Torture tests improve reliability p. 80
Speed/power chart for digital ICs p. 48
IC op amp selection charts p. 61
Handling digital
Is the 901 counter-timer just too good to be true?

NO!

But we can't blame you if you think so.

Picture a state-of-the-art, 200-MHz, universal counter-timer selling for $250 to $1000 below the competition. Having trouble? Picture won’t focus? Of course not. Cheap price tags usually mean cheap products.

Focus in again. This time, picture technological breakthroughs - new circuitry and new components that the competition hasn’t caught up with yet. Now, see how easy it is to make a better product and sell it for less, too?

How much better is the CMC 901? Take a look. Range: 200 MHz (instead of 125 or 135) without prescaling or plug-ins. Gate times: 1µsec to 100 sec instead of to just 10 sec. TIM: built-in, with a resolution of 10 nsec instead of 100. Input sensitivity: 10 mV instead of the usual 50 or 100. Readout: 9 decades not just 8.

But specs aren’t everything. How about the Model 901’s “universatility”? Besides counting to 200 MHz directly (and 1.3 GHz or 3.3 GHz with optional plug-ins) the 901 also scales signals, measures time interval, period, and multiple-period average. It provides frequency and multiple-frequency ratios as well as total count; and, as an optional extra, it can be operated completely by remote control. The basic price tag? Just $2475. So we can’t blame you if you’re skeptical, but would you be happy if you bought a lesser model and paid more?

For the full facts, circle the reader service card.

COMPUTER MEASUREMENTS COMPANY

A Division of Pacific Industries

12970 Bradley/San Fernando, Calif. 91342/(213) 367-2161/TWX 910:496:1487

Circle 1 on Inquiry Card
All the advantages of tantalum...at low cost!

Type 196D Dipped Solid-Electrolyte Tantalex® Capacitors

Here's a capacitor design that admirably fills the need for low-cost yet dependable solid tantalum capacitors suitable for printed wiring boards. Straight leads as well as crimped leads are readily available to meet your manufacturing needs.

Covering a broad range of capacitance values from .1 µF to 330 µF, with voltage ratings from 4 to 50 VDC, Type 196D Capacitors are protected by a tough insulating coating which is highly resistant to moisture and mechanical damage.

Tiny in size...Giants in volume efficiency!

Type 160D, 161D Solid-Electrolyte Tantalex® Capacitors for hearing aids and ultra-miniature circuits

Tiny Type 160D/161D Tantalex Capacitors are sealed within a polyester film tube with tightly-bonded epoxy fill, so the assembly is both electrically insulated and highly resistant to moisture. They are available with axial leads as well as in single-ended construction.

Offering extremely high capacitance per unit volume (for example: 0.25 µF @ 20 VDC in a case only .065" D. x .125" L.), Tantalex Hearing-aid Capacitors let you select from a broad range of ratings in five different case sizes.


THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS
Semtech Silicon Rectifiers & Assemblies

"Cool Power"

Semtech Corporation manufactures a complete line of silicon rectifiers and devices. Offering unique packages—designed to solve old and new circuit problems efficiently, reliably and at low cost.

Semtech has a continuing research and development program, utilizing interrelated technologies, to guarantee state-of-the-art rectifiers and assemblies. The new "Metoxilite" rectifier is just such a device—the result of years of intensive materials research and testing. Fashioned from metal-oxides, this new device offers impermeable monolithic construction and advanced electrical characteristics.

Unique devices introduced by Semtech include:
- SEMPAC® (100 to 1000V)
- MINISTAC (1 to 7kV)
- COMPAC (50 to 3000V)
- MINISTIC (10 to 40kV)
- SLIMPAC® (2.5 to 45kV)
- ALPAC® (50 to 600V)
- STACPAC (500V to 25kV)
- "METOXILITE" (100 to 1000V)
- A complete line of Multipliers (up to 50kV).

For complete information, contact your nearest representative and get your Free copy of Semtech's 1969 Silicon Rectifier Catalog. All products listed in our catalog are available for immediate delivery.

