets all these criteria, so compromises must be made.

IBM's compromise was to apply a thin layer (1-2 μm) of a high-expansion (62 x 10^{-7}) low-firing glass (563-570°C) by sedimenting a suspension of submicron glass particles in a centrifuge. This technique is flexible, allows for rapid increase in production capacity at small capital cost and obviously has been successful and economical. It is especially attractive for automatic IC manufacturing where it not only eliminates tweezer scratches but also gives positive ambient protection.

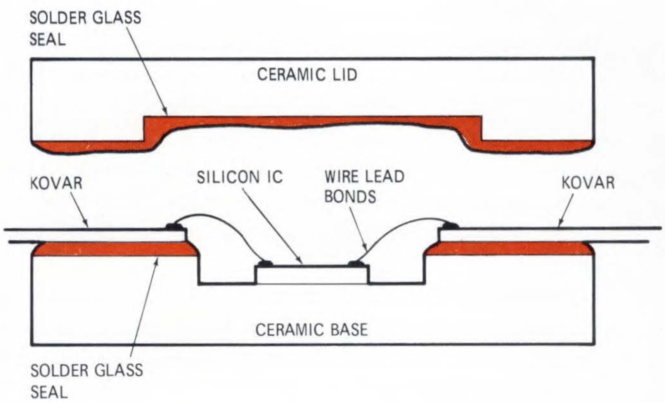
At Sperry Semiconductor, two additional facts were gathered. First, when using the "CERDIP" packages, yields through the sealing furnace were consistently higher when hermetic glass passivation was used. Second, *units packaged in plastic* fully met all biased temperature, temperature-humidity and cycling requirements (everything except hermeticity) that the hermetic units met (some significantly better).

Once a stable dielectric such as glass is applied over the aluminum, flexible packaging geometry and automation become economic realities. With the aluminum covered, the actual contact can be made anywhere, and the packaging geometry can be identical for many different devices. Flip-chip or beam-lead devices can be made more efficiently, and the choice of contact metallurgies can be broadened. With the flip-chip approach, automatic orientation and bonding is relatively simple, as proven by IBM's experience.

On-the-Junction Passivation

Passivating directly on the junction is a much different technology, with different advantages and compromises. Since there is no prior contact metallurgy, the glass can be chosen to have a coefficient of thermal expansion close to that of silicon, and the glazing temperature can be tailored to fulfill a specific need.

If a mesa device is to be passivated, the geometry controls the choice of glass. In order to insure that the junction is completely coated, a relatively thick (>0.0005-in) coating must be applied. The coefficient of expansion must be close to that of silicon. With planar devices, a fuller spectrum of choices is available, with the application technique varying to suit the



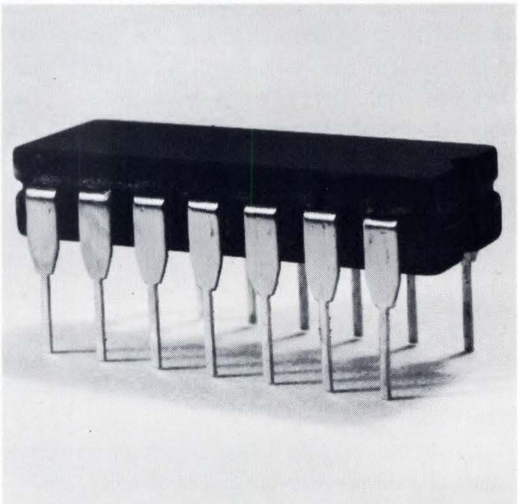


Fig. 4—**Fairchild's CERDIP** seals leads and lid in a single operation, uses devitrifiable-type glass for seal. *(FAIRCHILD SEMICONDUCTOR)*

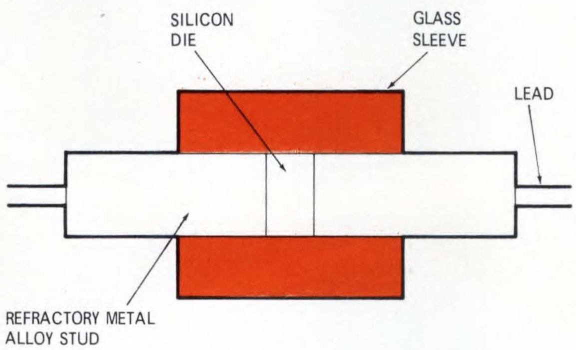
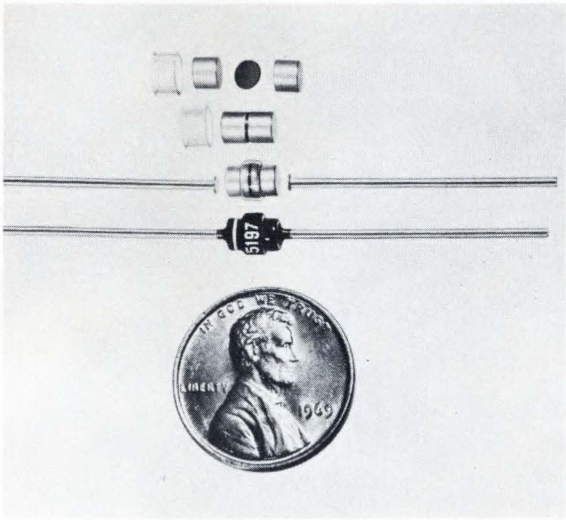
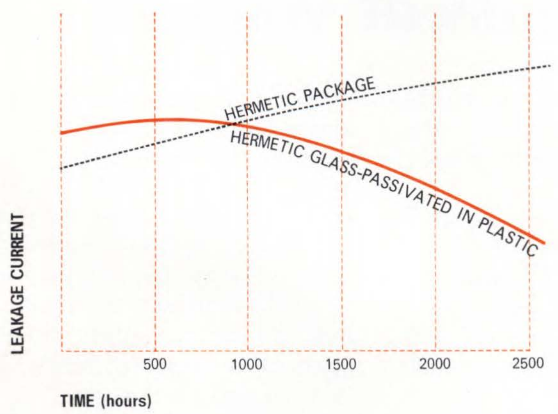


Fig. 5 – **Unitrode's double-stud package** features glass passivation directly on the junction. Refractory-metal alloy studs, silicon die and glass sleeve have closely matched TCs. (*UNITRODE*)



specific device. The key here is *removing* the oxide and replacing it with glass. Since the interconnection metal is applied *after* glassing, metal processing restrictions often determine the glass to be used.

Device characteristics attributable to hermetic, on-the-junction passivation are sharp breakdown (excluding bulk effects), total ambient protection and stability of the surface under normally adverse conditions. Indeed, in many cases observed at Innotech, parameter distribution on wafers tightened significantly and V_{CEO} increased 30% or more.



For highly complex structures such as thyristors, major manufacturers have come out with successful, reliable, plastic power units by using a glassed, hermetically-passivated die. At least three manufacturers have adopted the double-stud type package, and at least two sell hermetically passivated chips.

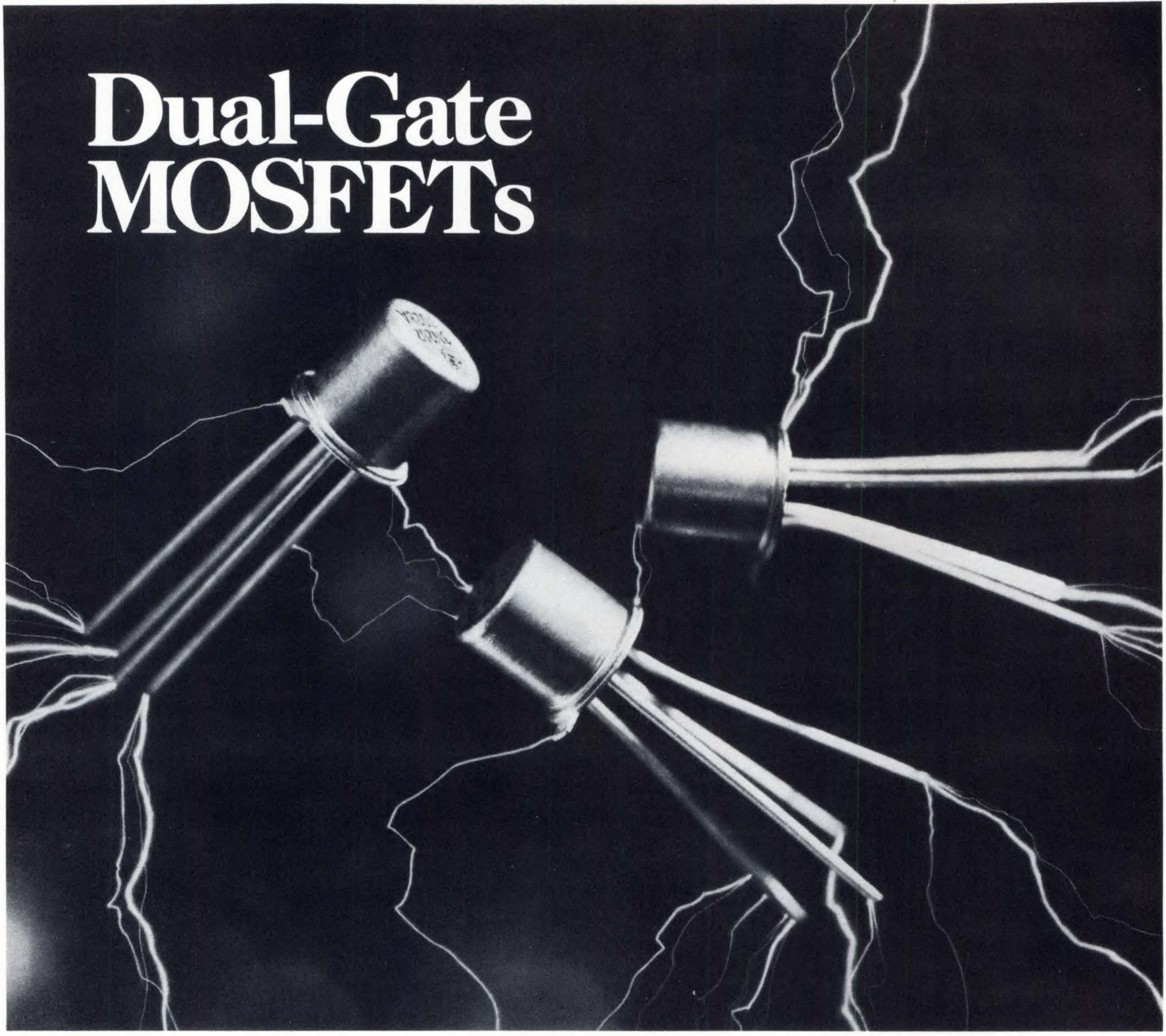
Future Prospects

Competition is forcing semiconductor houses to improve packaging technology by integrating it more closely with the device manufacturing process. Reliability, for semiconductors, has always implied hermeticity. Because older hermetic sealing methods are inherently costly, the seal must be moved close to, if not onto, the device itself.

The successful history of fired-on hermetic glass passivation indicates that this method of sealing the device can give the required reliability and lower costs. However, to be successful, the glass materials must be tailored to the devices and the processing. ▭

Author **Seymour Merrin** is vice president of Innotech Corp., specializing in hermetic passivation and surface-stabilizing glasses and appropriate application technologies. A Ph.D. from Penn State University, Dr. Merrin has been a key figure in semiconductor packaging technology with Sperry and IBM and has done extensive consulting with other semiconductor houses.

Dual-Gate MOSFETs



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TEXAS INSTRUMENTS
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Laser Scans Documents for Remote Readout

Systems approach spurns exotic solutions and "breakthroughs" to produce a manufacturable document reader with a potential for discriminating between 16 gray levels.

THOMAS J. HEALEY, McCown Labs. and MILTON C. KURTZ, Marco Scientific Instruments

Despite a decade of significant improvement in cost, reliability, performance, efficiency and spectrum signature, the laser today is conspicuous by its absence from the general industry and consumer market. It remains the nearly-exclusive property of the scientific-technical-military community. To date, there are no standard equipment catalogs for the design engineer who wants to incorporate laser subsystems in his product.

A document translator was one of the most promising prospects turned up in a recent survey of possible laser applications that could serve general business and industrial companies. The high energy density and coherent radiation available led to the development of the laser document translator. This system consists of:

- Specimen handling system
- Helium-neon laser
- Spot-forming optics
- Beam deflector
- Light collection optics and sensors
- Data processing system
- Read-out device

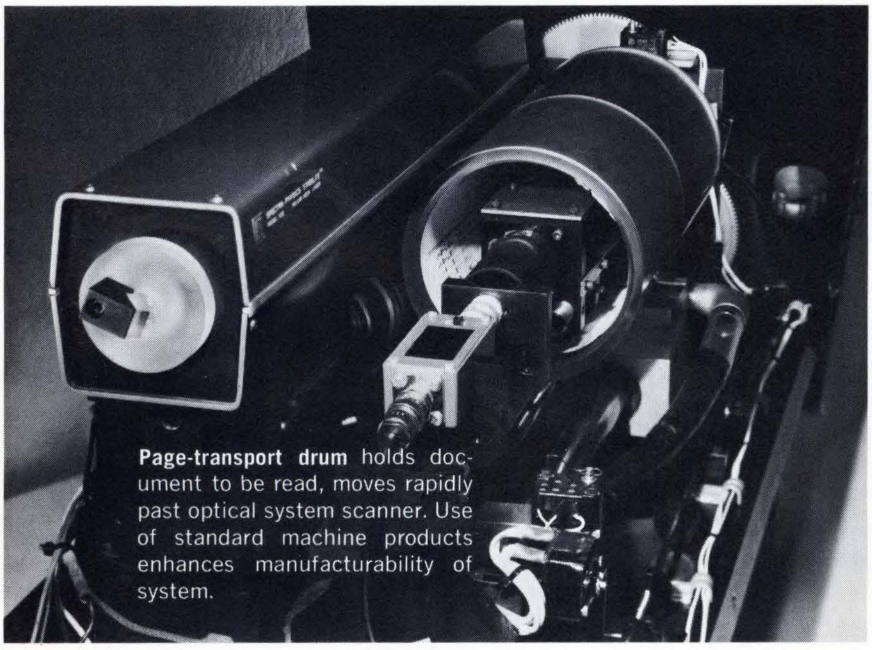
Design philosophy, based on accepted machine shop practices and tolerances, eliminated "state-of-the-art concepts" and "technological breakthroughs". Consequently, the system operates in a very simple manner.

