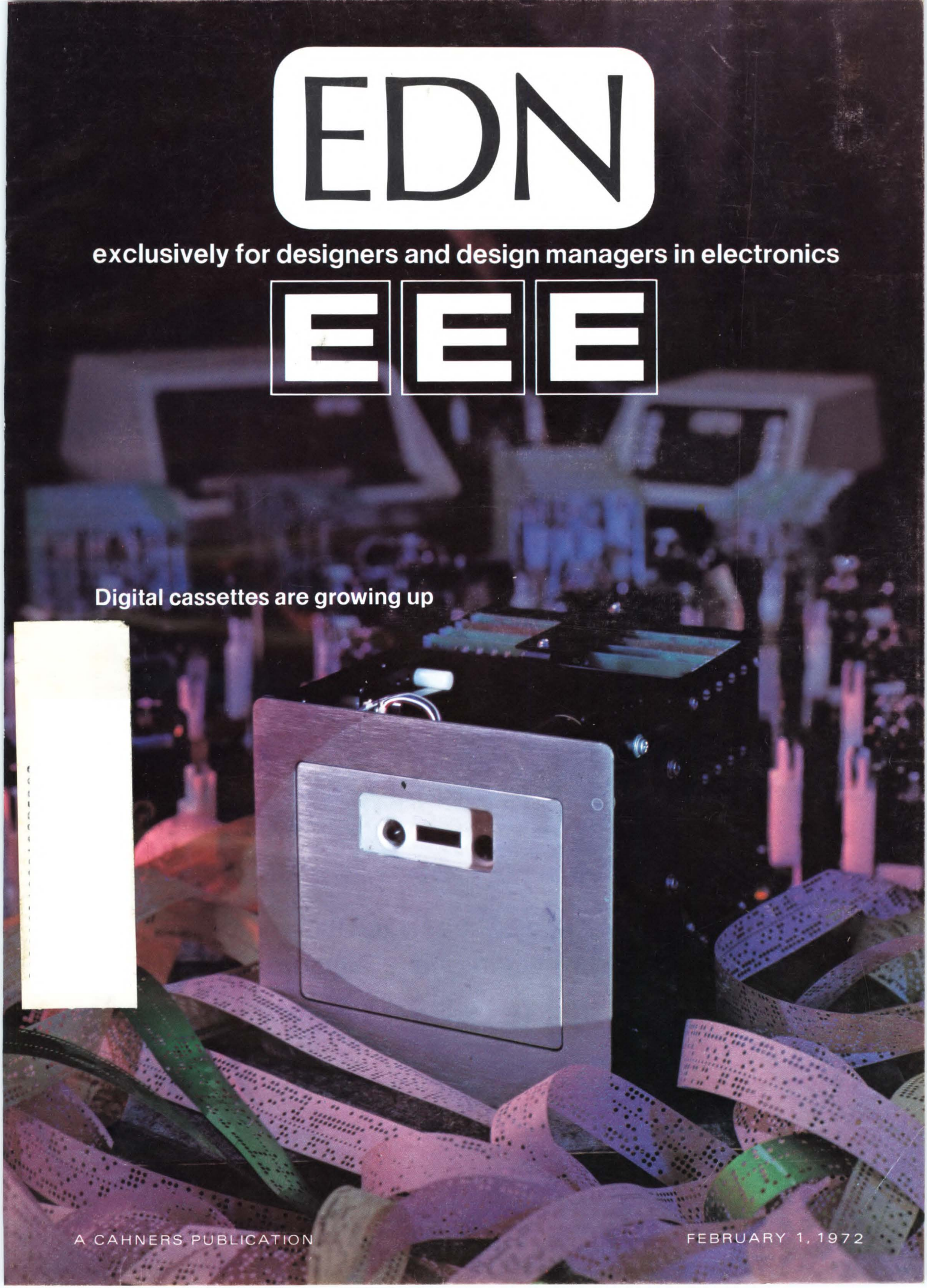
EDN

exclusively for designers and design managers in electronics

EEE

Digital cassettes are growing up



A CAHNERS PUBLICATION

FEBRUARY 1, 1972

Leave my power supply system alone!
You can get your own in only 9 days from Acopian.

"I tried struggling through that old power supply system catalog. It was like a jigsaw puzzle, hunting for the pieces I needed for my new power system. There had to be a better way.

"Then I remembered the Acopian hotline. I called it. I told them the DC voltages and currents I wanted. Discussed panel size. Meters. Switches. And other accessories.

"They gave me a firm price. Right on the phone. It was a lot less than I expected. I had our buyer phone in the P.O. And Acopian designed, built, tested and shipped it in nine days. Completely wired.

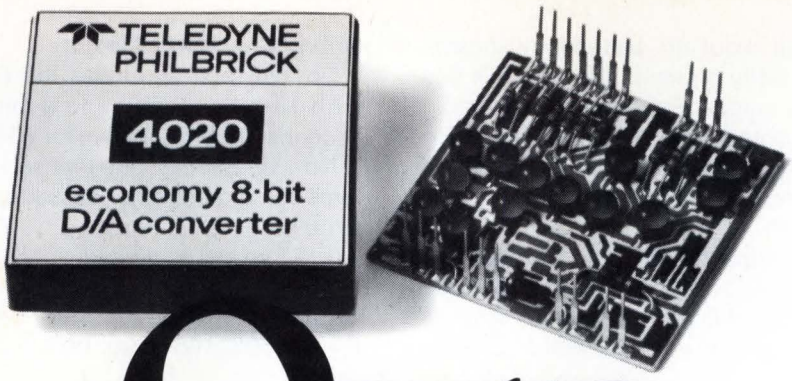
"So go order your own Acopian power system . . . It's easy!"

HOW TO ORDER ACOPIAN POWER SYSTEMS

- **Call** Acopian collect
- **Tell us** the outputs and accessories you need
- **Get** a firm price
- **Shipment** of completely wired system will be made in 9 days.

CIRCLE NO. 1

For immediate service, call the Acopian hotline: (215) 258-5441. For literature, write Acopian Corp., Easton, Pa. 18042. And remember, Acopian also offers 82,000 different DC power modules, every one shipped with this tag . . .



Ours.

A bit ahead of theirs.

Another $19 DAC? But, don't put us down until you've tried it.

Competition gives you exactly what you pay for... a $19 circuit... no more, no less. Ours is based on Philbrick's famous 4006/4007 digital to analog converters selling originally for $70 to $75.

Combined thick-film and re-flow techniques have endowed our 4020/4021 8-bit model with higher performance than you'll get from any competitive unit. Things like – linearity of $\pm 1/2$ LSB with a settling time of 25 μsec and temperature coefficient of 40 ppm/°C.

Match this with any other $19 DAC and you'll know why we say it's a bit ahead of theirs.

Looking for a 10-bit model?

Then compare our 4022/4023 $29 version with anybody's. We welcome the comparison. Evaluation samples are yours for the asking. While you're asking, request our new 1972 Product Guide.

Ask your local Philbrick representative or write, Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026. For toll-free ready data dial (800) 225-7883. In Mass., (617) 329-1600.

Philbrick Data Converters. The good ones.

CIRCLE NO. 2

The one you've talked about and waited for just came onstage. The Eye modestly presents the new EPI Cassette Transport. Totally unique. Extremely low-priced.

Our transport is as simple as it is revolutionary. Retracting idler arms draw tape out of the cassette and against a "flying" write/read head—eliminating skew, flutter and wow.

Utilizing Phase recording techniques, the EPI cassette unit features a storage capacity of 2.4 million bits.

Add to this a block modification capability with its truly remarkable price tag, and you may well be already writing your letter of inquiry.

Do. Our first coup was the EPI-118 mini-computer with 18-bit capacity and a cycle time of 900 nanoseconds. We brought it in for $5,900.

Now, an EPI cassette unit solves all the familiar problems common to other cassette drives. At last, you can write-read-verify. And modify. With absolute fidelity.

The Eye just winked again.

EPI • Electronic Processors, Incorporated, 5050 South Federal Blvd., Englewood, Colorado 80110. Phone (303) 798-9305. TWX 910-935-0874.

It's happened! A tape cassette drive that writes, reads, verifies, and modifies! All in favor say EYE!

EPI—118 Mini

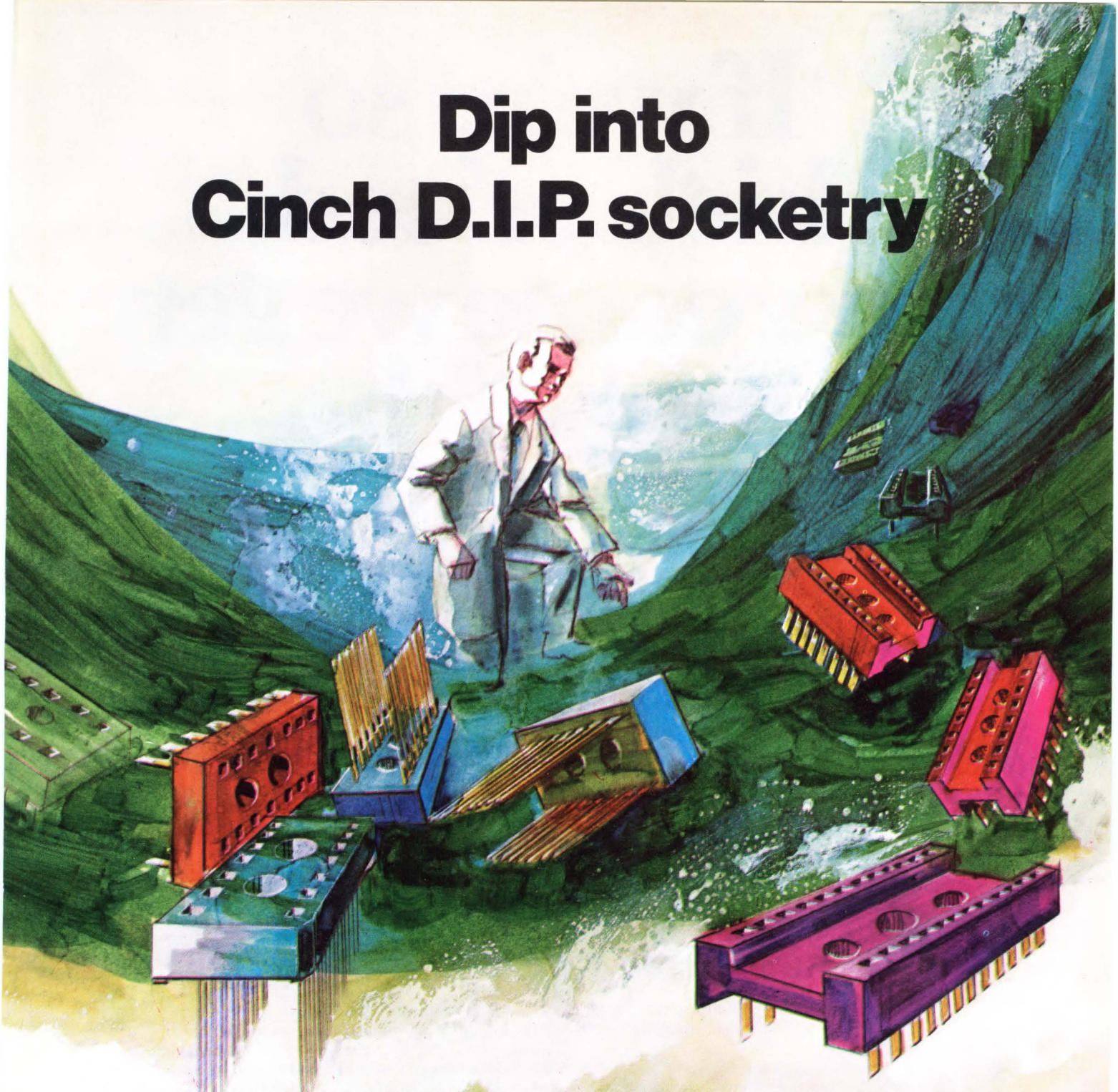
WRV™ 200 Cassette—Patents Pending

ELECTRONIC PROCESSORS INCORPORATED

A Subsidiary of the Samsonite Corporation

CIRCLE NO. 3

Dip into Cinch D.I.P. socketry



You'll find the 14, 16 or 24 pin DIP socket you need in the Cinch line. Try it . . . you'll like it!

Cinch sockets have a unique bowed pin contact that provides high contact forces but permits easy insertion and removal of the DIP. Broad contact surfaces give you maximum wiping action on two sides of the DIP terminal, be it flat, round or square.

You can choose from high performance diallyl phthalate or economical GP black phenolic mono-block insulators. The contacts are of beryllium copper for the best temperature stability, either gold or electro-tin plated.

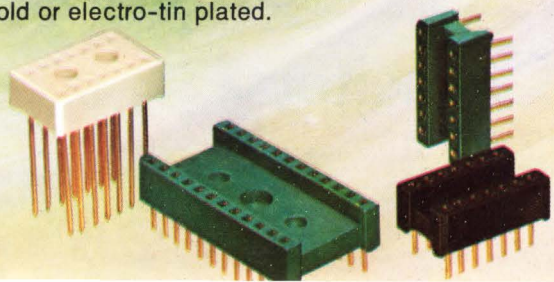
Sockets with Wire Wrap* terminals and closed entry, one-piece insulators are also available in a variety of insulations and terminal materials . . . in addition to our DIP sockets with dip solder terminals.

Many styles are available off-the-shelf from Cinch distributors nationwide.

You can find out all about these sockets from your Cinch Distributor, Cinch Sales Office or by writing to Cinch Connectors, an Operation of TRW Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800.

*Trade name Gardner-Denver

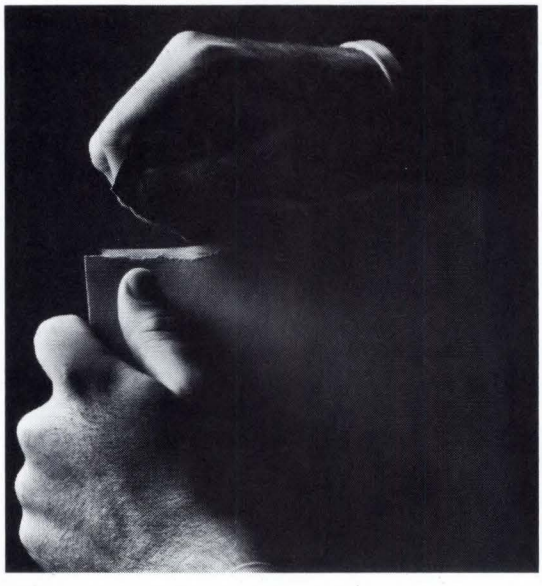
C-7202



CIRCLE NO. 4

TRW®
CINCH CONNECTORS

If we're so high priced, how come we get most of the jobs we bid on?



We're surprised now and then to hear that some people think CORNING® resistors and capacitors are high-priced.

Because they're not.

If they were, why have our customers made us the largest supplier of metal film resistors in the country—and that metal film market includes glazed resistors.

Our components are far from high-priced. For many product styles, our quantity resistor pricing is under 5¢ and often less than 3¢.

In capacitors we offer the best performance for the price from Established Reliability through industrial types, like GMV's.

And the reason is logical. In finding new ways to make our components more reliable, we've found new processes that make them less expensive, too.

We've built our reputation on extra reliability in component performance, QC, and personal service. But just because we provide quality don't assume we're not competitive.

Our technology gives us the advantage. And we can prove that when you ask us to bid.

Write for our catalog to see our full line. Then give us a try next time you're asking for bids.

We'd like to better our bid-winning record by coming through the winner for you, too.

And if you need CORNING components in the meantime—call a Corning authorized distributor for off-the-shelf delivery from an inventory in excess of 50,000,000 components.

Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830, Dept. EDN-1. Or call (607) 962-4444, Ext. 8381.

CORNING
ELECTRONICS

Resistors & Capacitors

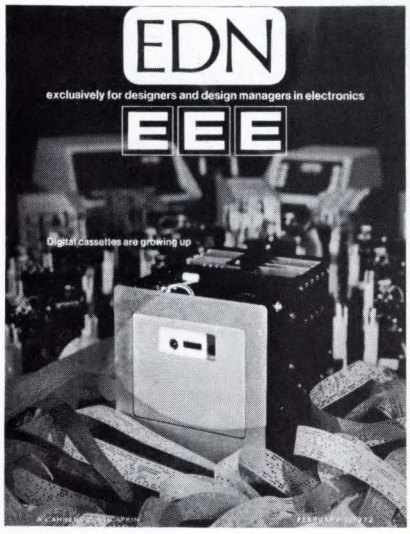
for guys who can't stand failures

CIRCLE NO. 5

FEBRUARY 1, 1972
VOLUME 17, NUMBER 3

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS



COVER.

Cover photo, courtesy of ICP, Dallas, Texas, shows digital cassette in a bed of punched paper tape it replaces. (For story, see pg. 28).

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

MCB BPA ibpa International Business Press Associates
DESIGN ELECTRONICS
ELECTRONICS WEEKLY
EDN/EEE
ELEKTRONIK
ELEKTRONIK-ZEITUNG
INTER ELECTRONIQUE
ABP

 EDN/EEE (formerly Electrical Design News) is published semi-monthly. Editorial, Advertising offices, 221 Columbus Ave., Boston, Mass. 02116 (617) 536-7780. Subscription offices, 270 St. Paul St., Denver, Colo. 80206 (303) 388-4511. Printed at 85 W. Harrison St., Chicago, Ill. 60605. Controlled circulation postage paid at Chicago, Ill. Send form 3579 to Subscription office. EDN/EEE is circulated to electronic design engineers and engineering managers in electronic OEM industries. Plants having more than twenty employees and manufacturing electronically operated or controlled equipment of their own design are considered part of this industry. Engineers in such plants responsible for specification of components, materials and test equipment for electronic application may receive EDN/EEE without charge. Completed qualification form and company letterhead required. Subscriptions to others in continental United States, $2 per copy. $20 per year. Send requests for qualification forms and changes of address to subscription office in Denver, Colo.

Everybody wants your components business.

But we're doing 6 things to earn it.

1 Extra reliability. We build extra reliability into our components to let you build extra reliability into your systems. We offer documented reliability from ER through industrial, from precision through general purpose.

2 Pricing you'll like. For many product styles, our quantity resistor pricing is under 5c and often less than 3c. And that's for metal film resistors (including glazed resistors) that significantly outperform other metal films, wirewounds and carbon comps.

3 Faster delivery. Our distributors can give you off-the-shelf delivery from an inventory of over 50,000,000 components. And our "ball parks" are firm, real and reliable. This lets you keep expediting and inventory levels to a minimum.

4 Production savings. Our unique product configurations greatly simplify both hand insertion and automatic insertion operations. This saves you money. And our QC is so stringent, many of our customers have totally eliminated their incoming QC testing of our parts. This saves them money.

5 Product innovations. Like our new CORDIP™ Component Networks. With up to 23 discrete resistors/capacitors/diodes in a miniature, pre-tested, plug-in package to save you time, money, and a whole lot of board space.

6 Sharper support. We've hand-picked the 30 most competent distributors in the country and built the industry's largest technically trained field force—then backed everything with a full team of specialists—to give you all the in-depth service you want and then some.

We too want your business. But we're doing 6 extra things to earn it.

Give us a chance to prove it. Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830. Or call: (607) 962-4444, Extension 8381.

CORNING
ELECTRONICS

Resistors & Capacitors

for guys who can't stand failures

CIRCLE NO. 6

a pocketful of solutions for your measurement problems

Now there's a 3-pound scope that can be carried in your tool kit, suitcase, briefcase, coat pocket, glove compartment . . . almost anywhere.

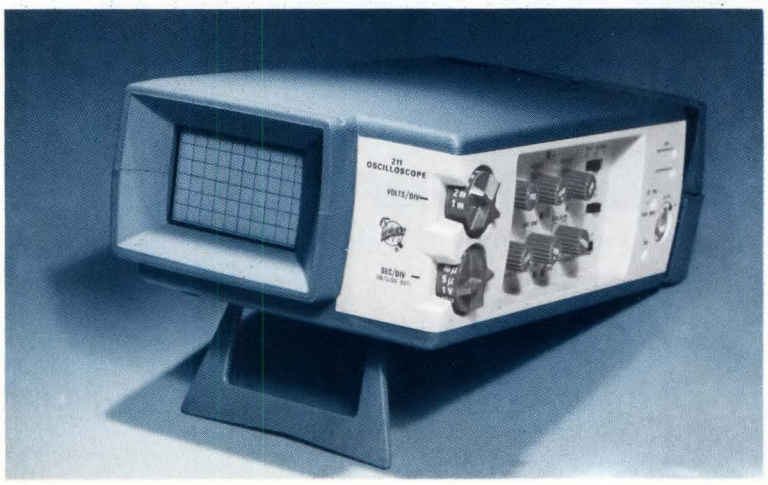
It's the **211,** our first laboratory-quality mini-scope. Size is only 3 x 5¼ x 9 inches. Bandwidth is 500 kHz. A lot of scope in a small package.

The **211** is easy to use. You spend your time solving measurement problems, not studying scope operation. Deflection factors from 1 mV/div and sweep rates from 5 μs/div are read out from controls easily related directly to the CRT. One rotary control does all the triggering.

Ever wanted to float a scope? Here's one that floats to 500 volts RMS when operated from its internal batteries.

How many times have you misplaced a probe or power cord? There's no chance of that with the **211.** The probe and cord are attached and stored in a convenient, recessed area of the case. When you arrive on the job, both are right there, where you can find them.

And the **211** is built to take rugged trips. The double insulated high-impact plastic case takes tool kit knocks and bangs. Knobs are recessed for added protection. It's packaged in a real survival kit.



Need battery operation? The **211** operates from internal rechargeable batteries for up to 5 hours, and from AC.

Price? It's lower than many other 500-kHz scopes. Only $545, FOB Beaverton, Oregon.

For a demo, just contact your local TEKTRONIX Field Engineer. He probably has a **211** in his briefcase. Ask him for complete information or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

TEKTRONIX®

CIRCLE NO. 7

Editorial

What is it that we're trying to do?

It was pointed out to me recently—twice, in fact, within the past week—that since assuming the editorial reins at EDN/EEE I have never detailed for the readership our editorial philosophy.

This is true, of course, and for a very good reason. Specifically, I don't see any overriding necessity for telling people what already is, or soon will be, apparent to them. Put bluntly, it's what a magazine does that counts, and not what it says it's going to do.

This personal feeling notwithstanding, here, for those interested in the verbalizing of such things, is the philosophy that underlies all of our editorial actions at EDN/EEE.

First, and foremost, the reader is the key element in everything we do. All gathering, selecting, editing and writing is for the reader. We don't prepare or style editorial material to impress advertisers or other editors, or to show how smart we are.

Our reader, of course, is the design engineer and the engineering manager. However, instead of catering to all of his interests, we limit ourselves almost exclusively to material that he can put to practical use on the job. Material that aids him in carrying out his design function.

We realize that the engineer is busy, usually working against tough deadlines and frequently on more than one project at a time. And he has more reading material at his disposal than he could ever hope to read thoroughly. With all of this competition, we have to make our material not just technically useful, but easy to read and understand as well as esthetically attractive if it is to be read.

Also fundamental to our editorial philosophy are those two very overworked words: honesty and integrity. In other words, our pages exclusively reflect what we think is right and beneficial for our readers. We try to make our editorial coverage of any subject complete and objective and do not avoid controversial topics. By the same token, though, we do not believe in muckraking, and will never inject controversy into material just for the sake of sensationalism. We may goof on occasion, and not everyone will like or agree with everything we publish. But we feel that our motives are unassailable.

So there it is—a capsule rundown on our editorial philosophy. That's the last you'll hear of it, I promise. From now on we'll just implement it.

Frank Egan

Editor

STAFF

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E. Patrick Wiesner

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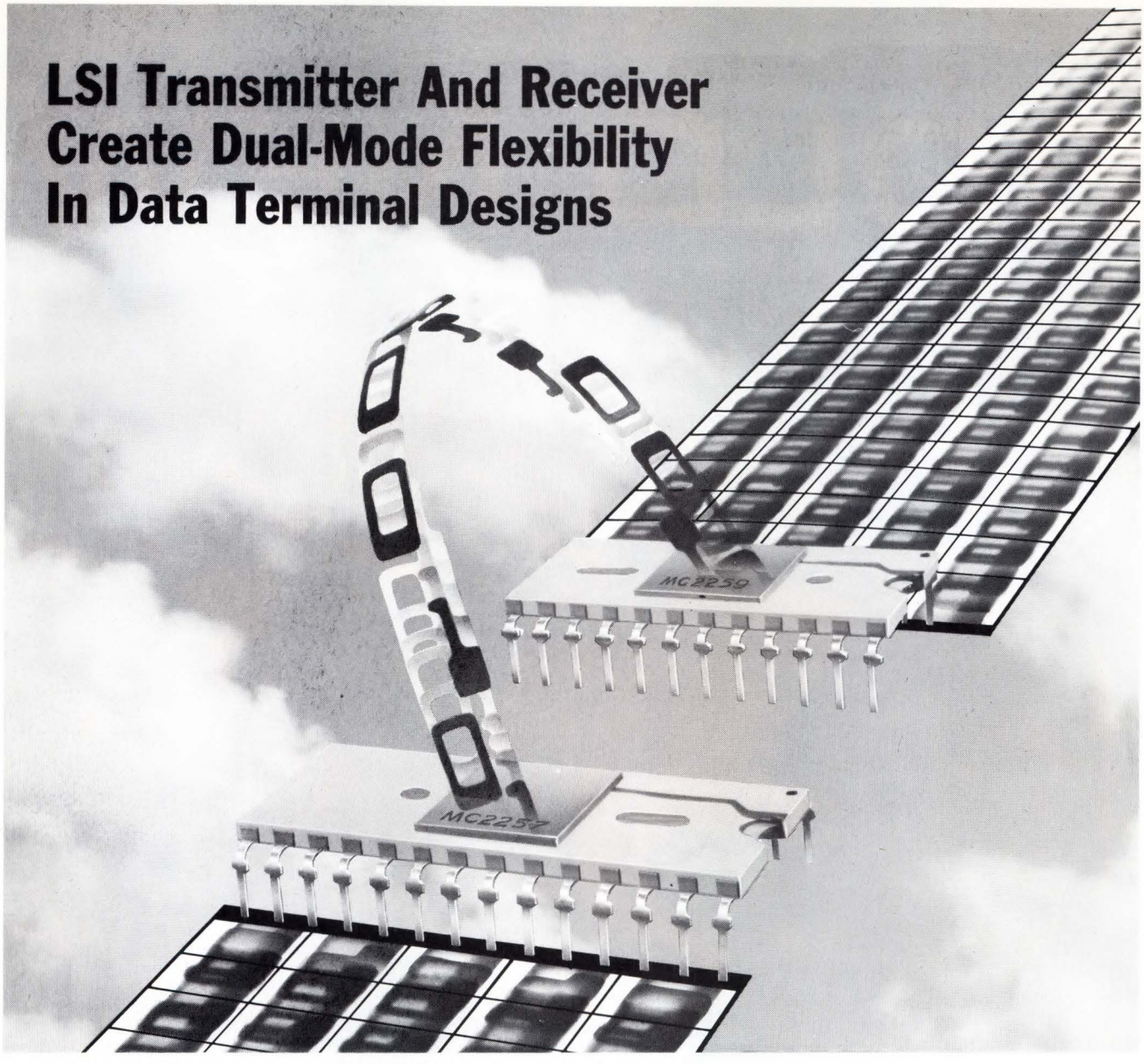
LSI Transmitter And Receiver Create Dual-Mode Flexibility In Data Terminal Designs



A different, and improved, approach to the terminal transmitter and receiver functions in data communications systems is available now in Motorola's new MOS LSI MC2257 and MC2259. They operate in both asynchronous and synchronous modes to provide a new dimension of flexibility. Compared to present bipolar designs they make big reductions in package count and space requirements. When the receive-only function is required there is no need to buy and waste half the unit. And both parts are compatible with TTL circuitry.

These exciting innovations are designed to serve the requirements of the ubiquitous communications input-output section of data communications systems. Use them in alphanumeric CRTs, serial printers, teletypes, various types of remote terminals, factory data collection terminals, concentrators and multiplexers, and mini-computers.

MC2257, the transmitter, takes parallel binary data in the form of characters and transmits them serially. Internally generated parity (odd or even), when applicable, and control bits (a start bit and one or two stop bits) for the asynchronous mode are transmitted with the characters. It displaces up to 30 bipolar packages.

The receiver, MC2259, accepts serial data, organizes the bits into fixed word lengths corresponding to characters and transfers them to a buffer register where the characters are accessed in a parallel format. Provision of a wired-OR configuration on all outputs is a feature it shares with the MC2257. On-chip synchronization of the clock to data is provided for both synchronous and asynchronous operation. An over-run signal is generated to denote a lost character, and an error is indicated when received parity differs from the externally selectable parity. This part eliminates some 41 bipolar units.

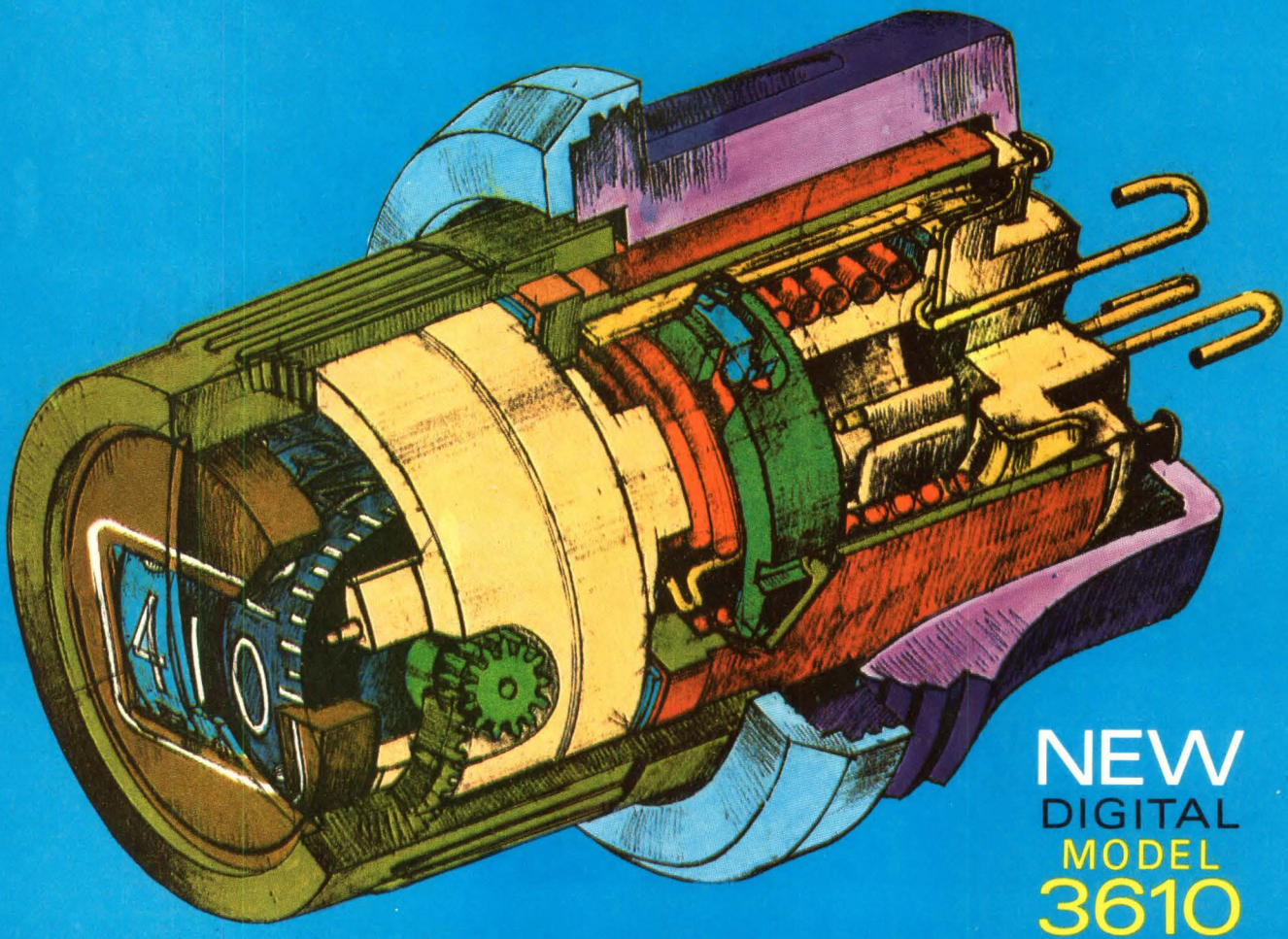
Both packages are dual in-line ceramic, 24 pin for the MC2257 and 28 pin for the MC2259. The low pricing is remarkable at $13.60 for the MC2257 and $18.60 for the MC2259. Learn more about this unique pair of data communications adapters by writing to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036. Or just go right out and buy a get acquainted quantity from your Motorola distributor now.

MOTOROLA MOS

—the broad line is our specialty!

CIRCLE NO. 9

BOURNS
BOLD NEW



NEW
DIGITAL
MODEL
3610

KNOBPOT®
POTENTIOMETER

FACTORY-PHASED TO ±0.5% ACCURACY ...

...AT LESS COST* THAN MOST SEPARATE
DIAL/POTENTIOMETER COMBINATIONS

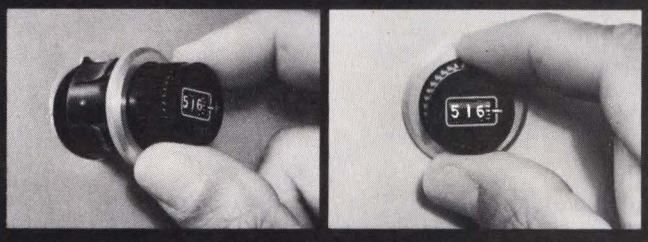
*SAVES HIDDEN COSTS OF PHASING AND INSTALLATION TIME NOT REFLECTED IN COMPETITIVE PRICES.

CONCEPT!

A DIAL AND POTENTIOMETER IN A SINGLE INTEGRAL UNIT—

. . . AT NEW REDUCED PRICES!

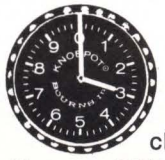
NO DIALS TO ASSEMBLE!



Unlike SEPARATE Digital dial and potentiometer combinations . . . the dial and pot are INTEGRAL IN ONE, ⅞" DIAMETER UNIT. No screws, nuts, or bushing to mess with . . . JUST SNAP UNIT INTO PANEL AND CONNECT TERMINALS.

NO PHASING REQUIRED

Model 3610 is prephased at the factory to a GUARANTEED ACCURACY OF ±0.5% BETWEEN ELECTRICAL OUTPUT AND DIAL (This is equivalent to BETTER THAN 0.5% terminal base linearity).



IF YOU PREFER A CLOCKFACE READOUT . .

. . . ask about the Model 3600; clockface brother of the Model 3610. Also an INTEGRAL DIAL/POTENTIOMETER, it's only ¾ inches in diameter and *PRICED EVEN LOWER THAN MOST SEPARATE DIAL/POTENTIOMETER COMBINATIONS.*

COMPARE PRICES . . .

With the labor-savings factored-in, Models 3610 and 3600 cost *less* than separate dial and potentiometer combinations.

Model 3610	Model 3600
$15.30*	$14.42*

*500-999 quantity price; U.S. dollars, F.O.B., U.S.A.

⅞" DIAMETER	¾" DIAMETER
TEN-TURN	

NOW CHECK THE SPECS!

ACCURACY: ±0.5% (Maximum error between electrical output and dial reading.)