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European Sales—Bourns A. G., Alpenstrasse 1, S. Switzerland / (044) 4 65 72-73

SEMTECH CORPORATION
652 Mitchell Road, Newbury Park, California 91320 / (805) 498-3111, (213) 628-5392 / TWX: 910-336-1264

*SEMPAC, SLIMPAC and ALPAC are registered trademarks of the Semtech Corporation.
Project management accomplishes "impossible" mission

The mission was to verify the structural integrity of the Apollo short stack—a task estimated to take at least a year—in four months. Project management techniques helped get the job done on time.

Speed/power chart for digital ICs

This 1969 specifying chart compares digital ICs by their two most important parameters—propagation delay and power dissipation.

Operational amplifiers application guide

You will find this multi-colored pullout wall chart a very useful design guide. The chart contains primary functions that can be performed by op amps. Remove your copy now, lest you forget.

Operational amplifier charts

Whether monolithic or hybrid, you'll find all commercial op amps here, classified by five important parameters.

Digital data: play it like it is

Distortion and noise in tape-playback amplifiers often give you false data. An improved peak detector for NRZI amps rejects both low- and high-level noise, and responds only to the true peak of the playback signal.

Torture tests improve equipment reliability

You can vibrate it, accelerate it, sand blast it, shock it, heat it, and chill it yourself, or you can send it out to be done, but the result will be the same—an improved product.

IC Ideas

- Fault monitor checks for circulating logic bit
- Shape pulses for RTL circuit use
- Counter counts to find faults

Jack-of-all-trades: monolithic i-f a universal subsystem

A single chip serves a multitude of transmission modes, and lets you switch economically from one to another, within a single receiver.
You say you want a low-profile snap-in-mounting push button switch or matching indicator that is interchangeable with most 4-lamp displays... available in a full range of cap colors... with a choice of bezels with or without barriers in black, gray, dark gray or white.

and a legend presentation that's positive (like this one) or negative (like the one below) or just plain (like the one above)... one that's white when "off" and red, green, yellow (amber), blue or light yellow when "on"... or colored both "on" and "off."

and a highly reliable switch proven in thousands of installations... available in momentary or alternate action... N.O., N.C. or two circuit (one N.O., one N.C.)... that accommodates a T-1 1/4 bulb with midget flanged base, incandescent, in a range of voltages from 6-28V.

e tc. etc. etc.

Now, for the first time Dialight gives you custom panel designing with a standard line of push-button switches and matching indicators

Dialight offers a broader range of switch and indicator possibilities than you'll find anywhere in a standard single-lamp line.

Sizes: ¾” x 1”, ¾” square and round.

Send today for our new full-color catalog L-209.

DIALIGHT
Dialight Corporation, 60 Stewart Ave., Brooklyn, N.Y. 11237

EE
The Electronic Engineer
Vol. 28 No. 6 June 1969

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"The Pill"

for price control

We keep our promises! Last month we promised a low-priced industrial application DPDT TO-5 case relay with an internal transistor driver. We call this new contraption "THE PILL." "THE PILL" contains a transistor driver and suppression diode, attaches externally to our DPDT industrial 712 relay to form the 712T... and does double duty as a transapad.

The 712T combines the advantages of relay operation, i.e., high isolation, low contact resistance, double throw contacts, high current and overload capability with the low signal drive requirement offered by the transistor front-end.

It's hermetically sealed; utilizes all welded construction; requires a turn on (trigger) power of only 200 microwatts or less depending on coil voltage; and may be driven directly from standard T7L or similar logic. The relay coil is paralleled with a diode to suppress transients.

The entire package is only 0.405 high by 0.370 in diameter (including "THE PILL"), and is available from stock at your local Teledyne Relay distributor or from the factory at the following price schedule:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>100</th>
<th>1,000</th>
<th>10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$12.50</td>
<td>$10.40</td>
<td>$9.25</td>
</tr>
</tbody>
</table>

We call our first price control PILL the 712T... Look for an op-amp PILL in July for DO-IT-YOURSELF time delays and level sensing applications.