The document to be read is placed in a holder mounted on a carriage whose movement is controlled by a motorized lead screw. This carriage holds the document in the focal plane of spot-forming optics that converge a collimated beam from a laser beam expander into a 0.001-in-diam spot. Deflected in a circular path by a rotating mirror, the light reflected by the paper is gathered by an optical system and detected by a PIN-diode detector that feeds video image information to the data processing system.

A separate detector, positioned to intercept the line scan just before it scans the document, generates a synchronizing reference pulse for the data processing system. Pulse width depends on the time required for the scanned spot to sweep over the detector's surface, and can be sharpened by an aperture plate that masks the detector's sensitive area.

An electronic data processing system interfaces the scanner-reader with the following functions: start frame signal, start line signal, video pulse train and end frame signal. The serial function signals are processed in a 16-bit parallel digital system. In use, the scanning motor is activated, and the single-faced mirror scans the laser-light spot at 1800 rpm. A synchronizing pulse occurs once each revolution of the mirror, immediately

(Continued)



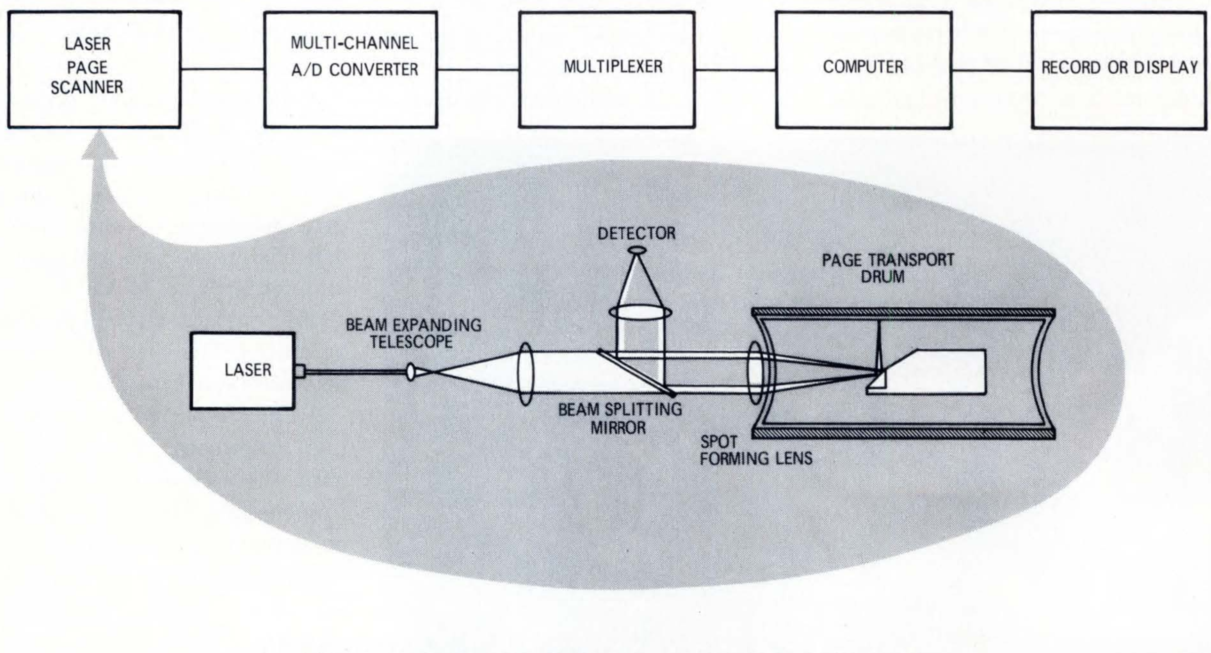
Page-transport drum holds document to be read, moves rapidly past optical system scanner. Use of standard machine products enhances manufacturability of system.

Design Ideas

Document Reader *(Cont'd)*

before the document is scanned. These pulses are blocked from the data processing system until the read mode is activated by a switch that opens the read gate in the data processing system and starts the document carriage. The next scan line synchronizing pulse enters the data processor through this open gate and turns on the internal synchronous clock. Clock activation is entered as the most significant bit of the 16-bit digital train. The next bit indicates that a document is being read. These two bits are used as control bits. As the system clock runs, a gate is opened in synchronization with the clock to admit video information if present. The video information is entered in bit number three as a "1" if video is present and a "0" if no video is present at the time the gate is opened. Obviously, this system is sensitive only to light-dark information. Later units will have a pulse height discriminator and digital storage corresponding to a specified gray scale for graphics reading and storage. In addition to enabling the video gate, clock pulses are used to switch bit number four to indicate coordinates on the document, alternately recording position along the scan (y direction) and scan number (x direction). As the first two bits are used as control bits, the second two bits are used as synchronizing bits.

As the system clock runs, the clock pulses are counted in a 12-bit register corresponding to reading increments along the scan line (approximately 2000). The beginning of line scan synchronizing pulse is used to count the scan number five in the same register but is identified by bit number four. Therefore, the data would appear in the register as 1st scan 1st increment, 1st scan 2nd increment, 1st scan 3rd increment . . . 1st scan 1998th increment, 1st scan 1999th increment, 1st scan 2000th increment. The beginning of line scan synchronizing pulse at the beginning of line scan number two would be counted in the y register and would appear as 2nd scan 1st increment, 2nd scan 2nd increment . . . 2nd scan 2000th increment. The process would be repeated for approximately 600 scans. At the end of the document carriage travel, a switch closure indicates the end of frame sequence and closes the gate to block further data entry. The system is compatible for storing the document as dots of information in two coordinates. The information can be processed for image enhancement, decoding, or simply stored for later or archival retrieval.



Graphic representation of document reader system illustrates method of expanding a computer's read-in/read-out capability.

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The image is reconstructed at a remote source over hard line, data link, modem or any other appropriate means. The initial system was read out for convenience on a storage oscilloscope fed by a digital-to-analog processor-converter. Conversion from the 2000 point register generates a 0-1V ramp to control one axis of the oscilloscope. A similar 0-1V ramp controls the other axis to create a symmetrical raster. Stored data points are fed in synchronism with the axis generation to Z-axis-modulate the scope and restore the document. Buffer amplifiers in the D/A converter provide image inversion (positive to negative), mirror imaging, and aspect ratio change. These functions allow great flexibility especially if hard copy is to be the output.

Further developments led to the construction of a reproducing unit which has resolution comparable to the input. It generates hard copy not only on conventional silver film emulsions, but also on a large variety of other materials, possible only because of the high power density inherent in lasers. Documents with up to 16 gray levels are practical.

This system is the basis for McCown Labs. LTD-8511-1 laser document translator. □

Thomas J. Healey, director of marketing for McCown Labs., Tempe, Ariz., and **Milton C. Kurtz**, president of Marco Scientific Instruments, Sunnyvale, Calif., co-authored this article. Both men have extensive experience in the application of electro-optic devices in industrial and systems applications.

The Great Idea...by Kelvin, Varley, Poggendorff and Porter.

Porter is the gentleman seated second from the left. With a little help from his friends, Hank Porter came up with a great idea. Or really, two great ideas. The DIGIVIDER® and the DIGIDECADE®.

The DIGIVIDER is a voltage divider that comes in two configurations. The Kelvin-Varley-Porter version and the Poggendorff-Porter configuration. They are Thumbwheel Switches that act like ten-turn potentiometers, only better. Now you can "click" the dial settings to whatever voltage you want (as an output) and that's exactly what you get. And you don't need a magnifying glass to read the digits.

DIGIVIDER accuracies range from 0.1 to 0.025% full scale voltage ratio (0.01% available) with resolutions to 0.0001% and input impedances from 100 to 100,000 ohms. Trimming options are also available.

The Poggendorff-Porter DIGIVIDER configuration can also be used as a resistance decade. Again, similar to a ten-turn potentiometer, only in this case, resistance as well as voltage settings are directly related to dial settings.

The DIGIDECADE also comes in a different circuit configuration without anyone's name attached to it. Here, as a

resistance decade, it utilizes a weighted code of 1-2-2-2-2-, using five resistors to achieve nine discrete steps of resistance from (0-9) or multiples thereof. It is a linear progression that yields the desired total resistance.

DIGIDECADES have accuracies to 0.1% of setting, resistance ranges from 10 ohms to 1 megohm and step sizes of 1 to 100,000 ohms.

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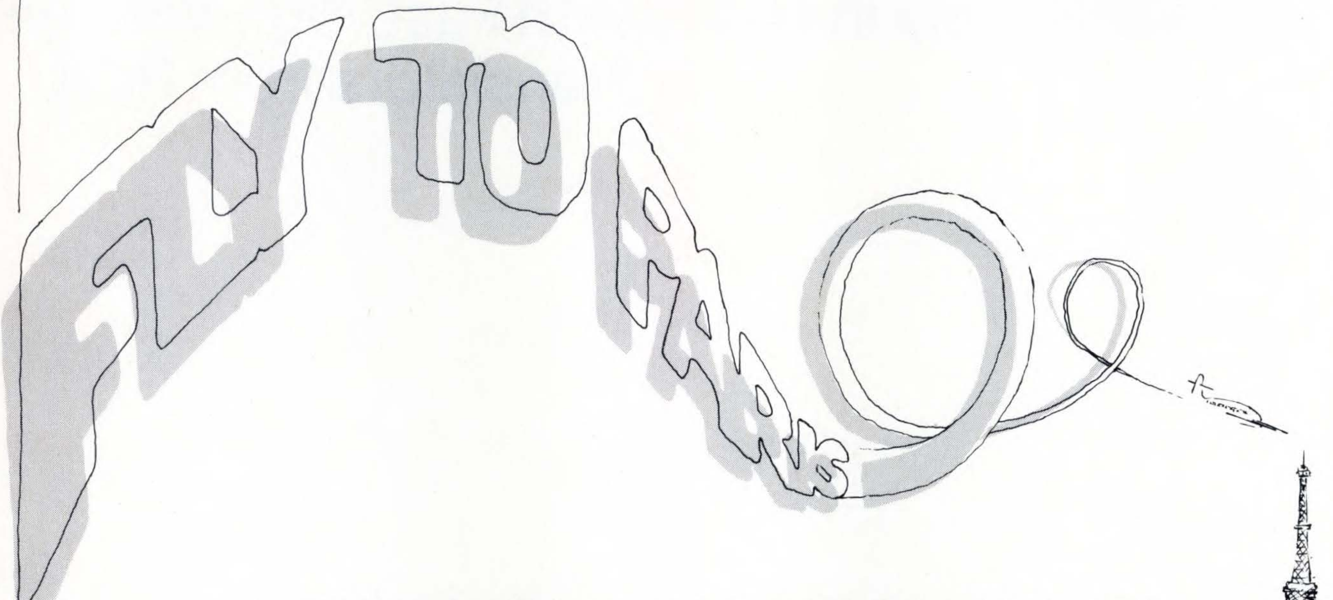
Pictured l. to r.: William Thompson Kelvin, 1824-1907, England, Hank Porter, U.S.A., Cromwell Fleetwood Varley, 1828-1883 England, Johann Christian Poggendorff 1796-1877, Germany.

CIRCLE NO. 12



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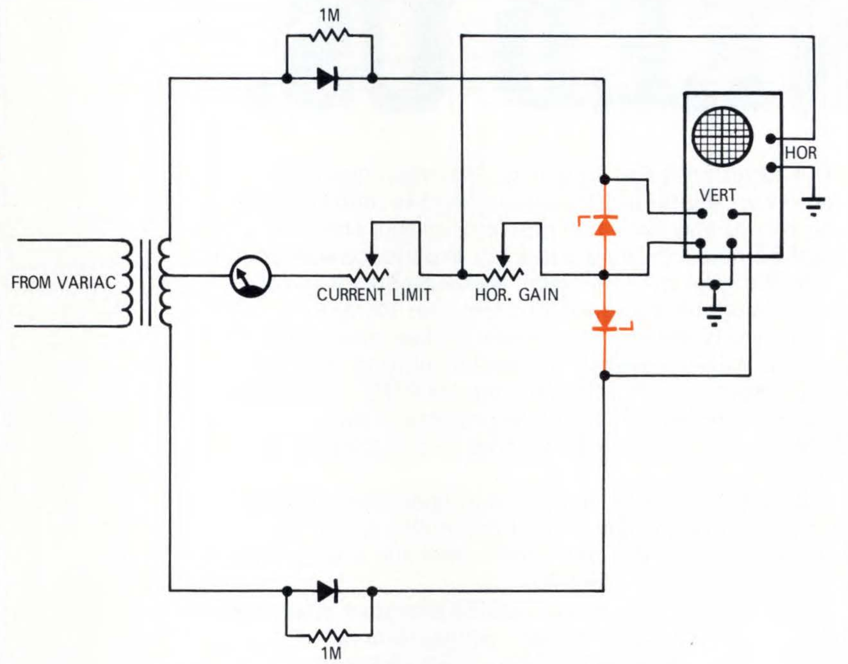
CIRCLE NO. 13

CUSTOMER ENGINEERING CLINIC

Found— 600 Solutions for One Problem

In the July 15 Clinic, EDN issued a call for solutions to a test problem. A simple circuit was needed to permit the simultaneous testing of two zener diodes with a dual-channel oscilloscope. Some unsuccessful approaches were documented—and $50 was offered for the first workable solution, with the winner to be decided by the person whose company needed the answer.