REPEATABILITY: 0.1%

POWER RATING: 1.5 watts

RESISTANCE RANGE: 100 to 250,000 ohms

RESISTANCE TOLERANCE: ±5%

TEMPERATURE COEFFICIENT OF RESISTANCE WIRE: 20ppm/°C

TEMPERATURE RANGE

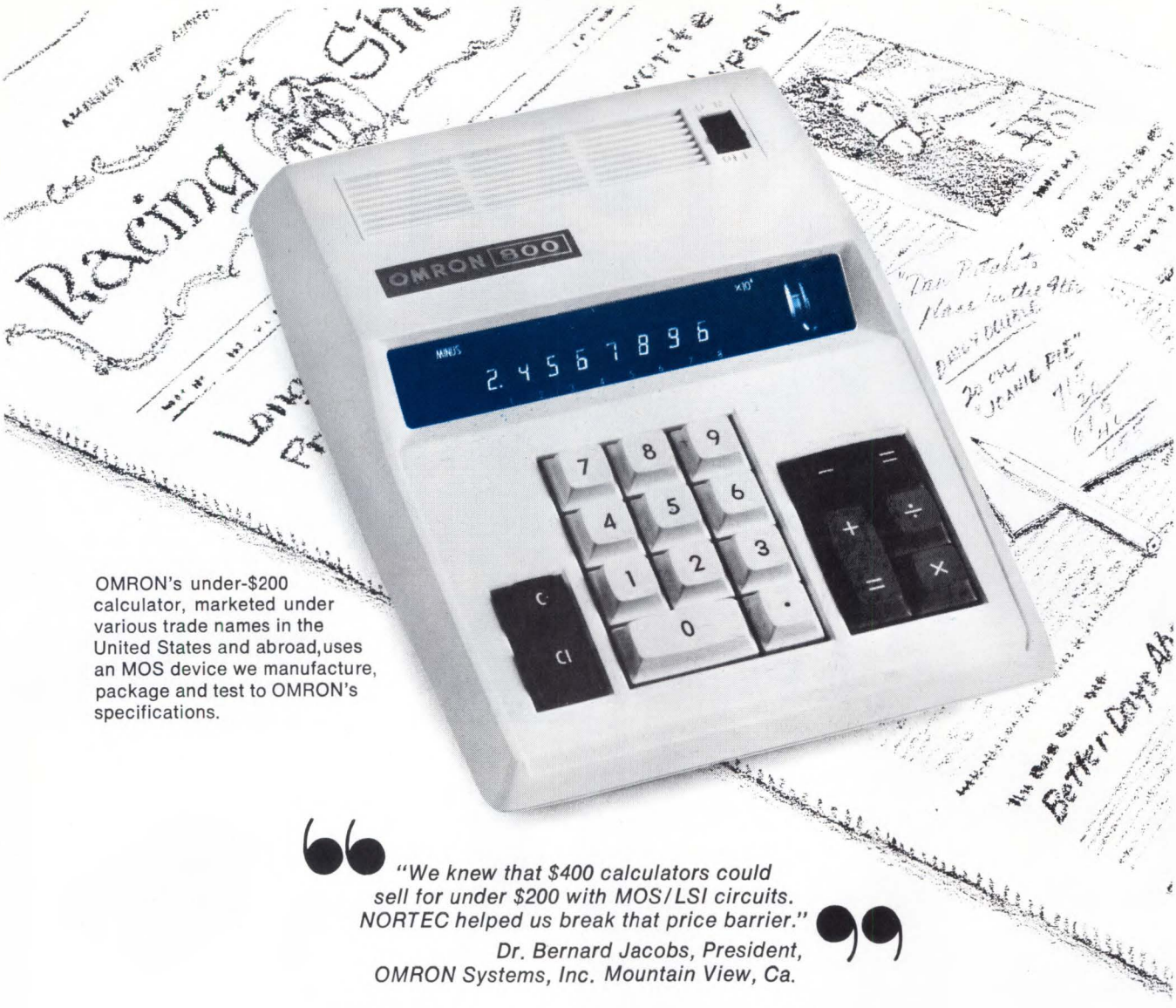
Model 3610	Model 3600
−25 to +85°C	−65 to +85°C

For details, contact your local Bourns Distributor, Representative, or Bourns Sales Office.

BOURNS INC.

CIRCLE NO. 10

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507



OMRON's under-$200 calculator, marketed under various trade names in the United States and abroad, uses an MOS device we manufacture, package and test to OMRON's specifications.

"We knew that $400 calculators could sell for under $200 with MOS/LSI circuits. NORTEC helped us break that price barrier."

Dr. Bernard Jacobs, President, OMRON Systems, Inc. Mountain View, Ca.

NORTEC Electronics is in business to make winners of our customers. We're designing and building parts for bill changers, computers, entertainment consoles, panel meters, and communications blackboxes. The only way we'll make it big in MOS/LSI is by helping our customers make it big. Try us for design, prototypes, or production. Send in the bingo card or call (408) 732-2204.

NORTEC MOS AT WORK.

NORTEC ELECTRONICS CORPORATION

3697 Tahoe Way, Santa Clara, Ca. 95051 • Tel. (408) 732-2204 • Telex 348-359

CIRCLE NO. 11

series 1400

illuminated push button controls

a versatile concept that gives you flexibility in designing interrelated switching combinations . . . plus prototypes in 72 hours

Momentary . . . push/push . . . reciprocal release . . . master release . . . interlock . . . one assembly does the job of several.

Mount vertically or horizontally. Up to 20 stations on a single frame. Contacts are DPDT, 2 amps, 250 VAC. Single series 1400 push buttons and indicator lights to match.

For details, or to order a custom 72-hour prototype, write or call:

LEDEX the total technology people

LEDEX INC.
123 Webster Street
Dayton, Ohio 45401
(513) 224-9891

POSITIONING SWITCHING MICROELECTRONICS

CIRCLE NO. 12

NEW 140° FIELD OF VIEW.
The presence or absence of light is easily detected through a full, 140° viewing angle . . . on/off condition can readily be determined from an "off-axis" viewing angle.

NEW DIFFUSING LENS.
Makes the MLED55 appear as a large area light source emitting from the entire lens surface. The emitter appears much larger than the actual chip size and is more easily seen from a distance.

NEW LONG LEADS.
Nearly 7/16"-long leads and a visible difference between anode and cathode make the MLED55 easy to work with and easy to install . . . without polarity error.

HIGH LUMINOUS INTENSITY.
The MLED55 shines at 0.6 millicandellas at a drive current of only 20 mA. Applicable to both diffusing lens and point source light emitting devices, axial luminous intensity in millicandellas is a more explicit and translatable LED visibility measurement.

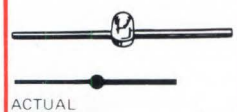
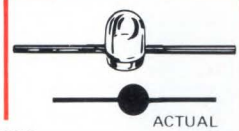
TURN ON THE REDS

VOLUME AVAILABILITY.
High-speed, low-cost stripline fabrication techniques originally pioneered by Motorola for the plastic transistor have been adapted to MLED55 production. There's immediate availability from your Motorola distributor . . . in our factory warehouse . . . for your prototype/production needs.

LOW FORWARD VOLTAGE.
Low V_F in the "on" condition means the MLED55 is compatible with typical IC voltage and current outputs. No separate power supply is needed.

RELIABILITY.
No filaments to burn out, no parts to shake loose. Operated under forward voltage conditions only so current-steering circuit conditions are realized, the MLED55 has a life expectancy in excess of 100,000 hours.

LOW COST.
Just 57¢ for 100-up quantities of the MLED55 puts solid-state LEDs in reach of designers of circuit/status indicators, fault indicators in systems requiring frequent trouble-shooting, on-off indicators for small, hand-held instruments and linear or large matrix displays.

LIGHT EMITTING DIODES	 ACTUAL SIZE PLASTIC	 ACTUAL SIZE	 ACTUAL SIZE HERMETICALLY SEALED	 ACTUAL SIZE	 ACTUAL SIZE
Visible Red 660 nM	LED / Axial Luminous Intensity MLED50 1.0 mcd @ 20 mA MLED55 0.6 mcd @ 20 mA	LED / Brightness MLED600 1100 fl @ 50 mA	LED / Brightness MLED610 1100 fl @ 50 mA	LED / Brightness MLED630 1100 fl @ 50 mA	
Infra Red 900 nM	LED / Power Output MLED60 550 μW @ 50 mA MLED90 350 μW @ 50 mA	LED / Power Output MLED900 550 μW @ 50 mA	LED / Power Output MLED910 150 μW @ 50 mA		LED / Power Output MLED930 650 μW @ 100 mA

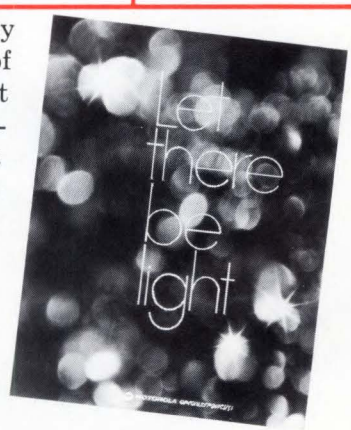
A LED for every application!
Volume-availability on every LED!

. . . an unbeatable combination to fill today's exploding application needs for red and infrared light-emitting diodes in instruments, computers, peripherals, industrial controls, optical communications and entertainment equipment.

And a variety of packaging techniques makes it easy to choose a just-right LED for your design, too: tiny, hermetically-sealed "pill" packages, — large, bright REDHEADS* in the industry-standard, TO-18 — economical, plastic Mini-T* cases.

Motorola has a full complement of photodiodes, phototransistors, photo Darlingtons and PIN diodes to match its capability in LEDs. All available for your needs from distributor or factory.

Write on your company letterhead for a copy of our new, updated Let There Be Light brochure . . . full of specs and applications to turn you on to the world of optoelectronics. Send for it: Box 20912, Phoenix, AZ 85036!



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CIRCLE NO. 13

cmos is important to your immediate future

It's going to change your product . . . your profitability . . . even your warranty. And if you're going to be in-business in the '70's . . . you're going to be in CMOS. So, stay ahead on this fast-paced technology . . . get the facts through our technical newsletter that covers CMOS and our wide range of both high and low threshold voltage PMOS circuits including RAMS, ROMS, standard low shift registers, D/A converters and character generators.

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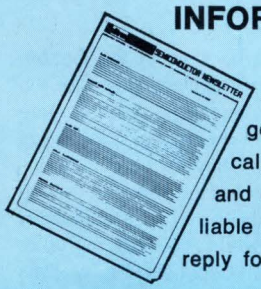

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CIRCLE NO. 14

Mini power supply put on PC backplane

Data General Corp., the successful minicomputer maker of Southboro, Mass., has gone one step further in its use of printed-circuit tooling to cut minicomputer prices. Data General has incorporated the mini's power supplies on the backpanel board.

"It's the logical evolutionary step," the company's spokesman, Lawrence Seligman told EDN/EEE. "We've just shipped our two-thousandth "Nova," so we are pretty confident that we will be shipping thousands of this third-generation design. Our success is tied to being able to give the most computer for the least money. If we want to keep our leadership position, we've got to keep offering more for less in each new model. From our beginning, we've gone to big-board packaging that eliminated the expense of interconnections. This included a printed-wiring backplane. Now we've invested in the design and tooling effort to merge the power-supply wiring with the backplane, further cutting down expensive interconnections."

"An all-inclusive PC backplane like this allows your factory people to put a more reliable mini together right the first time," Seligman said. "It replaces a maze of wires strung individually with interconnections that are safely frozen in PC artwork and joints that are made simultaneously in one pass through a flow-soldering machine. From the design standpoint, it allows us to carry power to all the system boards with short leads. This lowers noise pickup and enhances the effectiveness of the filter capacitors.

Easy With One-Board Subsystems

"It wasn't as difficult as one would think, freezing all this wire onto a single large PC board," Seligman said. "We had already pretty well gathered up all our random type interconnections onto the large 15-inch boards that plug into the backplane. We'd put our processor on a single board and all the memories and I/O units on their own self-sufficient boards (Data General has crammed up to 8k-words of core memory onto a single board). So we already had a highly standardized backpanel and had committed that to printed wiring on previous designs (Data General uses two-sided boards exclusively). As proof of the standardization we had achieved at this level, you can plug any of our boards into any slot. Further, we had been using efficient (about 85 percent) switching type regulators, so our power supplies were compact and ran cool."

Additional Benefits

The PC backplane benefits the customer too, according to Data General. The wiring patterns are brought out to printed-circuit connector fingers at the top and side edges of the backplane board. These allow the customer to plug his control consoles, peripheral equipment (such as Teletypes) and I/O channels directly into the Nova backplane with inexpensive PC edge-card connectors.

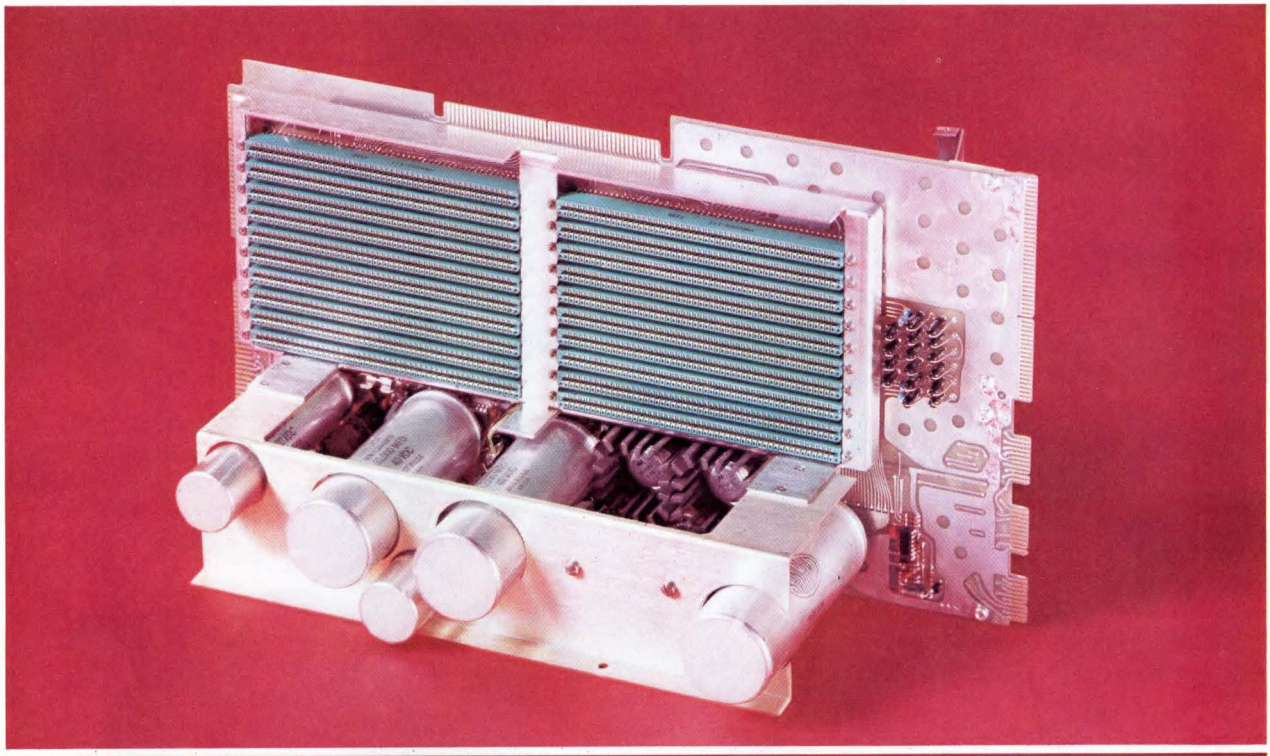
Further customer benefits from the PC backplane concept result from the ease with which minis can be tailored to individual needs. With this highly-modular packaging approach, all the subsystems run through the factory as "standards." Then, just before shipment, custom units are made up by plugging the customer-specified memory and I/O boards into the universal backplane.

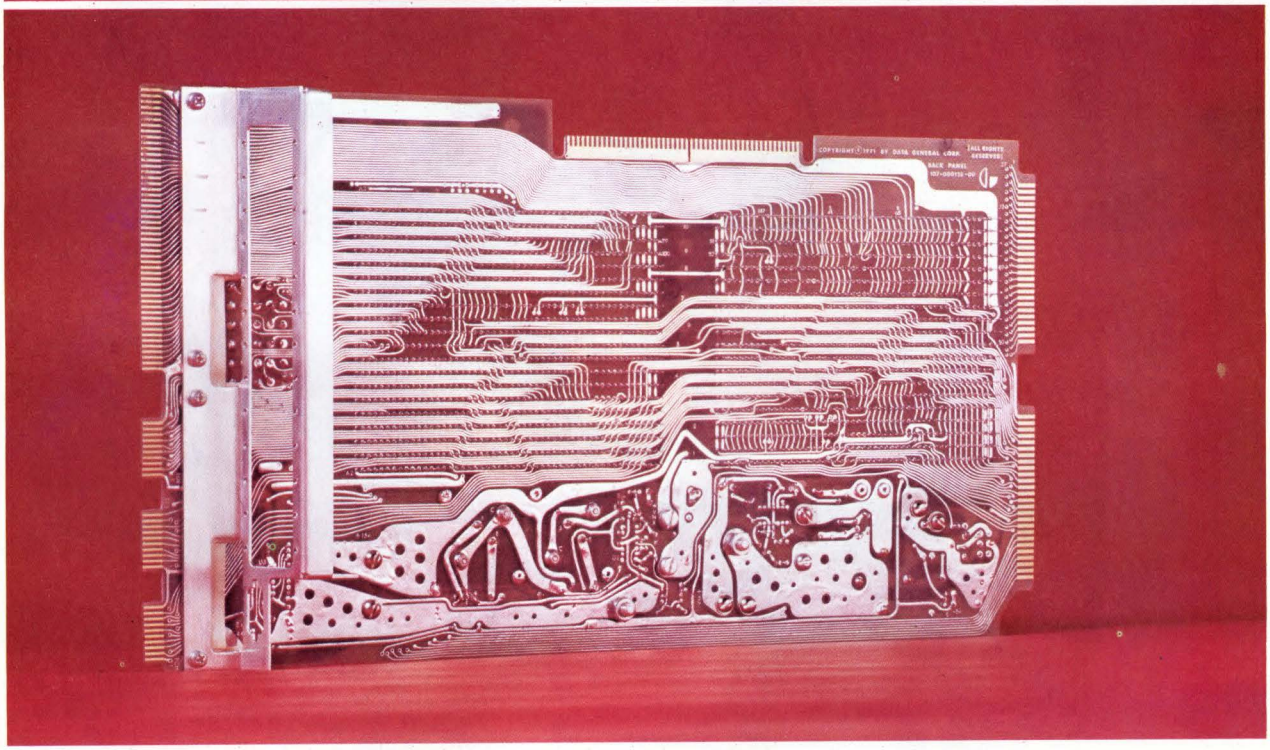
Data General apparently gains some extra protection for their new design by having a larger percentage of the system architecture copyrightable as printed circuit "artwork". They copyright all their board patterns, just as an artist copyrights his drawings. This gives them immediate protection when they "publish" (i.e. sell their computer) and they can wait to see if any patents will be granted. This copyrighting as artwork would presumably be difficult, if not impossible, to do with point-to-point wiring. As viewed by the company, the mechanical packaging scheme they used on the Nova line is simple, reliable and economical. It yields very low parts counts, and makes for extremely easy maintenance. Because subsystems are built as single, modular units, and because the total number of subsystems is small, it is easy to isolate a fault to a subsystem. It is then quite simple, because of the system's modular design, to temporarily replace the suspect subsystem for servicing. Meanwhile, the computer can continue to run, using a spare.

What will Data General's next evolutionary step along these lines be? Seligman doesn't know, but he guesses that some day the processor will join the power supply on the back panel. "We ship one of our standard processor boards along with each computer, just like the power supply, so why not incorporate the processor, too, on the back panel."

Front side of large back panel PC (top photo) shows how the rows of dual-card-edge connectors and power supply components all mount on one board. Note how aluminum structural members have been added to take the thrust of board insertion into the PC connectors and the weight of the heavier power supply components.

Back side of the back panel PC (bottom photo) carries the irregular patterns of the power supply wiring below and the more regular patterns of the system back panel bussing above. Note how the horizontal wiring fans out to connector fingers at the top and side where this panel itself is plugged into the outside world. The lettering up in the corner says: "Copyright 71 by Data General Corp." This is one way of protecting your system architecture.





Think Twice:

The "hidden costs" on your next oscilloscopes may be thousands of dollars. Here's why...

Oscilloscopes today give you more measurement capability per dollar than ever before. Higher frequency ranges, all-solid-state reliability, storage capability, and battery operation—all in smaller, lighter packages than you'd have believed possible only a few years ago.

But, while the purchase price of a scope today is lower, in relation to its capabilities, *hidden* costs—like the costs of use, maintenance, and calibration—are proportionately higher. (Professional and skilled-labor costs have risen by more than 50% in the last 10 years.) Over five years of use, factors like these can bring *total acquisition cost* up to more than double the original purchase price. On a purchase of a dozen scopes, the *hidden* costs can be well in excess of $20,000.

Why do we point this out? Because, unless you consider *hidden* costs, you can easily fall into the trap of just choosing a scope on the basis of familiarity with previous models of "the other scope"—figuring that there will be less difficulty and expense if you stay with the same make.

The trouble is, that's just not true, anymore. *Any* scope you buy today—whether ours or theirs—is going to be so different from their older models that you'll be faced with the same *hidden* costs. No matter which way you go, your people will have to learn new controls and test procedures, and you'll have to buy new plug-ins and stock new parts. But if you choose HP, we'll provide you with aids like seminars and training video tapes, to help *minimize* these costs.

Thus, it's crucial for you to compare *both* major manufacturers' offerings before you commit yourself. Protect yourself from making a decision that may later turn out to be costly. Get the facts on every aspect of each available alternative. If you have the facts, nobody will be able to challenge your decision... wheras, if you don't, they *could.*

Prices—at least ours—begin as low as $1680 for portable scopes that let you trouble-shoot the latest digital circuitry, and as low as $1750 for lab scopes that give you full plug-in flexibility.

Check before you choose. For a revealing package of information on H-P scopes, send for a free copy of our "No-Nonsense Guide to Oscilloscope Selection." Or, contact your local H-P field engineer for a demonstration. Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes Are Changing; Think Twice.

082/3

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

CIRCLE NO. 15

Hand-sized scientific calculator packs a big wallop in only 9 ounces

Newly offered by Hewlett-Packard, a tiny but powerful new electronic pocket calculator has many of the capabilities of large desk-type units. The Model 35 measures only 3 by 6 by 1 inch and weighs just 9 ounces, complete with self-contained nickel-cadmium batteries.

Most miniature calculators are of the "4 capability" class: that is, they do only addition, subtraction, multiplication and division. Not this one! It performs all trigonometric and logarithmic functions, square root, the four usual functions and several others. And its price of $395 is considerably less than what you'd expect to pay for such capability in an American-made device.

Readout is by light-emitting-diode display that can show numbers having up to 10 digits, plus two-digit exponents and appropriate signs. Particularly important to a user is the fact that decimal point placement is automatic. Also there is automatic scientific notation for very large or very small numbers. Trailing zeroes are blanked to make the display easier to read.

The Model 35 has an "operational stack" of four registers, plus a data storage register for constants. The stack holds intermediate answers and, at the appropriate time, automatically brings them back for further use. This eliminates the need for scratch notes or the re-entry of intermediate answers when performing chains of calculations such as sums of products or products of sums.

A comfortable handful, the H-P Model 35 pocket calculator can be used virtually anywhere there is a need for calculations.

Pocket answer machine packs big-unit capability into a compact 3 by 6 by 1 inch, 9-ounce, battery-powered format. Functions are performed with a single key stroke, thanks to the operational stack of four registers. The unit's 10-digit LED readout display is bright and clear.

Like larger, more expensive, calculators the new one is accurate to 10 significant digits and has the ability to handle numbers as small as 1×10^{-99} or as large as $9.999999999 \times 10^{99}$.

When he introduced the new calculator, H-P's president, Mr. William R. Hewlett, commented on its potential for changing the present patterns of calculator usage. He pointed out that until now most intricate calculations have been handled at laboratories or offices because the large calculators had to be based there. Now these same tasks readily can be done on the spot—in the field, in meetings, at home or while traveling.

An interesting variation from H-P tradition is that the new calculator will be marketed primarily by direct mail. Service, if ever necessary, will be done at the factory on a one- or two-day turnaround basis. Operation can be from 120 or 240V ac lines, or for up to 5 hours from the integral nickel-cadmium batteries. It will also operate from the line while the batteries are charging.

As miniaturized as it is, the Model 35 doesn't lack such touches as an indication that batteries are low, a warning that an "improper" calculation has been attempted and an overflow indication.

Included in the $395 price, in addition to the calculator, are a sturdy travel case, a soft leather personal carrying case, a battery pack, an ac adapter and battery recharger, foil name tags and an instruction manual.

All in all, its mighty easy to want your own after you've seen and used this latest addition to H-P's calculator line.

(For more information Circle No. 300)

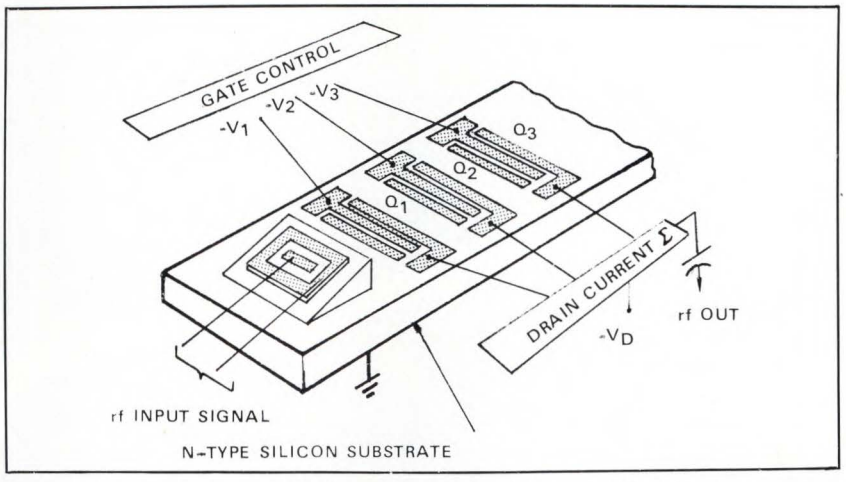
Surface-wave detectors hold promise of fully programmable filters

The forerunner of what may eventually lead to fully-programmable surface-wave filters has been developed at the Advanced Technology Lab. of Texas Instruments. Device operation is based on the piezoresistive interaction of an ultrasonic surface wave with the inversion layer of a silicon MOS structure into which a series of MOSFETs has been fabricated (see illustration).

As the surface wave propagates along the substrate it sequentially modulates the drain current of the individual MOSFETs. The device thus acts as a surface-wave detector, or tapped delay line. By controlling the on/off state of each MOSFET it is possible to use the device as a sequence generator for phase-shift keyed (PSK) waveforms or for a variety of other applications involving this type of surface-wave pattern recognition.

The experimental device has a lithium niobate input transducer, mounted on a glass wedge, which converts bulk waves to surface waves. The MOSFET detectors are controlled by other MOS devices on the same substrate.

Most of the work on these programmable filters has been in the frequency range of 10 to 100 MHz, with higher frequency operation expected in the near future.



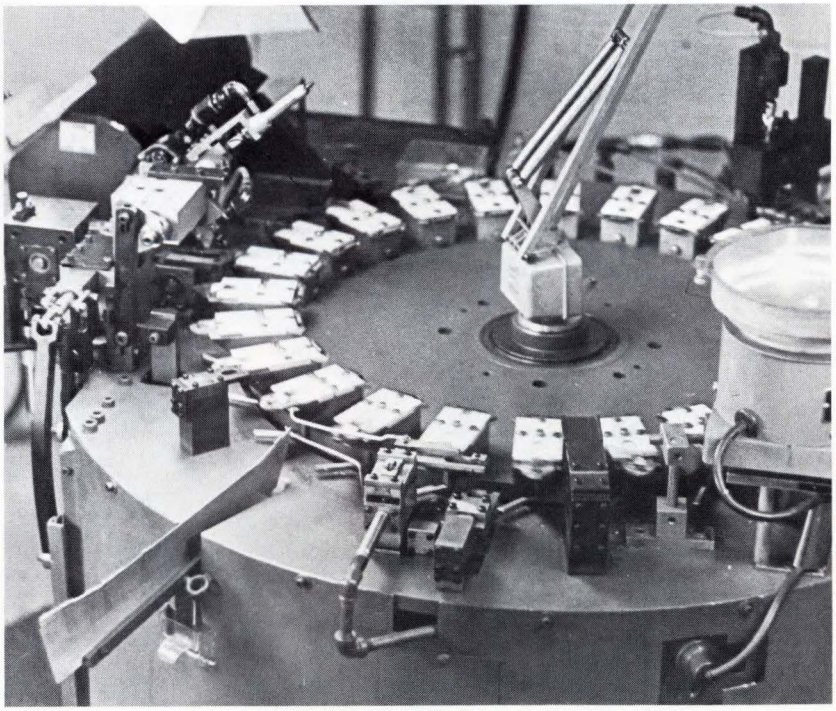
In the tapped delay line, modulation of the MOSFET (Q_1, Q_2, Q_3) drain currents takes place sequentially as the surface wave propagates along the substrate.

Miniature-lamp prices cut in half with high-speed automatic machine

Thanks to a unique automatic machine that mounts filaments of T-1 (1/8-in.-diameter, tubular) incandescent lamps at high speed, Ragen Precision, Inc. is entering the miniature lamp market with incandescent lamps reportedly selling at 1/2 current market prices, in large quantities.

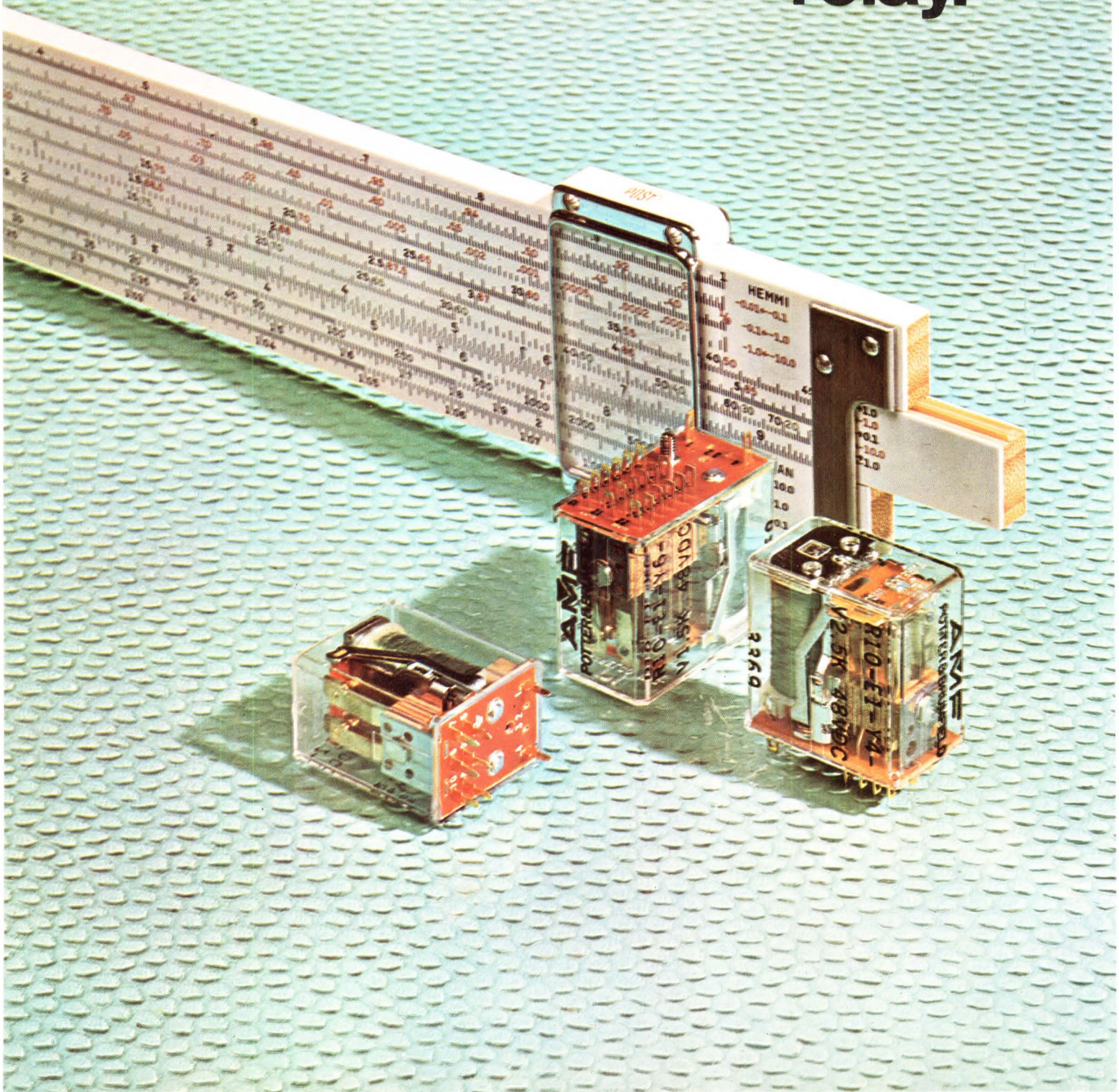
Designed and built by the North Arlington, N. J. firm, the machine produces the equivalent output of 25 skilled lamp assemblers and is expected to cut prices from the current 50¢ to 55¢ range to 25¢ to 30¢, in lots of 1000.

Indexing through 26 steps, the Ragen automatic machine starts with glass beads and within seconds: feeds pairs of Dumet leads; trims them to the proper lengths; drops the beads over the leads; tracks the beads to the Dumet leads at the proper heights; melts and molds the beads; winds, cuts and forms the filaments; transfers the filaments and stakes to the Dumet leads; forms mounts; and releases the completed mounts.



The equivalent output of 25 skilled lamp assemblers is duplicated in seconds with this unique high-speed automatic filament-mount machine from Ragen Precision. The system is expected to cut miniature incandescent lamp prices in half.

Our R-IO series offers more design options than any other single industrial relay.



The P&B R-10 Series offers designers a whole family of AC and DC industrial relays that combine extraordinary versatility in application, the reliability of telephone-type relays, and small size (less than a cubic inch). They are widely used in copiers, computer peripherals, business machines and precision instruments.

So versatile is this series that each model is literally designed by you, to meet your special needs. You use a single family of relays, with common mechanical dimensions and common mounting techniques, to cover the whole range of switching loads you may desire, from dry circuit to 10 amps, 28 V DC, 120 V AC. There are several terminal styles for solder or pc board mounting. Special octal plug mounting is available, and sockets multiply design options even more.

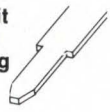
R-10's can now be ordered with Form A, B and D contacts as well as Form C, with arrangements up to 8 Form C. Underwriters' Laboratories, Component Recognition, File 42810. DC relays have a continuous power dissipation of 2.2 watts maximum. Standard sensitivity is 125 milliwatts per pole. Mechanical life is up to 100 million operations, electrical life ranges from 100,000 to 100 million operations. Special light emitting diode (LED) indicator, a convenient check when trouble shooting a circuit is available as an option on R-10 relays.

Take just four easy steps to "design" the R-10 relay that fits your requirements perfectly.

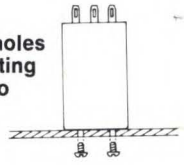
1 *Decide on the type of terminal mounting you want:*

Solder terminals. Stud or plug-in mounting

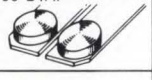
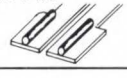
Printed circuit terminals. No stud mounting



Tapped holes for mounting directly to surface



2 *Select desired rating and contact form:*

Rating	10 amp†	5 amp (Bifurcated)	5 amp	2 amp	Low Level (Bifurcated)	Dry Circuit (Cross Bar)
	Poles Forms	Poles Forms	Poles Forms	Poles Forms	Poles Forms	Poles Forms
Contact form	2 A,B,C,D 4 A,B,C,D 6 A,B	2 A,B,C,D 4 A,B,C,D 6 A,B,C 8 A,B,C	2 A,B,C,D 4 A,B,C,D 6 A,B,C 8 A,B,C	2 A,B,C,D 4 A,B,C,D 6 A,B,C,D 8 A,B,C	2 A,B,C,D 4 A,B,C,D 6 A,B,C,D 8 A,B,C	2 A,B,C,D 4 A,B,C,D 6 A,B,C,D 8 A,B,C
Contact data	.125 DIA. 	.100 DIA. 	.100 DIA. 	.078 DIA. 	.062 DIA. 	.017 DIA. 
Resistive load* @ 28 VDC or 115 VAC	Typ. 7.5 Amps Max. 10 Amps Min. .200 Amps	Typ. 5 Amps Max. 7.5 Amps Min. .200 Amps	Typ. 5 Amps Max. 7.5 Amps Min. .050 Amps	Typ. 2.0 Amps Max. 3.0 Amps Min. 0.01 Amps	Typ. 0.1 Amp Max. 2.0 Amps Min. 0.001 Amp	Typ. 500 mA Max. 250 mA Min. Dry Circuit

*Total load not to exceed 30 amperes per relay. †Use ungrounded frame for loads over 5 amperes.