No blue sky promises from us... just fast delivery for quick price relief.

Phone, wire or write for technical data.

TELEDYNE RELAYS
A TELEDYNE COMPANY
3155 West El Segundo Boulevard Hawthorne, California 90250 Telephone: (213) 679-2205

Circle 8 on Inquiry Card
True to our tradition, we've got something great to tell you about this month.

Raytheon now has an op amp that draws less power than any other you can buy. Anywhere. It works within specifications with supplies as low as ±3 volts. We call it the RM4132, and it's sitting on our distributors' shelves, right now, waiting for you to come and give it a home.

This graph plots power and current against supply voltage, and we guarantee that 150 µW figure at ±3 V! Maximum input bias is 10 nA, max input offset current is 2 nA, with no more than 0.1 nA/°C drift.

It has typical unity-gain frequency response of 150 kHz. And small signal open loop gain is 94 dB minimum.

The RM4132 is internally frequency compensated. It's pin-for-pin compatible with the 709, 741, 107, 4131 and like that.

And the full military version costs only $30 for 100-999.

How do we do it?
It's simple. This patent-pending little current regulator holds the amplifier quiescent current to 20 µA from ±3 to ±20 volts, and never shows more than ±10% current variation across our whole -55 to +125°C temperature range. And those little bitty batteries seem to last forever.

So immortalize your system with an RM4132 from the company that's getting the ideas and delivering the goods. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.

Don't let your system run down.

Our new RM4132 microwatt op amp keeps your cells young and active.
On heckling and doing

A pretty girl handed me a leaflet at the Spring Joint Computer Conference in Boston. It was a "statement of purpose" by the Computer Professionals for Peace, a group based in Brooklyn, N.Y. Together with unconditional withdrawal from Vietnam and cancellation of the ABM, the leaflet urged all computer professionals to seek employment in projects unrelated to war, and demanded that the two popular computer conferences (Spring and Fall JCC) cease to be a publicity forum for war contractors.

Fortunately, the Conference was ahead of this group. Most of the papers and the exhibits were devoted to computer applications that had nothing to do with war. And one of the paper sessions—"Computers and the underprivileged"—turned up the following examples of professional involvement in the causes the Brooklyn group claimed to espouse:

• The Urban Education Committee, a group formed by members of the Delaware Valley Chapter of the Association for Computer Machinery, provides free advice to the Philadelphia Board of Education on data processing curricula, consults for the Philadelphia Urban Coalition, and trains high school students as computer operators.

• Both faculty and students at MIT cooperate in a project* teaching computer programming to underprivileged people in Boston.


In addition, the Conference featured sessions on subjects such as "Applications of computers in the urban environment," "Computer systems vs health systems," and "Urgent—Increased dialogue with society." Although it promised to be an interesting session and it was well attended, the latter one got nowhere thanks to the heckling by a group organized by CPP.

What the hecklers shouted for is already being implemented, for example, by the General Electric Valley Forge Space Center, which developed a mathematical model to study the pollution of the Delaware River, and by companies such as Philco-Ford, whose Education Operations group has contracts with the Department of Labor, with the Bureau of Indian Affairs, and with many community organizations to improve the lot and the education of the disadvantaged.

Perhaps the hecklers see themselves as the subject of the Socratic quote: "God put me upon your city as a gadfly on a noble horse, to bite him and keep him awake." We should be thankful for gadflies, but it's the quiet ones who do the constructive work.

Alberto Socovsky
Editor

*This project at MIT also includes courses in modern technology for the "overprivileged." It trains well-educated people in subjects such as lasers and computer systems.
Fairchild announces the future. Available today.
You're looking at the technology that's going to be used for the largest, least expensive bipolar and MOS memories. And it's here now to give you a fast start on economical high-performance scratchpad and buffer memories.