Your response was so magnificent, and effective, that we are printing the letter we received from Mr. Cone along with the circuit he finally used.



Final Two-Zener Test Circuit. The meter has been calibrated to show equivalent steady-state dc zener current.

Mr. Bob Koeper
EDN
270 St. Paul
Denver, Colorado 80206

Dear Bob:

As winner of the $50 award for the best solution to the July 15 Customer Engineering Clinic problem "How to Test Two Zener Diodes Simultaneously", we have chosen Mark D. Broussard, of 1317 Melrose, Garland, Texas, with honorable mention to Robert Gelbman of Farmingdale, N.Y.

Approximately 900 answers were received, of which some 600 could be considered "correct",—these involved use of a center-tapped transformer, a dual-secondary transformer, or a 4-diode bridge.

In actual tests the center-tapped design proved most satisfactory, and the many individuals who suggested

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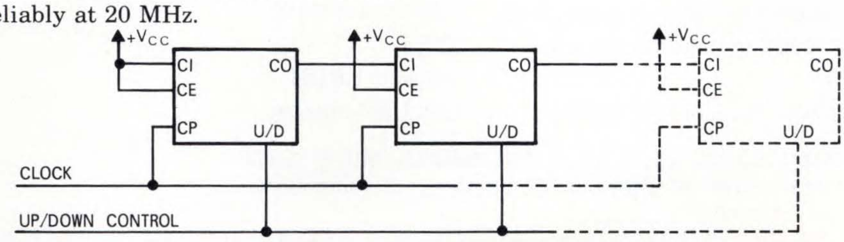
NEXT ISSUE'S PROBLEM:
30-MHz Synchronous Counter Is Erratic at 20 MHz

Next issue's Clinic tells how to make a 30-MHz synchronous counter count reliably at 20 MHz.



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CLINIC (Cont'd)

it were narrowed to a dozen semi-finalists who had also recommended a 100 kΩ or 1 MΩ resistor across the zeners to eliminate the baseline phase shift (generally ascribed to diode leakage but probably caused by capacitance).

Further testing showed that 1 MΩ resistors connected across the steering diodes were more effective than any value that was acceptable across the zeners. However, nobody had suggested that particular configuration, so Mr. Broussard's six-page answer was chosen because it was the most complete and detailed, and covered every other conceivable permutation and possibility.

Among other solutions submitted were those requiring special scopes, probes, plug-ins, op amps or transistors.

Thanks for your kindness in running this problem, although I might not so readily have jumped at it, had I known there would be 900 answers to read! Anyhow, it proves that the column is popular, and I strongly feel that other problems of this type would be extremely interesting.

The comments in my original letter showed that we were already close to the correct solution. All of us have these mental blocks from time to time, and many individuals must be sweating over things that someone else, not necessarily more intelligent or better trained, will see instantly.

Thanks again,
John H. Cone

P.S. If you doubt this, and will pay the postage, we'll send you 40 pounds of letters, at least half of which say, in effect, "This is great sport, hope they do more of it!" ▭

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

KTI Is Alive and Well—And Operating under Chapter 11

As the economic blight continues, young electronic firms are fighting for survival. One such firm, Kinetic Technology, Inc., has gone bankrupt—but, under Chapter 11, that's one way of becoming solvent again.

THOMAS P. RIGOLI, San Francisco Regional Editor

Back in May 1968, Hal Tenney, Gunnar Hurtig and Rich Simoni spun out of Western Microwave, Inc. to form their own company. Bustling with confident enthusiasm, the maverick trio planned their venture around the then-virgin active-filter technology.

Everything seemed right. Tenney, formerly Group VP at Western Microwave, had the marketing savvy and was just the man to head up the new company. Hurtig was second to none as a designer of active filters—and Simoni's strong background in personnel administration was sure to keep everyone running in the same direction. To top it all off, the three founders enjoyed a warm personal friendship. They named their brainchild, located in Santa Clara, Calif., "Kinetic Technology, Incorporated"—and affectionately referred to her as KTI.

Almost two years later to the day, KTI went to court and filed for bankruptcy—or as the lawyers put it, "Chapter 11".

What happened to the West Coast firm during those two years that led them to seek out Chapter 11 of the Bankruptcy Act? And what are their hopes for the future? Believing that others might learn from their experience, KTI agreed to share their plight and their plan with EDN's readers.

"The Best Laid Plans . . ."

When Robert Burns poeticized about man's "best laid plans" going astray, he probably wasn't thinking about electronics companies. Nevertheless, KTI's plight is an exemplar of the poet's timeless adage.

On paper, the company's growth plan looked great. First, the newfound venture planned to develop a standard line of active filter components. Then, sometime later, they would move to the next level of complexity by developing subsystem modules around these

(Continued)

standard components. And, of course, their ultimate goal would be to develop whole signal-processing systems where their standard line of active filter components would continue to play a major role. The founders agreed that if all went according to plan, their corporation would become financially self-sufficient during its second year of operation.

As poet Burns would have it, KTI's plans had gone far astray before the enthusiastic personnel celebrated their first company Christmas party.

Feeding on each other's enthusiastic optimism, the founders agreed to accept a system job before they had developed a standard line of components. The system job seemed too good to pass up because it was sure to result in profitable follow-on business. After signing the contract, KTI devoted their total effort during the next 120 days toward developing their first system. For the time being, their original growth plan was held in abeyance.

Because the system was delivered on time and according to specification, a satisfied customer gave KTI the follow-on business that they expected—but all was not roses. Accepting the system job prematurely did cause some perturbations. For one thing, the magnitude of the job was underestimated and KTI lost money. This was easy to swallow because the follow-on was sure to make up for the loss. More serious, however, KTI's staff was built up much more quickly than planned. And it was now impossible to continue operating on the personal money of the founders who had already guaranteed the lease of $45,000 worth of equipment. KTI now needed financial assistance.

Ironically, many investment houses ignored KTI's financial plea because they weren't asking for enough money. It seemed that most investors preferred to invest chunks of money that were far larger than what KTI needed. Finally, financial relief to the tune of $200,900 came from a New York-based investment fund. Received in the Fall of 1968, this money went fast, and by the Spring of 1969, more money was needed.

Because of a law governing regulated investment funds, KTI could not get additional capital from their original source. From another East Coast investment house, however, KTI secured $450,000. At this point the investment houses were the two major stockholders. Together, they held 50% ownership in the year-old company.

The founders soon came to realize that they had received "sink-or-swim" investments. When the large investors chose not to serve on KTI's board of directors, the three founders thought that this would be to their advantage. But as time went on, they began to wish that they had a financial advisor on their board. And when the struggling firm phoned the investment firms for financial guidance, the typical response at the other end of the line was "KTI who??"

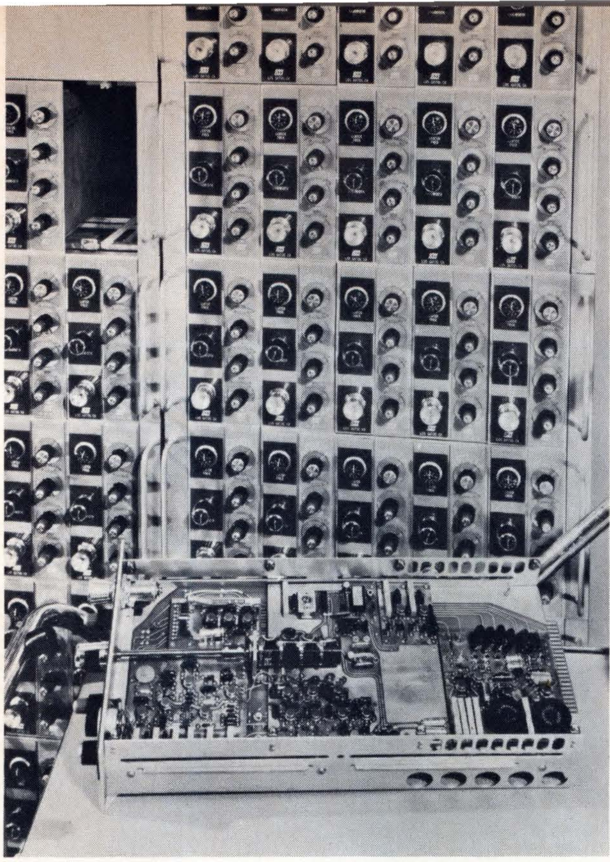
At KTI's grand opening, President Hal Tenney (holding scissors) was very optimistic about his company's future. Little did he realize that KTI would experience two difficult years followed by bankruptcy.

Still feeding on each other's optimism, KTI's founders forged ahead without sound financial guidance. Unfortunately, they learned too late that what they needed was a good financial administrator—or at the very least, a pessimist in their group.

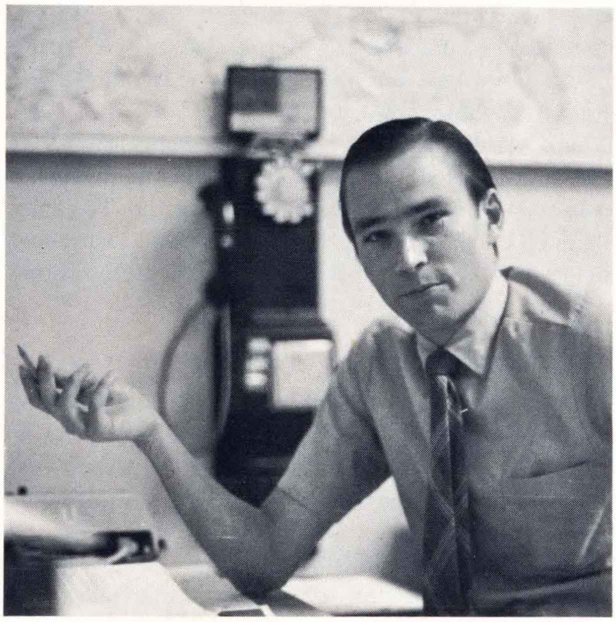
Sequence of Setbacks

If sound financial planning had been the only thing that the California firm needed, they probably wouldn't be bankrupt today. Quite a number of companies have been formed by highly-competent engineers who lacked the necessary business acumen. In due time, these engineers either became smart businessmen—or they hired some. Under ordinary circumstances, it's likely that KTI would have done the same thing. But the circumstances for KTI were rather extraordinary. Their need for sound financial planning was heavily aggravated by a sequence of setbacks that virtually snowballed them into Chapter 11.

Faced with developing a new product for an old



KTI's active-filter prowess is demonstrated by this system, a tunable audio spectrum analyzer. Each module is a fourth-order bandpass filter that is tunable over the audio range. Though KTI successfully developed this system, they did so at the expense of deviating from their original plan to develop a standard line of active filter components first.



On Chapter 11, KTI's VP Gunnar Hurtig comments, "It's a hell of a way to run a company—every Friday we have to decide if we're going to open the doors on Monday."

market, KTI encountered her first setback because she depended on what turned out to be an undependable company to do some critical hybrid work. After the hybrid source accepted a small order for 100 pieces, they didn't inform KTI until 90 days later that they couldn't deliver. Falling behind schedule and with orders that couldn't be met, KTI quickly looked for another source of income. This largely contributed to their decision to accept the system job prematurely. Because the magnitude of the job was underestimated, the young firm was burdened with the task of rapidly building an effective team to do the work. After completing the job at a loss, KTI was content to chalk their first setback up to the "learning curve".

Just after the company marked its first anniversary, they experienced their most tragic setback. It all began when President Tenney decided to take a much-needed vacation. On May 17, 1969, he and his wife climbed aboard his private plane and took off for what was to be a two-week rest in Mexico. It wasn't until three months later that President Tenney returned to work—thankful to be alive. While attempting to land in Mexico, the Tenney couple had a close brush with death as their plane somersaulted after overshooting the runway. During Tenney's three-month recuperation, the already-struggling KTI became demoralized without his leadership.

Late in 1969, it looked as though KTI would get a reprieve from the DIFAR military program. After successfully developing prototypes for the program, KTI expanded her staff to 70 people and anxiously awaited the follow-on business. There was good reason to expect the follow-on business because KTI had no competition—and the parts were needed right away. Then the unexpected happened—the program was put on "hold". It was then that the country was just beginning to feel the economic pinch that today prevails more like a stranglehold. During the program's suspension, KTI lost its competitive edge—and with that went the follow-on business.

About the same time the DIFAR program was suspended, KTI found herself in need of more money if she hoped to remain in operation. Just before Thanksgiving 1969, KTI was about to receive $50,000 more from their second investor. But there was a financial string attached. Before parting with the money, the investor insisted that KTI secure professional help from a financial planning consultant—and furthermore, that the KTI employee currently responsible for the firm's financial planning be dismissed. Now KTI didn't have a financial administrator, as such, because the three founders shared that responsibility. Nevertheless, the investment firm insisted on a scapegoat—or else the "blood money" would not be given.