3 *Choose the proper coil resistance:*

- Standard and sensitive DC voltage coils available from 3.0 to 115 volts @ 25°C.
- AC voltage coils from 12 to 115 V @ 25°C.
- DC sensitivity as high as 20 milliwatts per pole.
- Bifilar coils to protect relay drive transistors available to 48 V nominal.

4 *Pick the socket that fits.*

R-10 Relay Socket

Retains floating terminals of either solder or P/C pin configurations.

Printed Circuit Right Angle Socket

Allows relay to mount flat on P/C board, reduces height from 1.720″ to .860″ max.

Bracket Mount Socket

Allows solder terminal relay to mount flat on a chassis.

Versatile R-10 industrial relays, with their almost limitless design options and application capabilities, are available nationwide from leading electronic parts distributors. Or call your P&B representative. For a free 214 page relay catalog, write Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385-5251.

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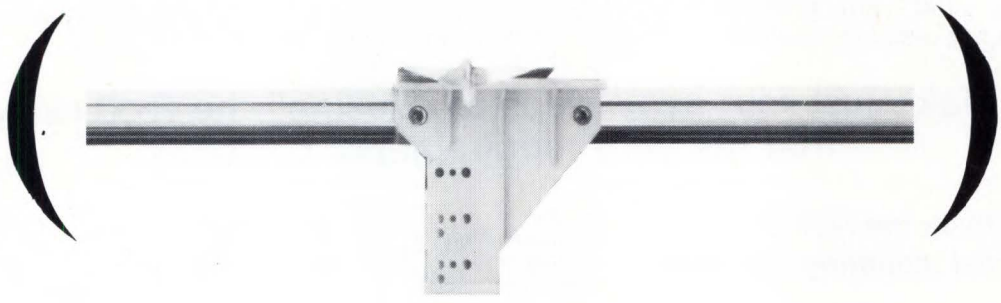
Potter & Brumfield

P&B makes more of more kinds of relays than anybody in the business.

Anybody.

CIRCLE NO. 16

A very uncomplicated new OEM recorder with just one thing going for it...



You'll like what you see in our new approach to dedicated OEM strip chart recorders. First, we eliminated all those complicated moving parts from the writing mechanisms. No more pulleys, cables and slip clutches. Instead, there's just one simple moving part—the slider/pen assembly. That's because a linear servo motor keeps the pen going magnetically ... and very reliably.

When you see the HP Model 7123, you'll notice how the low power servo system makes the recorder smooth, precise and trouble-free. You could drive it off scale around the clock without noise or danger.

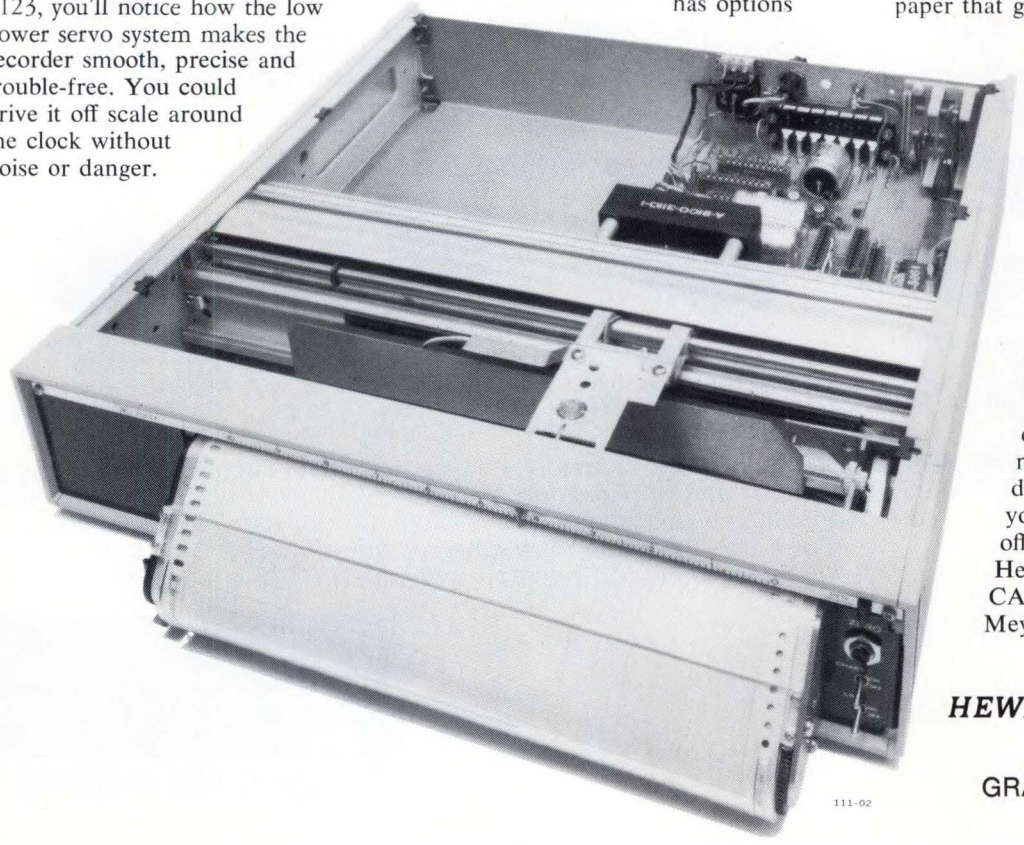
Even with all that, you've got a lot more going for you with the 7123. Like a swing-out chart paper drive for quick reloading and reinking. The viewing/writing area is slanted so you can make notes right at the disposable pen tip. And you can work without worrying about a lot of circuit adjustments. They're simply not needed anymore.

Since it's an OEM machine from the ground up, the 7123 has options for everybody. Select any chart speed and voltage span in English or Metric scaling. In all, nearly 50 options will customize the recorder exactly to a specific application.

You'll probably be most intrigued by an option we call electric writing. Normally, the ink system works like a cartridge fountain pen. But electric writing is designed for people who don't even want to mess around with that. A highly stable electrosensitive paper that gives you a crisp, clear trace without ink.

Available in full rack or half rack versions, the 3½ inch high 7123 makes totally unattended operation a reality. Simplicity, reliability, precision and even electric writing. With all that going for you, you can turn it on Friday and forget about your work all weekend.

To see the uncomplicated new 7123 and its matching price and OEM discount schedule, call your nearest HP sales office. Or write, Hewlett-Packard, Palo Alto, CA 94304; Europe: 1217 Meyrin-Geneva, Switzerland.



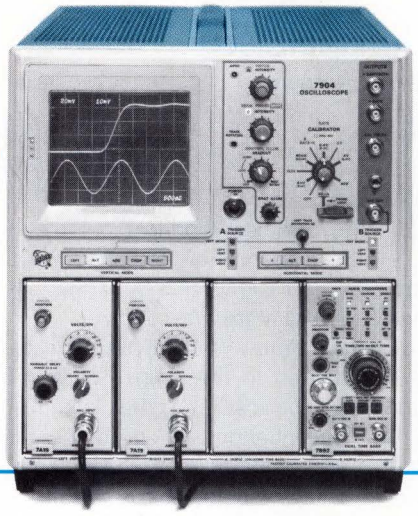
111-02

HEWLETT hp PACKARD

GRAPHIC RECORDERS

CIRCLE NO. 40

THE GROWING TEKTRONIX® 7000-Series Oscilloscope Systems



7904 Oscilloscope

From 500 MHz at 10 mV

or: 1 GHz @ <4 V/cm direct access plug-in

For those who have requirements in between 500 MHz and 50 MHz there's the 150-MHz 7704 (R7704 rackmount), 90-MHz 7504 (7514 storage), all with 4 plug-in compartments; 90-MHz 7503 with 3 plug-in compartments.

Exclusive to the 7000 Series is:

CRT READOUT—

Deflection factors and sweep speeds, the DMM and counter outputs, invert and uncalibrated symbols, etc., are automatically displayed on the CRT—where you look for information. CRT Readout can be ordered initially or as a conversion kit that is easily installed. In each case the cost is only $400. And it is available in all scopes except the 7403N.

MULTIPLE-PLUG-IN MAINFRAMES

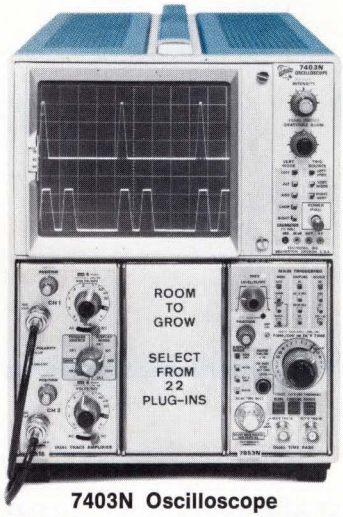
Three or four-plug-in mainframes allow up to twenty combinations of vertical and horizontal operating modes. You can now use plug-ins with widely different features . . . simultaneously. If you wish, start with only one horizontal and one vertical plug-in and add more as your measurement requirements change.

PLUG-IN VERSATILITY

Plug-ins are available to make virtually any measurement desired. Examples are: ● single trace ● dual trace ● combinations for multiple trace ● 10 μV/div differential ● 1 mA/div current amplifier ● differential comparator ● Sampling to 14 GHz ● 45-ps risetime TDR ● 1.8 GHz spectrum analyzer ● curve tracer ● single time bases ● dual time bases with calibrated mixed sweep ● 500-ps dual time base with triggering to 600 MHz ● 525-MHz direct counter ● digital multimeter.

RUGGEDIZED MILITARY VERSION

The AN/USM-281C consisting of mainframe, vertical plug-ins, dual time base and accessory cover is the militarized version of the 7403N Oscilloscope System.



7403N Oscilloscope
(R7403N 5 1/4-inch rackmount)

to 50 MHz at 5 mV

dual-trace, 6½-inch CRT and delaying sweep for only $2200

7000-Series Scopes, complete with plug-ins, start as low as $1670. Call your nearby TEKTRONIX Field Engineer today for a demonstration of the scopes that make *more* measurements *easier* and *quicker* or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

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Tektronix lease and rental programs are available in the U.S.

CIRCLE NO. 17

Digital Cassettes. . . . growing like wonderful weeds

Pulled forward by a genuine, widespread need, beset by standardization traumas, the digital cassette lurches toward several different destinies

Robert H. Cushman, New York Editor

The Philips cassette has excited the imagination of digital tape-deck designers like no other modular container for pairs of tape reels. About three-dozen design groups have brought out some form of miniature tape transport based on the Philips cassette in the past three years. There is no sign that this wave of creativity is subsiding. In fact, there are signs that it is bubbling out beyond the Philips cassette into some novel transports and cartridges.

Now that there are about 10,000 digital cassettes out in the field and there is a proposed standard to make at least some of these little machines compatible, it is time to take stock of this upstart field. What has it got to offer the systems designer? How does an outsider classify the confusing array of machines and recording techniques? What are they good for anyway?

Fig. 1 shows in a simplified way how cassettes fit into the flow of data. To the left are the myriad sources of future data. . . . the ecological monitors . . . the inventory tabulators. . . . the man-machine terminals. To the right is the modern computer facility that by design has an unceasing appetite for data at megabyte rates.

How are the multitudinous 0-300 bytes/sec data-transfer rates at the left married to the single 100 kilo-byte/sec appetite to the right? The answer, as the diagram shows, is to have a data-concentration station in the middle in which all the cassettes from the data acquisition recorders are pooled onto a large, computer-compatible 10-1/2-in. dia. 1/2-in. wide tape.

The high (100,000 bytes/sec) data flow desired by the lone computer is built up by having thousands of cassette recorders out in the field, each taking, say, an 8-hr day to fill up a cassette. Then the contents of a hundred of these source-data cassettes would be read onto the large 1/2-in tape at the pooling station.

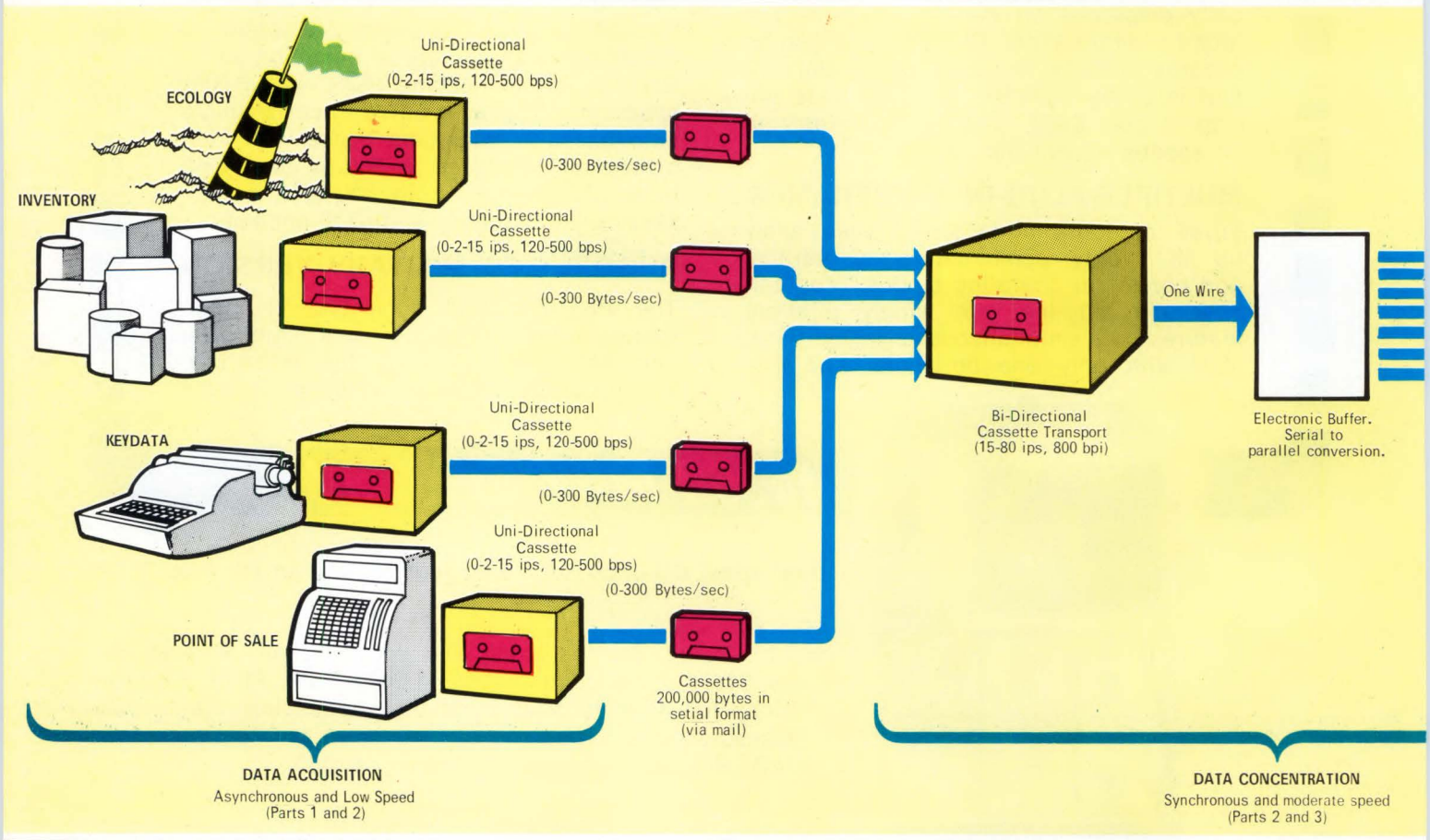


Fig. 1—How cassettes aid data flow. This diagram depicts how little rivulets of data acquired slowly and randomly from the real world are combined to form the torrents of data required to satisfy a computer's appetite—even the minicomputer shown. Cassettes are ide-

There is a certain economic symmetry to this crude picture of data flow. The single large computer facility at the right might cost $100,000. The 1000 cassette data recorders at the left might also cost (at $100 each) the same $100,000.

The pooling station in the middle would be less expensive. It might be made up of three $1000 high-performance cassette transports and one $3000, 1/2-in. reel transport, or a total of $6000. The system might have an inventory of tens of thousands of the little $4 cassettes that it would keep in constant rotation, sending them back for reuse after their data had been taken off.

The thing to appreciate about **Fig. 1** is that each of the applications pictured for cassettes needs quite a different type of cassette transport. In this report we will accordingly divide up our coverage of cassettes into three distinct parts. Part-1 will look at the very low cost, data collectors suitable for the left side of **Fig. 1**. Part-2 will look at the moderate-cost, general-purpose machines needed for the middle of **Fig. 1**. Part-3 will look at the expensive transports that try to upgrade the cassette so it can indulge in the data-manipulation of the right side of **Fig. 1**. In a future issue of EDN/EEE we will look at the new data cartridges that have been designed from scratch to take over where cassettes leave off.

Throughout the report we will point out how these designs relate to the ECM/ANSI standards that have been proposed and may become formally accepted this year.

Abbreviations Used In This Report

Technical

ips ..... inches per second (tape speed).

bpi ..... bits per inch (bit packing density on tape).

bps ..... Bits per second (data-transfer rate).

byte ..... Sequence of bits acted on as unit (in cassette usage often the 8-bit ASCII character).

Record ..... Block of characters treated as a unit and separated from other records by an inter-record gap.

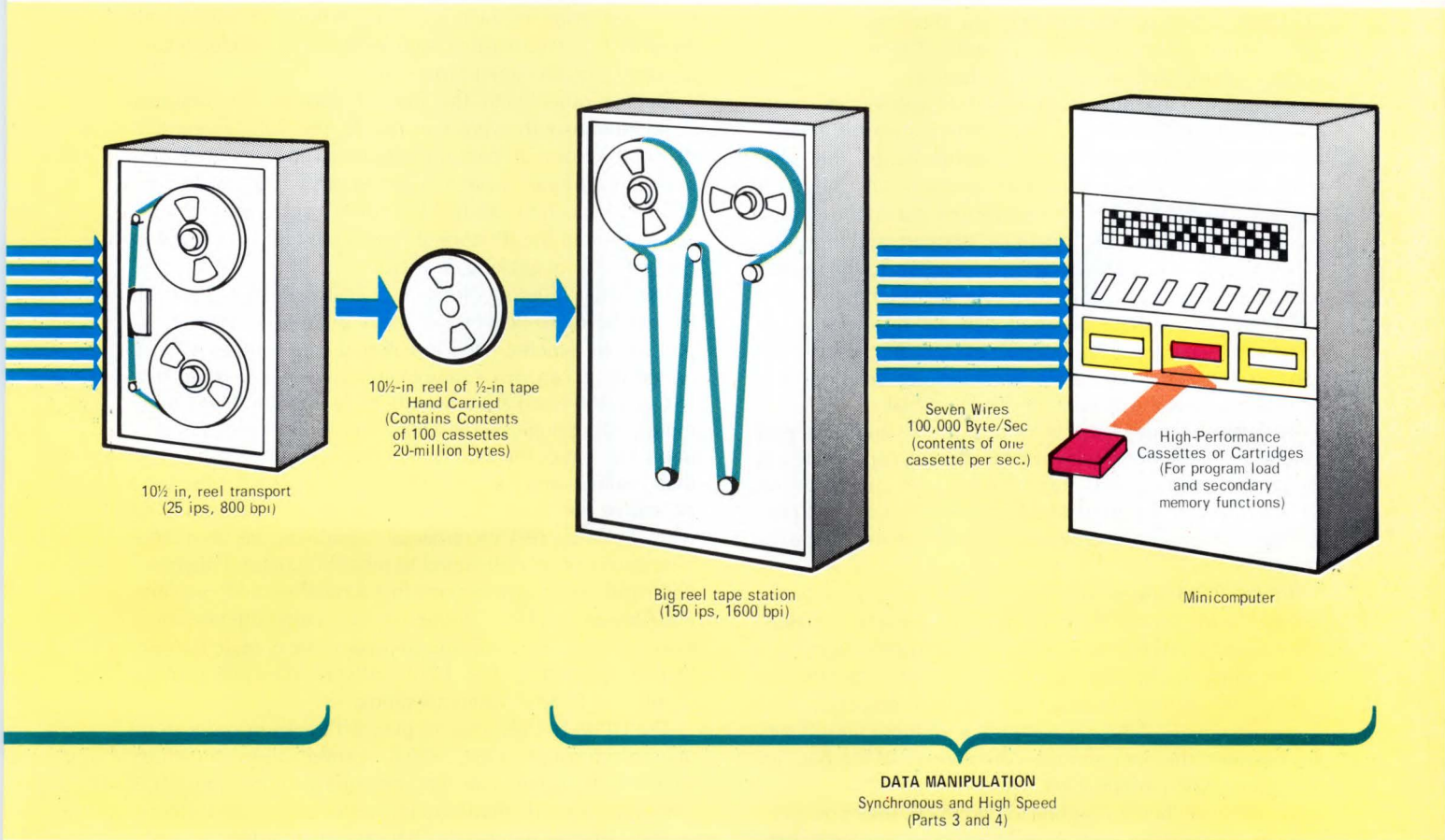
Non-Technical

ECMA ..... European Computer Manufacturers Association.

ANSI ..... American National Standards Inst., Inc. (New York).

ISO ..... International Standards Organization (part of ANSI).

ASCII ..... American Standards Code for Information Exchange.



al for the fountainheads of data to the left, because they provide a low-cost, transportable medium for the little packets of data produced. But cassettes don't have the performance required in the mad, thrashing world of computers, to the right.

1—Low-cost data recorders

The 5¢ cigar of the digital cassette world is the $100 asynchronous data-capture recorder. Everybody seems to agree that low-speed data acquisition (left side of Fig. 1,) is a logical application for digital cassettes, but nobody seems to agree on just what standards ought to be applied. The proposed ECMA/ANSI standards were derived from the standards for 1/2-in., continuous large reel drives, and these large machines were intended for high-speed, on-line, synchronous operation with computers. Many of the cassette system designers believe that paper tape standards would provide better models for this low-performance, low-cost area.

We will look at two units of this category:

1—ICP's spindle-driven units.

2—Memodyne's stepper-motor units.

Both transports are intended to sit and wait for data from the real world, of keyboard inputs, and to respond by coming to life, advancing the tape, putting down a character (invariably an 8-bit ASCII) and stopping. The idea is to advance in small steps so the information is packed with reasonable tightness on the 300 ft of cassette tape. These machines must be inexpensive to be suitable for the expected large number of data capture stations, and $100 is typically given as the going price. One would not want to invest more in recorders that one was designing into oceangraphic buoys or cash registers.

ICP's spindle-driven recorders (see this issue's cover) do not use capstans. The tape is advanced by rotating the cassette take-up reel, as in the simplest, lowest-cost ($10) audio tape players. As shown in **Fig. 2a**, there is a motor (dc permanent magnet) for each hub spindle. The rewind motor is also used for fast braking and drag tension.

Say that this machine is recording a typist's work. It sits idle until the typist strikes a key. That character is entered into the machine's bipolar shift-register buffer, the drive motor started to accelerate the tape to about 5 ips, the ASCII bits shifted serially out of the register and put on the tape by the head, and then the motor is stopped and the tape brought quickly to a halt by applying braking to the rewind reel. The machine lies ready to accept the next bit.

All this takes 40-mils of tape length, 10 mils to start, 20 mils for the character, and 10 mils to stop. As the machine can respond at the rate of 40 characters per second, it has no problem keeping up with any human typist.

Reel drive is more feasible for digital than audio, at least as long as the bit density is low. Most of the capstan-driven digital cassette transports only maintain a 5% speed accuracy anyway and the proposed ECMA/ANSI standards only call for 9%. For audio, anything over 1% can irritate the listener.

But the 2.3:1 speed variations that occur as the tape diameter builds up on the drive reel do present problems. They have forced ICP to develop a time-independent form of encoding on the tape. ICP uses two tracks so they can distinguish start-of-character and end-of-character bits. They put down a ONE on each track for these housekeeping bits then the data and the complement of the data for the regular ASCII information.

But because they have gone to two tracks they now have to worry about skew, so they must keep the bit density low. They recommend keeping it under 600 bpi at the start of tape, which means that it will be 600/2.3, or just 260 bpi, by the end of the tape. Yet this low bit density really is not a drawback in many data capture applications because the 300-ft length of cassette tapes is plenty long enough to contain a typist's day's work (25 pages), and the lower density and redundant tracks contribute to that most important user requirement of all—reliability.

Unfortunately, these innovations now render ICP—a pioneer in this young field with a record 4000 machines out in the field—out of tune with the proposed ECMA/ANSI standards. The standards call for single-track, high-density phase encoding at 800 bpi (with phase encoding this means 1600 flux changes per in.). It is possible to use a single track with phase encoding because PE is self clocking upon playback and can recognize the start of characters.

Robert Miller of ICP and others who use dual-track systems for various reasons do not like the way the proposed EMCA/ANSI standards restrict designers to single, phase-encoded tracks. They argue that while this may be fine for the continuous multiple-character blocks that flow synchronously in computer environments, it is unsuited to the discontinuous character-by-character blocks of data that flow so sporadically in data-capture environments.

The Memodyne U1W-101 uses a permanent-magnet stepping motor driving a capstan to inch the tape along at 8.4-mils per bit. Unlike the ICP unit, it does not start up a continuously-running DC motor and run until it has put the 8 bits or so of ASCII code plus control marks down, but starts and stops for each bit. This permits the Memodyne recorder to avoid wasting tape length as it accelerates up to speed and decelerates to a stop.

On the other hand the 8.4-mil steps of Memodyne's standard transports represents just 120-ips bit packing and for long strings of continuously-received characters this may take up more space than the original 100-mil deceleration. On special models, Memodyne uses higher gear ratios to shorten the distance it moves the tape on each step and gets 800-bi packing density.

The value of going along on a start-stop basis for each bit, according to Bob Hill of Memodyne, is that the transport can be synchronized to external data sources without buffering. It can, for example, follow the common 100, 150 and 300 Baud rates coming off teleprinter lines (as the motor will operate incrementally up to 300 steps per second). This saves the cost of electronic buffer registers and their controls and can make this type of recorder the least expensive for these types of applications, says Hill. As with the large reel incremental recorders, this true stepping approach is well suited to recording natural phenomenon and Memodyne reports that a number of Universities and Oceanographic Institutes are evaluating the version of their recorder that uses micropower C-MOS logic for ecological monitoring. This 12-V unit consumes just 2 uA for standby and 53mA when operating.

The ULW-101 also has to use two tracks in order to be able to put down "ONE—ONE" combinations in parallel so that characters can be recognized upon playback. Therefore, records made by this recorder are also incompatible with the proposed ECM/ANSI standard.

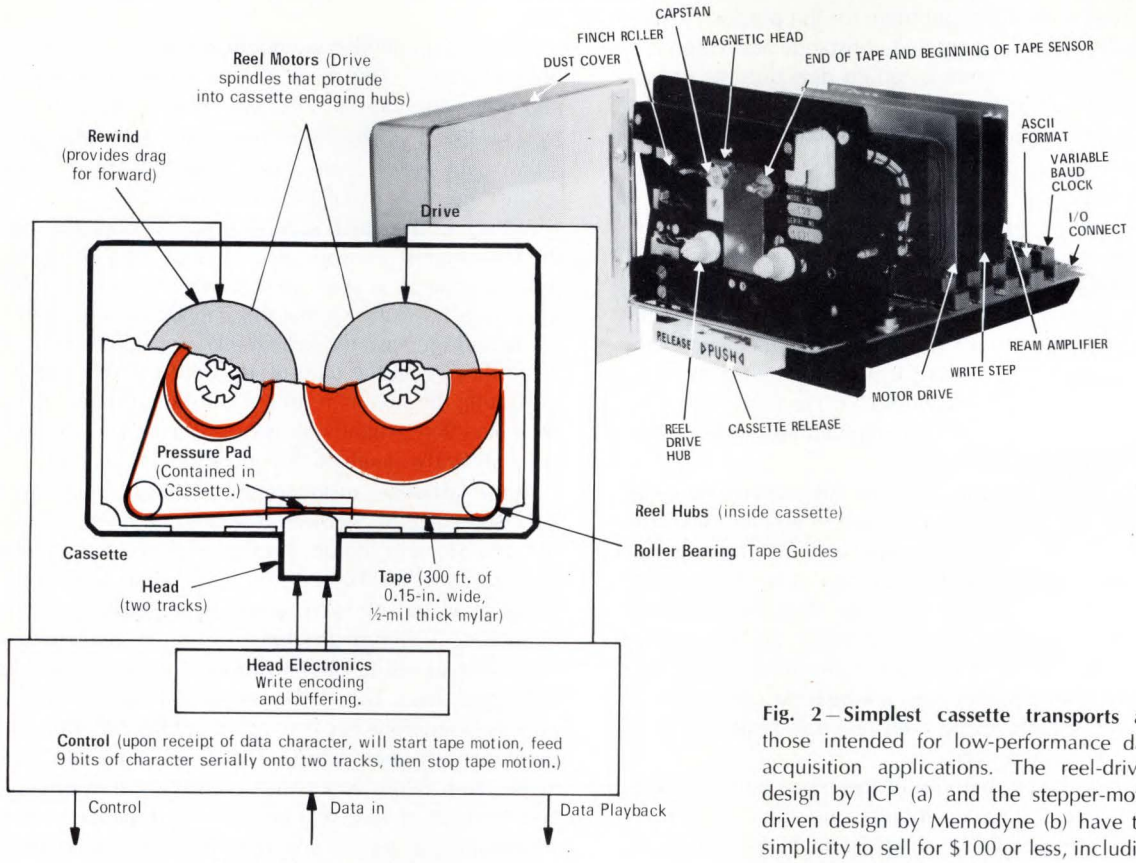


Fig. 2—Simplest cassette transports are those intended for low-performance data acquisition applications. The reel-driven design by ICP (a) and the stepper-motor driven design by Memodyne (b) have the simplicity to sell for $100 or less, including electronics (OEM quantities).

2—General-purpose cassette transports

Most of the machines being offered on the market today fall into what might be called the general-purpose category. Their basic prices, complete with electronics, range from $200 to $600 at OEM levels (thousands of pieces over a year's delivery time). These basic prices can easily escalate up to $1000 and beyond with additional custom features.

Some "horrendous" frustrations have faced the designers of these machines. It is nice to sport high performance specifications, such as high tape speed and fast starts and stops, but in these basically mechanical devices dazzling specifications only mean that almost every other desirable quality—reliability, maintainability, cost and weight—may have gone down. It is nice to say you adhere to a standard but in this young field it may only mean you aren't optimally suited to many applications.

Some examples of transports in this category are:

1—Cipher
2—Auricord
3—Ampex
4—Telex
5—PSC
6—3M

These have been selected somewhat randomly and it is not implied that they are any better than the many others not named. We'll discuss their features together, on the assumption that they have all been aimed at what we call the main-stream, general-purpose market.

First, let's look back at **Fig. 1** and ask what such a data system needs from a general-purpose cassette transport. Obviously, it needs a transport for the central data concentration area to read the many cassettes being "mailed" in from the Data-Acquisition area and transfer their contents onto the large computer tapes.

It might seem that all that is needed is a read-only transport that operates continuously in one direction and at a higher rate of speed than the simple uni-directional machines of the Data-Capture area. But this is not so. The machine should have bi-directional capability so it can go back and re-read data where an error bit cropped up (it may have been caused by just a transient bit of dust).

The transport should also be capable of high-speed search in case only certain selected blocks of data were to be sent on to the large computer. And the transport really should have write as well as read ability so it can play a useful part in pre-reducing the data before it is sent onto the large computer.

The electro-mechanical features of these general purpose transports are diagrammed in a generalized way in **Fig. 3**. All the mechanical operation must be accomplished by remote logic control through logic-level signals (invariably TTL these days), so there is an extensive use of controllable dc motors and solenoids.

The head is driven into the cassette by one of these solenoids where the oxide-side of the tape is pressed against the read and write gaps by the pressure pad. Read- after-write gaps, as shown, are being used more and more to permit verification that a bit was actually magnetized on the oxide. Among other things, a poor read back will give the user a clue that his head is getting dirty (as with audio systems, the heads should be cleaned every 100 hours).

Two capstans, one on either side of the head, protrude into the cassette via holes put there for the purpose. These capstans will typically be rotated constantly and when it is desired to move the tape in a certain direction the proper pressure roller will be pushed in by its solenoid to press the tape against the capstan and drag the tape past the head. The diagram shows the right-hand roller engaged for forward tape motion.

Because of the high friction of this dragging action, especially due to the pressure pad, most designers don't think the tape should be advanced at over 15-20 ips. But if the head is slightly retracted, it is possible to conduct high-speed searches at up to 80 ips. In this case, the head is not reading the data bit by bit but is just looking for the long gaps that indicate ends of data blocks. However, it is usually not the capstan that pulls the tape for these high-speed searches but the reel-drive motors.

The supply and take-up reels are also driven by small motors. With the head fully retracted, they can move the tape at up to 125 ips for fast rewind and fast forward. But many cassette transport designers frown at any speed even near 100 ips for a cassette. They say that even with the digital-quality cassettes that have roller bearing guides along the main bends of the tape path, there are still too many places where plastic parts are bearing against plastic parts for such speeds. Large open-reel transports will go at speeds of 200 ips and over.

The overwhelming majority of these machines use permanent-magnet dc motors, though one still occasionally sees rugged, inexpensive ac shaded-pole motors. These dc motors are often in servo feedback loops to control the speed. Cipher uses optical tachometers and phase-locked loops referenced to a clock to maintain their speed control.

One sees an endless variety of design variations in these little transports. Ampex for example uses only one motor and drives the capstan and reel spindles from that motor by a series of pulleys and idlers. But, they give this one motor tight speed control, specifying 2% speed variations against the more usual 5% variations.

3M leaves the pinch rollers constantly engaged, holding the tape against the capstans. 3M says they do not like to jerk the tape to a start by slamming the pinch roller in. Their tests have shown that this can locally stretch the tape oxide and increase the probability of a bit drop out. So instead they bring the tape up to a more gentle start by accelerating the motors from a standstill. Though this makes their start times slightly longer, −50 ms vs 20 ms, they say it significantly increases the operational reliability.

In the last year, an increasing number of the transports have started using Siemens brushless dc motors for longer life. The Siemens motors employ Hall-effect commutation, and are rated for 10,000 hours, or much above the 100 hours expected of even good-quality brush-cummutated dc motors. Auricord uses three of the Siemens motors and yet is able to sell its deck (without electronics) for $125 in OEM quantities. The Hall-commutated motors have rather poor accelerations because of the additional mass of their permanent-magnet rotors. However, this can actually make them better as constant-speed capstan drives, says Lee Milligan of PSC. It's possible to dispense with a flywheel and yet get 1% speed control because of the extra inertia. Also, the sinewave commutation rather than step-function commutation helps give a smooth rotation.