The product is the new Fairchild MUL4027 Bipolar 128-Bit Read/Write Random Access Memory. Inside, we've used bipolar technology to give you read and write times of 35ns. And we've used face-down bonding and multilayer ceramic to eliminate flying-wire leads and increase both performance and reliability. The 128 bits are organized as 64 2-bit words with uncommitted collectors that allow easy word or bit expansion. Addressing is through eight X and eight Y coincident-select lines to simplify memory organization. All outputs are CCSL-compatible.

The completed memory comes in a 1" x 1" hermetic ceramic plug-in package that saves you weight and space. And it's yours for less than 52¢/bit ($100, 1-24; $80, 25-99; $66, 100-999).

So write for the complete specs and application notes. Or pick up several units from your Fairchild distributor. The technology is for the future; the product is here today.

Fairchild Semiconductor / A Division of Fairchild Camera and Instrument Corporation
Mountain View, California 94040
(415) 962-5011/ TWX: 910-379-6435
FAIRCHILD SEMICONDUCTOR
New entry in plated wire memories

The Stromberg-Carlson Corp. has just developed plated wire memories, which will be the heart of a new type data storage unit it is building.

Ten times faster than normal ferrite cores, these memories can also be reused without destroying stored information. Each device consists of parallel wires arranged in a plane configuration 12 1/2 x 5 1/2 x 1/2 in. to provide storage of about 10,240 data bits. In this plane about 800 bits are stored per square inch. The plated wire switching speed is 20 billionths of a second.

How it works

The magnetic alloy coated wires are placed in parallel insulated tunnel structures, smaller than the diameter of a common pin, and crossed at right angles by rows of printed copper electrical conductors (word straps) to form a memory plane. A plated wire plane offers 128 words of 80 bits each.

Hundreds of data bits can be written on the same wire. Each is written as a narrow magnetic band by directing the polarity clockwise or counter-clockwise around the circumference of the wire. Since each of these polarized bands is unaffected by the bands next to it, different magnetic directions can exist on the same wire.

The magnetic direction of each band is read by sending a brief current pulse through the word straps and sensing the voltages across the end of the wires. With sequential pulsing and sensing, reading more than one bit on each wire is possible. To write or change a bit, current is pulsed through the word straps, with a second, simultaneous current pulsed through the wire.

The memories will be used in future computer-type telephone systems. The systems' subscriber's services will be provided by tape programs and will eliminate the need for making equipment changes. Stored information which would include all necessary instructions for computing a telephone call or for providing the subscriber's service is retained even if system power fails. Stromberg-Carlson Corp., 100 Carlson Rd., Rochester, N.Y. 14603.

IBM goes from copper balls to solder pads

In adapting solder pads as terminals for its semiconductor chips, IBM has joined the rest of the industry. Originally, when it introduced its SLT (Solid Logic Technology) hybrid system, IBM provided its semiconductor chips with copper ball terminals, which were criticized because they depended on a rather complicated metallurgical system involving two solders or different eutectic points: A high temperature solder to bond the ball to its chip, and a low temperature solder that was relxed to bond the chip's ball to the circuit.

Other manufacturers such as Fairchild, Hughes and Sperry have been using solder pads for a number of years already, and its use has extended to the rest of the industry.

IBM's "controlled collapse" chip joining technique was described at the Electronic Components Conference, April 30-May 2. It extends the chip ponding method of their SLT, announced in April 1964, for producing circuit modules used in System/360 computers. Originally, the SLT fabrication techniques bonded silicon transistor chips with three solder-coated (continued on page 13)
Now... with CTS Cermet Multi-Turn Square Trimmers you get Characteristic C Mil-spec performance for all military applications. All new series 165 (style RJ24) and series 175 (style RJ22) meet tough Characteristic C of Mil-R-22097C. These same environmental characteristics are available... at lower cost... for commercial and industrial applications.

Both small ¾"-square series 165 and compact ⅝"-square series 175 trimmers assure infinite resolution over a 20 ohm to 2.5 megohm range... and power rating of ½ watt @ 85°C. TC±150 ppm/°C for 2k ohms and above, ±0±175 ppm/°C from 50 ohms through 250 ohms and -0±250 ppm/°C from 500 ohms through 1k ohm. All available at no extra cost.