(Continued)

The short straw fell to KTI's personnel administrator, Rich Simoni. Just before Thanksgiving, 1969, President Tenney was forced to ask his good friend, Simoni, to leave the company.

As if to rub salt in their wounds, one of KTI's former customers started its own active-filter facility by hiring away two of KTI's engineers. Alleging that the engineers left with proprietary literature and techniques for developing active filters, KTI is now in the throes of suing their former customer.

Acquisition Goes Up in Smoke

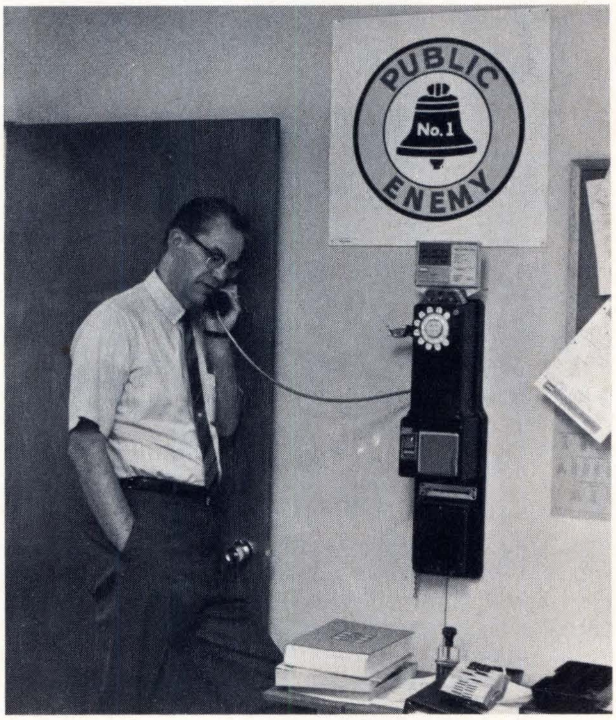
When it looked like there wouldn't be any follow-on business from the DIFAR program, KTI set out to find an "honorable" acquisition. After considering several possibilities, they finally chose to be acquired by a large, Midwestern resistor manufacturer.

As they began negotiations, both parties agreed that theirs would truly be a profitable marriage. The resistor manufacturer looked forward to acquiring a high technology business – and in return, KTI would receive a solid financial base plus the services of a seasoned marketing organization. For the next three months, KTI devoted the majority of her efforts toward closing the deal.

After the initial purchase document was drawn up, it went through four subsequent revisions – until finally, both KTI and her prospective parent were satisfied with all the provisions. As if to put the ribbon on the final package, President Tenney flew to New York to wrap up the last-minute details with KTI's two major stockholders. Upon returning home the second week in May, 1970, Tenney thought that everything was taken care of, save for the final signing. Then the proverbial fly landed in the ointment.

During that second week in May, KTI's honorable acquisition went up in smoke. One of KTI's major stockholders started the fire when he insisted, at this late stage, that certain wording be changed in the purchase document. Interpreting this as a rejection, the Midwestern firm quickly withdrew its offer. Despite the fact that KTI convinced her dissenting stockholder that the word change was unnecessary, her prospective partner refused to resubmit the offer.

In retrospect, KTI feels that the hassle over the wording gave the acquiring company just the excuse it was looking for to back out of the deal. Negotiations spanned the first quarter of 1970 – the period when money grew tight and electronic companies throughout the country were feeling the pinch. During that same period, the value of the acquiring company's stock plummeted from 12 to 4. Because of this, the acquiring company had to part with three times as many shares as originally planned to consummate the acquisition. KTI now feels that it was the tight-money economy, rather than the wording hassle, that caused the imminent acquisition to fall through.

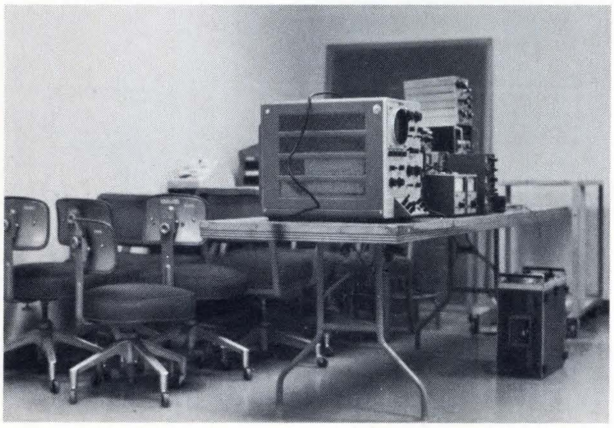


Understanding to unmerciful describes the range of creditors' attitudes after KTI filed for Chapter 11. As the "pop" poster over the pay phone indicates, Ma Bell was not very understanding.

Subsequent to withdrawing their original offer to purchase KTI, the Midwestern resistor manufacturer made a much less attractive offer which reflected the economic blight that was beginning to afflict the country. Basically, the offer amounted to buying KTI's entire product line – moving it to the Midwestern facility – and retaining only Tenney and Hurtig on the West Coast to handle engineering and marketing functions. A very disappointed KTI refused this offer. And by June 1, 1970, KTI had reduced her staff from 70 to 7 people and was operating under Chapter 11.

Chapter 11 – An Uncomfortable Shelter

"It's a hell of a way to run a company – every Friday we have to decide if we're going to open the doors on Monday." So responded Gunnar Hurtig when EDN



Small production staff presently handles manufacturing while the unused equipment stacked in the corner awaits better times. Hal Tenney comments, "It's amazing how efficient you can be when you have such limited resources to work with—we're fortunate to have Jack Geissinger as our manufacturing manager because he's an expert at getting the maximum output from the minimum input."

Home-brew ad, aimed at stimulating cash sales, kicked off the August sales campaign. Costing $7000, the modest sales promotion resulted in $35,000 sales and $215,000 in long-term orders.

asked what it was like to operate under Chapter 11.

Although operating under Chapter 11 is difficult, both Tenney and Hurtig are thankful for its legal shelter that gives them an opportunity to get back into the black. As Tenney puts it, "I don't know why a company would file for Chapter 11 unless they had the intention of becoming solvent again. It certainly puts a lot of restrictions on you—but on the other hand, it gives you time to solve your problems. Nothing happens in a rash way—everything happens in an orderly manner."

Elaborating on what it's like, Hurtig added, "Nobody trusts you. Everything is cash-and-carry right down to the pay telephones you see hanging on our wall. Without the coin in the bank, you have no alternative but to close your doors."

Often credited with "keeping the wolves away", Chapter 11 permits a flagging company to suspend past debts temporarily—and continue to operate on a cash-on-delivery basis. Chapter 11 aims to give struggling businesses a chance to get back into the black.

After coming under the Chapter 11 shelter, the debtor firm must propose an acceptable arrangement to handle past debts to a committee composed of the firm's creditors. At the writing of this article, KTI had proposed such an arrangement which has met the approval of their creditors' committee.

As KTI will testify, operating under Chapter 11 has been quite an experience. They report that their creditors fall into one of three categories:

- —those that recognize you're in Chapter 11 and simply do nothing.
- —those that are very understanding and go out of their way to help you.
- —and of course, the unmerciful Simon Legrees.

To give some examples, let's consider two of KTI's creditors that present quite a contrast in attitudes. One is the fellow who supplied KTI with their daily coffee service—and the other is the Pacific Telephone Co.

When the coffee serviceman learned of KTI's plight, he was very sympathetic and asked if there was anything that he could do personally. On that same visit, he left a gift of more coffee, cream and cups—despite the fact that KTI owed him money.

(Continued)

Then there's Ma Bell, referred to by KTI as "their favorite bad creditor". Bankrupt or not, a business without telephones is going to find it impossible to function. Ma Bell understands this better than anyone—and it appears that she's not above taking advantage of it. For example, KTI's phones were shut down without warning shortly after they filed for Chapter 11. They were summarily told that if they wished to have a single phone installed (without referral service from the old number), they must make a deposit of $1200. KTI contended that this deposit was far too exorbitant—and it must have been—because the phone company then agreed to reduce the required deposit to $500 (which included the referral service). After considering other possibilities, KTI chose to have pay phones installed because they required only a $300 deposit. Besides, most outgoing business calls would have to go through the operator anyway. Except for the inconvenience of overflowing coin boxes, KTI finds that their three pay phones do the job well. They still feel, however, that Ma Bell is "Public Enemy No. 1" on their list of creditors.

In contrast to their creditors with wide-ranging attitudes KTI has experienced with few exceptions a somewhat unanimous attitude in their sales representatives. KTI's sales managers, Dick Smith on the East Coast and Fred Glynn on the West Coast, have made particular note of this. Fred Glynn (who handles everything West of the Mississippi) refers to this attitude as "the fair-weather friend syndrome". Glynn, who also wears the hat of senior applications engineer in the home office, explains that, for the most part, KTI's sales representatives "just weren't around when we needed them most." He attributes their desertion to one of the following reasons:

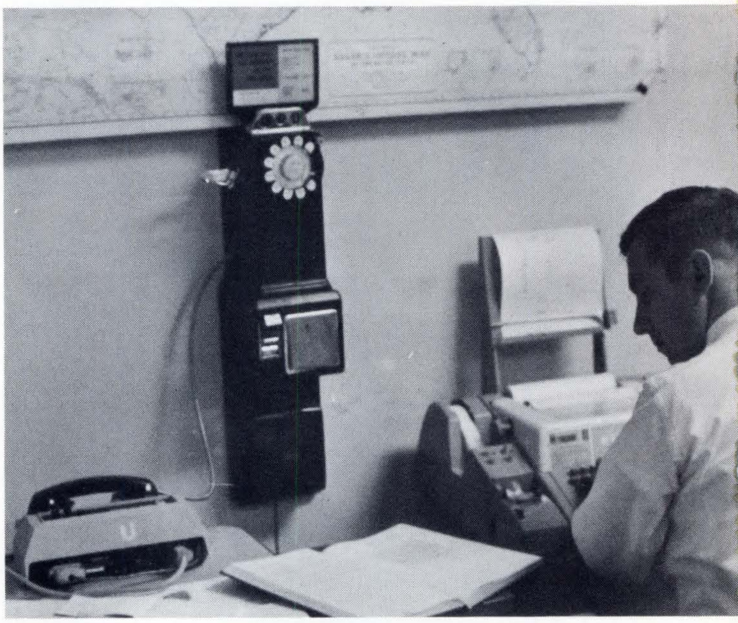
—sales representatives were skeptical about receiving commissions from a bankrupt company, or . . .

—they didn't want to attach their name to something that might fail, or . . .

—they felt that if KTI did go out of business, there would be no replacement parts. Hence, customers buying KTI products could be placed in a difficult situation—and their reputation as sales representatives would suffer.

The few outside these classifications were truly exceptional in that they seemed to work even harder to help their bankrupt client.

Faced with the apprehensions of their sales representatives and a worsening economic climate, the future for the bankrupt firm did indeed look bleak.



KTI timeshares a computer to tailor their active filters to their customer's unique requirements quickly. Replacing several people, it has become a great asset during the Chapter 11 operation.

August Sales Campaign

As KTI entered her second month of bankruptcy, the morale of the half-dozen employees had rapidly ebbed. President Tenney, who learned financial administration the hard way, continued his search for investors—while Engineer Hurtig continued to service the few faithful customers. The remaining personnel—including the firm's only secretary—became involved in stimulating cash sales. Despite the ardent effort of the hopeful half-dozen, KTI was getting very little cooperation from their sales representatives. On top of this, the nation's economic blight grew worse with each passing day.

During the second month of bankruptcy, Paul Newcomb, a business consultant, suggested that KTI stage an innovative sales campaign. Tenney and Hurtig warmed to the idea.

After a brainstorming session, KTI home-brewed their own sales campaign—right down to creating an unusual advertisement that touted "Save 30% or more—NOW!" Billed as a "cash-builder sale", the ad offered large savings on KTI's universal active filters if cash payments were made before the end of August, 1970. As further enticement, the quaint ad offered

KTI team, once 70 people, has been reduced to the handful shown. Although each employee has a primary function, all have learned to wear many hats as KTI struggles toward solvency.

"one free with each (sic) ten purchased"—and "10% kickback in free engineering services". To inspire their sales representatives, a contest was also announced whereby the KTI representative with the most sales could win an attractive cash bonus.

Total cost of the modest sales promotion was $7000. This was a rather good investment, considering the results it produced. During the month of August, KTI received a long-term order for $120,000. On top of that, $35,000 was garnered from several individual sales, and the bankrupt firm convinced a "foot-dragging" customer to place a $95,000 order.

The August sales campaign was successful in more ways than one. It did indeed build cash and create a backlog of business—essential ingredients for becoming profitable. But additionally, the sales campaign delivered KTI from a limbo operation to a goal-seeking environment. This boosted morale—and KTI's customers began to be convinced that the bankrupt firm was still a viable entity that had every intention of becoming solvent again.

Nobody's In a Hurry But Us

Having received a morale boost from the August sales campaign, KTI renewed its efforts more strongly than ever to find new financial backing. To date, the company has contacted 54 potential investors, trying to convince them that KTI's future is so positive that it will overcome the problems associated with the past. Summarizing KTI's effort, Tenney told EDN; "At any other time, I don't think that we would have any problem finding financial backing—but right now the money is just too tight." Tenney went on to explain that the 54 investors contacted by KTI can be typically categorized as:

1. Those who understand the product and market potential and are genuinely interested—but they currently have too many of their own problems caused by the tight money environment.
2. Those in the business of acquisition who are very selective, recognizing that they are in a position to acquire companies already turning a profit.
3. Those who are seriously interested in providing financial backing and are trying to work out a feasible plan.
4. Those not interested at all.