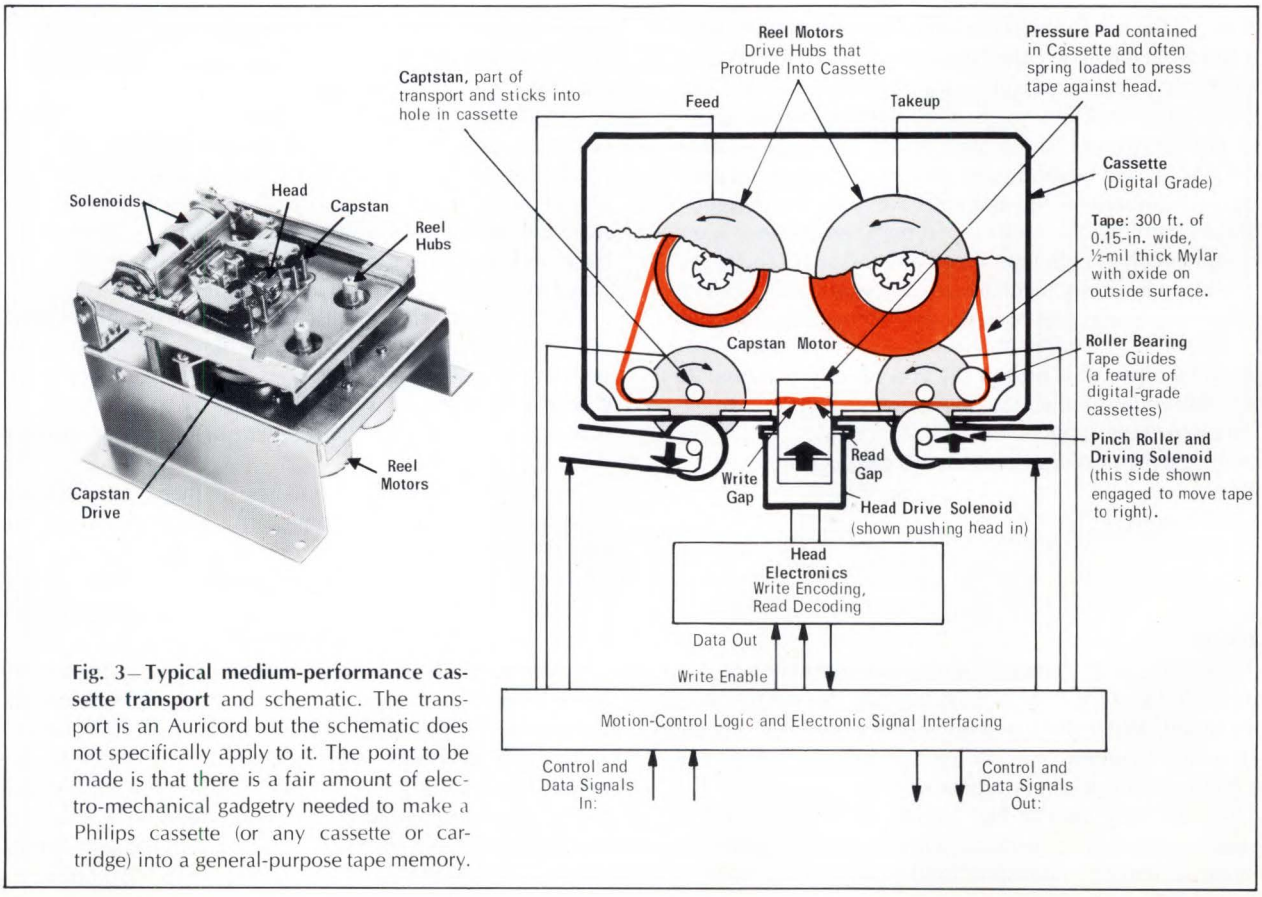


Fig. 3—Typical medium-performance cassette transport and schematic. The transport is an Auricord but the schematic does not specifically apply to it. The point to be made is that there is a fair amount of electro-mechanical gadgetry needed to make a Philips cassette (or any cassette or cartridge) into a general-purpose tape memory.

Most of these general-purpose machines already comform to the proposed ECMA/ANSI standards, for some of the designers have been on the standardization committees. But there is still, as we have said, the controversy as to whether a single recording standard will satisfy all application areas. The biggest bone of contention seems to be the pattern of encoding data onto the tape.

The proposed EMCA/ANSI standard, following the precedent of 1/2-in. tape, calls for a single, self-clocked track of 800 bpi phase encoding, with all the 8-bit ASCII characters strung together end to end. We have already explained in Part I why makers of slow, incremental machines do not like this approach, but there is another reason why a number of the cassette makers in this general-purpose area object. With all the characters strung together end to end, there is no way of limiting error propagation. If just one bit is lost in a block of characters, there is a danger that the self-clocking synchronization will be lost—the read clock slips a bit—and all the data from that point on will be lost.

The objectors—notably Dicom—say that it would be good to have intercharacter gaps or other control markers that would allow resynchronizing on each character, so the error would not propagate beyond the character in which the error bit occured. They say that it is only if such "character delimiting" is adopted that there is any hope of the proposed ECMA/ANSI standard becoming universally applicable. With such delimiting, they believe it may be more feasible to extend the standard down to asynchronous data-capture applications—especially if designers take advantage of the growing availability of low-cost MOS shift register buffers.

Countering these objections, those in favor of the proposed ECMA/ANSI standard, say that it is unrealistic to try to recover garbled data by human inspection. They say that the system will have to command the cassette to go back and re-read the whole block anyway . . . so why worry about trying to recover individual characters.

3—High performance cassettes

Three of the cassette drives introduced during 1971 illustrate what can be done to upgrade the performance of a cassette system, if price is no object:

1—Dicom's model 440 vacuum transport.

2—Bell & Howell's model 240 external-drive transport.

3—EPI's series WRV-200 rotating-head transport.

All three circumvent the deficiencies of the Philips cassette by pulling the tape out of the cassette, reducing the cassette's function to just holding the tape.

The Dicom 440 is really like a baby version of the large computer-room reel drives, and approaches the performance of these large drives. It sucks the tape out into two vacuum columns that "wrap" the tape against the head and a large-diameter capstan. Photoelectric sensors monitor the length of the tape loop in the vacuum columns and control the motors driving the reels inside the cassette. The large, 1-in. diameter capstan is driven by a very high-performance servo motor. Each time this capstan rotates, the photoelectric sensors detect the change of length of the two tape loops and drive the cassette reels to keep the loop lengths constant.

The 440 will read and write at up to 80 ips with 40 msec start and stop times. This compares favorably with the 112 ips read-write speeds of some large reel stations.

For slow-speed operation, the buffering provided by the vacuum column allows the 440 to inch tapes along incrementally with very tight bit packing. The 440 can step a 2-mil bit spacing, which is 500 bpi. Furthermore, the Dicom system has the ability to go back and correct individual bits (though in most applications it would go back and correct whole 8-bit ASCII characters).

Because the tape is guided by the precision machined metal parts of the transport, and not by the often plastic parts of a mass-produced cassette, there is less lateral wandering of the tape and less skew. Dicom says it could use four-channel heads (Nortronics, Michigan Magnetics and others make these) and pack four parallel tracks across the narrow (0.15 in.) cassette tape. Drop outs due to dust or oxide particles would be more of a problem with these narrow tracks, but Dicom engineers claim their vacuum air flow provides a cleaning action that sucks loose particles out of the chambers.

The Bell & Howell 240 transport pulls the tape out of the cassette by a mechanical "cherry picker," consisting of fingers that reach into the cassette. These fingers drop the tape loop over the capstan, threading it past the head in the process. Strain gages on feeler arms provide the feedback information needed to drive the reels in the cassette so that they maintain the light (0.25 - 1.5 ounce) tension that keeps the tape against the capstan and head.

Bell & Howell achieves the same objectives as Dicom, but they say they do this with a more conservative system. They do not need a vacuum pump. But the performance they quote is also more conservative. They speak of read-write speeds up to 20 ips and search speeds up to 50 ips. They, too, can increment at slow speeds, but apparently do not have such fine start-stop distances as Dicom for they only quote the equivalent of 80-bpi packing density for 2-ips incremental operation.

The EPI WRV-200 series transport is the most novel of all cassette systems. EPI not only pulls the tape out, but holds the tape stationary against one side of a 3-rev/sec rotating drum that carries two separate heads past the tape at about 12-1/2 ips. The records are put down on the tape in fixed 132-character blocks. At the 800 bpi recording density, each block takes up 1.66-in. Since this is shorter than the length of tape held against the drum, the whole of one of these standard record blocks can be accessed by each half-rotation of a tape head.

EPI says they developed this configuration for use with their own minicomputers. They wanted to handle data blocks of the length that would be fed to a line printer for a single line. They also wanted to be able to both check and correct any errors. Because the heads keep periodically rotating around past the data block on the tape, EPI can write with one head, and read for verification purposes, with the other head. Then, if there is any error, they can re-write with the first head. There is no need to back up the tape to make a change or correction.

It is possible to use non-certified audio tape, EPI says, because this system constantly checks the tape as it records. EPI's write logic automatically keeps checking and rewriting until a verification is obtained. One of their more expensive units contains a 132-character bipolar semicon-

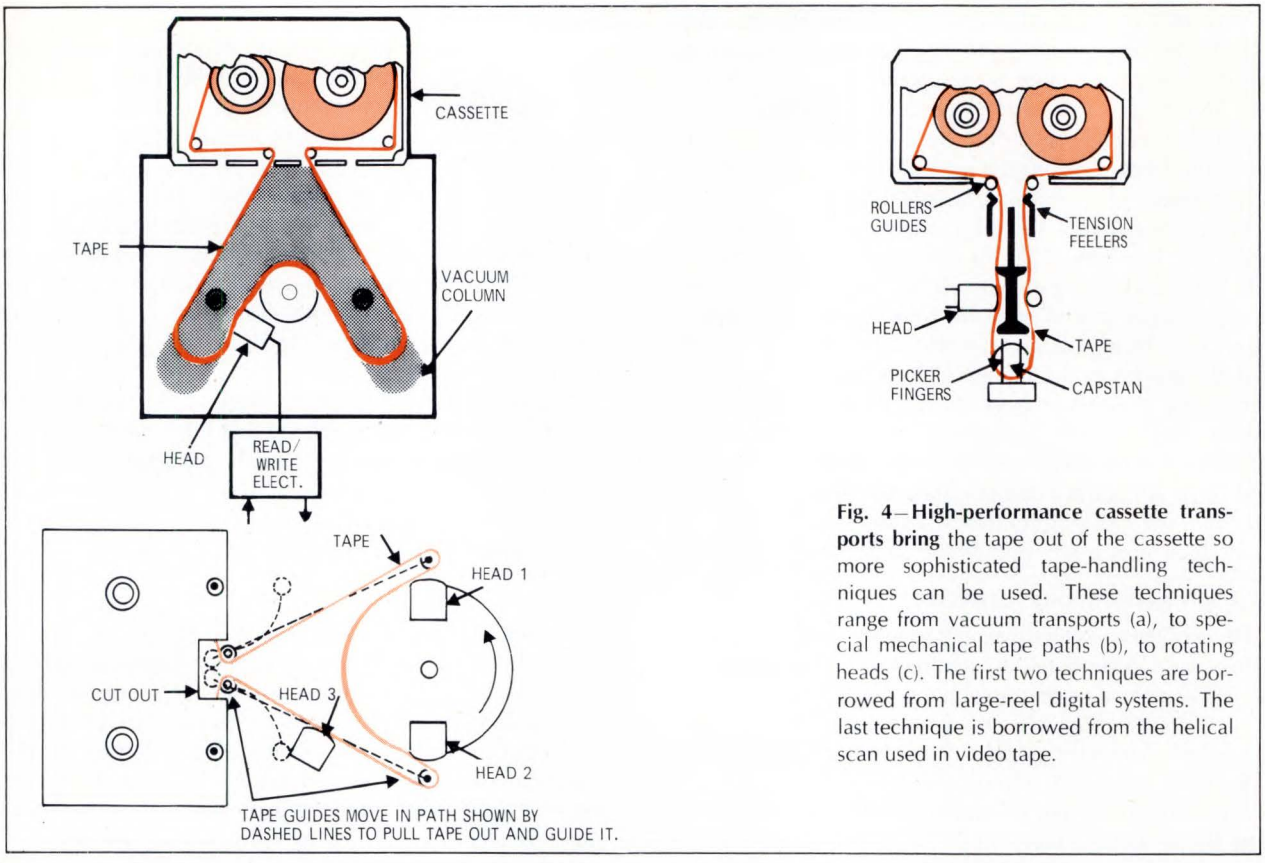


Fig. 4—High-performance cassette transports bring the tape out of the cassette so more sophisticated tape-handling techniques can be used. These techniques range from vacuum transports (a), to special mechanical tape paths (b), to rotating heads (c). The first two techniques are borrowed from large-reel digital systems. The last technique is borrowed from the helical scan used in video tape.

ductor memory that serves as the buffer against which the whole block is compared.

When it comes time to advance to another 132-character block, the reel motors are actuated to thread the tape forward until a third and stationary head along the tape feed path detects the inter-block gap that indicates the next block is in place. EPI is able to move the tape forward at speeds of 60 ips and even 160 ips. This is possible, they say, even while the tape is in contact with the rotating drum because the drum rotation entrains a layer of air that aerodynamically floats the tape away from its groove in the drum.

A problem with the design is that a small cutout must be provided in the cassette to allow the picker mechanism to reach in and grab the tape. Thus, of all the cassette transports on the market, this is the only one that needs a modification on the cassette.

You get what you pay for

Obviously, you don't get all this "extra-cassette" sophistication for nothing. These high performance transports cost more. Dicom's 440 costs in the vicinity of $400 to $1800. Bell & Howell's 240 costs about $500. EPI's WRV cost $300 to $700. All these prices are for OEM quantities and are crude approximations as there are many different mechanical and electronic options.

But you do obtain a greater range of performance in one transport. You can inch forward incrementally as you asynchronously gather incoming data from real-world events or keyboard operators. Then you can go very fast as you dump that data into a minicomputer or pool it on a large reel. As discussed, the Dicom unit can inch along at 2-mil increments as it responds to asynchronously-received data from the real world or keyboard operator, packing that data closely at 500 bpi; then the same unit can spew the data out at a rate of over 5,000 ASCII-length characters per second (about 64,000 bits per second). This may not be the 180,000 characters per second transfer rate of a large computer vacuum tape station, (as those characters come off in parallel), but it is much better than the pedestrian 300 characters per second produced by some $100 decks.

These "out-of-the-cassette" transports are also much better at thrashing the tapes about for sort and merge operations. Because they get the tape away from the friction of the head pressure pads etc., inside the cassettes, these transports are less apt to wear-out either the tape or themselves so readily when asked to go through long chains of starting, stopping and searching at high speed. They may turn out to be perfect for small "calculator-level" computing systems for small businesses. □

Note: A future issue of EDN/EEE will have a sequel to this report covering the even newer field of digital magnetic cartridges.

Manufacturers of Digital Cassette Transports

Including some who make similar cartridge systems, marked "(Car.)"

Ampex Corporation
13031 West Jefferson Blvd.
Culver City, Calif. 90230

Analog Digital Data Systems, Inc.
830 Linden Ave.
Rochester, N.Y. 14625

Auricord Div. CONRAC
35-41 29th Street
Long Island City, N.Y. 11106

Bell & Howell
360 Sierra Madre Villa
Pasedena, Calif. 91109

Canberra Industries, Inc.
45 Gracey Ave.
Meriden, Ct. 06450

Cipher Data Products
7655 Convoy Court
San Diego, Calif. 92111

Computer Access Systems
2645 East Buckeye
Phoenix, Ariz 85034

Datacord, Inc. (Car.)
795 Kifer Road
Sunnyvale, Calif. 94086

Data Trends, Inc.
50 Intervale Rd.
Parsippany, N. J. 07054

Dicom Industries
715 N. Pastoria
Sunnyvale, Calif. 94086

Digitronics Corp. (Car.)
One Albertson Avenue
Albertson, LI, New York 11507

Electronic Processors Inc. (EPI)
5050 S. Federal Blvd.
Englewood, Co. 80110

Information Terminals Corp.
1160 Terra Bella Ave.
Mountain View, Calif. 94040

Interdyne Corp.
14761 Calisa
Van Nuys, Calif. 91401

International Computer Products
P.O. Box 34484
Dallas, Texas 75234

Kybe Corp.
132 Calvary Street
Waltham, Mass. 02154

Memodyne Corp.
369 Elliot Street
Newton Upper Falls, Mass. 02164

North American Philips Corp.
100 East 42nd Street
New York, N.Y. 10017

Novar GTE (Car.)
2370 Charleston Rd.
Mountain View, CA. 94040

Peripheral Systems Corp.
215 Little Falls Rd.
Fairfield, N. J. 07006

Raymond Engineering Inc.
217 Smith St.
Middletown, Ct. 06457

Redactron Corp. (also Car.)
100 Parkway Drive South
Hauppauge, N.Y. 11787

Remex, Ex-cell-O Corp.
1733 Alton St.
Santa Ana, Calif. 92705

Sycor Inc.
100 Phoenix Drive
Ann Arbor, Mich. 48104

Sykes Datatronics Inc.
375 Orchard St.
Rochester, N.Y. 14606

Telex Communications Div.
9600 Aldrich Ave. South
Minneapolis, Minn. 55420

3M Company (also Car.)
300 South Lewis Rd.
Camarillo, Calif. 93010

Tri-Data
800 Maude Ave.
Mountain View, Calif. 94040

University Communication Systems
P.O. Box 6228
Dallas, Texas 75222

Wang Computer Products (Car.)
2400 Broadway
Santa Monica CA. 90404

Wang Laboratories, Inc.
836 North St.
Tewksbury, Mass.

(Additional names will be included in forthcoming report on cartridges.)

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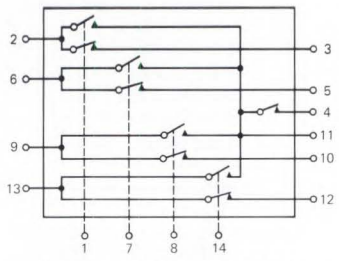
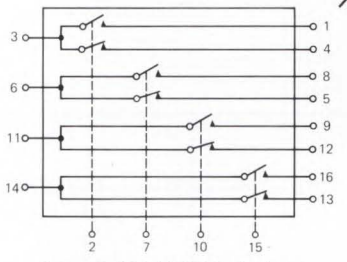
The gate is great.



Intersil 5009/5010 4-channel analog gate. Compensating FET (pin 4) is closely matched to switching FETs. Connecting compensating FET in feedback loop of "virtual ground" inverting amplifier gives $R_{ON(MATCH)}$ (Effective Switch-On Resistance) as low as 5 ohms.



Intersil 5011/5012 4-channel analog gate.

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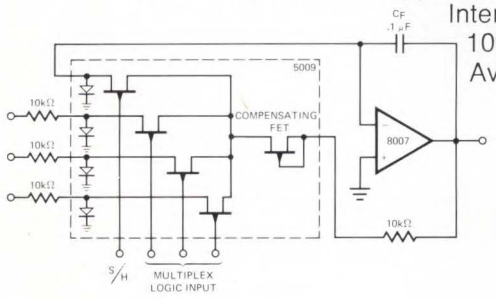

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CIRCLE NO. 18

Automatically tuned filter uses IC operational amplifiers

Minimize system noise by tracking the input signal with a voltage-controlled bandpass filter

GORDON J. DEBOO and ROGER C. HEDLUND,
Ames Research Center, NASA

Audio and instrumentation systems frequently employ bandpass filters to improve the signal-to-noise ratio. If the input-signal frequency varies over a wide range—as it does with many types of vibrating transducers—the bandwidth of the filter usually must be large enough to avoid undue attenuation and phase shift at the frequency extremes. But a wideband filter will be less effective in rejecting noise.

One solution to this dilemma is to use a self-tuning filter that automatically adjusts its center frequency to track the signal frequency. This technique allows the use of a filter that has a bandwidth considerably less than the range of input signal frequencies.

The circuit described here (**Fig. 2**) tunes itself over a frequency range from 2 to 20 kHz. It requires no reference frequency other than the input signal, and there is no internal oscillator or synchronization circuitry. The frequency range can be extended in decade steps by capacitor switching.

Basic Active Filter

The simple active RC bandpass filter shown in **Fig. 1** can be readily modified for self-tuning operation. Examination of the transfer function reveals why it is especially suitable for such an application. For the case where $C_1 = C_2 = C$, the transfer function is:

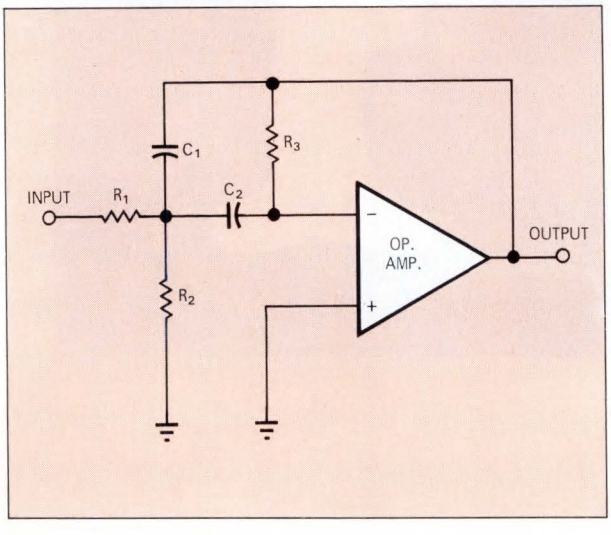


Fig. 1—**Multiple-feedback RC active filter** lends itself to voltage-controlled operation because variation of R_2 adjusts the center frequency without affecting gain or bandwidth.

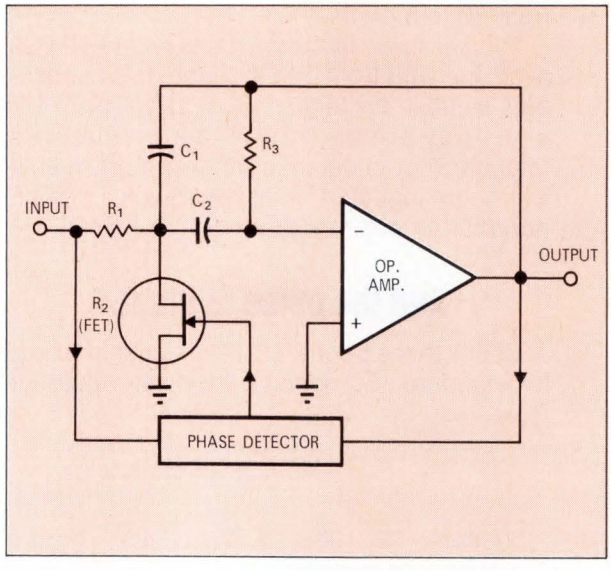


Fig. 2—**Simplified schematic** shows how the basic circuit of **Fig. 1** can be modified for the self-tuned operation. Resistor R_2 is replaced by a FET that is controlled by a phase detector.

$$\frac{e_{out}}{e_{in}} = -\frac{s/CR_1}{s^2 + \frac{2}{CR_3}s + \frac{1}{C^2R_3}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)} \qquad (1)$$

It can be seen from **Eq. 1** that the resonant frequency f_o, resonant-frequency gain A_o, bandwidth β, and Q of a filter described by the transfer function are as follows:

$$f_o = \frac{1}{2\pi C}\sqrt{\frac{1}{R_3}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}\ \text{Hz} \qquad (2)$$

$$A_o = -\frac{R_3}{2R_1} \qquad (3)$$

$$\beta + \frac{2}{CR_3}\ \text{rad/sec} = \frac{1}{\pi CR_3}\ \text{Hz} \qquad (4)$$

$$Q = \frac{f_o}{\beta} = \frac{2}{\sqrt{R_3\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}} \qquad (5)$$

These equations show that f_o can be varied merely by changing R_2, and without affecting the gain A_o or the bandwidth β. Also, **Eq. 2** and **Eq. 4** show that the center frequency and bandwidth can be changed by changing the value of C (without affecting the center frequency gain or the Q). This allows convenient range switching.

If resistance R_2 can be made to vary appropriately as the frequency of the input signal varies, the filter can be made to stay tuned to the signal frequency. **Fig. 2** shows a method by which this may be accomplished.

If the filter is properly tuned, there will be 180° of phase shift between the input and the output of the filter as indicated by the minus sign in **Eq. 3.** If, however, the filter is not tuned to the input frequency, then the phase shift is not 180°, and the phase detector generates an error signal, which is applied to the gate of the field-effect transistor (FET) to control its drain-to-source resistance, R_2. The phase detector and FET form part of a negative-feedback loop around the filter. Because of this configuration, any error in phase resulting from detuning will change the resistance of the FET, thereby retuning the filter. Thus, the FET acts as the variable resistance R_2 in **Eq. 2**.

The complete self-tuning circuit is shown in **Fig. 3**, while **Fig. 4** shows the waveforms at various points in the circuit. In **Fig. 3**, amplifier A_1, and resistors R_1, R_2, R_3 and R_5, FET Q_1, and capacitors C_1, C_2, and C_3 comprise the filter. FET Q_1 functions as the variable resistor. Resistors R_2 and R_5 limit the amount of variable resistance in the circuit and prevent latch-up as the electronic servo hunts for the center frequency when confronted with a noisy input signal. Capacitor C_3 prevents self-oscillation in the operational-amplifier A_1. Amplifier A_2 is used as a differentiator, A_3 as an integrator, and A_4 and A_5 as comparators.

In the timing diagram of **Fig. 4**, the top waveform is a sinusoidal input signal and the waveform immediately below it is the corresponding output. Since the phase shift between these two waveforms is not exactly 180°, this indicates that the filter is not tuned to the input signal frequency. The A_2 output waveform in **Fig. 4** is a differentiated and inverted version of the filter output. The differen-

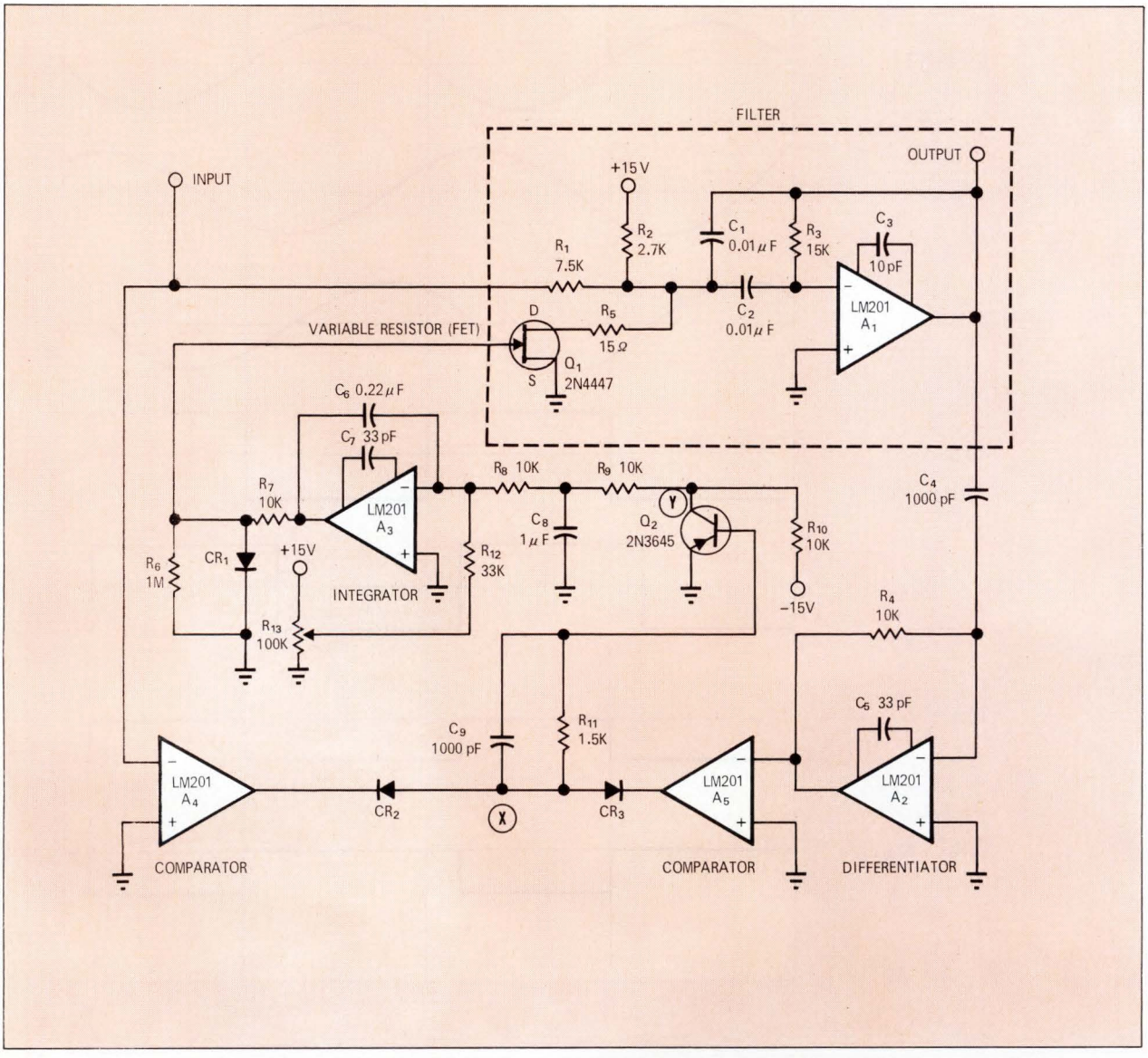


Fig. 3—**Complete self-tuned** active bandpass filter uses inexpensive IC op amps. The two comparators, and the rectifiers CR_2 and CR_3, comprise the phase detector. Resistor R_{13} nulls the error signal when the filter's input and output signals are exactly 180° out of phase.

tiation introduces the additional 90° phase shift necessary to make the final FET control voltage go both positive and negative on demand. Amplifiers A_4 and A_5 limit the input signal and differentiator output, respectively, resulting in the waveforms illustrated for the output of these amplifiers.

Diodes CR_2 and CR_3, and transistor Q_2 form a logic circuit, the output of which is the "Point-X" waveform in **Fig. 4**. When the filter input and output are exactly 180° out of phase (filter in tune), the waveform for point X has a certain average dc level, E_o. As the phase shift increases or decreases, the dc level changes to $E_o \pm \Delta E_o$, where $\pm\Delta E_o$ is the error signal produced when the filter is not tuned.

Transistor Q_2 inverts the error signal to produce the bottom waveform in **Fig. 4**. The E_o component is cancelled by an opposing voltage derived from R_{13} and R_{12}. The error signal is amplified by the integrator A_3 to provide a correcting signal to FET Q_1. The integrator has a dc gain of about 10^5. But it has a low ac gain, and this helps remove ripple from the correcting voltage. Resistors R_8, R_9, and R_{10}, and capacitor C_8, provide some prefiltering of the error-signal waveform prior to integration.

With the values shown, the filter self-tunes at center frequencies from 2 to 20 kHz. Over this range, the output amplitude remains constant to within ±1%. The oscilloscope picture of **Fig. 5** illustrates the effect of the circuit on a noisy signal. All noise measurements were performed

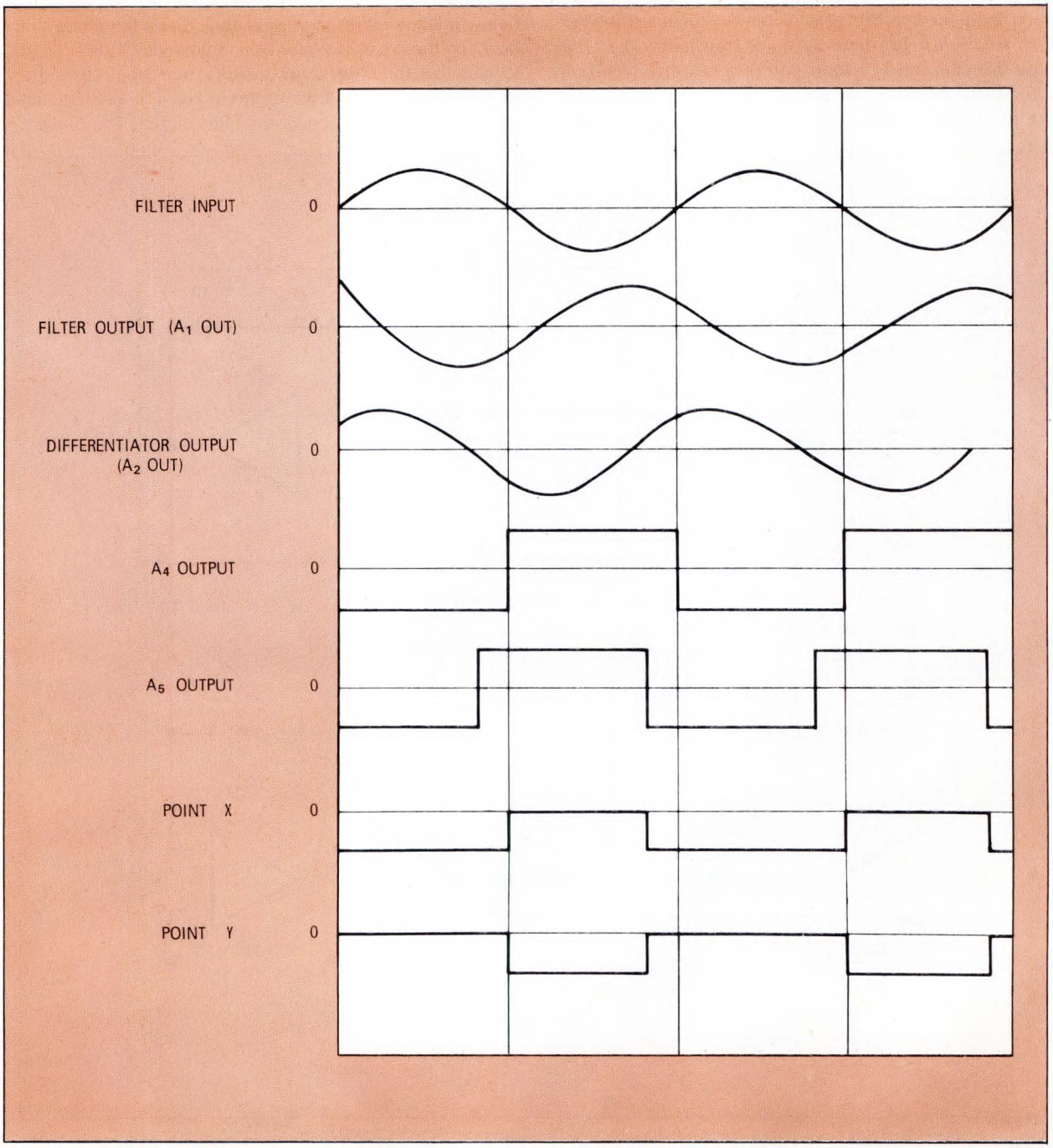


Fig. 4—**Voltage waveforms** at various points in the circuit of **Fig. 3**. Because the input and output waveforms are not exactly 180° out of phase, an error signal is produced at point X (the output of the phase detector).

using a calibrated white-noise source having a 3-dB point at 30 kHz and a roll-off of 6 dB per octave above 30 kHz.

Fig. 6 is a plot of the minimum signal-to-noise ratio necessary for the filter to lock in with an input signal of 1V rms. The filter tends to lock in better at higher frequencies. This is because there are more cycles of signal per unit time.

The curves in **Fig. 7** show how long it takes for the filter to lock in to a signal suddenly applied in the presence of various levels of noise. As expected, the lock-in time is shorter for higher frequencies and for higher signal-to-noise ratios.

As shown in **Fig. 3**, Type LM201 amplifiers were used throughout for the original version of the circuit. Other types can be used. Of course, the op amps used must have adequate gain and frequency response for the application. A gain-bandwidth product of about a hundred times the filter's upper frequency is adequate. For the FET, any type is suitable that has a minimum on resistance low enough to tune the filter to its highest frequency. ▭

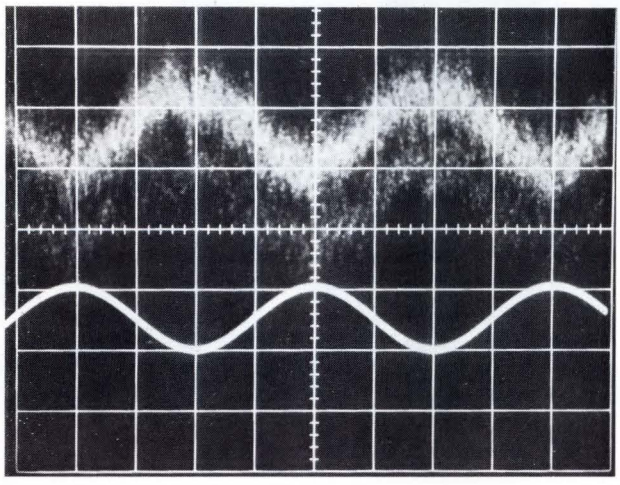


Fig. 5—**Scope picture shows** how a noisy input signal (top) is filtered by the circuit of **Fig. 3** to produce a clean output signal (below).

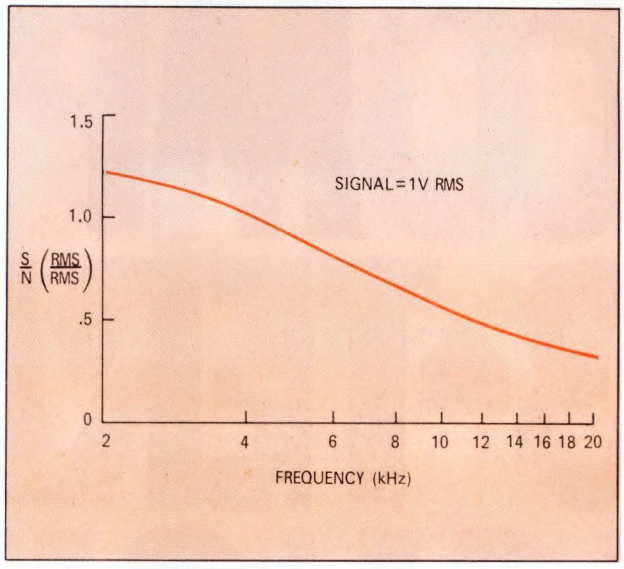


Fig. 6—**Plots of minimum** signal-to-noise ratio needed for the active filter to track input signals of various center frequencies.

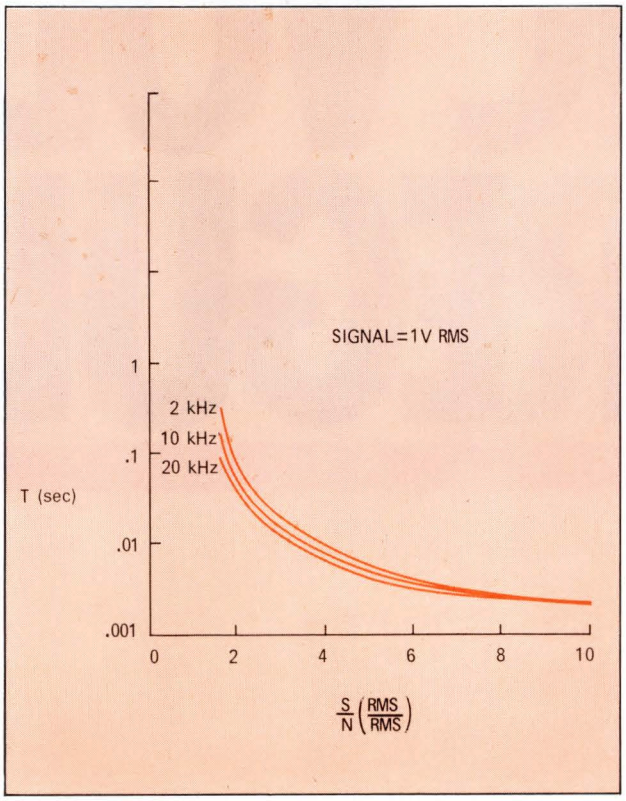
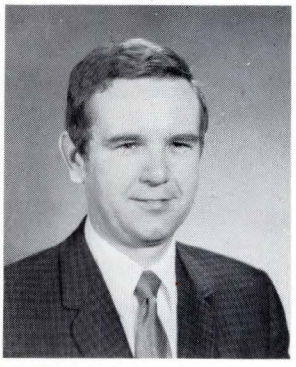


Fig. 7—**Curves show lock-in times,** τ, for various input frequencies as a function of signal-to-noise ratio. Higher-frequency signals with good signal-to-noise ratios are captured the fastest.

Author's Biography

Gordon Deboo (L) and Roger Hedlund (R) are both Research Scientists at NASA's Ames Research Center, Moffet Field, Calif. Deboo and Hedlund have been with NASA for 8 years and 9 years, respectively. The two engineers specialize in circuit design for electronic instruments. Deboo has a B.S.c. from London University (England). Hedlund has a B.S.E.E. from Colorado State University.



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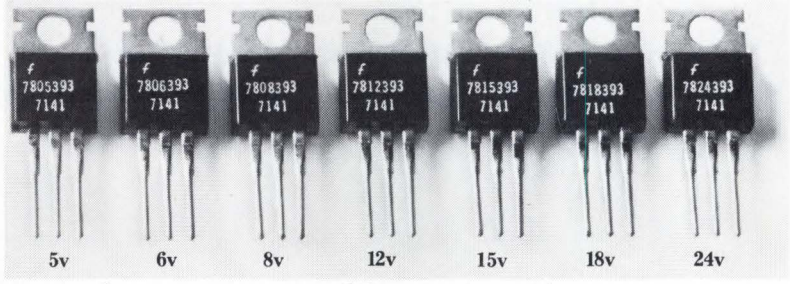

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CIRCLE NO. 19

Design toroids the easy way, using a computer to find the smallest core

This program performs the necessary trial and error process. And it provides you with a manual override capability.

JOHN P. KING, ESL, Inc.

Toroidal coils must be designed with care if they are to behave properly and be as small as possible. The choice of core material must take into account the circuit's operating frequency. Also, current through the toroid must be considered, so that the core does not become saturated or nonlinear. Wire size must be large enough so that the coil doesn't suffer from an excessive IR drop or poor Q. These factors force the designer to use larger and larger coils in an effort to produce a properly working circuit.

Design involves a trial and error process of selecting a core and calculating the coil parameters. A number of trials are required before the smallest usable core can be found. Here's a computer program that performs the calculations and removes much of the drudgery from toroidal coil design. The flow chart of **Fig. 1** shows the logical process used to select the smallest core and winding that will meet all design requirements. A corresponding program listing, written in SUPERBASIC, is shown in **Fig. 2**.

In this approach, the design requirements are compared by the program against all members of a set of standard toroids whose parameters are stored in the computer. Of course, the more cores stored, the greater the choice.

The only operator inputs required are the basic requirements for the finished coil. The operator is also provided with a review and override capability at two points in the program, so that another choice can be made.

How It Works

A preliminary core selection is done on the basis of maximum usable permeability. It is assumed that the inductors should be useful at frequencies up to three times their nominal operating frequency. A maximum magnetic flux density of 4000 gauss is allowed. This leads to a corresponding maximum magnetic field intensity (Table).

After the first selection, the smallest core of the correct permeability is tried for suitability. Using Ampere's law, $T = H(Z+O)/0.8A$ (where H = magnetic field intensity (oersted), Z = core inner diameter (cm), O = core outer diameter (cm), and A = peak current in amperes, the number of turns, T, required for saturation is calculated. From this, the maximum inductance this core can have without being saturated is calculated. This inductance is compared to the required inductance. If the required inductance is greater, increasingly larger cores are tried until a suitable core size is found. When a suitable core has been found, the required number of turns is calculated using the single-turn inductance value given by the core manufacturer.

Permeability (gauss/oersted)	Max. Frequency (kHz)	Max. Field Intensity (oersted)
550	4	8
300	15	15
200	50	22
125	100	36
60	100	65

FREQUENCY VS. FIELD INTENSITY

The minimum usable wire size is then determined (using a table look-up procedure) and the required window area is computed. In computing this area, a "stacking factor" is taken into account to allow for the unused area present in any core window because of the round wires and imperfect winding.

The required area is compared to that available. If the comparison is favorable, the IR drop and Q are calculated. (It should be noted that Q calculations are based on winding resistance only. Calculated Qs of 100 or more should be suspect, because core losses are often the limiting factor with Qs of this magnitude). If the area comparison was unfavorable, the next larger core is tried. Assuming that there now is a favorable area comparison, the program prints out the IR drop and Q for review by the operator (an unfavorable review of the IR drop and Q indicates that the next larger wire size should be used). On the other hand, a favorable review causes the core and coil winding data to be printed out. The designer can now choose to accept or reject the coil for any reason not considered by the program.

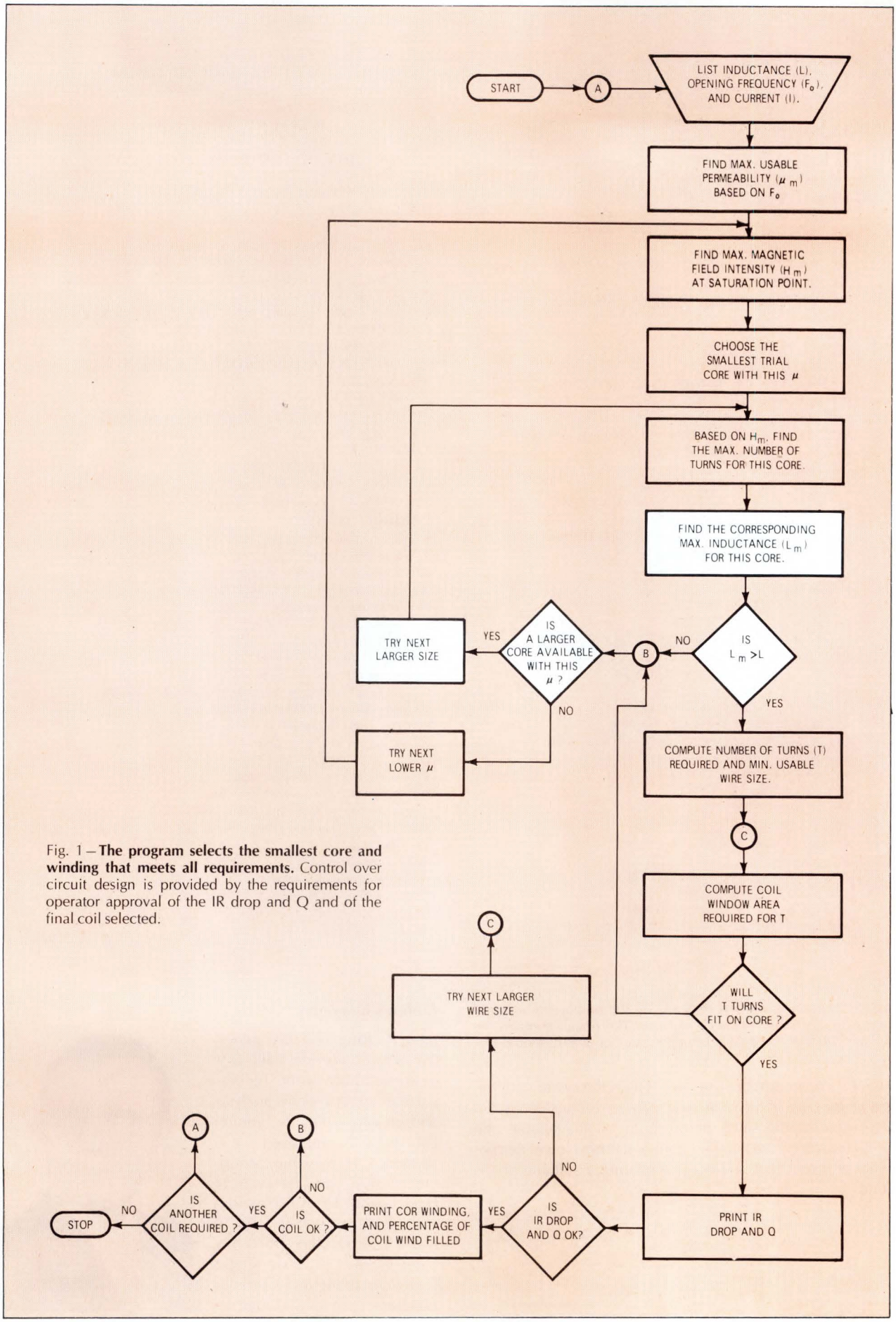

Fig. 1 – **The program selects the smallest core and winding that meets all requirements.** Control over circuit design is provided by the requirements for operator approval of the IR drop and Q and of the final coil selected.

Program Listing

```
 10 BASE 1
 20 INTEGER B(5,1), P(5,7), U(5,1), S(19,1)
 30 MAT READ B
 40 MAT READ Z(5,7), O(5,7)
 50 MAT READ W(5,7), Q(5,7)
 60 MAT READ P,U
 70 MAT READ E(5,7), K(19,1)
 80 MAT READ D(19,1), R(19,1)
 90 MAT READ S
100 PRINT "REQUIRED INDUCTANCE IN HENRYS IS"
101 INPUT L
102 PRINT "MAX LOAD CURRENT IN AMPERES IS"
103 INPUT A
104 PRINT "OPERATING FREQUENCY IN KHZ IS"
105 INPUT F1
106 F1 = 1000.0*F1
200 IF A < .25 THEN J1 = 1
201 FOR J = 1 TO 18
202 IF A < K(J + 1, 1) THEN IF A > K(J,1) THEN J1 = J + 1
203 IF A = K(J,1)THEN J1 = J + 1
204 NEXT J
205 IF A > 16.0 THEN PRINT "CURRENT TOO LARGE"
206 IF A > 16.0 THEN GO TO 434
300 F2 = 3.0*F1
301 IF F2 < 4.0E3 THEN M = 1
302 IF F2 > 3.99E3 THEN IF F2 > 1.5E4 THEN M = 2
303 IF F2 > 1.49E4 THEN IS F2 < 5.0E4 THEN M = 3
304 IF F2 > 4.99E4 THEN IF F2 < 1.0E5 THEN M = 4
305 IF F2 > 9.99E4 THEN M = 5
306 IF M = 1 THEN H = 8.0
307 IF M = 2 THEN H = 15.0
308 IF M = 3 THEN H = 22.0
309 IF M = 4 THEN H = 36.0
310 IF M = 5 THEN H = 65.0
400 N = 1
401 T = (H*(Z(M,N) + 0(M,N)))/(0.8*A)
402 L2 = Y(M,N)*T*T
403 IF L2 > L THEN GO TO 411
404 IF N < B(M,1) THEN GO TO 409
405 IF M = 5 THEN PRINT "NO SUITABLE CORE"
406 IF M = 5 THEN GO TO 434
407 ID M < 5 THEN M = M + 1
408 GO TO 400
409 N = N + 1
410 TO TO 401
411 U2 = SQR(L/Y(M.N))
412 R1 = U2*D(J1,1)*1.8
413 IF R1 > W(M,N) THEN GO TO 404
414 V1 = A*Q(M,N)*U2*R(J1,1)
415 Q1 = 6.28*F1*L/(Q(M,N)*U2*R(J1,1))
416 D1 = "IR DROP IS %%.%% VOLTS, Q IS %%%.%"
417 PRINT IN IMAGE D5: V1, Q1
418 PRINT "IF IR DROP AND Q ARE OK, TYPE 1.0;
    IF NOT, TYPE 2.0"
419 INPUT T1
420 IF T1 > 1.5 THEN J1 = J1 + 1
421 IF T1 > 1.5 THEN GO TO 205
422 D2 = "SELECTED CORE IS PART NO %%%%% A2,
    MU IS %%%"
423 PRINT IN IMAGE D2: P(M,N), U(M,1)
424 D3 = "ID IS %%%% CM, OD IS %%%% CM,
    HEIGHT IS %%%% CM"
425 PRINT IN IMAGE D3: Z(M,N), 0(M,N), E(M,N)
426 D4 = "COIL IS %%%.% TURNS OF %% WIRE"
427 PRINT IN IMAGE D4: U2,S(J1,1)
428 P2 = (R1/W(M,N))*100.0
429 D5 = "CORE IS %%% PCNT FULL WITH STACKING
    FACTOR 1 8/10"
430 PRINT IN IMAGE D5: P2
431 PRINT "IF COIL IS OK, TYPE 1.0; IF NOT, TYPE 2.0"
432 INPUT T2
433 IF T2 > 1.5, THEN GO TO 404
434 PRINT "TYPE 1.0 IF ANOTHER COIL IS REQUIRED;
    IF NOT TYPE 2.0"
435 INPUT T3
436 IF T3 < 1.5 GO TO 100
437 PRINT "END OF PROGRAM"
500 DATA—(Data statements not included)
```

VARIABLE NAMES

L = Required inductance
A = Max load current
F1 = Operating frequency in kHz
(K(J1,1) = Max current for a particular wire size
F2 = Max usable frequency
H = Max magnetic field intensity
T = Turns needed for H
Z(M,N) = Core inner diameter
0(M,N) = Core outer diameter
L2 = Max non-saturating inductance for a particular core
Y(M,N) = Single turn inductance for a core
B(M,1) = Number of cores of this permeability
U2 = Number of turns required for L
D(J1,1) = Crossectional area of a wire size
R1 = Required core window area
W(M,N) = Available core window area
Q(M,N) = Core single turn winding length in cm.
R(J1,1) = Resistance of a given wire size per cm.
V1 = IR drop
Q1 = Operating coil Q
P(M,N) = Core part number
U(M,1) = Core permeability
E(M,N) = Height of core in cm.
S(J1,1) = Wire size

Fig. 2—**Program usefulness** depends on the number of standard cores stored in the computer's memory. The output contains the core part number, the wire size and the number of turns required.

If for some reason the operator rejects the entire coil, the next larger core of the same permeability is considered. If a larger core of the same permeability is unavailable, the computer selects the smallest core of the next lower permeability and proceeds to larger cores until a suitable one is found.

Author's biography

John P. King recently joined ESL, Inc., Sunnyvale, Calif. as a senior Member of the Technical Staff doing systems analysis and design. Prior to joining ESL, he was employed for 4 years at GTE Sylvania, Mountain View. He received a B.S.E.E. from Texas Technological College (1964) and a M.S.E.E. from the University Santa Clara (1971). Mr. King is a member of the IEEE Communications Technology Group.

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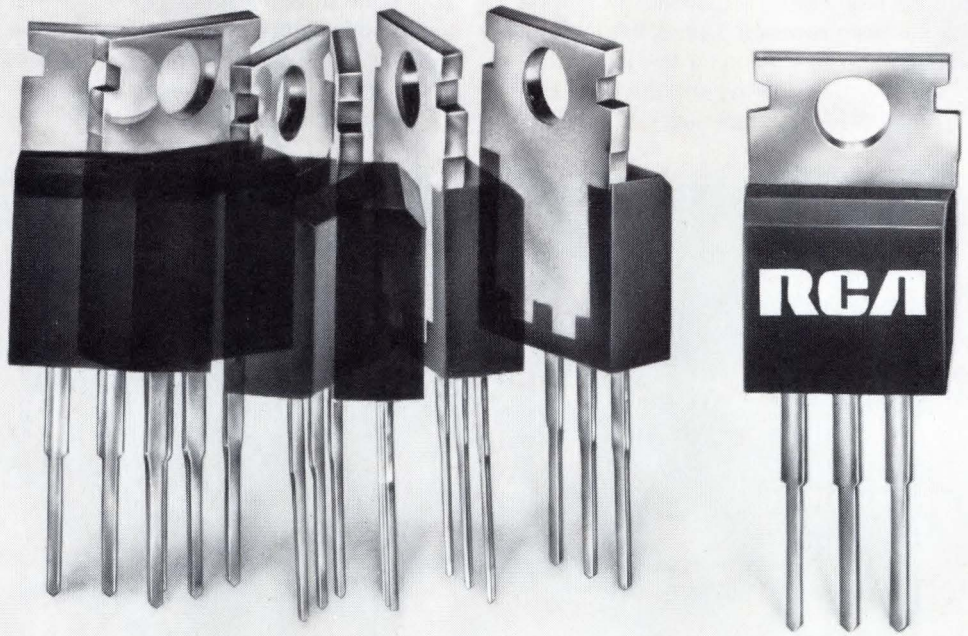
MJE-203	RCA-203	MJE-103	RCA-103
MJE-204	RCA-204	MJE-104	RCA-104
MJE-205	RCA-205	MJE-105	RCA-105
2N5190	RCA-45190	2N5193	RCA-45193
2N5191	RCA-45191	2N5194	RCA-45194
2N5192	RCA-45192	2N5195	RCA-45195
MJE-520	RCA-520	MJE-370	RCA-370
MJE-521	RCA-521	MJE-371	RCA-371



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CIRCLE NO. 20

Minimize overlap to maximize efficiency in saturated push-pull circuits

Are your dc-to-dc converters operating at low efficiency? Base-drive delay techniques can significantly increase their operating efficiency and frequency capability.

Robert F. Downs, Ocean and Atmospheric Science, Inc.

Overlap in saturated push-pull converters is primarily due to the storage-time delay inherent in power transistors. This delay is the time required for a transistor to turn off after its base drive has been removed. During this interval, both of the push-pull transistors present a low impedance to ground (i.e., one is driven ON by the driving signal while the other is still ON in its storage state). As a consequence, a large amount of power is drawn from the source and dissipated by the transistors. This action is particularly noticeable in applications where the storage time is an appreciable portion of the switching period.

Some of the solutions that can be used by the circuit designer to combat this overlap problem are:

a) Tolerate the condition—this yields lower power-con-

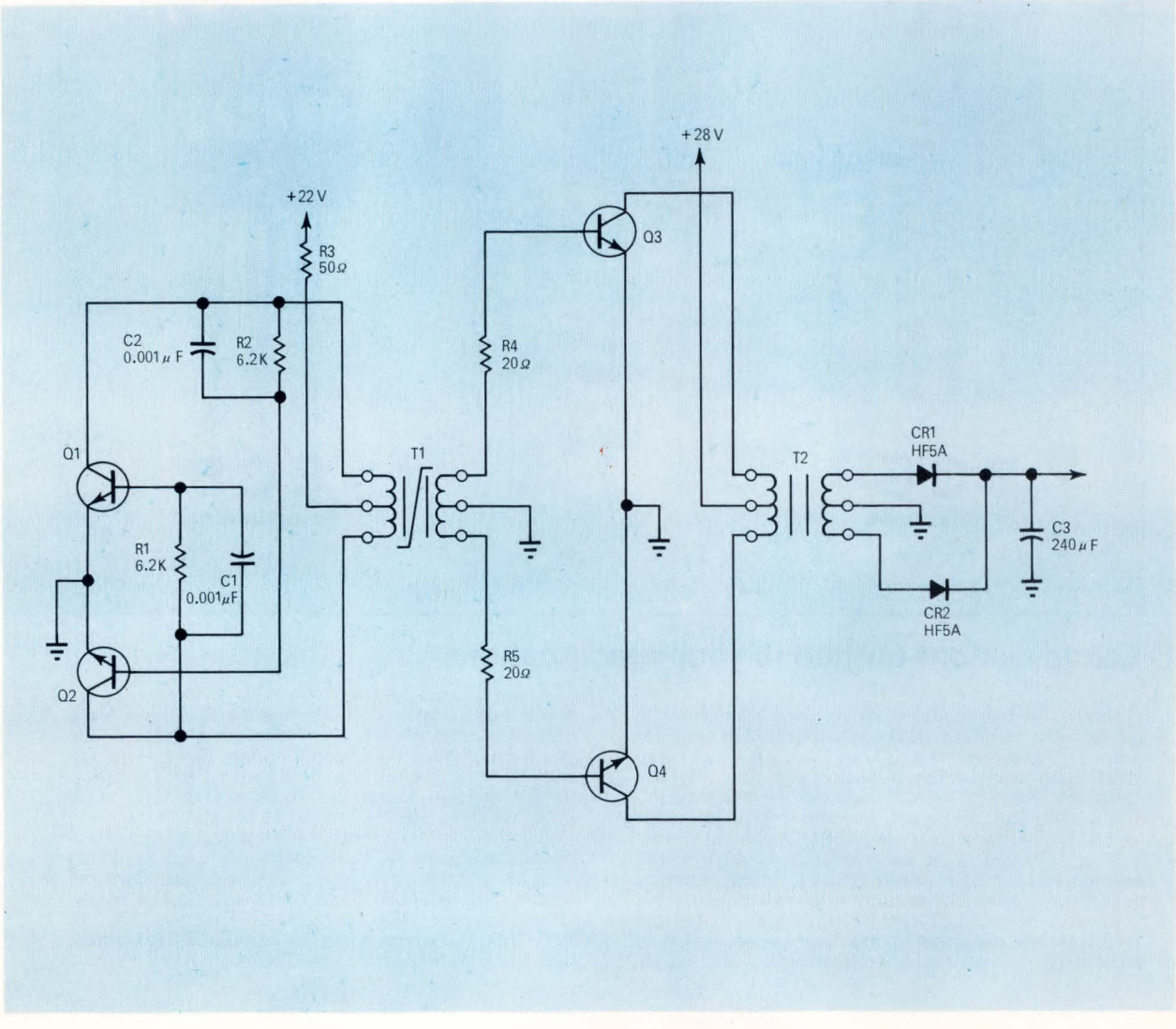

Fig. 1—**Basic dc-to-dc converter,** designed to operate at 13 kHz, loses conversion efficiency because there is a storage delay of 5 to 10 μsec between the time the base drive is removed and the time the transitor turns off. During this time both transistors conduct.

version efficiency and limits the total power that can be delivered to the load. It will also require an increase in the physical bulk to take care of cooling requirements.

b) Lower the operating frequency—this increases power conversion efficiency, but also increases the size and cost of the unit.

c) Add source inductance—efficiency is improved because this limits the amount of overlap current. However, this deforms the switching waveforms. The overall size of the unit is increased and the additional expense of magnetic elements is not attractive.

d) Delay the turn-on—a preferred approach is to delay the application of base drive to each transistor by an amount of time equal to the storage time of the opposite device.

The schematic in **Fig. 1** is a typical dc-to-dc converter operating at 13 kHz and using 2N1016 power transistors. These devices have storage times in the order of 5 to 10 μsec, and normally would not be used as saturating switches at frequencies above approximately 5 kHz. The higher operating frequency was used to demonstrate the degree of improvement afforded by the turn-on delay technique.

Fig. 2 is similar to **Fig. 1** except for the modification circuitry, which consists of 10 active and passive components. Operation of the additional circuitry is fairly straightforward.

The basic dc-to-dc converter used is a driven type whose signal source is a simple two-transistor "flux" oscillator. Q5 and Q6 are the switching power transistors. Now assume that the converter is operating, and that at a particular point in time Q5 is ON and Q6 is OFF. When the driving signal, e_1, goes negative and e_2 goes positive, the positive edge of e_2 is coupled through R4 and C4, which turns on Q4 and thus prevents Q6 from changing its OFF state. Even though e_1 is negative, Q5 will still conduct during its storage time. R4 and C4 are selected to hold Q4 on

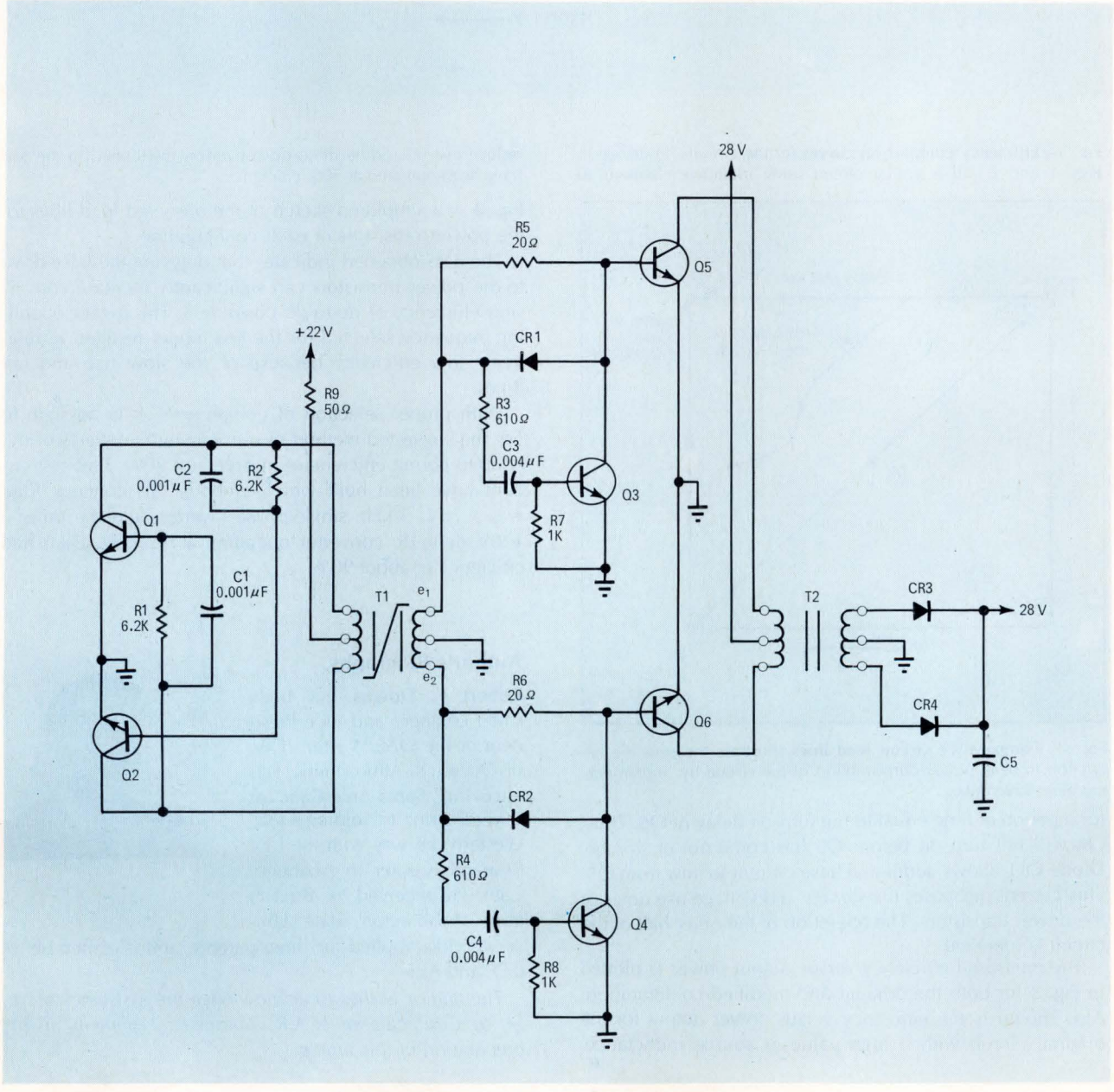

Fig. 2—**Adding two transistors** reduces overlap by preventing the OFF transistor from conducting until the opposite device has turned off.

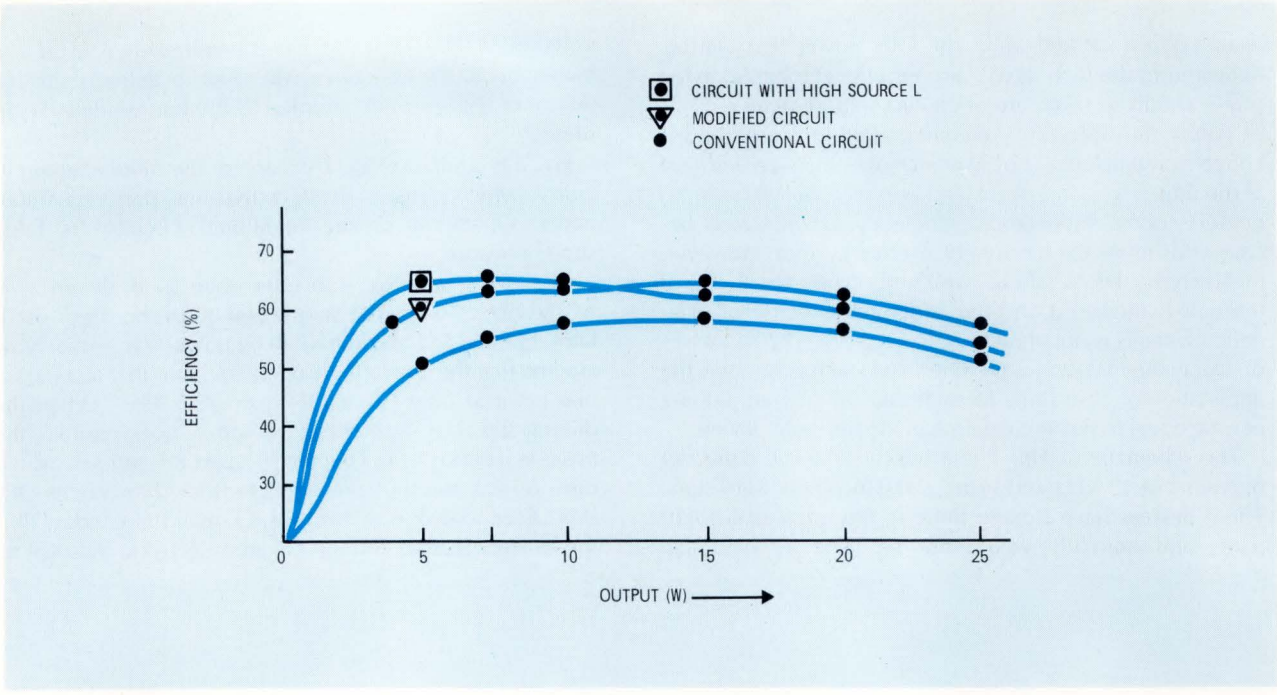

Fig. 3 – **Efficiency comparison curves** for the circuits described in **Figs. 1** and **2** and a similar circuit using inductive elements to reduce overlap. Some dc-to-dc converters mentioned in the text have been operated at 90% efficiency.

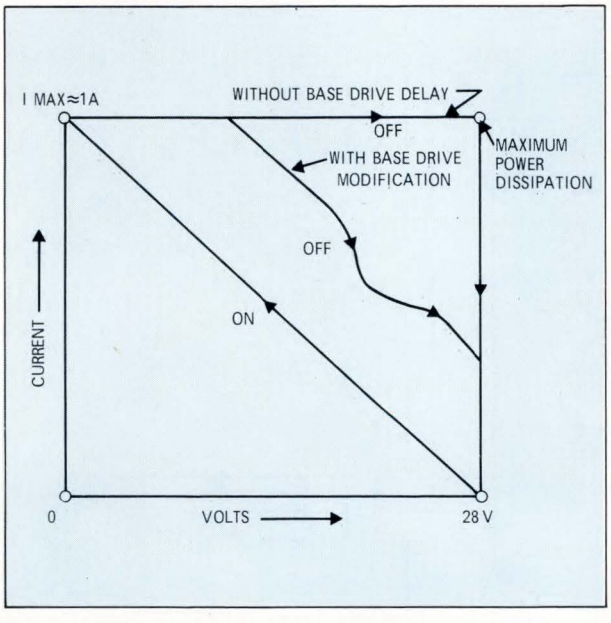

Fig. 4 – **Comparative circuit load lines** illustrate the possible reduction in peak power consumption of the circuit by implementing base-drive delay.

for a period of time equal to the turn-off delay of Q5. Thus, Q6 will not turn on before Q5 has come out of storage. Diode CR1 allows additional base current to flow from Q5. This current decreases the storage and voltage rise times of the power transistors. The operation of the other half of the circuit is identical.

The measured efficiency versus output power is plotted in **Fig. 3** for both the original and modified configuration. Also shown is the efficiency versus power output for the original circuit with a high value of source inductance.

Fig. 4 is a simplified sketch of the observed load lines for the power transistors of each configuration.

The data obtained indicates that delaying the base drive to the power transistors can significantly increase conversion efficiency of dc-to-dc converters. The higher operating frequency selected for the test model resulted in relatively low efficiency because of the slow rise and fall times.

With proper selection of components, it is possible to use the suggested method of minimizing the effects of overlap to permit efficiencies in excess of 90%. Two test circuits have been built which embody this concept. One was a 28V, 5-kHz single-phase inverter, and the other a 120V dc-to-dc converter operating at 12 kHz. Each had efficiency of about 90%.

Author's Biography

Robert F. Downs has been Chief Engineer and Vice President of the OAS/Western Div. of Ocean & Atmospheric Science, Inc., Santa Ana, Calif. for 1 year. Prior to joining OAS/Western, he was with the LTV Research Center in Anaheim, Calif. He received his B.S.E.E. from Washington State University, has applied for three patents, and is a member of IEEE and AES.

The author wishes to acknowledge the assistance of Mr. M. S. Chrupcala of N.A.R. Autonetics, Anaheim in the preparation of this article.

ANOTHER MYTH DESTROYED.

Myth: National doesn't make FET op amps. And, even if they did, they probably wouldn't be as good as bipolar devices. And, besides, everybody knows that FET op amps have lousy offset voltage and drift specs. And, FET op amps are too expensive. And, anyway, why not just go to a module house in the first place...

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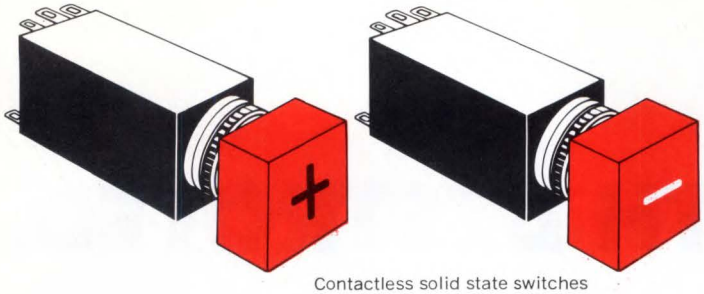
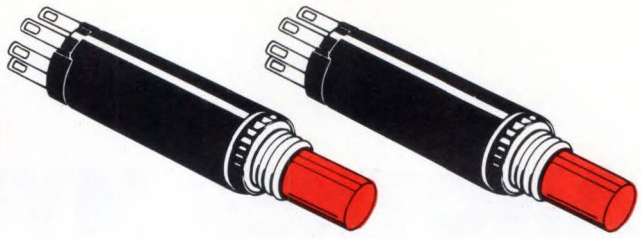
NATIONAL.