Of the 54 potential investors contacted so far, most of them fall into the first two categories and very few fall into the last. The third category, which seems to be the most promising, represents about 10% of the total. As KTI continues its search for a financial oasis, Tenney laments, "Nobody seems to be in a hurry but us."

Monday Morning Quarterbacking

Looking back, both Tenney and Hurtig will be the first to admit that they made mistakes. Unlike typical Monday morning quarterbacks, however, KTI's two remaining founders intend to do more than just talk about how they "should" have played the game.

With enthusiasm now tempered with realism, Tenney explained, "When we came under Chapter 11, it was just like starting the company all over again—but this time from a negative position." Chapter 11 has indeed made it a new ball game. Armed with experience from two tough years in business, the KTI team has learned from their mistakes—and this time they aim to win.

How does KTI plan to avoid those big mistakes that they made as a fledgling business? When EDN posed this question, Tenney first replied, "For one thing, we've become more realistic, particularly where financial planning is concerned. In soliciting future financial backing, we now realize the advantages of having a local investor that will sit on our board of directors

(Continued)

and look over our shoulder. Though I've learned much about financial administration through hard experience, I still plan to use professional guidance. I think we could be successful today if, in our early stages, we had sound financial planning."

Hurtig added to this, "I think we underestimated the time it would take to cultivate an old market to accept a new product. And because our product was new, we spent a great deal of time educating our customers – only to find out too late that we were doing it to our detriment. Our over-educated customers began using our technology to build their own active filters rather then relying on us to do the work. Though we still appreciate the importance of customer education, we will be more careful in the future to avoid giving away the store."

In spite of KTI's catastrophic chronology, a few important things have remained unchanged: Hal Tenney is still a highly competent strategist when it comes to marketing – and Gunnar Hurtig is still a wizard when it comes to designing active filters. Both men still believe in the brainchild that they created a little over two years ago.

With sharpened business acumen garnered from two years of hard experience, the two remaining founders now seem to have all the essential ingredients to be a successful company. As Hal Tenney pilots the bankrupt firm into the black, Gunnar Hurtig continues to share his talents with industry as Chairman of the EIA Working Group on Active Filters. From all indications, the happy ending – or "new beginning" – to KTI's story is not far away. But for the moment, KTI is alive and well – and operating under Chapter 11. ▭

As EDN went to press, KTI was negotiating a very promising refinancing arrangement that could restore them to solvency. To learn more of KTI's active-filter capability – and, very likely, the happy ending, write: Kinetic Technology, Inc., 3393 De La Cruz Blvd., Santa Clara, CA 95050.

Chapter XI Explained

During these austere times, it's become quite common to hear or read about financially-stressed companies filing for "Chapter 11". Just what is "Chapter 11" all about? Because it is a legal term, EDN took this question to a lawyer. Attorney Robert G. Moore, Los Altos, Calif., offered the following explanation:

"Though the Bankruptcy Act may not be very exciting reading for electronic designers, it does contain a very important chapter for companies in serious financial trouble who want to stay in business. Of course, I'm referring to Chapter XI.

"Let me first make it clear that Chapter XI provides for a *special* bankruptcy proceeding. Unlike *ordinary* bankruptcy proceedings that result in liquidation of the company, Chapter XI allows a financially-anemic enterprise a reasonable opportunity to rehabilitate itself and regain solvency.

"After filing for Chapter XI, the over-burdened debtor must promptly present his creditors with a feasible plan for payment of outstanding debts. Typically, the debtor proposes that his creditors reduce the amounts on their claims – and/or extend the due date of same. While the creditors are considering the proposal, they are barred from harassing the debtor, who during this same period is allowed to continue his business operation. It takes only a simple majority of the creditors to accept or reject the debtor's proposed payment plan. If accepted, the debtor's financial burden is alleviated because his creditors have agreed to accept a loss or extend time for payment. Rejection of the proposal, however, dooms a debtor to liquidate through ordinary bankruptcy proceedings.

"There's great incentive for the creditors to accept the debtor's payment plan even if it does result in a loss. Though liquidation may give the creditor an immediate under-par payoff, he stands to gain much more if the debtor survives, prospers and becomes a long-term customer of his product and/or services.

"Like a boxer between rounds, a company under Chapter XI is being given a short respite, after which he resumes the match with a stronger will to win. As a famous sea-lawyer by the name of J. P. Jones once said, 'I have not yet begun to fight, . . . under Chapter XI.' "

Say Goodby to Bulky X-Ray Generators

X-ray technology has come a long way since Roentgen accidentally discovered the mysterious "X" radiation in 1895. Until now, X-ray equipment has remained characteristically bulky and cumbersome because of the high-voltage cables and heavy radiation shielding required. Thanks to the Watkins-Johnson Co., the X-ray generator has now entered the Lilliputian world.

Developed by W-J's Stewart Div., the portable X-ray generator owes its small size to a revolutionary X-ray tube design. The W-J engineers succeeded in integrating a specially-developed pulse transformer into the X-ray tube's sealed assembly—thereby eliminating the 1/2-in HV cable normally required for the tube/transformer interface. Encased in lead shielding and weighing 6 lb, the novel X-ray tube combines a computer-designed electron gun with an indirectly heated cathode. Compared to convential, power-hungry tungsten filaments, the indirectly heated cathode provides the same large current pulse emission levels at one-tenth the power input. X-ray generators the size of footballs and smaller have been built with pulse output capabilities approaching 100,000V at 600 mA. Originally developed for a jet fighter, the rugged, miniature X-ray tube should introduce a new dimension in portability and placement of the generating heads.

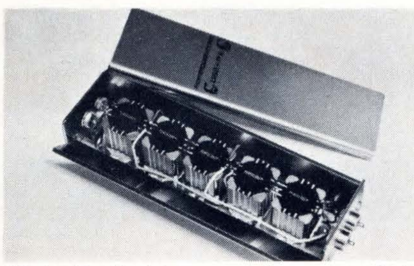
Beyond its successful airborne role, the X-ray generator aims to find many new industrial, analytical and medical applications. The photo suggests non-destructive testing (film and electronic imaging) of packaged ICs. As a gauging device, the X-ray generator could also provide accurate thickness and density measurements of semiconductor materials. Handy for production-line testing, this X-ray generator can be readily placed in the most advantageous position without requiring a HV cable assembly.

With 400V, 3-μs pulses, the new entry delivers an X-ray intensity of 200 meV/cm^2/μs (10,000 roentgens per hour) at 1 meter. W-J reports that the X-ray generator dissipates about 30W and can continuously deliver 400 pulses/s for 8 min without external cooling. The generators have been packaged as shown in the photo; the smallest X-ray tube transformer assembly currently available measures 2.5 by 2.5 by 8 in. Costs for the X-ray generator, including compact power supply range from \$3000 to \$5000. Watkins-Johnson Co., Stewart Div., 440 Mount Hermon Rd., Scotts Valley, CA 95060. **250**

Mini Cube Makes Midi Power Supplies

In announcing a new series of power supplies, Powercube Corp., has squeezed maxi power into a midi "Cube-Pac". The series provides voltages from 4 to 100V and up to 50W output power in packages no larger than 7-1/2 in^3—this compares to competitive units ranging from 100 to 500 in^3. Although a standard line is available, Powercube offers "off-the-shelf" custom units with up to eight different outputs, merely by tying together standard mini power cubes as required. "Cube-Pacs" use as few as two power cubes (one inverter, one regulator converter) to as many as seven cubes (one switching preregulator, one inverter and five regulator converters). Line and load regulation spec range from $< \pm 5$ mV for supplies up to 10V output, to $< \pm 100$ mV for 100V supplies.

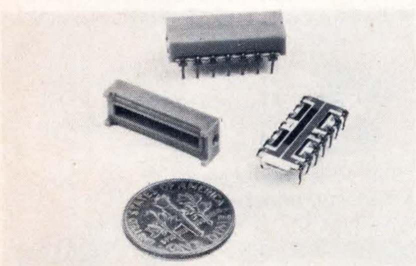
The "Cube-Pac" enclosure is provided with special feedthroughs for RFI/EMI suppression and can be supplied to meet MIL Specs 461 and 826. Powercube Corp., A Subs. of Unitrode Corp., 214 Calvary St., Waltham, MA 02154. **251**



"Cube-Pac" shown contains one switching preregulator, one inverter and three regulator converters.

DIP Trimmer Exhibits TCR of ±2 PPM/°C

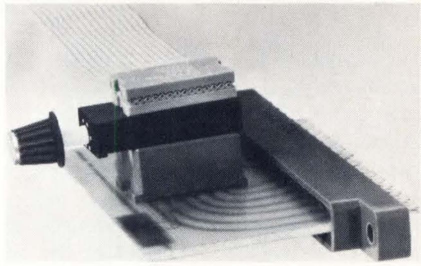
Using IC technology, Amphenol Controls Div. of the Bunker-Ramo Corp. has developed a 14-lead, dual-in-line packaged trimmer/resistor network—ideal for automatic insertion and frugal with board space. Designated TRN Series 3765, each network contains a combination of fixed and variable resistance cermet elements fabricated on a common substrate. These units sell for approximately \$3 each in production quantities.



Resistive elements are prepared from a newly developed cermet paste that exhibits a nominal temperature coefficient of 50 PPM over −40 through 85°C. One-step depositon yields uniform, predictable TCR draft limited to ±2 PPM/°C between resistors. Resistance range is 10Ω to 1 MΩ with standard tolerance of ±10 percent (±1 percent special).

Each resistor within the package has its own set of terminals—enabling the designer to interconnect terminals in any manner he desires. These trimmer/resistor networks offer convenient voltage or current compensation of operational amplifiers. For such application, two anticipated off-the-shelf networks will contain 10 kΩ trimmer with two 10 kΩ and two 5 kΩ resistors; and 1 kΩ trimmer with two 1 kΩ and two 500Ω resistors. Both networks will have a 500 kΩ current limiting resistor as well. Amphenol Controls Div., The Bunker-Ramo Corp., 120 S. Main St., Janesville, WI 53545. **252**

"Dipswitch" Broadens DIP Possibilities

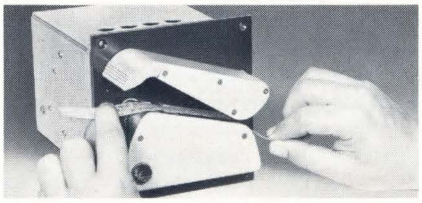


Dual in-line package, designated **"Dipswitch"** by Daven Div., McGraw-Edison, contains six separate switches that can be programmed to be NO or NC in any of the six shaft positions. Using individual cams to control closure and opening of contact pairs, Daven can program any desired switching configuration without special tooling and assembly costs.

An option offered is tandem operation where two **"Dipswitches"** are coupled by a special rear shaft extension. Common poles also can be tied together internally at the factory.

Contacts have a positive wiping action and are made of gold-plated beryllium copper. They are rated 125 mA at 115V ac or 28V dc. Daven, A Div. of Thomas A. Edison Industries, Grenier Field, Manchester, N H 03103. 253

Photoelectric Mini-Reader at Mini-Price



Low-cost and compact photoelectric mini-reader MTR-2000 is designed for such applications as typesetting, programmed machine tool and test equipment.

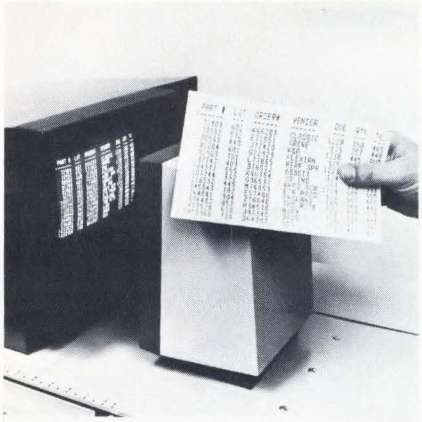
Priced below \$500 in OEM quantities, the perforated tape reader reads at rates up to 200 characters/s and mounts in <0.25 ft^2 of front panel space.

Data and sprocket output reliability tests show no dropout for more than 150 million bits at 75°C and more than 500 million bits at 25°C.

The only moving assembly in the reader is a low-inertia drive sprocket attached directly to the electrically-controlled step motor.