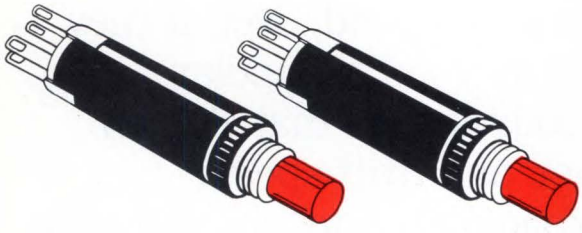
CIRCLE NO. 21



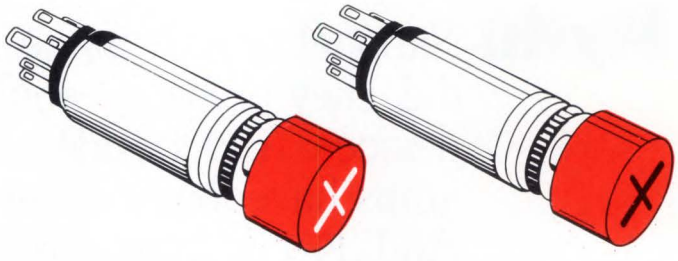
Contactless solid state switches



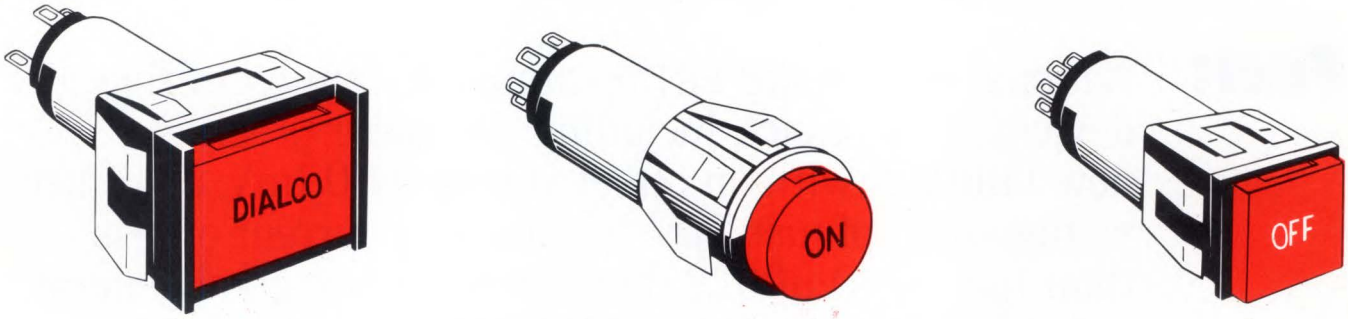
Incandescent or neon lighted switches



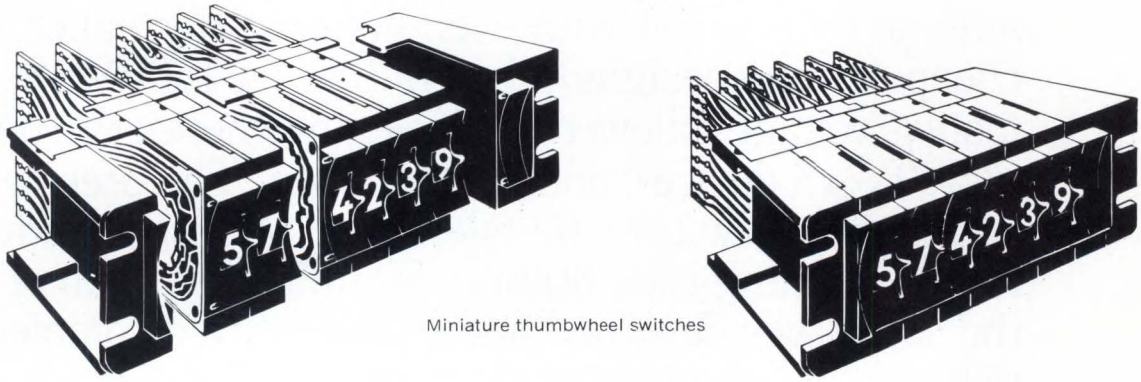
LED lighted switches... panel mounting



Incandescent lighted switches... panel mounting



Incandescent lighted switches... snap-in mounting



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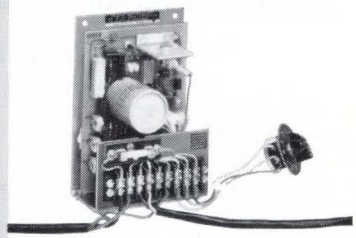

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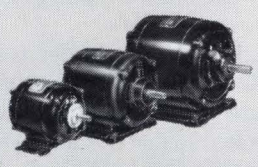
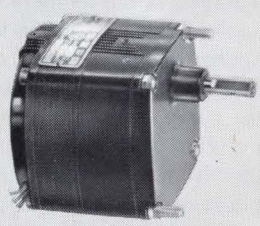
Since 1905 Bodine has manufactured fractional horsepower motors and gearmotors. Close tolerance machining and careful attention to even the smallest detail of construction enables Bodine not only to produce better motors, but to produce them at a lower cost to customers in terms of value received. STOCK Bodine motors and gearmotors are available in all types and sizes within a range of 1/2000 to 1/4 Hp; torques from 0.3 Oz-in. to well over 200 Lb-in.



Type N Motors: Three basic sizes; 3.36″, 4.50″ and 5.68″ in diameter. Stock ratings from 1/125 to 1/4 Hp. Almost any type of winding.

Type K Motors: Permanent-split capacitor instrument motors. Normal slip, high slip and synchronous windings. Stock ratings to 2.4 Oz-in. Only 2.405″ square.



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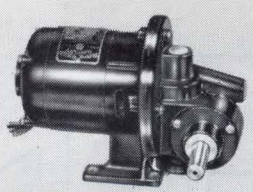

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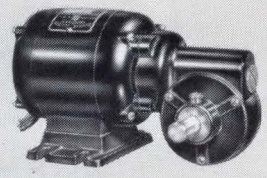

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CIRCLE NO. 23

CIRCUIT DESIGN AWARD PROGRAM

Temperature-coefficient measuring circuit

by **Richard C. Gerdes**
Optical Electronics, Inc. Tucson, Ariz.

Temperature testing of amplifiers and other analog circuits is usually a tedious process. The output voltage must be measured at discrete temperatures and then the temperature coefficient must be calculated by subtraction and division. Here is a circuit that performs the required measurements and calculations automatically and continuously.

Silicon diode CR_1 senses the temperature of the device under test. FET-input amplifier A_1 converts the forward voltage drop of the temperature-probe diode into a high-level analog voltage. The diode specified has a forward drop of approximately 2 mV/°C and the temperature coefficient is linear within 3% over the range from −55 to +125°C. With the component values shown, the output from A_1 changes by 325 mV/°C and is −10V at +55°C and +10V at −5°C. If the 10-MΩ scaling resistor is changed to 3.6 MΩ, the output from A_1 will be −10V at +110°C and +10V at −60°C.

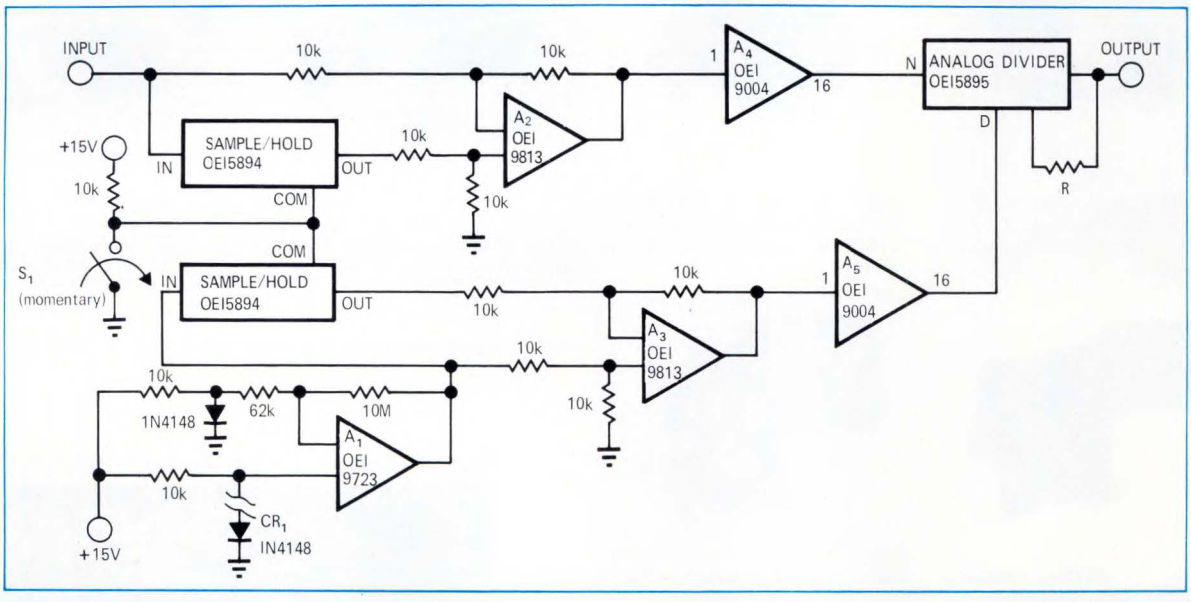
The output from the temperature-sensing circuit is applied to a sample-and-hold circuit, while the analog voltage from the device under test is applied to a second sample/hold. Actuation of S_1 causes the voltage and temperature information to be stored in the sample/hold circuits at the commencement of the test. The specified sample/hold circuits have no memory decay, hence there is no upper time limit for the temperature-coefficient measurements.

Data stored in the sample/hold circuits at the beginning of the test bias amplifiers A_2 and A_3. During the test, the initial bias voltages are automatically subtracted from the input voltages to the amplifier. Thus the amplifiers respond solely to the changes in temperature and output voltage of the device under test.

The outputs from amplifier A_2 and A_3 can, of course, be either positive or negative depending on the direction of the temperature change and on the performance of the device under test. Unity-gain absolute-value amplifiers A_4 and A_5 ensure that the inputs to the analog divider are always positive.

The analog divider calculates the temperature coefficient. Its output is the ratio of voltage change to temperature change. Scaling resistor R allows the output to be calibrated so that it is a convenient analog of the desired engineering units (μV/°C, mV/°C, mV/°F, etc.).

To Vote For This Circuit
Circle 150



Circuit automatically measures and calculates temperature coefficients of analog circuits or devices. Diode CR_1 is used as a temperature probe. Resistor R allows the output scale factor to be adjusted for the desired measurement units.

Optical coupler and level shifter

by **Charles E. Mitchell**
Paradyne Corp. Clearwater, Fla.

The circuit shown in **Fig. 1** uses optical coupling to provide complete electrical isolation between two digital circuits.

Input signals with peak amplitudes as low as +4V can cause the output circuit to change state. Yet the circuit will handle input signals with peak amplitudes up to +100V without breakdown. For input voltages between +50 and +100V, however, transistors Q_1 and Q_2 should be mounted with heat sinks. The circuit operates equally well with input signals having very slow rise times or those with fast rise times.

The input side of the circuit consists of a current regulator which limits the loop current through the input side of the optical coupler OC_1. This current is limited to 7 mA and represents the maximum load on the input line. In the regulator circuit, zener diode CR_2 provides a reference voltage which defines the current through R_2.

In the output circuit, Schmitt trigger ST_1 eliminates oscillations that could otherwise occur when a slow-rise-time signal is applied to fast TTL circuits. The output signal changes state when the input signal reaches sufficient amplitude to light the LED within the optical coupler. When the LED leaves the dark state, current starts to flow in the phototransistor portion of OC_1. This current is sufficient to drive Q_3 into saturation, thus triggering ST_1 and producing an output pulse.

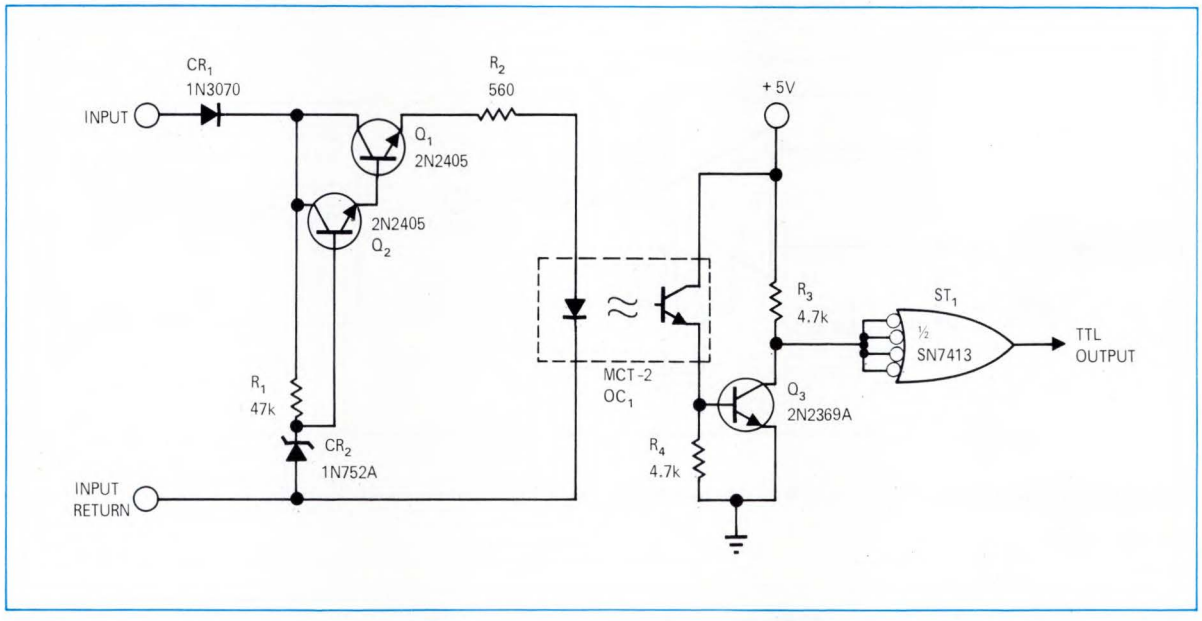


Fig. 1—**Optical coupling in this interface circuit** provides almost perfect isolation between digital systems. Schmitt-trigger ST_1 prevents unwanted oscillations with input signals having slow rise times.

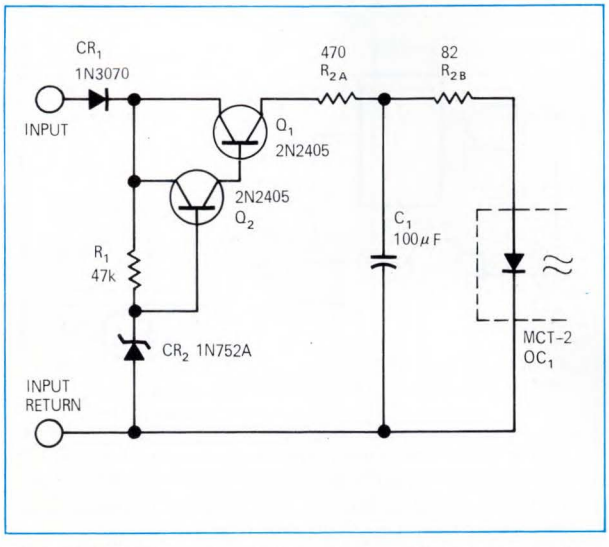


Fig. 2—**Modified version** of the input circuit includes an integrating filter (C_1 and R_2) which eliminates the effects of contact bounce which may be superimposed on the input signal.

The maximum throughput rate for the circuit is approximately 50 kHz. However, the circuit can be adjusted, for a given input signal, to increase the bandwidth significantly.

The circuit can also be modified, as shown in **Fig. 2**, for use with electromechanical switches or relays to eliminate the effects of contact bounce. In the modified circuit, R_2 is split into two separate resistors and a filter capacitor is added. Capacitor C_1 integrates the input signal and causes a delay at the output which amounts to approximately 1 msec for each 10 μF of capacitance.

A Monsanto optical coupler is specified in **Fig. 1**. However, equivalent devices manufactured by Texas Instruments and Litronix will function equally well in this circuit.

To Vote For This Circuit
Circle 151

High-gain ac/dc oscilloscope amplifier

by **Glen Coers**
Texas Instruments Incorporated, Dallas, Tex.

You can extend the vertical sensitivity range of your scope at minimum cost by adding this simple adapter. It can also be used to extend the voltage sensitivity of your VOM.

The circuit uses a SN72741 op amp, which has internal frequency compensation and requires no external compensation. The ac input is through a 1.0μF capacitor C1 that is connected to the noninverting input of the op amp. The voltage at the output will be in phase with the input. A switch is connected across the capacitor to provide ac (switch open) or dc (switch closed) operation.

The 1 MΩ resistor R1 establishes input bias current for the op amp. Because of its high resistance value an offset voltage is developed, but this can be nulled with the 5 kΩ pot, R2 (offset adj). The output of the op amp is connected to a 100Ω resistor, R3, so that if coax or shielded cable are used, the output of the device will not have to drive their highly capacitive load directly. (Direct drive sometimes causes instabilities.)

The frequency and output voltage limitations are listed in **Fig. 1**, along with the schematic. Input impedance is approximately 500 kΩ.

To Vote For This Circuit
Circle 152

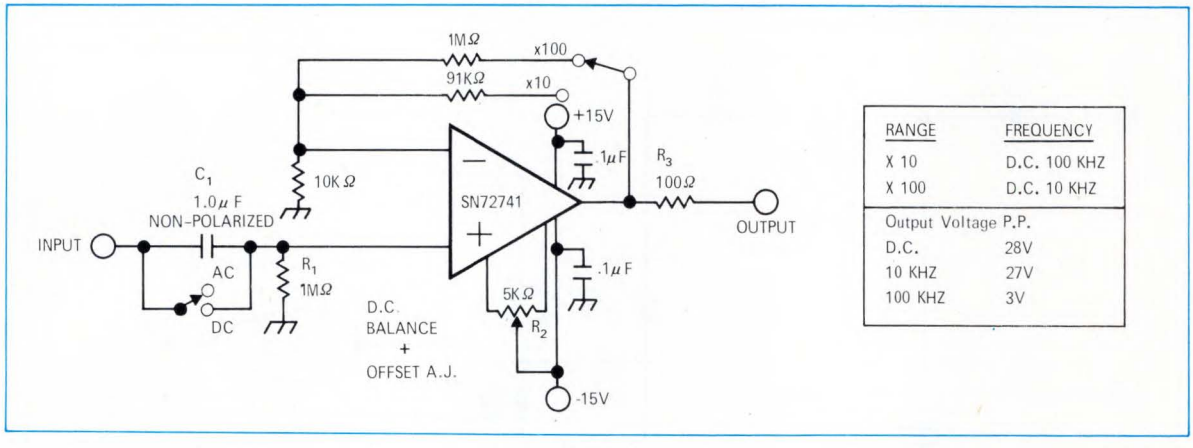


Fig. 1 – **This simple op amp circuit** permits an oscilloscope to monitor signals that would normally be below its input sensitivity.

Latching circuit provides noise immunity

by **Steven R. Martin**
Chicago, Ill.

This circuit is especially useful for noise rejection, since any noise spike or other undesired pulse whose duration is less than a predetermined minimum length will not erroneously set the latch. The minimum length of a pulse that will activate the circuit is determined by the RC combination. If R is selected at 10 kΩ, then C is determined by C = T/3.424 (for C > 10^3 pF and nonpolarized (where C is in pF, and T (in nsec) is the desired minimum length of a pulse that will activate the circuit. (For C < 10^3pF or C being polarized, you should check the specification sheet on the Fairchild 9601 monostable multivibrator.)

A high to low transition at pin 1 of the 9601 causes the output to produce a high to low pulse of length T. If the input pulse is longer than T, two highs will be seen at pins 4 and 5 of the 846 causing a low at its output, thus setting the latch. If the input pulse is shorter than T, pin 5 of the 846 will go low before pin 4 goes high and the circuit will not activate.

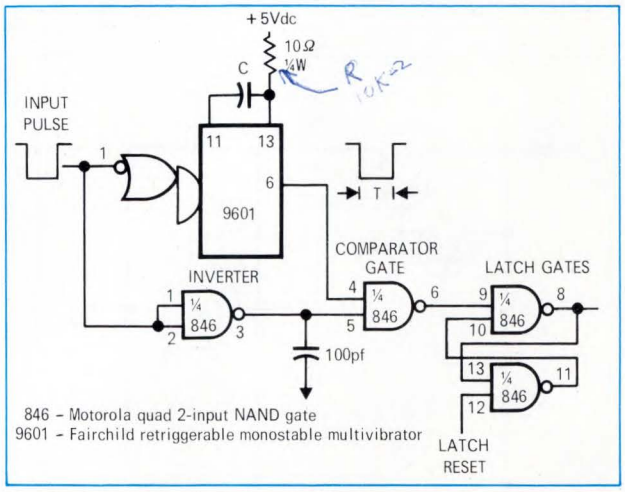


Fig. 1 – **False triggering** is prevented by generating a pulse, T, equal to the minimum input pulse. Pins 4 and 5 of the 846 must be high simultaneously to set the latch, but this cannot occur unless the input pulse equals or exceeds time "T".

To Vote For This Circuit
Circle 153

PRF monitor with adjustable end limits

by **Len Birkwood and Dan Porat**
Stanford Linear Accelerator Center, Stanford, Calif.

This circuit (**Fig. 1**) automatically checks that the pulse repetition frequency (PRF) of a train of pulses is within specified limits.

The circuit has two independent channels. The upper channel will latch when the PRF is higher than a predetermined limit, while the lower channel latches when the PRF is below a second specified limit. This is shown diagramatically in **Fig. 2**. Moreover, the upper channel will detect a single extraneous pulse (e.g. one generated by noise), while the lower channel will detect a single missing pulse.

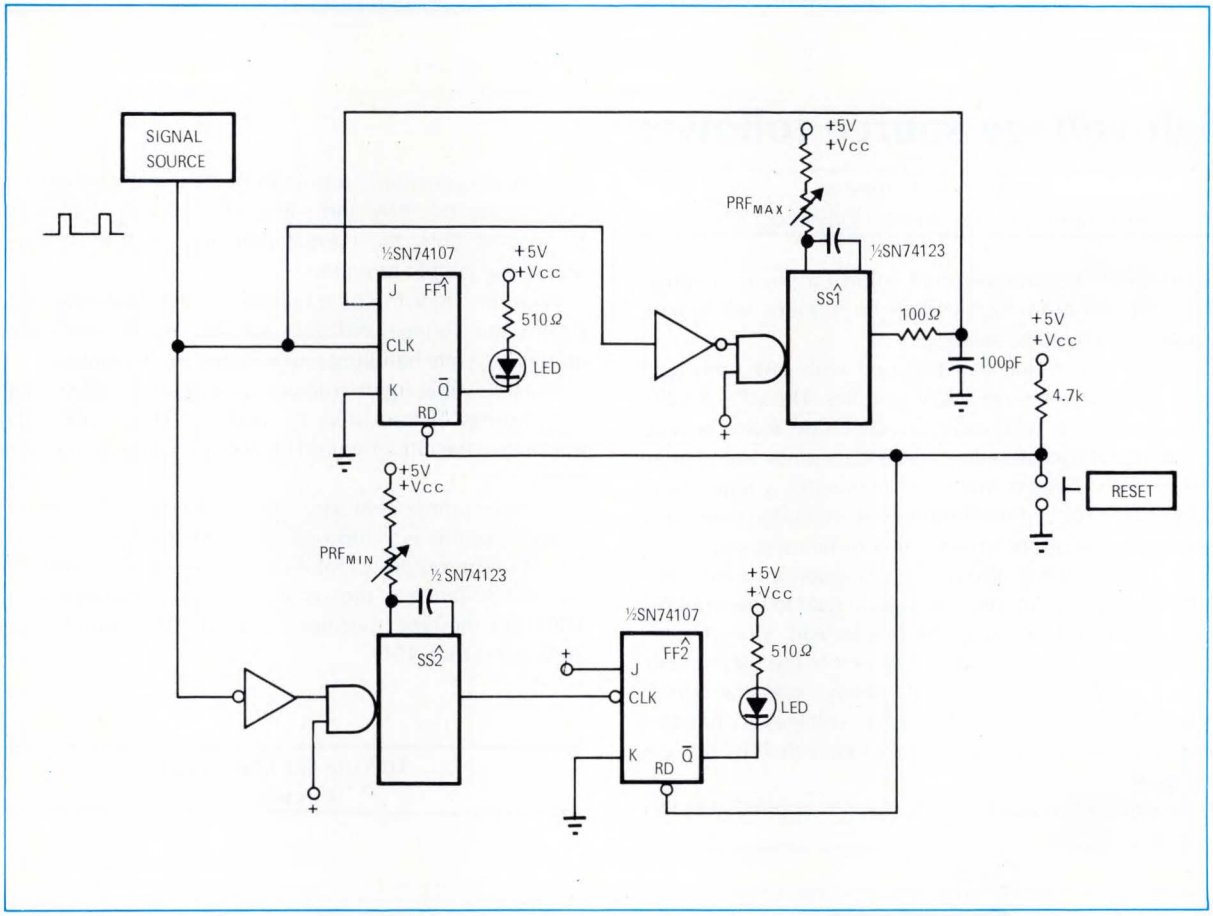


Fig. 1—**Monitor circuit gives a visual indication** when the PRF of the input signal strays outside predetermined limits. The upper portion of the circuit detects high PRF and the lower portion detects low PRF.

In the upper channel, the input pulse train is applied to the clock terminal of J-K flip-flop FF_1, and simultaneously to the one-shot SS_1. The latter produces a positive pulse of duration T_1,

where,
$$T_1 = \frac{1}{PRF_{max}} \qquad (1)$$

This pulse is fed back to the J terminal of FF_1. As long as the input PRF is less than PRF_{max}, the pulse at J of FF_1 will return to zero before the subsequent pulse of the input train has arrived. Otherwise FF_1 will be set.

In the lower channel, input pulses are applied to retriggerable one-shot SS_2 which produces an output pulse T_2,

where,
$$T_2 = \frac{1}{PRF_{min}} \qquad (2)$$

Note that T_2 is the output from SS_2 for only one input. When the input PRF is less than PRF_{min}, the Q output of SS_2 will return to zero and the trailing edge of the pulse sets FF_2.

LEDs are included in the circuit to provide out-of-limit indication. If required, the outputs from FF_1 and FF_2 can be applied to an OR gate whose input can trigger an audible

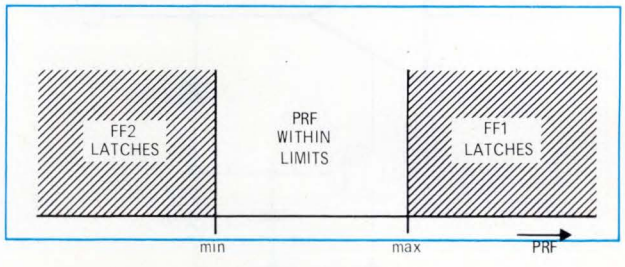


Fig. 2—**Diagram illustrates** the three possible conditions for the PRF of the signal monitored by the circuit of **Fig. 1** and also shows the corresponding circuit responses. In addition to detecting out-of-limit PRF, the circuit can also detect missing and extraneous pulses.

alarm. After a fault occurs, the fault indication persists until the circuit is reset with the push button.

A minor circuit modification allows one to count the number of times the input PRF goes outside the predetermined limits. In other words, it allows the circuit to detect the number of extraneous pulses and missing pulses. The modification consists of simply strapping FF_1 and FF_2 as T flip-flops (by tying J and K to V_{cc}) and then connecting a binary or decimal counter to the output of each flip-flop.

To Vote For This Circuit
Circle 155

High-voltage source follower

by **Stephen A. Jensen**
Radiant Industries, Inc. North Hollywood, Calif.

This circuit allows conventional voltage-follower modules or ICs to operate from high-voltage dc supplies and to handle large signal-voltage swings.

The same technique can be used with any unity-gain amplifier that operates on ±15V supplies. The GPS amplifier specified in the schematic is a precision follower. This type was needed to provide sufficient accuracy in the original application which involved interfacing a tachometer signal to the ±100V input amplifier of an analog computer. However the circuit technique can also be used with ICs such as the LM110 or the μA741 strapped for unity gain.

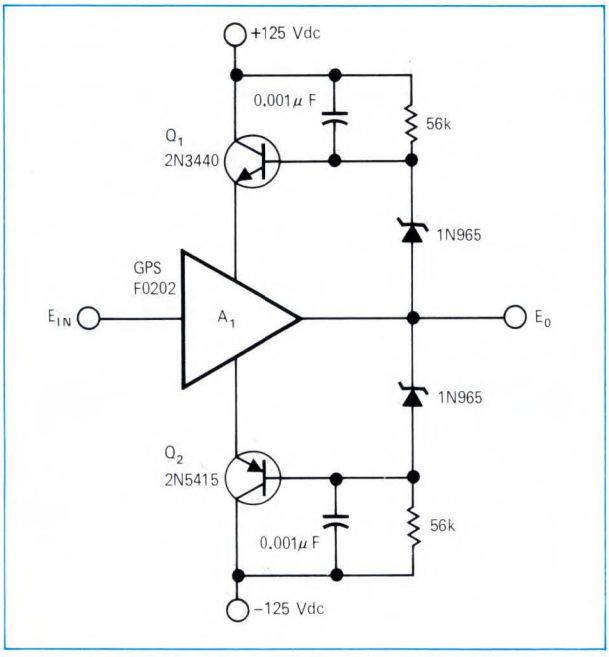
With this circuit, the positive supply lead to the amplifier is always held at 15V above the output lead. Similarly, the negative supply lead is held at 15V below the output lead. Thus the amplifier module or IC always sees the correct supply voltages. Large common-mode voltages are handled by the transistors in the supply lines rather than by the amplifier itself.

If, for example, a positive 75V signal is applied at the input, the power-supply terminals of the basic amplifier will see voltages of ±90V and +60V, respectively, with respect to ground. Thus the correct potential of 30V is applied across the supply terminals.

With this bootstrapping technique, the complete circuit retains the voltage and gain stability of the low-voltage amplifier, while handling much higher input voltages.

The allowable input-voltage range depends solely on the V_{CEO} ratings of transistors Q_1 and Q_2. Thus, with 1000V transistors, the circuit would be able to handle input signals of ±475V.

With the component types specified in the schematic, the input capability is ±100V pk-pk for frequencies from dc to 10 kHz. The output capability is 5 mA pk at ±100V. The input impedance is the same as for the amplifier A_1 (*i.e.* $10^{12}\Omega$ for the type specified). Similarly the output impedance is less than 10Ω.



Bootstrapping technique allows low-voltage unity-gain amplifiers to operate from large supply voltages and to handle large input signals.

To Vote For This Circuit
Circle 156

Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by circling the appropriate number on the reader inquiry card.

Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN/EEE, 221 Columbus Ave., Boston, MA 02116.

Readers have voted Robert L. Wilbur winner of the September 15 Savings Bond Award. His winning circuit was called "Proportional oven-temperature controller". Mr. Wilbur is with the Southwest Research Institute.

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CIRCLE NO. 24

SIGNAL ANALYZERS

Tiny new DPM's operate from logic supplies

PROGRESS IN INSTRUMENTATION

By eliminating conventional internal power supplies, two companies have slashed the sizes and costs of digital panel meters. The new instruments—model AN2535 from Analogic Corporation and model AD2001 from Analog Devices Inc.—operate from 5-Vdc power lines.

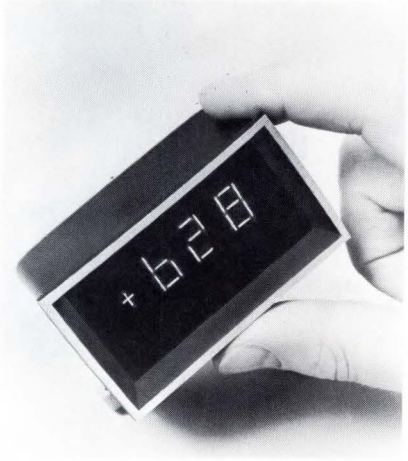
ADI announced its new DPM a couple of weeks before Analogic introduced its new version. For ADI, the AD2001 represented the company's first venture into the fiercely competitive DPM market. So, to achieve maximum impact, the company's engineering team put together an apparently unbeatable product and the marketing team launched it with a fanfare as "the world's smallest, least costly, DPM." To emphasize the instrument's innovative design, ADI gave it a suitably futuristic and heroic model number.

The company's triumph was short-lived, however. Analogic, one of the veterans of the DPM business, immediately counterattacked with its new AN2535. Thus the AD2001 relinquished its briefly held title and became the world's second smallest and least costly DPM.

Vital Statistics

The AD2001 shaped up for the fight with a width of 3 in., a height of 1-3/4 in., and a depth of 1-1/2 in. These dimensions yield an overall volume of approximately 7.9 cubic in. For the AN2535, the corresponding dimensions are 3.2 by 1-1/4 by 1.6 in., yielding a volume of only 6.4 cubic in.

At the one-hundred quantity level, the ADI unit costs $89 whereas the Analogic meter costs a few dollars less at $82 in the same quantities. Both the AD2001 and the AN2535 are 3-1/2 digit instruments. Analogic also offers a 2-1/2 digit version (AN2525) and a 4-1/2 digit version (AN2545). ADI currently offers only one type but intends to introduce other versions later.



Analog Devices' AD2001 has a width of 3 in., a height of 1-3/4 in., and a depth of 1-1/2 in.

Analogic's AN2535 has a width of 3.2 in., a height of 1-1/4 in., and a depth of 1.6 in.

Of course, size and cost may capture headlines but they are only two of the many factors that an engineer should consider when choosing a DPM. Some of the other differences between the two instruments may be less obvious but are no less important.

Electrical Specs

One factor that is becoming increasingly important in today's densely packaged systems is power consumation. On this score, Analogic wins easily with a power consumption of only 2W compared with 5W for the ADI unit.

The reason why both units have quite high dispensations (even though they don't include power supplies) is that they both use incandescent readouts instead of the more efficient Nixie-style readouts. ADI uses RCA Numitrons while Analogic uses a flat-plane seven-segment readout recently developed by Pinlites. According to Analogic, the Pinlites readout appears equally legible while consuming much less power than the Numitron. Also, Analogic says that the Pinlites readout has a less confusing location for its decimal point.

Both companies developed unique conversion circuitry for use in their DPMs. Analogic uses its Tri-Phasic technique (see EDN/EEE, July 1, 1971, pp. 12-13) and ADI uses what it calls the Analok circuit. Patent applications have been filed for both circuit techniques.

The two new circuits offer many of the same advantages as the familiar dual-slope integrating converter, but they also reduce the effects of internal offsets and drift. Thus both instruments have temperature coefficients of 50 ppm/°C and accuracies of ±0.05% of reading ± digit.

Some Differences

One difference between the two circuits, however, is that, whereas the ADI circuit operates directly from the single-ended 5-V supply, the Analogic circuit requires a ±4V supply. In the AN2535, Analogic generates the necessary bipolar supply voltage by chopping and transforming the 5-V input. Because of these differences, the AD2001 has only one standard range of ±199 mV and requires external attenuators or amplifiers to operate over other ranges. The AN2535, on the other hand, is available with standard

ranges of ±1.999V or ±0.1999 V.

Also, one of the input terminals of the ADI unit is always grounded, whereas the Analogic unit accepts floating inputs. According to Analogic, the grounded input terminal of the ADI unit restricts the DPM's usefulness in many applications—especially those involving current measurements. ADI spokesmen point out, however, that the AD2001 is merely the first in a family of DPM's and that isolated-input versions will be available later. Both units have input impedances of 100 MΩ and input bias currents under 1 nA.

The two instruments have slightly different ways of indicating an out-of-range condition. ADI sets all digits to zero and blinks the "1" digit when the input exceeds 200% of full scale. Analogic completely blanks the numeric digits to avoid false readings under out-of-range conditions.

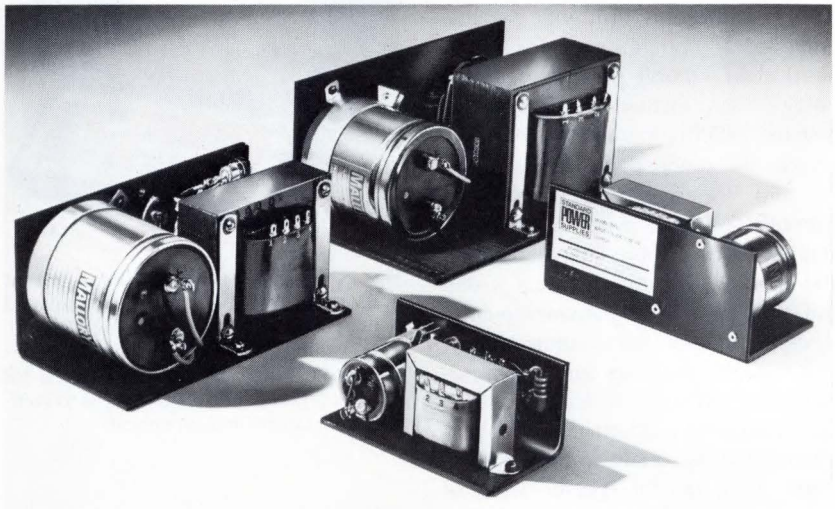
The AD2001 is packaged in an aluminum case while the AN2535 is available in either aluminum or plastic. In unit quantity, the AD2001 costs $135 while the AN2535 costs $110. The AD2001 is available from stock. The AN2535 will be available in evaluation quantities within eight weeks and in OEM quantities within 120 days.

Analog Devices Inc., Rte 1 Industrial Park, Norwood, MA 02062. **301**

Analogic Corp., Audubon Rd., Wakefield, MA 01880. **302**

Power supplies trade regulation for cost

PROGRESS IN POWER SUPPLIES



Output range of 12 to 48V and 0.3 to 15A with guaranteed zero regulation is offered in the new power supply line.

Some people may find it advantageous to buy a Black Line power supply and cannibalize it for parts.

A new product is usually significant either because it offers better performance than others, or equal performance at lower cost. Rarely is something worth talking about that offers greatly reduced performance, albeit at a very reasonable price. One of those rare birds, though, has just been introduced.

It is a new series of extremely low-cost OEM dc power supplies, guaranteed to provide absolutely no line or load regulation. According to the manufacturer, it answers the growing need for 0.00 (zero) regulation—a seemingly overlooked specification.

This giant step backwards in power supply sophistication and price has been taken by Standard Power, Inc. in what it calls its Black Line. This name was chosen for the new line because it is a black sheep in what Standard calls its meadow of power supply products. By comparison to typical units offered, the Black Line verges upon becoming the "Un" power supply: Unregulated, Uncomplicated, Uncompensated, Unprotected and Unexpensive.

Twelve different models spanning the output voltage range of 12 to 48V at current ratings from 0.3 to 15A are priced from $11.90 in 50-99 unit quantities, and are available from selected distributors and the factory. The ruggedly constructed units use high-quality, computer-grade components on black anodized heat sink/mounting frames (aluminum angles).

Astute observers will note that the value of the individual components in each supply is higher than the unit cost in quantity. Thus, a user can either use these supplies for raw power, or he can cannibalize the components. A word of warning, though, it will probably cost a couple of bucks to take one apart.

This rather mundane line is the brain

child of Standard's Board Chairman, Dr. S. Dean Wanlass, who until recently was the president of Wanlass Electric.

According to Wanlass, his suggestion that such a line be developed met with instantaneous staff rejection, verging on rebellion. "Since I run a democratic organization," Wanlass told EDN/EEE, "I assembled all pertinent marketing facts and gently reminded them that I was Board Chairman." In response, marketing manager Norm Mehl said, "When the (marketing) facts were presented to me by Dr. Wanlass, I immediately became a believer that the Black Line will be of great interest to manufacturers of equipment where regulation is not required."

Standard Power also markets a line of supplies similar to the Black Line but providing 0.25% line and load regulation. The company, quite naturally, calls this their Blue Line.

Standard Power, Inc., 1140 W. Collins Ave., Orange, Calif. 92667. **303**

Versatile programmer is truly universal

PROGRESS IN TEST EQUIPMENT

Spectrum Dynamics of Fort Lauderdale, Fla., the only firm with portable universal field programmers for ROMs, has pushed portable-programmer technology a step further with its versatile new model 550 programmer/verifier.

Like its predecessor model 500, the 550 is designed to program all currently available types of programmable ROMs—fusible-link, diode junction-shorting, electro-chemical fusing and floating-gate avalanche-injection types—manually or automatically. This machine however goes a step further. It can provide verification for any semiconductor mask-made ROM and uses plug-in personality modules of PC cards—designed for specific types of programmable ROMs—to provide expandibility, facilitate servicing and minimize downtime. The plug-in-module approach allows future adaptation of the 550 to newer types of ROMs as they are developed by semiconductor manufacturers by simply plugging in the appropriate personality cards. There are six additional card racks available in the 550 for custom modification.

The 550 also has a larger capacity than its predecessor—9999 words expandable to 99,999 words vs 4096 words expandable to 65,536 words for the 500. It utilizes a keyboard for addressing thus providing direct word selection. An additional key is available to increment one word at a time.

Programming can be automatically provided either from a master ROM or through optional interfacing with other equipment. A data keyboard allows data entry into a RAM (located in the programmer) for ROM checkout before actual programming, thus allowing programming errors to be easily corrected before the ROM device is actually programmed.

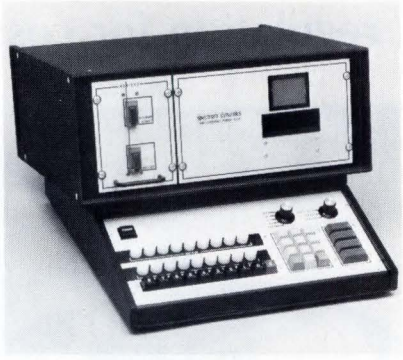


Fig. 1—**All programmable ROMs—current and future types**—can be programmed with Spectrum Dynamics' new model 550. The instrument uses plug-in modules containing PC personality cards designed for specific programmable-ROM types to facilitate adaptability and expansion.

A 10-MHz crystal-controlled clock, in conjunction with a frequency dividing circuit, provides the 550 with binary pulses down to 1 Hz making it possible not only to control all logic functions, but also to provide accurate program timing, including duty cycle and test signals as required for each programmed device.

Control of the program pulse length, duty cycle and read pulse is performed directly in the personality modules, so that when a module is inserted it automatically sets up the instrument for programming a particular device in accordance with specifications given by the ROM manufacturer.

Zero check of blank ROMs and automatic verification of ROM patterns is performed at 100 kHz per word. During an automatic programming cycle, words and bits not to be programmed are skipped at the same rate.

The 550 is designed to program and verify the required bits in one word before proceeding to the next word. When verifying or zero checking it checks all of the bits in one word simultaneously.

Options include a buffer circuit for external control, an interfaced punched paper tape-reader to accomodate ASCII-coded tapes, satellite modules for simultaneous programming of duplicate ROMs and extender PC cards for system trouble-shooting.

Presently, there are three other companies making portable programmers—Intel, Intersil and Curtis Electro Devices. They, however, make programmers designed specifically for single types of programmable ROMs. Intel's programmer is designed for its own floating silicon gate ROMs and Intersil's is designed for its own avalanche induced-migration ROMs. Curtis Electro Devices makes a machine to handle Signetics' fusible-link ROMs.

The basic price of Spectrum Dynamics' 550 is $2200. Personality modules are available for every type of programmable ROM, starting from $380. Availability is stock to 8 weeks.

Spectrum Dynamics, Inc., 2300 E. Oakland Park Blvd., Fort Lauderdale, Fla. 33306. Phone (305) 566-4467. **304**

Intel Corp., 2065 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 246-7501. **305**

Intersil, Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. Phone (408) 257-5450. **306**

Curtis Electro Devices, Box 4090, Mountain View, Calif. 94040. Phone (415) 964-3136. **307**

Latest monolithic D/A switches surmount earlier problems

PROGRESS IN MICROELECTRONICS

Healthy competition between two companies—Analog Devices Inc., and Burr-Brown Research—has precipitated dramatic improvements in both performance and cost of monolithic quad current switches that are used for digital-to-analog conversion.

Today a new quad switch from ADI, the AD551, has a 12-bit settling time of only 200 nsec. This contrasts with a figure of 1.8 μsec for the company's earlier version, type AD550.

The price plunge has been even more spectacular. Originally, in March 1970, a kit of three quad switches for a 12-bit converter to operate over the full military temperature range cost $210. Today a kit of the new AD551 switches for the same function would cost only $75 (in lots of 100). And, of course, the slower AD550 units are now priced even lower than the high-speed versions.

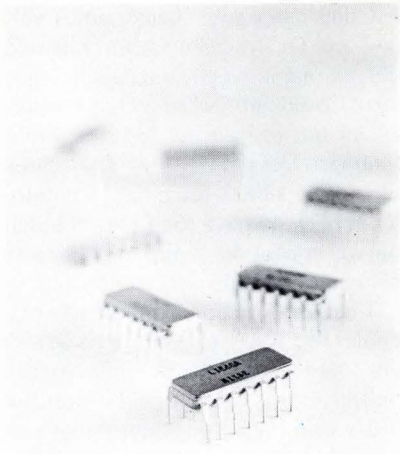
Technological Evolution

ADI pioneered the design of monolithic quad current switches and introduced the original AD550 about a year and a half ago. But the IC found only limited acceptance in the marketplace because of its slow speed and high cost.

Then Burr-Brown entered the picture and upstaged the AD550, with its own version, the 4550, which boasted a 12-bit settling time of only 200 nsec. Burr-Brown engineers achieved the high speed by using npn transistors throughout the switching circuitry. (ADI had used a sluggish pnp transistor for level shifting.)

ADI was forced to counter the Burr-Brown threat by slashing prices. Also ADI applications engineers questioned the alleged TTL compatibility of the 4550. They pointed out that, with the input logic levels (2.5V minimum and 0.4V maximum) listed in Burr-Brown's data sheet, the circuit would have almost no noise immunity.

Now ADI's new AD551 has incorporated the high-speed npn circuitry of the Burr-Brown device and, in addition, ADI engineers have designed different circuitry for driving the switches, so that there is much better noise immunity. The specified input levels (2.0V min and 0.8V max) conform to the industry standard for TTL logic.



New monolithic quad switch from Analog Devices has a switching speed of 60 nsec and is said to avoid the noise-immunity problems of a similar device from Burr-Brown. Currently the circuit is packaged in a ceramic DIP, but will soon be available in plastic also.

TTL Compatibility

The question of TTL compatibility of D/A converters was debated during a panel discussion at last year's International Solid-State Circuits Conference (Philadelphia, Feb. 17-19). The panel included representatives from both ADI and Burr-Brown. At one point, a logic designer in the audience suggested that perhaps Burr-Brown had mistaken the standard TTL output levels for the input levels when preparing the data sheet for the 4550.

Burr-Brown engineers admit that their data sheet is misleading, but they say that the specified input levels truly represent the worst-case performance. This is because there is a possible combination of supply voltage and temperature which could cause the noise immunity to be as poor as that implied by the specified limits on the input levels. If the bias voltage of the 4550 is held at exactly −5V, then the device will yield the standard TTL noise immunity. Thus Burr-Brown could have listed the standard TTL input levels on the data sheet provided they also added a restriction on bias-voltage variation.

The improvement in the new ADI circuit allows the bias voltage to be varied from −5V to −2V without any loss of noise immunity. However, Burr-Brown points out that ADI's noise-immunity is guaranteed for 25°C operation only, whereas Burr-Brown had attempted to include the effects of temperature when specifying limits for the input logic levels. But, as the ADI method of specifying input logic levels corresponds to accepted industry practice for digital ICs, it is less likely to cause confusion than the Burr-Brown approach.

A Third Vendor

In addition to ADI and Burr-Brown, Intersil also markets monolithic quad switches. Intersil originally manufactured the AD550 for ADI and also manufactured the Burr-Brown version. ADI now manufactures its own quad switches but Intersil still manufactures and sells the Burr-Brown device under a different part number.

Apart from noise immunity and bias voltage, the AD551 and BB4550 have similar performance. Switching time for a single quad is 60 nsec to within 90% of final value. Various versions are available with temperature coefficients from ±2 to ±20 ppm/°C and for the military or commercial temperature ranges.

The AD551 comes in a TO-116 ceramic package. Burr-Brown's commercial-temperature version is in a plastic DIP package while the military version is in ceramic. ADI will offer a plastic-package version within a few months.

The AD551 prices in quantities of 100 are as follows: $24 (8-bit set, commercial temp), $41 (12-bit set, commercial temp), $45 (8-bit set, military temp) and $75 (12-bit set, military temp). Corresponding prices for the 4550 are $22, $36, $44 and $72, respectively. Matched sets are available from stock from Burr-Brown, while ADI currently quotes two weeks delivery.

Analog Devices Inc., Rte. 1 Industrial Park, Norwood, MA 0206. **308**

Burr-Brown Research Corp., International Airport Industrial Park, Tuscon, AZ 85706. **309**

High-speed printer mates neatly with minicomputers

PROGRESS IN PRINTERS

The computer industry has long had a need for peripherals specifically designed to be compatible with minicomputers, both in speed and in cost. This is especially true in the printer area. In the past, both needs could not be met simultaneously, for low cost also brought low speed, as well as the converse.

Now that Printer Technology, Inc. has announced its PRINTEC-100, this is no longer true. Their machine is a full character (not dot matrix), impact, serial printer that prints 100 characters per second and costs $2200 in single quantities. It gives a ten-fold increase in output at about twice the cost of the previous industry standard, the Teletypewriter.

How Does It Stack Up?

Prior to the advent of PRINTEC-100, if the application required low cost you were limited to a Teletypewriter, with its extremely low print-rate of 10 characters/sec and narrow line width (80 characters). If you needed high speed you had to go to a line printer with a price tag in the $5000 to $50,000 range. In between, the available machines had price/performance limits. This middle area includes both impact and non-impact types, and full-character and dot-matrix types.

Full-character impact printers usually have print rates in the 10 to 35 character per second range. A modified IBM Selectric prints at 10 to 15 characters/sec. and sells at about $2000. An equivalently equipped Univac or Friden, printing at 35 characters/sec sells at $1500-$1600, while the Litton ABS Model 34 lists for $3195. The Memorex 1240 reaches 60 characters/sec using line-printer techniques and costs $4000.

Dot matrix printers come in both impact and non-impacting versions. One of the biggest drawbacks with the impact type is that the solenoid-actuated pins fire at a high rate per character and are subject to long-term mechanical problems. The non-impacting types suffer from an inability to make multiple copies. Both are unacceptable to banks since changes in a few dots can easily change dollar values; and OCR machines won't handle the dot-matrix typeface. Digital Equipment Corporation's Decwriter provides 30 characters/sec for $2500 while Mohawk Data gives 100 characters/sec for a $3000 price tag. Centronics appears to have the fastest through out for impact dot-matrix types at 165 characters/sec but costs $3500.

There are many non-impact machines that use such techniques as ink-jets, Xerography, heat, photo optics and electrostatics. Although most are faster than impact machines, they suffer in that they cannot make more than one copy, and most use dot-matrix methods with the additional above-listed limits.

How Does PRINTEC-100 Do It?

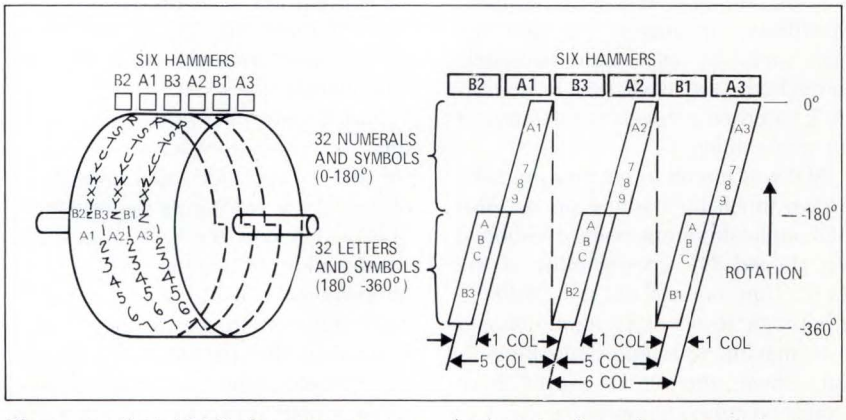
Basically, two mechanical factors limit "print-on-the-fly" machines to about 35 characters per second; character-wheel rotational speed and print-hammer performance. If wheel speed exceeds a certain limit, smeared print and excessive letter registration errors will result. Time of flight for the print hammer includes time to reach impact, impact dwell time, and time to settle to a full rest position. If the hammer is not allowed to settle fully, it will have a shorter flight time to next impact, resulting in registration errors and possible paper tearing.

Printer Technology has solved these problems with two basic innovations. To solve the first problem they placed three sets of characters on the character wheel; and as a solution for the second they doubled the number of hammers from 3 to 6. Each hammer is responsible for only 1/2 the character set, and together the two innovations triple the print rate. To make the second solution work, the character set is arranged in a helix as shown. The dual hammer arrangement also eliminates the need for a blank hammer settling region between the beginning and end of the character set, thus giving a further 10 to 20% speed improvement.

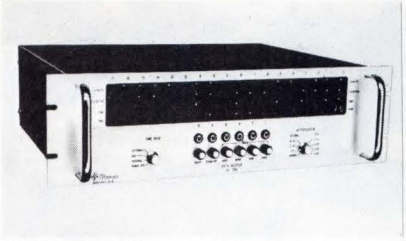
PRINTEC-100 also eliminates messy ink tapes by using an easily-replacable ink roller that is available in a variety of colors. The basic printer comes with a full 64-character ASCII font (others optional), handles any paper up to 136 columns wide, has a full vertical format unit (VFU) and all electronics ready to receive ASCII input data at TTL-logic levels. It sells for $2200 singly or $1760 in 100 lots, with 60 day delivery.

The new machine is not limited to minicomputer applications. It can be used to provide hard-copy readouts for CRT terminals, for off-line printing, and for communications in a TELEX or TWX network. It is ideally suited for the latter because its 100 character/sec printing rate is naturally compatible with 1200 Baud data links. Printer Technology, Inc., Sixth Rd, Woburn Industrial Park, Woburn, MA 01801.

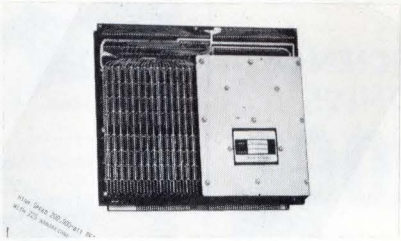
310



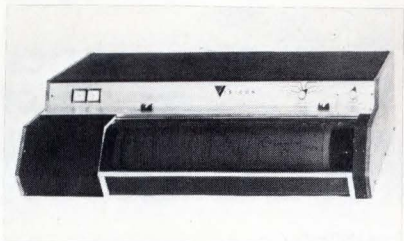
Three sets of 64 ASC-II characters are arranged in six 32-character segments around the print wheel (left). This allows use of six hammers, one for each segment, and gives each hammer 180° of print wheel rotation for settling. Unrolled surface of print wheel (right) shows how every character segment is displaced one column width to the left of its neighbor, ensuring that no hammer overlaps.



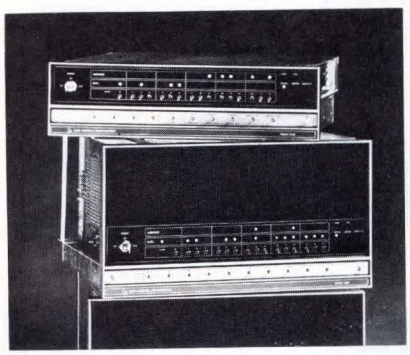
DATA BUFFER USES LED DISPLAY. Series 790 data buffer samples and stores input data in digital form for retransmitting at an output rate and format compatible with user's system. Data can be fed into a digital tape recorder or paper tape punch, or be transmitted directly to a computer for processing. The unit occupies 5-1/4 inches in a standard 19-inch relay rack. Budgetary price is $5,000. Hill Enterprices, 131 Garnet St., P.O. Box 665, Ridgecrest, CA 93555. **170**



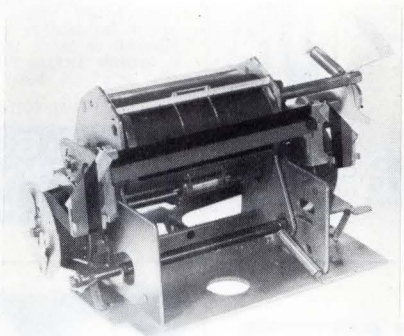
BRAID TRANSFORMER ROM SYSTEM accesses up to 1.6 million bits in 225 ns. Each 12.9 × 11.0 inch pc board holds 200K of memory. It is non-volatile, low power (0.5 mW per bit), has wide operating margins (0—+0.4V logic "0" and 2.5—5.0V logic "1"), and 500 ns cycle times. Price is $11,290 (3/4¢ per bit) for 1.6 million bit systems. Small quantities are 1—1-1/2¢ per bit. Memory Technology, Inc., 83 Boston Post Rd., Sudbury, MA 01776. **172**



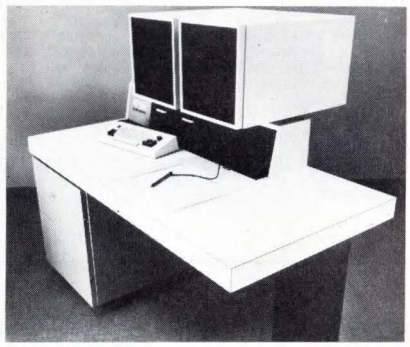
AUTOMATIC DRUM-TYPE DIGITIZER. Model GC-3A digitizes photographs, maps, overlays, and other graphic data with up to seven bits of gray shade information per sampling point. Resolutions available are 50, 100, or 200 samples per inch in both X and Y directions. 127 shades of gray can be provided with 100 samples per inch. Maximum document size is 11 × 17 inches. System prices begin at $24,000. Visicon, Inc., Box 1008, State College, PA 16801. **173**



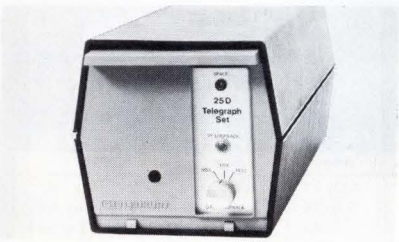
THREE NEW NOVA COMPUTERS are completely compatible with existing Novas but cost substantially less. Nova 1210 costs $4,350 with 4K 16-bit words of core memory, and $5,750 with 8K words; Nova 1220 offers low cost expansion capability and costs $5,250 with 4k of memory and $6,650 with 8K; and Nova 820 with 800 ns instruction execution for a price of $6,450 with 4K of core memory and $7,850 with 8K. Data General Corp., Southboro, MA 01772. **174**



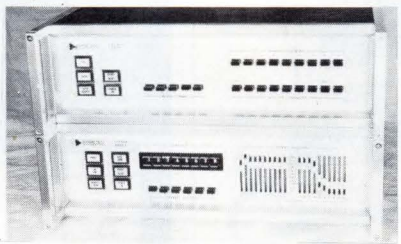
LOW COST PRINT HEAD. Model 40 prints up to 200 lines of 13 characters per min., comes complete with a paper feed and ribbon control mechanism and is assembled to the manufacturer's own sidewalls. It uses a standard single or two-color adding machine ribbon. Overall dimensions are 2-1/4 × 5-3/4 × 3 inches. The Model 40 lists at $18.64 each. Norlab Industries, P.O. Box 795, Torrington, Ct. 06790. **175**



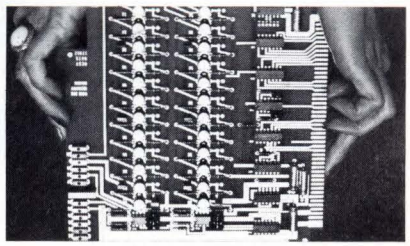
COMPUTERIZED DESIGN SYSTEM. The Design Assistant 700 is an interactive design and drafting system for printed circuit boards, integrated circuits, hybrid circuits, and schematic drawings. The DA 700 can be interfaced to other computer-aided design programs and NC machines, and may be connected as a remote terminal to larger computer systems. Basic price for a complete system is $60,000. Applicon, Inc., 83 Second Ave., Burlington, MA 01803. **176**



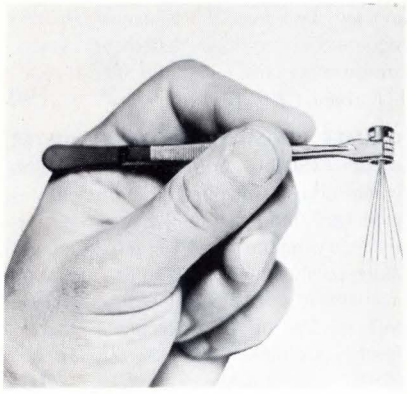
TELEGRAPH MULTIPLEX SYSTEM fills a wide range of applications. The Type 25D low-cost system provides four telegraph transmission rates: 75 baud, 110 baud, 150 baud, and 200 baud with up to 25 channels at 75 baud, 18 channels at 110 baud, 12 channels at 150 baud, and 21 channels at 200 baud (8 channels in the voice-frequency band 13 channels above). GTE Lenkurt, Inc., 1105 County Rd., San Carlos, CA 94070. **177**



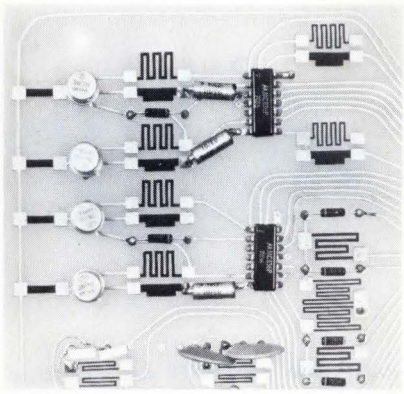
DATA LINKS. The 2600A and 6500 Series Data Links furnish a low cost, building block approach for assembly of automatic systems by providing plug-in compatibility to all digital instruments, digital medical equipment, pollution monitoring instruments, and process control systems. They may be coupled directly to a computer or through time-share, modems or Teletype terminals. Sagetec Corp., 20747 Dearborn St., Chatsworth, CA 91311. **179**



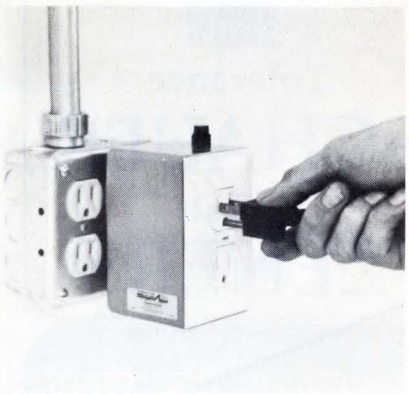
EXPANDABLE 24K MOS MEMORY has variable read/write rate from 400 Hz to 5 MHz, thus can assume the role of a small disc or drum. The basic 24K bits fit on a 7 × 7 inch pc board and can be arranged in 12K × 2-bit words. Additional boards can be arranged to provide 48K × 1, 24K × 2, 12K × 4 bit storage in *n* combinations. Price is $595 for DDM-300 24K-bit card in OEM quantities. DEST/DATA Corp., 1276 Forgewood Ave. Sunnyvale, CA 94086.**179**



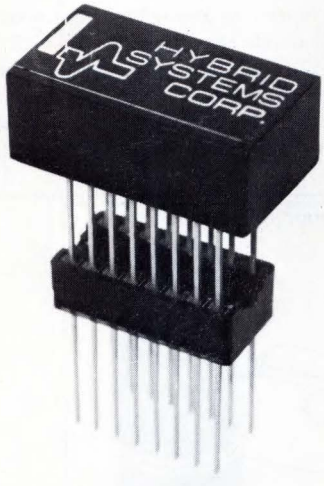
ULTRAMINIATURE TRANSFORMERS have guaranteed thermal stability. Typical specifications are primary and secondary impedances of 3Ω to 25 KΩ; frequency response of ± 3 dB from 300 Hz to 100 kHz; 600 mW; and maximum dimensions of 11/32 inch diam, 15/32 inch length. Price is $3 to $10 each. Pico Electronics, Inc., 316 W. First St., Mount Vernon, NY 10550. **180**



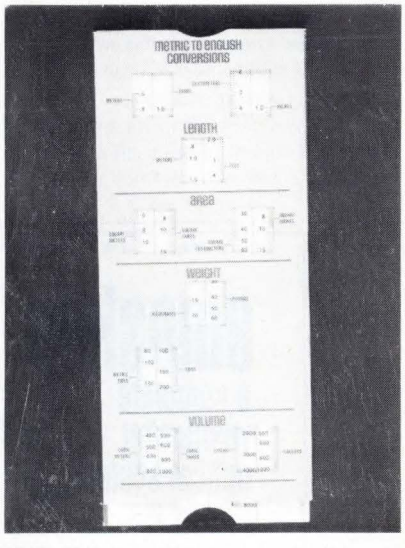
RESISTIVE-CONDUCTIVE LAMINATE permits etching resistors by standard PC-board production techniques. The layer against the substrate is resistive and the top layer is conductive. Maximum sheet resistivity is 25Ω/square, ±5%. Temperature coefficient is 50 ppm/°C. It is available in 8- by 12- by 0.062-inch standard sheets. The Mica Corp., 4031 Elenda St., Culver City, CA 90230. **181**



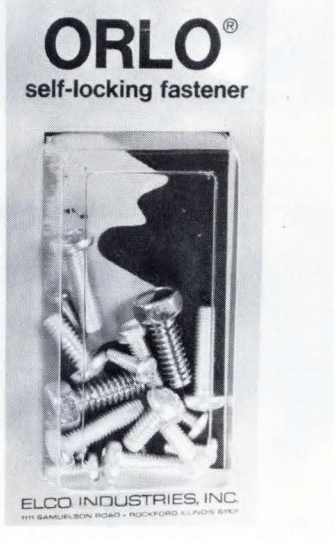
AC LINE SURGE SUPPRESSOR prevents malfunctions and inaccurate data from electronics equipment. Power-line transients in excess of 200V are shunted from the load by an SCR circuit with a 500 nsec response time. Max surge current is 36A for 10 msec. Price each is $39.50. Transtector Systems, 532 Monterey Pass Rd., Monterey Park, CA 91754. **182**



CURRENT-OUTPUT D/A CONVERTER 371-8 is an 8-bit unit that sells for under $10 in single quantity. Standard features include built-in reference, DTL/TTL compatibility and 950 nsec setting time. Linearity is within ±1/2 LSB, with an overall accuracy temperature coefficient of 100 ppm/°C. Full-scale output is 2 mA. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, MA 01803. **183**



FREE SLIDE RULE converts English and metric units directly. To introduce its new metric series of cartridge heaters in six diameters from 6.5 to 20 mm, this manufacturer is offering a slide rule that converts length, area, weight, volume and temperature from English to metric, or vice cersa, at a glance. Hotwatt, Inc., 128 Maple St., Danver, MA 01923. **184**



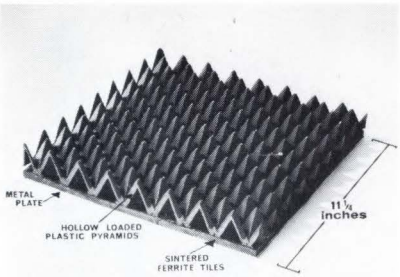
FREE SAMPLE—nine diameters and lengths of "Orlo" self-locking screws are available in an evaluation package. The locking feature is a resilient rib formed on the thread's flank. This rib can be placed on a single thread or on the entire threaded body. When assembled, the rib is compressed and generates a prevailing torque that is resistant to loosening. Elco Industries, Inc., 1111 Samuelson Rd., Rockford, IL 61101. **185**

LED SWITCH eliminates contact bounce. A light emitting diode, a photo-Darlington amplifier, a Schmitt trigger and a mechanical shutter combined within a single switch housing provide contactless operation for a minimum of 10 million cycles. Typical rise and fall times are 100 nsec, and switching capability is 50 mA at up to 16V. Available from stock at $6.82 each in unit quantities. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. **186**

COPPER/TEFLON LAMINATE permits fabrication of flexible printed circuits. The FEP Teflon film backing comes in 2, 3, 5, 10 or 20 mil thickness, and is thermo-laminated to printed-circuit-grade copper with an epoxy-base adhesive. The adhesive resists solder dip operations of 30 sec at 550°F and can withstand 400°F continuously. Circuit Materials Co., Div. of Dodge Industries, 1101 State Rd., Princeton, N J 08540. **187**

ELECTRIC HEAT GUN has interchangeable air-nozzle heating elements of 325, 475 and 525W. Colorcoded in green, gold and red, they provide nozzle temperatures from 175°F (for Mylar shrink tubing) to 621°F (required for "Teflon" or PTFE tubing). The plastic case is designed to stand on its back, top or either side for use, or it can be hand held. Ideal Industries, Inc., Sycamore, IL 60178. **188**

COMPONENTS/MATERIALS



RADIATION ABSORBER has −15 dB reflectivity from 100 MHz through 12 GHz. Eccosorb UPF is a very thin (1.5 inches) broadband absorber with reflectivity varying between 3% and 1% over its entire range. Weight is about 10 lbs/ft² and power handling capability is 3W/in². Maximum service temperature is 250°F. Standard sheet size is 11.25 inches per side, and cost is approximately $50 per ft². Emerson & Cuming, Inc., Canton, MA 02021. **189**

MINIATURE CURRENT PROBE, Model 7111, offers complete isolation from test circuits. It's wideband response (8 kHz to 100 MHz), speed (t_r <3.5 nsec) and sensitivity of 1 V/A ±1% allow measurement of high-speed current pulses such as found in GaAs diode laser systems. Price is $20 each and ten days free trial is available when requested on company letterhead. American Laser Systems, Inc., 3888 State St., Santa Barbara, CA 93105. **190**

CERMET TRIMMER POTENTIOMETER, Model ET50T features convenient thumbwheel adjustment. Electrim trimmers provide very fine resolution, offer contact-resistance variation of <3% and have temperature coefficient of ±100 PPM. They are available in resistance values from 10Ω to 2 MΩ in 5% or 10% tolerance. Mepco/Electra, Columbia Rd., Morristown, N J 07960. **191**

MICROMINIATURE SPST MOMENTARY PUSHBUTTON SWITCH, Model 8631, measures 0.635 inch overall length by 0.251 inch diam. It features coin-silver contacts rated at 1/2A resistive load at 115V ac or 28V dc. Contact resistance is 10 mΩ max, and operational life is rated at one million cycles. C & K Components, Inc., 103 Morse St., Watertown, MA 02172. **193**

BEZEL MOUNT TIME DELAY is designed for front-panel installation. PT Series solid-state timers are also offered with optional function-indicator lights on the 110V dc and 120V ac models. Standard operating voltages available are 24 and 120V ac and 12, 24, 48 and 110V dc. Potter & Brumfield, 1200 E. Broadway, Princeton, IN 47670. **194**

COMPONENTS/MATERIALS

MINIATURE TRIMMER CAPACITORS feature low-profile PC board mounting. The 9330 Series rotary ceramic trimmers protrude only 0.300 inch above board height, and are available in capacitances from 1.7 to 50 pF with a working voltage of 250V dc. All units are tested at 500V dc. Price, depending on quantity ordered, ranges from $0.20 to $1.35. Johanson Mfg., Corp., 400 Rockaway Valley Rd., Boonton, N J 07005. **209**

PLUGBOARDS mount ICs and discrete devices on 0.1-inch increments. All plugboards have 0.042-inch holes on 0.10-inch centers and are 2.7 by 4.5 inches wide. A wide variety of etched patterns is available, including interleaved vertical buses for V_{cc} and ground with groups of three hole pads for IC mounting. Price is $2.19 to $5.55 each. Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342. **201**

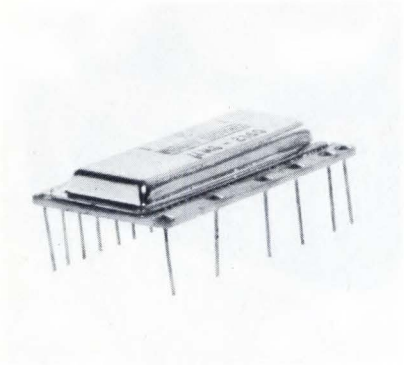
CERAMIC CHIP CAPACITORS are offered in two designer kits. Kit 1 contains 750 NPO dielectric ('A' characteristic) capacitors: 25 each of 30 values from 1.0 to 330 pF. Kit 2 offers 675 general-purpose dielectric ('X' characteristic) capacitors in values ranging from 100 to 15,000 pF. All "HyCirKit" chips are 0.080 by 0.050 by 0.050 inch in size. Price for either kit is $99.50. Vitramon Microwave Corp., Box 544, Bridgeport, CT 06601. **204**

MULTIPLE PUSHBUTTON SWITCHES of the 70-Series provide 10A capability in a small package. Measuring 4.375 by 1.772 by 0.62 inches, these switches are available in combinations of 12 SPST and SPDT circuits. Contacts are silver-plated 3/16-inch wide copper. McGill Mfg., Co., Inc., Electrical Div., Valparaiso, IN 46383. **205**