Standard features include: stop on stop character, continuous run or step mode, end-of-tape/no-tape sensing, 0 to 70°C operation, output data latches, power filtering, 6- and 8-level tape, spare lamp and advanced sprocket TTS tape. Electronic Engineering Co. of California, 1441 E. Chestnut Ave., Santa Ana, CA 92701. 254

Hard Copy



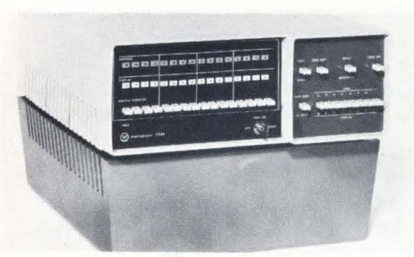
Display copier, Model 9750, makes permanent records of alphanumeric or graphic displays from CRT monitors quickly and reliably. Cost per copy, at five copies per minute, is < $0.02. A. B. Dick Co., 5700 W. Touhy Ave., Chicago, IL 60648. **255**

Card Reader M200 offers combined reliability of LED and semiconductor devices. Operating at 200 cards/min, the M200 sells for $1275 in OEM quantities. Documentation, Inc., Melbourne, FL 32901. **256**

Impact printer Model 101 prints on standard paper at 165 characters/s or 132 character lines/min. Price is from $2400 with OEM discount available. Centronics Data Computer Corp., 1 Wall St., Hudson, N H 03051. **257**

Multiple card reader Model 8800 handles 80-column cards at 650 cards/min or 96-column cards at 1000 cards/min. Hopper and stacker capacity is 1000 cards. Price in OEM quantities is $2500 each. Bridge Data Products, Inc., 738 S. 42nd St., Philadelphia, PA 19104. **258**

Systems

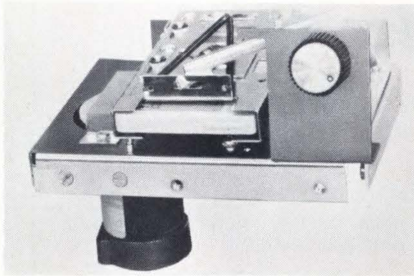


General purpose computer, Westinghouse 2500, has a 16-bit word length and an 850 ns memory. Basic computer with 4096 words of internal memory sells for $9950. Westinghouse Electric Corp., Box 2278, Pittsburgh, PA 15230. **259**

Minicomputer, Model CF16A, features 126-instruction repertoire, 1.6 μs memory cycle time and single I/O transfer rates up to 500,000 16-bit words/s. Memory is expandable to 32,768 words. Xerox Data Systems, 701 S. Aviation Blvd., El Segundo, CA 90245. **260**

Modem/acoustical coupler, Model ADC 300, operates from 0 to >300 baud, linear, using frequency modulation. The 4-1/2- by 5-1/2- by 1-1/2-in unit accepts only serial, binary asynchronous input data. National Midco Industries, Inc., Box 5433, Trenton, N J 08638. **261**

Magnetic Tape



Drive system DPC-202 for magnetic-tape cassettes (4 by 2-1/2 by 3/8 in) employs patented direction-sensing clutch that permits one dc motor for both run and fast rewind. The unit, developed for OEM market, is priced at under $100 each in quantity. 3M Co., 3M Center, St. Paul, MN 55101. **262**

Tape transports 20291 and 20292 feature automatic threading and loading. Drives operate at speeds of from 75 to 120 ips, respectively. Bucode, Inc., 175 Engineers Rd., Hauppage, NY 11787. **263**

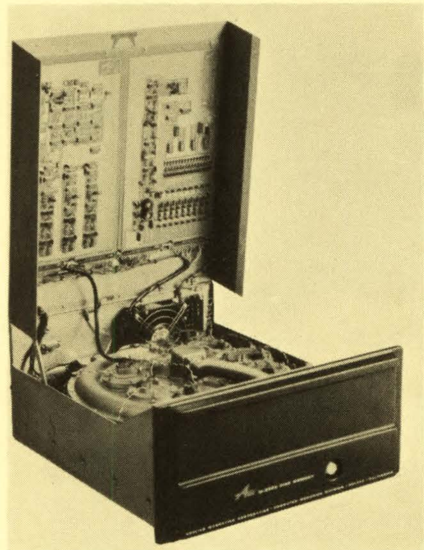
Incremental deck is an on-line cassette that has the ability to read and write on an incremental basis up to 30 characters/s. Price range is $355 to $775. International Computer Products, Inc., Box 34484, Dallas, TX 73234. **264**

Five models of magnetic tape transports, 2000 Series, move tape up to 45 ips and have clocked digital outputs. Available packing densities are 800 and 1600 bpi. Mohawk Data Sciences Corp., Palisade St., Herkimer, NY 13350. **265**

Incremental cassette magnetic-tape recorder, Model 400T, has selectable read/write baud rates of 110, 150 and 300. Stopping and starting on a character in read mode is achieved without loss of a character. Mobark Instruments Corp., 1038 W. Evelyn Ave., Sunnyvale, CA 94086. **266**

Computer Products

Memories



Disc memory M-200D, having a head-per-track configuration, has an average access time of 8.7 ms. Storage capacities are from 265,000 to 6,400,000 bits and from 16 to 128 tracks per nickel cobalt disc, 12 inches in diam. Applied Magnetics Corp., 75 Robin Hill Rd., Goleta, CA 93017. **267**

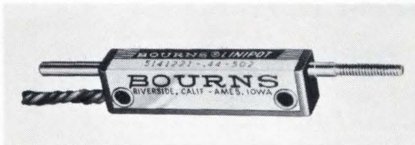
Read-only core memory, Model 401-11, has maximum capacity of 2k by 48 bits—four 8.8- by 9.2- by 1.2-in modules. Cycle time is 500 ns and access time is 180 ns. Quadri Corp., 2959 W. Fairmont, Phoenix, AZ 85017. **268**

Standard core memory systems, FI-4, offer capacities from 4k by 20 to 8k by 10 bits and feature 1 μs full cycle time. Access time is 390 ns. Construction is 3D, 3 wire organization using 18-mil cores. Ferroxcube Corp., Saugerties, NY 12477. **269**

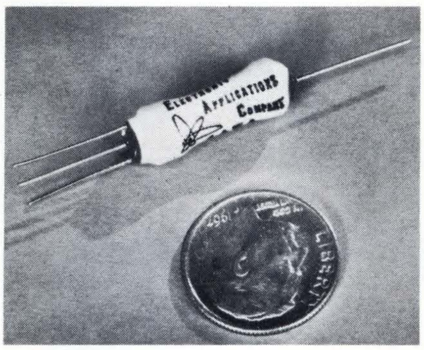
Semiconductor memory system has a storage capacity of 64,000 bits. System is completely self-contained, including control logic, power supplies and cooling. Advanced Memory Systems, 1276 Hammerwood Ave., Sunnyvale, CA 94086. **270**

Off-the-shelf MOS/LSI arrays include two ROMs (2560 bit), two read/write (256 and 128 bits), a 1024-bit dynamic shift register, and an analog switch. They are available in either flat pack or DIP and designed to operate at −55 to 125°C. Collins Radio Co., Newport Beach, CA 92663. **271**

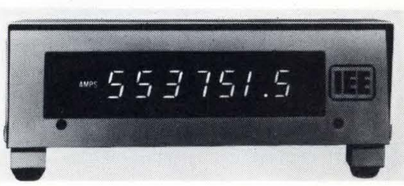
Components



Linear position transmitter, Model 5141, has shaft actuation force of 4 oz at 20°C, no backlash and a dither life of 10 million cycles. Stock ranges are 5 and 10 kΩ for 7/16-in travel with additional resistance and travel ranges available. Other specifications include 0.8W power rating (70°C), ±1 percent overall accuracy and a weight of 2 oz. Bourns, Inc., 1200 Columbia Ave., Riverside, CA 92507. **272**

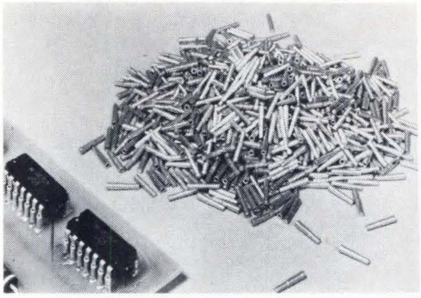


Subminiature reed relay is now available for $0.39. Unit measures only 0.275 (diam) by 0.95 in (length), and available coil voltages are 1, 3, 5, 6, 12, and 24V. Contacts are rated up to 1A at 20W and have a breakdown voltage of 750 Vdc. Rated life is over 100 million operations. Electronic Application Co., 2213 Edwards Ave., South El Monte, CA 91733. **273**

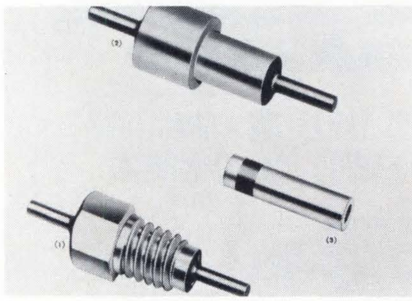


Seven bar-segment display has single plane viewing, front or rear lamp replacement, choice of screen colors and plug-in unit. Optional features include caption display of either three or six messages and conventional rear-projection 12-message display. Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. **274**

Components



Pin sockets, J-150, grip IC modules firmly, yet permit component removal and reinstallation without loss of holding power. Removal of a plugged-in module requires over 50 g/pin. Terminals are 0.15 in long, and they will accept both round leads (0.016-to 0.019-in diameter) and flat leads (0.015-to 0.023-in wide). Texas Electronic Instruments, Inc., 5619 Etheridge, Houston, TX 77017. **275**

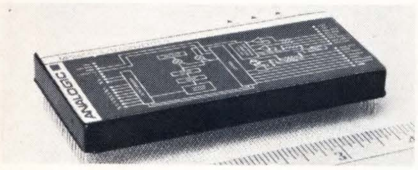


Ceramic multilayer feed-through capacitors, Type CL, have minimum capacitance value of 50,000 pF. Typical insertion loss is 20 dB at 1 MHz and 70 dB at 1000 MHz. Voltage rating is 100V dc with 10A rated current, with no voltage derating over operating temperature range of −55 to 125°C. Allen-Bradley Co., 1201 S. 2nd St., Milwaukee, WI 53204. **276**

Printed-circuit connector for 1/16- and 1/32-in boards has contact spacing on 0.05-in centers, and a choice of 20, 40, 60, or 80 terminations. Called .050 Series, the gold-plated solder tails on the connector back are staggered for easy access. Connector bodies, molded of dialyll phthalate, can be polarized with keys in selected contact positions. National Connector Div., Fabri-Tek, Inc., 9210 Science Center Dr., Minneapolis, MN 55428. **277**

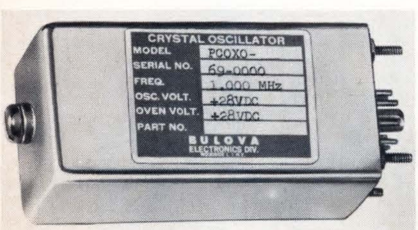
Circuits

VHF linear power amplifier is broadband, offers 5W output and provides both good linearity and low distortion. Model HSA-81D2 has a frequency range of 85 to 155 MHz and a 0.15 dB bandwidth of 70 MHz. Gain is 21 dB. Optimax, Inc., Box 105, Advance Lane, Colmar, PA 18915. **278**

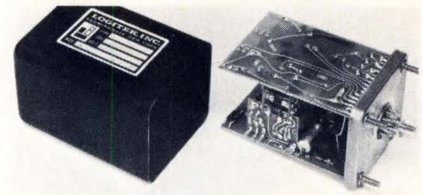


12-bit integrating A/D converter, Model ADPAC MP2600, provides 12 binary-bit or 3-1/2 BCD-digit outputs at 0.05% accuracy and 7.5 ms total conversion time. Its true differential input presents 1000 MΩ impedance. Dimensions of the mechanically and electrically shielded module are 4 by 2 by 0.39 inch. Price is $175 in unit quantities. Analogic Corp., Audubon Rd., Wakefield, MA 01880. **279**

A/D encoder modules have up to 8-bit resolution and 1-MHz word conversion speed. Designated the IAD-M family, these use modified successive approximation encoding. Currently available models provide 4-, 6- or 8-bit resolution and are priced from $525 to $855 in single lots. Inter-Computer Electronics, Inc., 1213 Walnut St., Lansdale, PA 19446. **280**

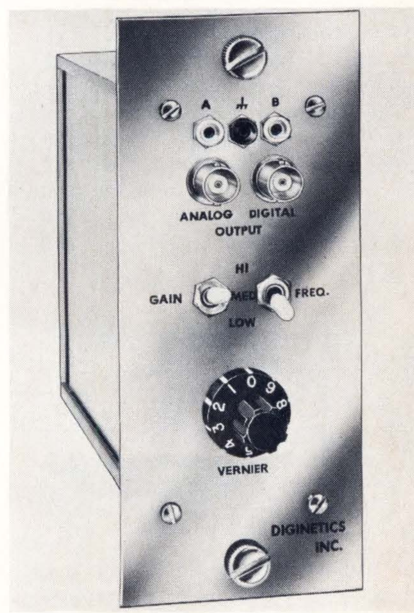


Crystal oscillator, Model PCOXO-5, has aging rate of 5 parts in 10^{10}/day and is available in 1, 3 or 5 MHz. Frequency stability is 2 parts in 10^{10}/°C between 0 and 60°C, input voltage is 28V dc and output is 1V rms. Size is 2 by 2 by 4 inches, and price is $297 in 10 piece lots. Bulova Watch Co., Inc., Electronics Div., 61-20 Woodside Ave., Woodside, NY 11377. **281**



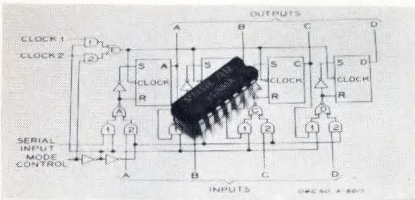
Voltage sensors, available in single and three-phase 60 or 400 Hz units, are designed to protect equipment from damaging dropouts or excessive levels. Type VAA sensors have accuracy of ±1%, use an rms type detector and are available with pickup and dropout time delay from 250 ms to 10s, preset at the factory for any sense voltage between 95 and 150V rms. Logitek, Inc., 42 Central Dr., Farmingdale, NY 11735. **282**