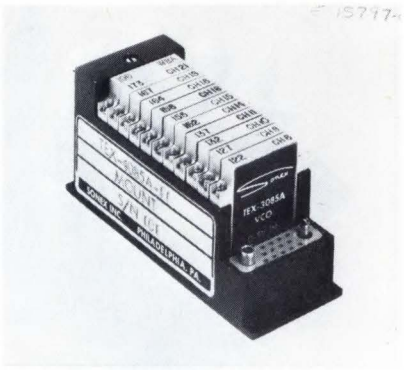
SILVER-FILLED SILICONE RUBBER, called E-Solder No. 3036, is designed for use in forming electrically-conductive flexible gaskets and seals. The two component compounds cure in 24 hours at room temperature. Volume resistivity is 0.1Ω/cm at 77°F, under slight compression. Epoxy Products Co., Box 1404, New Haven, CT 06505. **207**

PROTOTYPE CIRCUIT BOARDS featuring 2 oz copper-etch and tin-lead plating are reuseable. They are available in patterns for four-lead transistors (Model 131), 16-lead DIPs (Model 141), eight- and 10-lead TO-5 ICs (Models 151 and 152) and dot patterns (Models 121 and 122). All models measure 6 by 9 by 0.063 inch thick. Price is $9.95/board. Marathron Co., Box 777, Dallas, TX 75221. **208**

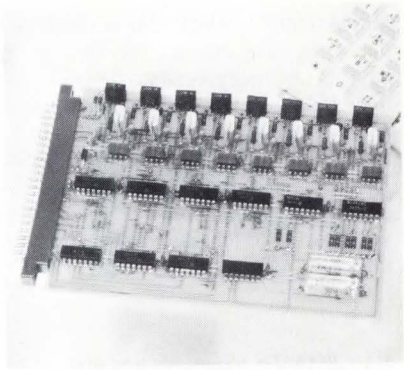
CIRCUITS



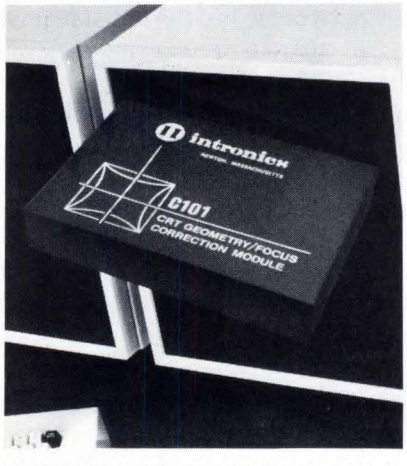
FREQUENCY SHIFT KEYER uMS-5103 can be used with either 103, 202 or IBM-type modems. Complete in a 24-pin, 0.69- by 1.2- by 1.5-inch DIP, the device is programmable for mark or space frequencies from 300 Hz to 10 kHz using external thin-film resistors. Stability is 4 Hz over an operating temperature range of 0 to 70°C. Off-the-shelf price is less than $8 in quantities of 5000 or more. Instrument Systems Corp., 410 Jericho Turnpike, Jericho, NY 11753. **210**



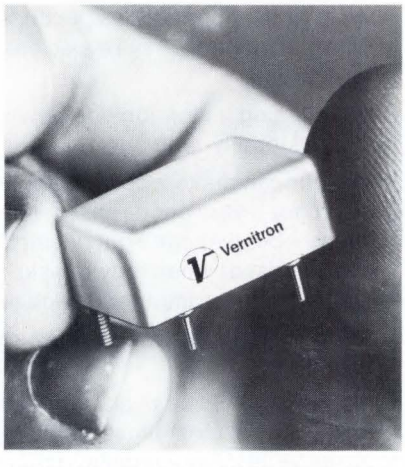
FM MULTIPLEXER SYSTEM Model TEX-5085 contains 10 voltage-controlled oscillators and a mixer amplifier, and occupies only 3.5 cubic inches. All components are plug-in. Subcarrier frequencies between 400 Hz and 300 kHz with peak deviations of 1 to 40% are available. Temperature stability is within ±1.5% dBw. Standard IRIG frequencies are available from stock at less than $150/channel. Sonex, Inc., 2337 Philmont Ave., Huntingdon Valley, PA 19006. **213**



MULTITONE DECODER decodes 12 functions with TTL outputs in decimal form, including "*" and "#". There is a two-tone parity output for simultaneous tone detection. Components are mounted on a 4.5- by 6.5-inch PC board. Basic price is $169.95 with a 16-function, eight-tone option for $189.95 and LED lamps to indicate seven or eight demodulated tones mounted on the same board for $16.50 or $18. Lee-Com Associates, Box 43204, Cleveland, OH 44143 **216**



GEOMETRY/FOCUS CORRECTION MODULE C101 eliminates pincushion and focus errors in precision CRT displays. The module corrects position errors to <0.1% for a 60° CRT and <0.01% for a 20° CRT. Bandwidth is 1 MHz, and the input/output signal range is ±5V. Price (1-9) for the 3.5- by 2.5- by 0.625-inch package is $348—with 2 week availability. Intronics Inc., 57 Chapel St., Newton, MA 02158. **211**



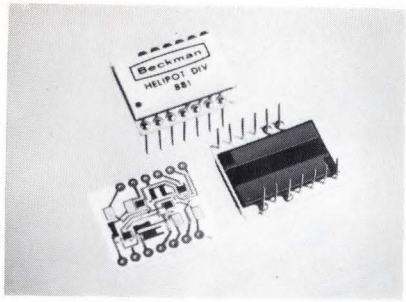
CERAMIC BANDPASS FILTERS TLE Series, offer a center-frequency range of 50 to 270 kHz with typical nominal bandwidth of 3%. Package size is 0.375 by 0.750 by 1.125 inches with suitable terminals for PC-board mounting. All elements are in a self-supporting structure that serves as the interconnecting network. Vernitron Piezoelectric Div., 232 Forbes Rd., Bedford, OH 44146. **214**

WIDEBAND GAIN CONTROLLER GC101 is a two-quadrant device that can control gain over a 60 dB range with 1% or 0.1 dB accuracy. The unit delivers ±10V, 10 mA and provides response from either dc to 12 MHz at unity gain or from dc to 70 kHz at 60 dB gain. Noise is 130 mV rms in a 20 kHz bandwidth, unity gain—and only 6 μV rms at -60 dB gain. Burwen Laboratories, 12 Holmes Rd., Lexington, MA 02173. **217**

BROADBAND POWER AMPLIFIER MP-100 comes in kit form and covers the 0.5 to 100 mHz frequency range. Unit accepts AM, SSB, pulse or other complex signals and delivers 2.5W CW when driven by a 0.15V source. Of PC board construction, the kit can be assembled in about 3 hrs. Price is $249. Larkton Scientific, Box 302, Monroeville, PA 15146. **212**

VARIABLE DELAY LINE 900 Series span the 5- to 50-nsec delay range with a maximum rise time of 2.5 to 15 nsec, covering bandwidths up to 150 MHz. Compatible with DIP packaging, all units come with an "O" ring seal and a single control shaft varies the delay. ESC Electronics, Inc., 534 Bergen Blvd., Palisades Park, N J 07650. **215**

ADJUSTABLE TIME-DELAY EQUALIZER Model L-604-11 provides an L-band system time delay of 30 nsec variations to better than ±3 nsec over 100 MHz bandwidth. The device consists of a cascade of single element equalizers that are adjustable in both peak time delay and frequency. Wavecom Inc., 9036 Winnetka Ave., Northridge, CA 91324. **218**



HYBRID ACTIVE FILTER Model 881 consist of three operational amplifiers with internal feedback elements. Two external resistors establish the resonant frequency that is adjustable over a range from <1 Hz to 10 kHz. A fourth uncommitted op amp is included for "odd-pole" requirements. Enclosed in ceramic, the unit operates over the 0 to 70°C temperature range. Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, CA 92634. **219**

UNBLANK/VIDEO AMPLIFIER Model BBA4324 is designed for either CRT or storage tube displays. Unblank amplifier portion accepts TTL or EIA input signals and provides 60V output. Video section provides up to 60V, 1 MHz superimposed on a variable dc bias level for modulation and brightness control. Price is $250. Beta Instrument Corp., 20 Ossipee Rd., Newton Upper Falls, MA 02164. **220**

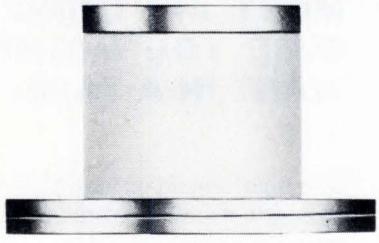
DUAL OUTPUT POWER SUPPLY provides 3 to 5.6V, 3A (regulated) and 185V, 50mA (unregulated). Regulation for the 3 to 5.6V section is ±0.1% for line, 0.2% for load and 2 mV ripple. Price is $50 in single quantities. Viking Electronics, Inc., 721 St. Croix, Hudson, WI 54016. **221**

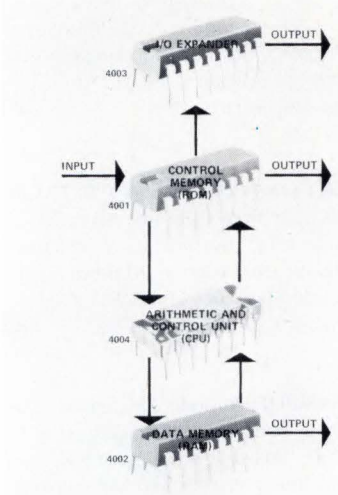
POWER CONVERTER Model PIC-5-M delivers 5V, 12A from 115V rms, 50 to 500 Hz input. The 1.625- by 3.625- by 7-inch package sells for $295 each in 20 piece quantities. Arnold Magnetics Corp., 11520 W. Jefferson Blvd., Culver City, CA 90230. **222**

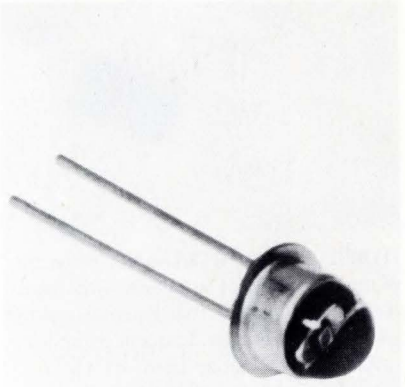
VIDEO AMPLIFIER Model 280 features a dc to 40 MHz bandwidth. Voltage gain is 40 dB and the rise time is 10 nsec, 5% overshoot maximum. Price is $98, with quantity discounts available. Add $29 for a built-in power supply for 115V ac operation. Beta-tronics, 1728 Monroe St., Evanston, IL 60202. **223**

MATCHED ATTENUATOR Model M190 provides 35 dB of variable attenuation from 200 MHz to 18 GHz. Insertion loss is 1.8 dB through 12.4 GHz and 2.5 dB through 18 GHz. Unit comes with SMA RF connectors. General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. **224**

NEW SCs







MICROWAVE TUNING VARACTORS of the HA1702 through HA1717 Series provide a capacitance tuning ratio equal to that of 60V varactors, but operate on 30V bias. This is achieved without sacrificing "Q". Hyperabrupt junction design and low-loss packaging of the new HA Series permits devices with capacitances up to 22 pF at 4V. MSI Electronics, Inc., 34-32 57th St., Woodside, NY 11377. **234**

SENSE AMPLIFIER IC, CA3541D, is a monolithic silicon dual-input device for core-memory applications. The circuit consists of two differential input amplifiers, a common second-stage amplifier, a dc-restorer circuit and an output logic gate. It is supplied in a 14-lead dual-in-line ceramic package and priced at $6.00 each in quantities of 1000. RCA Solid State Div., Box 3200, Somerville, N J 08876. **235**

MOS ELECTRONIC ORGAN CIRCUITS, MC1180, originally introduced by GE have been acquired by Motorola. They will be available in sample quantities in January, 1972. These circuits are: MC1180L frequency divider ($3 each); 1181L resettable rhythm counter ($4 each); 1182L rhythm pattern generator ROM ($9.95 each + mask charge); 1183L frequency synthesizer ($7 each); 1184L frequency synthesizer ($7 each); and 1185L digital clock ($24 each). Prices shown are per unit in 100-piece quantities. Motorola Inc., Semiconductor Products Div., Box 20912, Phoenix, AZ 85036. **236**

MSI COUNTERS, 8280, 81 and 88, have been redesigned to eliminate a fall time requirement for the clock signal. The "8000 Series" ICs now use dc-level-sensitive flip-flops in each stage, and have also been modified to minimize the strobe and reset hold times. The new counters are pin-for-pin compatible with the original design. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **237**

FOUR-BIT PARALLEL CPU on a single MOS-LSI chip is part of a set of standard ICs designed for low-cost microprogrammable applications. The 4004 CPU has a repertoire of 45 instructions. Other members of the kit include a shift register (4002) and a ROM (4001). Price for the 4004 CPU ranges from $100.00 (1-24) to $30.00 (100-999). Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. **238**

MONOLITHIC VOLTAGE REGULATOR operates in positive or negative supplies. Line and load regulation is 0.01% and output voltage is adjustable from 2 to 37V. Price is $2 each in plastic or $3.50 each in metal packages in quantities below 100. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **239**

MOS HIGH-LEVEL LOGIC ICs, Series DM7100, offer 5V noise immunity. Operating at supply voltages from 10.8 to 20V, the series is comprised initially of 13 devices that include multiple ANDs, NAND, J/K flip-flops, single-decade counters and a BCD-to-decimal decoder. Fan-out is 25 (worst case) and the devices are logic-compatible with other high-level MOS ICs. They are packaged in 14- and 16-pin ceramic DIPs at prices ranging from $1.10 to $6.00 each in 100-piece quantities. European Electronic Products Corp., 10180 W. Jefferson Blvd., Culver City, CA 90230. **240**

BROADBAND SILICON TRANSISTOR, Type 2N6105, offers 30W minimum output at 400 MHz. It is designed for broadband (225-400 MHz) operation in vhf/uhf equipment. Gain at 400 Mhz is 5 dB. It is supplied in a low-inductance ceramic-metal hermetic TO-216 package with radial leads for mounting in microstripline circuits. Price is $33.00 each in 1000-unit quantities. RCA Solid State Div., Box 3200, Somerville, N J 08876. **241**

GAASP LED Type CM4-1 requires only 2 to 10 mA to produce 50 fL. At 70 mA, 700 fL may be obtained. Packaged in a standard TO-18 header, the red LED is provided with a clear epoxy lens. Because of its low minimum operating current it is ideally DTL/TTL compatible. Chicago Miniature Lamp Works, 4433 N. Ravenswood, Chicago, IL 60640. **242**

MOS/LSI DIGITAL FILTER ARRAYS serve as building blocks for many digital filter configurations. By combining the basic arrays, many digital filter forms can be designed over a frequency range of dc to 3.5 kHz. Prices in lots of 10 units are: Multiplier $36.75 ea., I/O $43.80 ea., storage array $37.10 and timing array $38.55. Collins Radio Co., MOS Marketing Dept. 600, Newport Beach, CA 92663. **243**

DUAL 100-BIT SHIFT REGISTER, Model 2517, features clock capacitance of less than 40 pF and power dissipation of 400 μW per bit at 1 MHz. The MOS dynamic shift register uses two clock phases and operates at a typical clock frequency of 4 MHz. The devices are manufactured with low-threshold silicon gate MOS technology (p-channel enhancement mode) and can be driven directly by other MOS circuits or by standard TTL circuits. They are available in either 8-pin TO-5 cans or 8-pin miniature DIPs at $3.70 each in 100 quantities. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. **244**

COS/MOS DIGITAL ICS are available in unincapsulated chip form. Prices in 100-piece quantities range from $1.98 each for the CD4000AH, dual 3-input NOR gate plus driver to $8.90 each for the CD4033AH decade counter/divider with 7-segment display outputs and ripple blanking. RCA Solid State Div., Rte. 202, Somerville, N J 08876. **245**

NEW SCs

SWITCHING TRANSISTORS, Type 2N6249, 50 and 51, are rated at 175W. The NPN silicon devices, formerly designated TA 7005, 6 and 7, have V_{CBO} ratings from 300 to 450V. They are priced at $5 each for the 2N6249, $5.55 each for the 2N6250 and $5.95 each for Type 2N6251 when ordered in quantities of 1000. RCA Solid State Div., Box 3200, Somerville, N J 08876. **246**

PMOS ROM, Type UC65965, is a 1024 word by 4-bit sequentially-addressed static device for repetitive data pattern generation. Addressing is accomplished via two input lines and an internal static counter. Additional features include wired-OR capability and a reset input to the counter. Frequency range is from dc to 150 kHz, and access time is 600 nsec. Solitron Devices, Inc., Box 1416, San Diego, CA 92123. **247**

ZENER VOLTAGE REGULATORS have 50W power ratings. Types IN4549 to IN4564 have V_z ratings from 3.9 to 7.5V. Types IN2804 to 2838, in TO-3 package, and the stud mounted equivalents, IN3305 to 3340 have V_z ratings from 6.8 to 100V. Prices start at $4.75 each in small quantities. International Rectifier Corp., Semiconductor Div., 233 Kansas St., El Segundo 90245. **252**

LED LAMPS incorporate a diffuse red plastic dome to offer 180 degree viewing angle. Typical characteristics of the GaP diode OSL-3 lamp include radiated power output of 225 μW, equivalent to 4.5 millilumens, at 15 mA. Forward voltage is 2.1V at 15 mA, and reverse current is 0.001 μA at 4.0V. Opcoa Inc., 330 Talmadge Rd., Edison, N J 08817. **249**

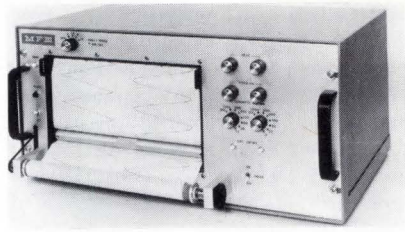
VHF/UHF POWER TRANSISTOR 2N5919A employs integral emitter ballasting to provide stabilization. The 16W, 400 MHz NPN silicon transistor is packaged in a ceramic-metal, radial-lead TO-216AA case. The 2N59191A is a direct replacement for the 2N5919 which does not have emitter ballast. Price is $16 each in lots of 1000. RCA Solid State Div., Rte. 202, Somerville, N J 08876. **250**

MONOLITHIC DIGITAL MULTIPLER Am2505 multiplies a 4-bit number by a 2-bit number and adds a 4-bit number to the product. All functions are performed in 2's complement and result in a 2's complement double-length product. For longer word lengths, several circuits can be connected in an array. Price for the Am 250559C (plastic DIP) is $26 each in quantities of 100. Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvale, CA 94086. **251**

EQUIPMENT

PORTABLE, IN-CIRCUIT IC TESTER for TTL or DTL operates on a comparison basis. Model 113 holds 12 known good ICs that serve as a comparison reference. Another set of 12 can be interchanged in one minute. DIPs with 14, 16 or 24 pins can be tested with all inputs buffered. Price is $499 and availability is stock to eight weeks. KAR Electronics, Inc., 4995 Telegraph Rd., S. Amherst, OH 44001. **261**

DPMS that operate from +5V power supply have a three-stage integrating converter and provide automatic zeroing. Readout is flat-plane 7-segment incandescent type. Standard features include BCD outputs, 1000 MΩ input impedance and less than 1 nA input bias current. Price of the 2-1/2-digit Model AN2525 is $69 each, for the 3-1/2-digit Model AN2535 $110, and for the 4-1/2-digit Model AN2545 $200. Analogic Corp., Audubon Rd., Wakefield, MA 01880. **260**



MULTI-CHANNEL CHART RECORDERS offer 100 mm channel width and are available in OEM, standard RETMA rack mount and portable configurations. Prices start at $800 and delivery is 45 to 60 days. MFE Corp., 340 Fordham Rd., Wilmington, MA 01887. **263**

CHART RECORDERS for medical, industrial and scientific useage have a heated inkless stylus that can be replaced in less than 10 sec by untrained personnel. The high-torque galvanometers provide accurate performance at frequencies beyond 125 Hz. Channel width is 50 mm, and standard chart speeds are 25 and 50 mm/sec. Astro-Med, Div. of Atlan-Tol Industries, Inc., Atlan-Tol Industrial Park, West Warwick, RI 02893. **264**

REAL-TIME SOUND SPECTROGRAPH, Model 500, gives instantaneous display of acoustical energy up to the frequency of 5 kHz with 63-channel resolution. Display is 3-D and relates frequency (y), time (x) and amplitude (z = gray scale density). Dynam. ic range is at least 40 dB. Price is $2950 (display extra). Voiceprint Laboratories Corp., Box 835, Somerville, N J 08876. **270**

DIGITAL PROCESS CONTROLLER, Model 500C, has an LED display and provides high noise immunity by using optical isolation of the internal logic. Dynapar Corp., 1675 Delany Rd., Gurnee, IL 60031. **268**

DATA ACQUISITION SYSTEM, Model DL-2, scans from 10 to 100 different signals that are then digitized and printed out with values to four places. Included are a scanner, DVM, digital printer and control unit in a single 5-1/4-inch-high cabinet. Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, OH 44146. **266**

BIT ERROR RATE TESTER counts bit errors and also counts block errors to measure the true effectiveness of data transmission systems. Bit error count, block error count and block count are displayed by the BERT 901 for each test. Remote printout, operation from a remote console and front panel error and sync self-test switches are added features. Pallace Inc., 10145 Colesville Rd., Silver Spring, MD 20901. **265**

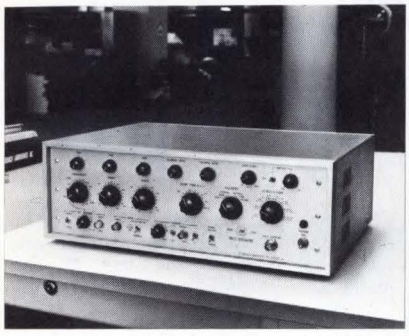
NONCONTACT FILAMENT DIAMETER SENSOR, Model SOS, can be supplied with analog or digital real-time outputs. Measuring range is from 0.003 to 0.1 inch with ±1% accuracy. Unit price is less than $2000. Servo-Optic Systems, 9062 Winnetka Ave., Northridge, CA 91324. **269**

SPECTRUM DISPLAY combined with a digital correlator provides a comprehensive frequency and time analysis of electrical signals representing physical phenomena. Model 3720A takes the autocorrelation or crosscorrelation function computed by the HP 3721A correlator, Fourier-transforms it, and displays the resulting power spectrum or cross-power spectrum on a builtin CRT. Tentative price is $5900. Delivery is for April, 1972. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA. 94304. **311**

A PROGRAMMABLE ADDRESS/DATA GENERATOR features 32-bit programming and an internal counter for address generation up to 10 MHz. Model 932 two-channel desktop unit employs 16-toggle switches per channel and provides one bit/one count or continuous data outputs. In the generation mode, the 32 front panel switches are set so 2 streams of 1 to 16-bit serial data are produced simultaneously. ARC Division/ Moxon Inc., 2222 Michelson Dr., Newport Beach, CA. 92664. **312**

TRANSIENT RECORDER reportedly features the fastest a/d converter and memory commercially available today. Model 8100 uses an eight-bit, a/d converter with maximum word conversation rate of 100 MHz which is combined with an eight-bit, 2000-word memory to capture and hold the digital equivalent of an analog signal. The 8100 costs $9500 and is available for 90-day delivery. Biomation Corp., 1070 E. Meadow Circle, Palo Alto, Ca. 94303. **313**

EQUIPMENT



PULSE GENERATOR, the state-of-the-art Model 135A, provides a 50 MHz, 10V output designed as a stimulus source for laboratory or production line applications. Features include predictable pulse shape and height, 50Ω output terminating impedance and step attenuator. Price is $1595 and delivery is 90 days ARO. E-H Research Laboratories, Inc., 515 11th St., Box 1289, Oakland, CA 94604. **262**

RESISTOR NOISE TEST SET measures resistor current noise, in the absolute values required by the latest technologies, of thick- and thin-film component processes. Resistance values from 1Ω to 25 MΩ can be evaluated accurately at noise indexes down to −30 dB. Model 315B meets the requirements of Method 308 of MIL-STD-202B. Quan-Tech, Div. KMS Industries, Inc., 43 S. Jefferson RD., Whippany, N J 07981. **267**

MAGNETIC TAPE TRANSPORTS with 8-1/2-inch reel are claimed to have twice the tape capacity of 7 inch (and performance equivalent to 10-1/2-inch) reel units. Versions in the 5000-Series are available in 7 or 9 track, 800 cpi NRZI; or 9 track, 1600 cpi phase-encoded tape formats. Price is $2380 in quantities of 100 for the read-after-write configuration. Pertec Corp., 10880 Wilshire Blvd., Los Angeles, CA 90024. **271**

TEMPERATURE ALARM that gives audible warning of danger from excessively high or low temperatures, Model 4043, is intended for use with any of the 90 model and range combinations of the company's Tele-Thermometers. Alarm point can be set anywhere between −80 and +150°C. Power is provided by four D cells that give 1000-hour life. Price is $110. Yellow Springs Instrument Co., Box 279, Yellow Springs, OH 45387. **272**

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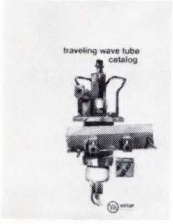
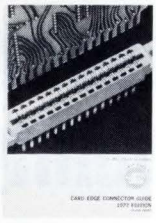


TRAVELING-WAVE-TUBE catalog contains 28 pages listing a complete line of low-, medium- and high-power CW TWTs, TWT amplifiers, pulse TWTs and low-noise TWT amplifiers. Fundamental concepts of TWTs and topics such as gain, efficiency, phase characteristics, AM to PM conversion, modulation methods and magnetic focusing are also included. Varian, TWT Div., 611 Hansen Way, Palo Alto, CA 94303. **273**

OSCILLOSCOPES, CAMERAS, CARTS AND ACCESSORIES are the subject of a 32-page product line catalog. Comprehensive specifications and prices are given for all items — including a 60 MHz dual-channel portable oscilloscope and an X-Y-Z monitor. Dumont Oscilloscope Laboratories, Inc., 40 Fairfield Pl., West Caldwell, N J 07006. **274**



CARD-EDGE CONNECTOR GUIDE, a 31-page revised catalog, includes four completely new connector series. Particularly useful is a three-page foldout index to all Elco PC connectors. All items are covered by complete drawings, detailed specifications and connector descriptions. Elco Corp., Willow Grove, PA 19090. **275**

ELECTRONIC PRODUCTION EQUIPMENT and miniature components, in five categories, are the subject of the new Circon catalog. Items such as precision microminiature handtools, lights and magnification devices for assembly workstations, microminiature indicators and lamps and microminiature hardware are included. The listings give descriptions, technical specifications, prices and delivery. Circon Corp., Santa Barbara Airport, Goleta, CA 93017. **276**

FM-FM TELEMETERING MODULES that are all solid-state are the subject of a 52-page catalog that describes such items as voltage-controlled oscillators, dc amplifiers, dc signal isolators, frequency-to-dc converters, tone oscillators, mixers, analog-to-digital converters, discriminators, pressure transducers and a telemetering system. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **277**

TRIMMERS/POTENTIOMETERS and rotary selector switches are included in a six-page distributor products catalog that gives both technical information and distributor quantity prices. CTS Corp., 905 N.W. Blvd., Elkhart, IN 46514. **278**

MERCURY-WETTED RELAYS are described in 20-page catalog number 861. The HGQ ultra-high-speed relays described provide bounce-free, hard-contact switching at frequencies to 500 Hz. C. P. Clare & Co., 3101 Pratt Ave., Chicago, IL 60645. **279**

FREE SAMPLE. Flat-bonded, round-conductor ribbon cable is described in a data sheet that includes a free sample. Complete technical specifications and ordering information is provided for PVC ribbon cabling in many gauges, colors and configurations. Bi-Tronics, Inc., 76 Main St., Tuckahoe, NY 10707. **280**

FIVE-DIGIT MULTIMETER, billed as the industry's best, is described in detail in an 8-page data sheet that covers such items as instrument accuracy, instrument capability, ac measurements, four-wire ohms capability, instrument design, servicing, and systems capability. Detailed specifications are provided along with a "How to Order" section. Dana Laboratories, Inc., 2401 Campus Dr., Irvine, CA 92664. **281**

LOW-PROFILE POWER SUPPLIES are described in a two-page brochure that is accompanied by a reply card to enable engineers to order evaluation units, receive price and delivery information and write for additional or custom specifications. GPS Corp., 14 Burr St., Farmingham, MA 01701. **282**

INSTRUMENTS AND SENSORS for the measurement of displacement, pressure, acceleration, and force and weight are featured in a product reply folder. Brief descriptions of each item are given on individual mailing cards for obtaining additional information. Schaevitz Engineering, Box 505, Camden, N J 08101. **283**

EMI FILTERS of the 8133-3101 Series are subminiature units designed for cable television, UHF, VHF, microwave and related applications. Electrical and environmental specifications are given in a data sheet. The Potter Co., Div. of Pemcor, Inc., 500 W. Florence Ave., Inglewood, CA 90301. **284**

TEMPERATURE CONVERSION chart can be added to a loose-leaf record or used as a wall chart. The expanded fahrenheit-centrigrade scales highlight many refractery metals and ceramic materials for ready reference by design and operational engineers. W. P. Keith Co., Inc., 8323 Loch Lomond Dr., Pico Rivera, CA 90660. **285**

PHOTODIODES with dark currents as low as 3 pA at 9V dc are described in a series of data sheets. Ten models with responses ranging from the ultraviolet to infrared are described. Outline drawings and spectral curves are included. Wagner Electric Corp., Tung-Sol Div., 630 W. Mt. Pleasant Ave., Livingston, N J 07039. **286**

SOLDERLESS ELECTRICAL TERMINALS and splices including nearly 900 items are described in a 24-page catalog that also lists the associated tooling and machinery. AMP Inc., Harrisburg, PA 17105. **287**

CONNECTORS AND SWITCHES are covered in a 28-page catalog. It includes descriptions of standard and miniature-pin connectors, relay and switch connectors, PC connectors and terminals and lighted push-button switches. Information on crimping tooling is included. Molex Inc., 5224 Katrine Ave., Downers Grove, IL 60515. **288**

TIMING AND CONTROL DEVICES are featured in a 28-page short-form catalog. Four separate sections describe indicators, motors, timers and fault isolation systems. A.W Haydon Co., 232 N. Elm St., Waterbury, CT 06720. **289**

COAXIAL CABLE characteristics are given on a 9-by-12 inch chart that tabulates rated power handling capability and nominal loss values for each RG/U Type at frequencies from 10 to 10,000 MHz. B & W Cable Co., B St., Burlington, MA 01803. **290**

DUAL IN-LINE PACKAGES for mounting miniature components and hybrids are the subject of a 4-page catalog that covers standard and custom 14- and 16-lead premolded versions. Aura Mfg. Co., 50 McDermott Rd., North Haven, CT 06473. **297**

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Index to Ads, Products and Literature

Application Notes

TIME CALIBRATION AND SYNCHRONIZATION is the topic of a handbook that presents a complete technical dissertation on the theory of time measurements and the techniques for precision calibration against primary and secondary time standards. CGS/Datametrics, a div. of CGS Scientific Corp., 127 Coolidge Hill Rd., Watertown, MA 02172. **291**

MICRO SWITCH APPLICATIONS are shown in "Uses Unlimited" No. 43, an 8-page publication that reviews and illustrates unusual switch applications. Micro Switch, a div. of Honeywell Inc., 11 W. Spring St., Freeport, IL 61032. **293**

VERSATILE INTERFACE FOR GRAPHIC RECORDERS is the subject of MPI Application Notes, Vol. 6, No. 4, Fall 1971. The eight pages include many diagrams, tables and recorder tracings to illustrate the various instruments/recorder applications. They also discuss specific instrument setups including recording conductimeters, ohmmeters, oxygen analyzers, thermistor and thermocouple thermometers and a DC polarographic analyzer. McKee-Pederson Instruments, Box 322, Danville, CA 94526. **295**

"TEFLON" APPLICATIONS, particularly for computer wiring, are described in the booklet "Computer Wiring with Cables and Circuits of "Teflon" that contains major articles from recent issues of The Journal of "Teflon". Du Pont Co., 1542 Farmers Bank Bldg., Wilmington, DE 19898. **292**

"THE VOLTSENSOR, a New Control Device" is the title of an 8-page paper describing various functions of this new solid-state voltage detectors. Graphs of the operating characteristics of this device, and of a competitive one, are included for comparison. California Electronics Mfg. Co., Inc., Box 555, Alamo, CA 94507. **294**

MEASURING TUNNEL DIODE PARAMETERS is the subject of Application Note T-240 which describes a simple method of measuring tunnel diode parameters through the use of phase-sensitive detection. Peak voltage, valley voltage and the region of negative conductance may be determined, allowing the circuit designer to make best use of dynamic range while minimizing noise and maximizing linearity. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **296**

Reference copies **of the following articles are available without charge:**

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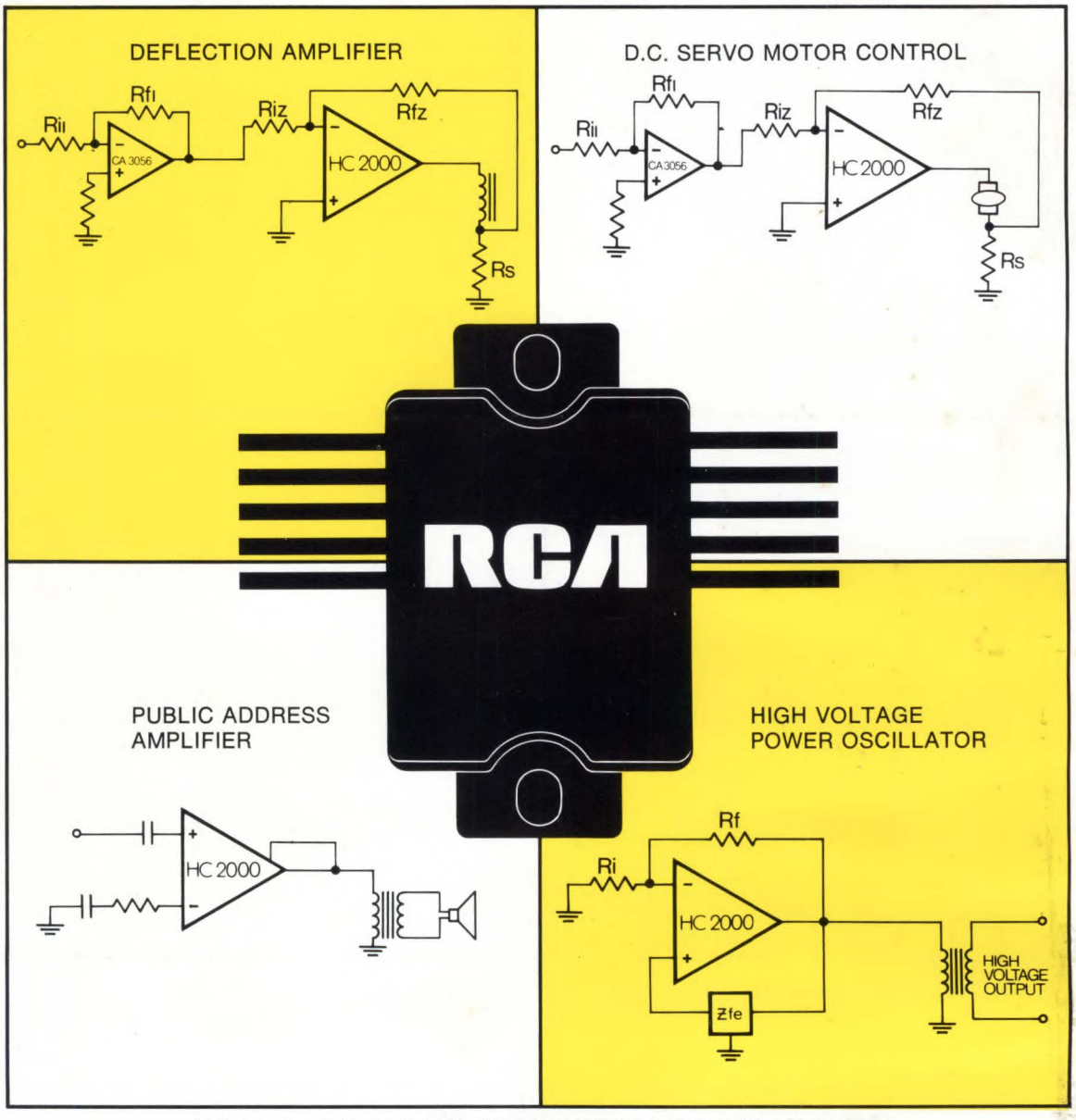

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