Dual voltage-tuned oscillator, Model 200302092, has outputs of 65 mW minimum over the frequency bands of 3.6 to 4.3 and 5.8 to 6.5 GHz. Ferrite load isolators enable smooth monotonic tuning and assure less than ±0.05% frequency shift into a 1.5:1 VSWR rotated through all phases. Temperature stability is 150 PPM/°C. Addington Labs., Inc., 1043 Di Giulio Ave., Santa Clara, CA 95050. **283**



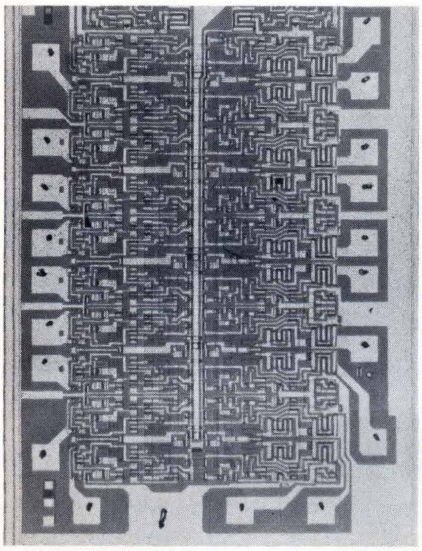
Data amplifier has unique design that permits recording of dc through 10 kHz data accurately, regardless of the dc bias or offset present. Differential input, gain of 2500 and system accuracy of better than 0.1% are features of the Model 1100. Diginetics, Inc., Box 777, Bridgeton, MO 63044. **284**

New SC's



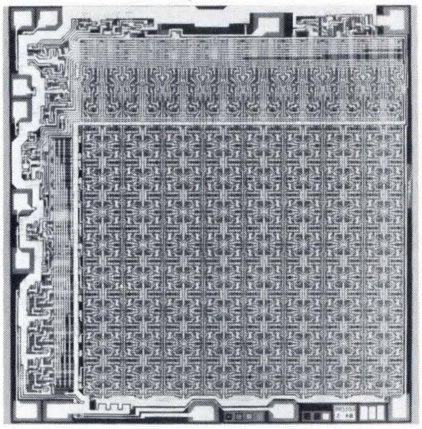
MSI shift register US7495A has been added to the Series 54/74 family of high speed logic. The unit is a four-bit, parallel-input, parallel-output device featuring selective right or left shift mode control and individual clock inputs for left or right shift timing. In lots of 100 to 999, price for the 0 to 70°C unit is $4.65 each. Sprague Electric Co., North Adams, MA 01247.
285

COS/MOS 14-stage ripple-carry binary counter/divider CD4020D operates from dc to 2.5 MHz typically, has 10 μW typical power dissipation, single power supply operation from 6 to 10V, operates over the full military temperature range of −55 to 125°C and at the 1000-unit level price costs $12.50 each for the 16-lead, dual in-line, ceramic-packaged device. RCA/Electronic Components, Harrison, N J 07029.
286



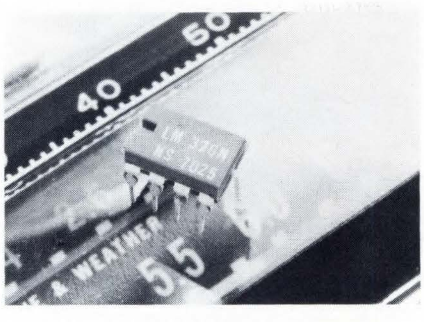
Buffer register ICs include four devices for parallel-in, parallel-out applications. Each unit contains ten clocked "D" flip-flops that are of the dc-coupled master-slave variety. Propagation delays are typically <30 ns, and transfer rate is typically <20 MHz for the 8200-8203 units. Available in both 0 to 75°C and −55 to 125°C versions, prices start at $8.39 each in quantities between 100 and 999. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086.
287

New SC's

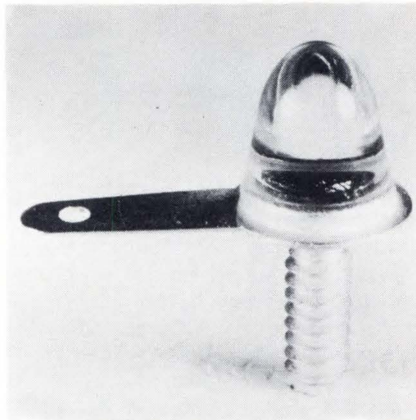


Random access semiconductor memory IM5503 is a 256-bit, high-speed T²L, fully binary decoded unit with access time of 75 ns and low power dissipation of 1.5 mW/bit. Chip select, write enable and open collector outputs also are provided in this 16-pin ceramic dual in-line packaged unit. Price in lots of 100 pieces is $57 each (0 to 75°C) and $85 each (−55 to 125°C). Intersil Memory, Inc., 10900 Tantau Ave., Cupertino, CA 95014. **288**

Balanced modulator/demodulator SG1596 is designed for use in suppressed carrier and amplitude modulation, synchronous detection, FM detection, phase detection and chopper applications. The unit features carrier suppression up to −65 dB, common mode rejection of −85 dB, adjustable gain, balanced inputs and outputs and temperature operation from −55 to 125°C. Price in lots of 100 items is $4.40 each. Silicon General, Inc., 7382 Bolsa Ave., Westminster, CA 92683. **292**

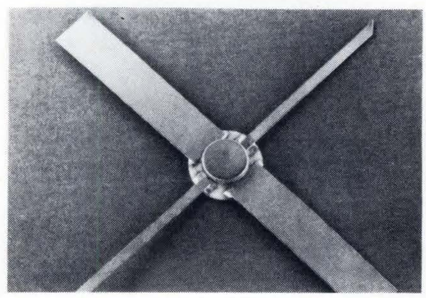


Voltage regulator LM376 provides an output voltage range from 5 to 25V, output current to 25 mA and load regulation of 1%. Series pass transistors can be added to obtain output currents as high as 10A. Packaged in an 8-pin silicone molded container for a 50% size advantage over the standard 16-pin package, price in quantities of 100 to 999 is $1.50 each. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **290**



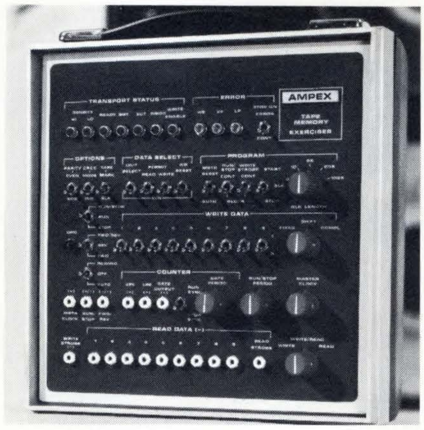
High-power red-light-emitting diodes in the MV 4 Series provide output levels of 5000 fL (at 2V, 1A). Light output wavelength (6700Å) is controlled to ±200Å, keeping it well above the sensitivity range of most photographic films. Peak currents to 25A are allowed for 1 μs at rates to 300 pulses/s. Price in lots of 100 to 999 is $9.25 each. Monsanto Electronic Special Products, 10131 Bubb Rd., Cupertino, CA 95014. **291**

MOS/LSI arrays include six new devices with access time for storage arrays of 40 ns. Units are a 512-word 2560-bit ROM ($32), a 256-word 2560-bit ROM ($32), a 256-bit 64 by 4 read/write storage array ($24) a 128-bit 64 by 2 read/write storage array ($20.50), a 1024-bit dynamic shift register ($20) and an analog switch ($13). Prices are for quantities of 100 to 999. MOS Marketing Dept. 600, Collins Radio Co., Newport Beach, CA 92663. **289**



Microwave transistor HP21 offers an f_{max} typically 12 GHz, which defines the state of the art today in commercially-available small-signal microwave transistors. Other characteristics include a gain >20 dB at 500 MHz, 3 dB at 8 GHz; power output 20 dBm (100 mW) at 4 GHz and +5 dBm at 8 GHz. Typical noise figure is 3 dB at 1 GHz and 5.5 dB at 3 GHz. In lots from 100 to 490 price is $12.50 each (chip) and $15 each (stripline). Inquiries Manager, Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **293**

Equipment



Tape drive tester, Model TDX, exercises and tests Ampex TMX and TMZ digital tape memory systems. Although priced under $1000, it fully checks out data electronics and transport capabilities. Ampex Corp., 9937 W. Jefferson Blvd., Culver City, CA 90230. **294**

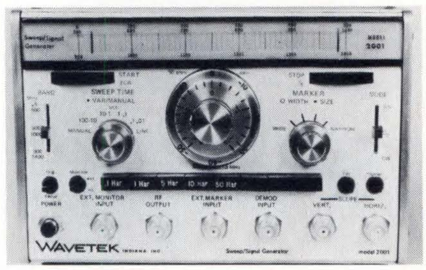
Ellipsometer, Model AME-5060, provides film thickness readings accurate within ±20Å and refractive indices within ±0.03 over the range of 20 to 2700Å. Lightweight and portable, it can be operated by production line technicians under normal ambient light conditions. Price is $4957. Applied Materials Technology, Inc., 2999 San Ysidro Way, Santa Clara, CA 95051. **295**

Frequency synthesizer, Model SY-100A, covers the 2 to 4 MHz range in 100 Hz increments with stability of better than 1 part in 10^6. Output is 1V. Tuning is normally by thumbwheel switch. Spectral purity is achieved by indirect synthesis, using a phase-locked loop and self-contained frequency standard. Price is $1975. Transcom Electronics Corp., Box 426, Skokie, IL 60076. **296**

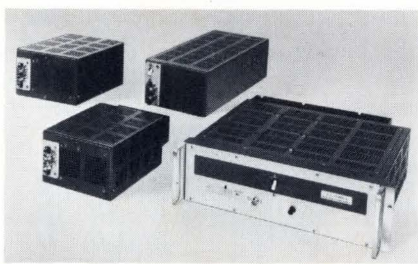
Digital multimeter measures ac and dc volts, ac and dc current and ohms with 100% over range and 3-1/2-digit display. Reading speed is 5/s and accuracy is 0.1%. The Model 1800 may be operated from either 115V ac or 12V dc. Price is $275. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, CA 94520. **302**

Logic circuit analyzer, Model 4040, does not need complex programming to verify every possible combination of the input/output logic or truth table for any logic circuit having up to 1200 independent inputs. Price is $2250. Data Test Corp., 822 Challenge Dr., Concord, CA 94520. **299**

Resolver/synchro-to-digital converter, Model 545/100, features 0.01° resolution "Nixie" readout, 0.01% accuracy, 20,000°/s tracking rate, 200,000 Sec^{-1} velocity constant and 100 ms maximum synchronization time for a 180° step-input—plus BCD output. Price is approximately $3500. North Atlantic Industries, Inc., Terminal Dr., Plainview, NY 11803. **297**



Sweep/signal generator, Model 2001, offers frequency range of 1 to 1400 MHz and may be operated in three modes; start/stop, sweeping from end to end, up or down; Δf with calibrated sweep width; and CW with a 100% duty cycle. RF output is leveled and calibrated. Price: $1695. Wavetek, 9045 Balboa Ave., San Diego, CA 92123. **300**



Power supplies of the LW Series have current ratings to 200A and voltage ranges to 48V dc in 42 models and four package sizes. Both price and space requirements have been cut nearly in half compared to conventional series regulated supplies. Regulation is generally 2%. Remote sensing is provided. Prices start at $250. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, NY 11746. **298**

Broadband optical radiometer accurately measures total radiant power in either specific wavelength intervals or over a continuous spectrum in the infrared, visible and ultraviolet. Priced at $1100, Model 8330A/8334A is direct reading and calibrated in absolute units at any wavelength. It measures irradiance, radiant flux and radiance. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. **301**

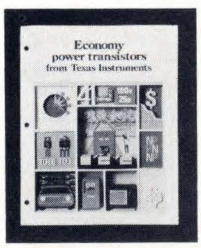
"Manual Switches" is a 64-page catalog, 51B, that contains over 300 photographs, drawings, mounting dimensions, cutaways, exploded views and schematic diagrams of 10 major categories of pushbuttons, indicators and toggle switches. This is the firm's first major revision of its manual switch catalog since 1966. Micro Switch, A Div. of Honeywell, Inc., 11 W. Spring St., Freeport, IL 61032. **325**

"Electron Tubes & Semiconductors 1971 Price List" is a 60-page catalog that covers more than 23,000 types of electron tubes and semiconductors including integrated circuits. Divided into more than 40 sections, the catalog is available from JSH Electronics, Inc., Box 2898, Dept. NR, Culver City, CA 90230. **326**

Connector products including plate and molded types are described in this connector design guide. The design and construction of components for wire wrapped plate systems is covered, and center-to-center terminal spacings of 0.05 to 0.2 in are included in this variety of standard and special configurations. National Connector Div., Fabri-Tek, Inc., 9210 Science Center Dr., Minneapolis, MN 55428. **327**

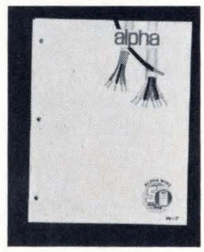
Plastic molded transistors packaged in a TO-18 base include 50 new devices added to a family that offer power dissipation of 360 mW and a junction temperature operation of 150°C. Both an interchangeability chart, as well as a complete set of data sheets are available. Sprague Electric Co., Corporate Technical Literature Section, Marshall St., North Adams, MA 01247. **328**

"Adjustment Potentiometers, Precision Potentiometers and Panel Controls" is a 20-page brochure that includes product photographs, specifications, order information and pricing for more than 100 potentiometers. Trimpot Products Div., Bourns, Inc., 1200 Columbia Ave., Riverside, CA 92507. **329**

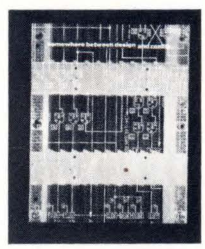


Economy power transistor brochure CB-124 contains six pages of information on an expanded line of 41 plastic-encapsulated silicon power transistors. An easy-to-read chart lists parameters for each device and arranges them by npn or pnp construction and by TO-3 to TO-66 package. A cross reference also is included. Texas Instruments, Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, TX 75222. **330**

Precision switches and typical switch assemblies are covered in Catalog 72-2. The 16 pages cover basic switches with resilient seals and glass-to-metal seals meeting categories 4 and 5 of MIL-S-8805. Also included are updated data on HSI high temperature switches for operation to 800°F. Haydon Switch & Instrument, Inc., 1500 Meriden Rd., Waterbury, CT 06720. **331**



Wire, cable and tubing products catalog contains 72 pages of descriptions. Products ranging from hook-up wire and multiconductor cable to coaxial cable and zipper tubing are included in catalog W-7. Marketing Services Dept., Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, N J 07207. **332**



Back panel connector arrays capability brochure describes a company's total packaging concept of manufacturing and servicing back panel interconnecting systems. Besides listing the many standard connector components available, back panel assemblies, laminated printed circuit boards, perforated metal plates and metal connector frame configurations also are included. Elco Corp., Willow Grove, PA 19090. **333**

Accuracy Considerations in Time-Interval Averaging

Gentlemen:
In the July 15 EDN Design Feature, "Period Averaging Locks Accuracy", Mr. Charles Ulrick described an averaging technique for measuring time intervals which greatly enhances accuracy and resolution. Time-interval averaging is also employed in Hewlett-Packard's Model 5326A/B Timer/Counter/DVM, introduced this past February. There are some differences between the HP approach and Mr. Ulrick's, and there are factors affecting accuracy that weren't discussed by Mr. Ulrick.

Assume a conventional single-shot time-interval counter as illustrated in **Fig. 1**. When such a counter measures an unknown time interval, the resolution of the measurement is equal to the period of the counted clock frequency – 0.1 μs in this case. The accuracy of the measurement, however, is limited by three major factors: (1) clock instability, (2) one-count ambiguity, (3) trigger errors in A and B channels due to noise. These three factors outweigh several smaller error factors which can be ignored with the traditional single-shot time interval technique. However, when time interval averaging is employed, the improved resolution and accuracy begins to approach these smaller error factors. At this point they can no longer be ignored. Among these error terms are: (1) unequal response times of A and B channels, (2) trigger error due to hysteresis of the Schmitt trigger.

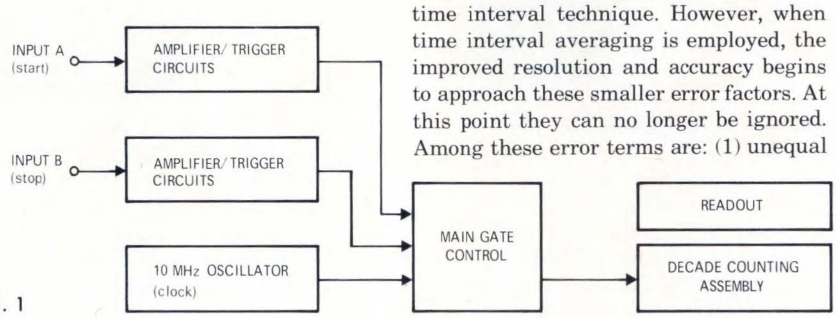


FIG. 1

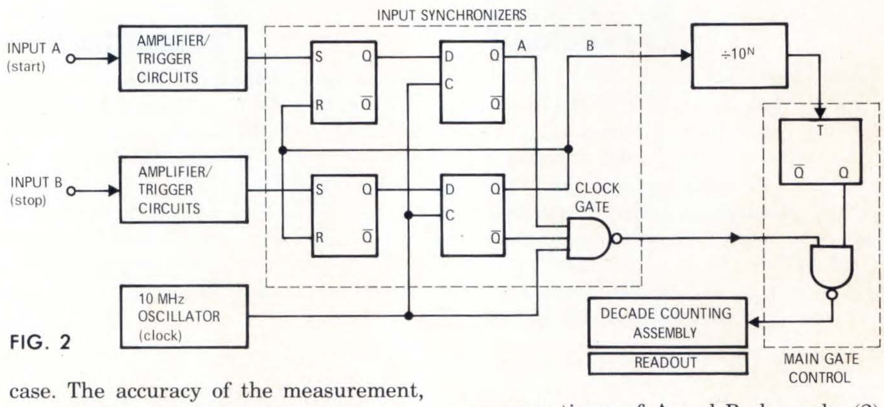


FIG. 2

Fig. 2 illustrates a counter capable of time-interval-average measurements. The differences between this counter and the traditional counter in **Fig. 1** are the divider circuits which are used to select the 10^N intervals to be averaged and the synchronizer circuits which make certain that the time-interval average will tend toward the true value. The synchronizers are the key difference from Mr. Ulrick's approach.

The strobe technique which Mr. Ulrick uses relies on accurately detecting coincidence between input and clock pulses and accumulating their number. As Mr. Ulrick pointed out, this technique has an inherent systematic error, since the strobe pulse cannot truly be an impulse, and hence true coincidence cannot be detected. In addition, the propagation delays and risetimes associated with the TTL gates used (in particular A7) also produce systematic errors. As Mr. Ulrick states, this technique yields a small percentage deviation in readings; however, he does not specify the measurement accuracy. In fact, accuracy is questionable for time intervals less than 10 ns.

The synchronizer technique makes it possible to measure averaged time intervals as short as 150 ps with a maximum repeatable resolution of 10 ps.

For a more detailed analysis, refer to these articles in the April 1970 issues of the Hewlett-Packard Journal: "Timer/Counter/DVM: A Synergistic Prodigy" and "Measuring Nanosecond Time Intervals by Averaging".

Roger A. Costa
Product Manager
Hewlett-Packard Co.

Wants Inclusion

Dear Sir:
In reference to your editorial (EDN, September 1) I take objection to your omission of the reliability engineer from the coalition of experts that is required to put forth a cooperative effort in the development of hybrid technology. As a reliability engineer who is working with the development of hybrid circuit modules, I see the reliability engineer playing a greater role in the challenge of developing reliable hybrids.

In many cases, classical statistical methodology cannot be applied as it was applied in reliability evaluation of the less expensive semiconductor components; however, one must learn how to characterize the reliability of hybrids so that proper design improvement can be made. Remember, the reliability engineer is concerned specifically with performance and failure during the entire life cycle of devices, and this therefore leads him to concern himself with the design as well as the manufacturing process.

Finally, to quote your editorial, "there is a learning curve which must be negotiated before economy and *reliability* can outstrip older technologies". I submit that the expertise of the reliability engineer is essential to the fulfillment of the goal – reliable hybrids in the 1970s.

Larry J. Gallace
RCA/Electronic Components

Advertiser's Index

Subject Index to Articles

Index to Ads, Products and Literature

Application Notes

"Design Guide to High Reliability Low-Cost Coils" includes selection charts on electrical tapes, insulating resins and heat shrinkable tubings to aid the engineer in choosing the right materials for original relay design, modification or value analysis. Dielectric Materials and Systems Div., 3M Co., 3M Center, Box 3050, St. Paul, MN 55101. **450**

"High Technology Focus" is an eight-page report that summarizes findings of two research studies. Brochure lists 109 manufacturers of 396 MODEM and multiplexer products and indicates their production of couplers, terminals, peripherals, and data communications systems. High Technology West, 1060 Crenshaw Blvd., Los Angeles, CA 90019. **453**

"To Make the Best Springs for the Worst Conditions" is the title of a new eight-page brochure giving technical data on more than 30 specialty spring alloys. Data includes recommended heat treatments, typical applications, mill limits, packaging information and a selection chart. Reader Service Dept., Techalloy Co., Inc., Rahns, PA 19426. **456**

"High Density Manual Switches" is an article reprint that contains a graph comparing the efficiency of patchboards, pinboards, matrix selector switches, shaft-type rotary switches, thumbwheel and leverwheel switches. Cherry Electrical Products Corp., Waukegan, IL 60085. **451**

"Series 54/74 Design Loading Rules" is an application note, 25636-1, that contains three tables of information on dc loading with normalized fan-out. All dc load factors are normalized with respect to a standard gate input. Sprague Electric Co., North Adams, MA 01247. **454**

"Testing and Evaluation of Servomechanisms" includes practical information on the subject. Sections cover servomechanism principles, testing, difficulties and data interpretation. Ling Electronics, 1515 S. Manchester Ave., Anaheim, CA 92803. **457**

Computing Counter Applications Library has been increased by 16 new application sheets. The Library is a collection of real-world measurements and computations made by the HP 5360A Computing Counter, an instrument which has both computing ability and precision frequency and time measurement capabilities. Inquiries Manager, Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **452**

"Synchro-To-Digital Converters: Pick the One That Fits the Job" is a four-page foldout app note that discusses two fundamental but very different methods for digitizing shaft angle information produced by synchro (or resolver) shaft transducers. Both sampling and tracking are treated. North Atlantic Industries, Inc., Terminal Dr., Plainview, NY 11803. **455**

Design advantages of machine-wound components are outlined for engineers planning use of servo motors and tachometers. The technique described permits a 1/3 reduction of motor length in comparison to standard components using conventional hand-wound stators. Magnetic Components Div., Cedar Products, Control Data Corp., 2300 Berkshire Lane N., Minneapolis, MN 55427. **458**

Reprints Available

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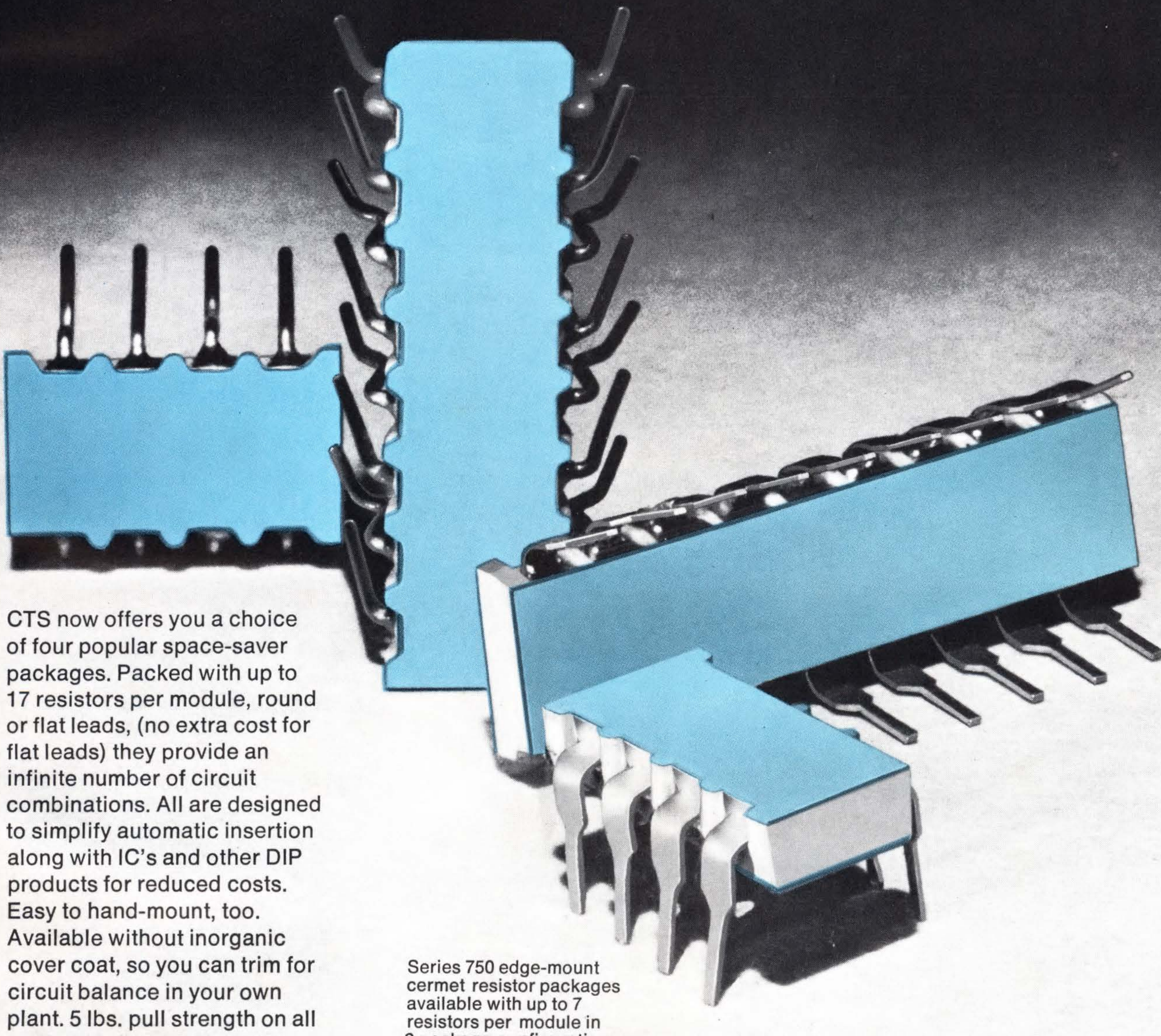

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