Low cost*, proven quality, and top performance—combined with fast distributor delivery—make CTS your best industrial trimmer choice. Can't use one of our standard series? Ask how we can solve specific application problems. Call or write for complete details to CTS of Berne, Inc., Berne, Indiana 46711. Phone (219) 589-3111.

*Check these prices for 4-6 week production delivery. (Small quantities from stock)

<table>
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<th>Quantity</th>
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<th>Series 175</th>
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<td>MIL-type (+10% Tol., Char. C)</td>
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<td>94.20</td>
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Other CTS Cermet Trimmers include:

- Series 185: 1-¾" x .290" x .364" multi-turn
- Series 190: ¾" x .160" x .310" multi-turn
- Series 340: ⅛" x ⅛" square x .270" high—single-turn
- Series 360: ⅜" high—single-turn
- Series 385: ⅜" high—single-turn
- Series 660: ⅝" round x ¼" high—single-turn
- Series 630: ⅝" round x ⅝" high—single-turn

The Electronic Engineer • June 1969

Circle 11 on Inquiry Card
SMALL DIMENSION
FUSES and Fuseholders

For the protection of all types of electronic & electrical circuits & devices

The complete BUSS line of fuses includes dual-element “slow-blowing,” single-element “quick-acting” and signal or visual indicating types... in sizes from 1/500 amp. up—plus a companion line of fuse clips, blocks and holders.

Only a representative listing is shown here of the thousands of different types and sizes of fuses and holders available from BUSS.

All standard items are easily obtained through your BUSS distributor.

When special fuses, fuse clips, fuse blocks or fuseholders are required, our staff of fuse engineers is at your service to help in selecting or designing the fuse or fuse mounting best suited to your requirements.

For detailed information on the complete BUSS line write for BUSS bulletin SFB.
IBM uses solder balls (continued)

copper balls to metallized substrates.

Now, malleable pads, consisting of vacuum-metallized lead/tin (95/5) solder, are constrained during the heating and bonding process, thus preventing solder from flowing to the edge of the semiconductor device and causing an electrical failure.

A key advantage of the technique is that the solder reflow characteristics compensate for minor variations in pad heights found in large monolithic semiconductor devices with many contacts. The ductility of the joint, which can absorb considerable stress during thermal cycling in normal operation, also provides more pliability to the bonded joint, thus improving its reliability.

IBM's "controlled collapse" method of joining a chip to its substrate uses solder balls instead of the original copper balls shown in the lower sketch. The copper ball method is being replaced with the solder method in IBM 360 computers. Several other companies have been using the solder ball method for quite a while, with success.

Desk calculator uses LSI/MOS

If you still have any doubts about the seriousness of large-scale integration (LSI) and the fact that it is here now, get rid of them. The SCM Corporation just showed a new desk-sized electronic calculator that uses LSI/MOS devices. And, the price of the unit, less than $900, is competitive to that of other office type calculators.

The Marchant Cogito 414 has a total of eight LSI/MOS elements. Each MOS element is a chip consisting of from several hundred to over 1200 MOS transistors and 40 connecting leads, all mounted on a wafer thin ceramic base, equal to a 1 x 2 in. rectangle.

The chip containing the metal oxide silicon transistors is 120 mils square. These dimensions are significant because a single MOS chip element or package performs the same calculator functions that previously required 600 discrete (large size) elements or 20 conventional ICS.

LSI made with MOS devices permits a drastic reduction in the total configuration of the calculator. If made with conventional integrated circuits, Cogito 414 would require 160 separate devices. The total of eight chip elements in the 414 are equivalent to 4800 discrete components.

The Cogito 414 has 14-digit capacity and is 10½ in long, 11½ in wide, 5½ in high, and weighs only 8 lb.
The new Delco Radio DTS-701 and 702 NPN triple-diffused silicon high voltage transistors. They were designed for the tough requirements of off-line deflection in large screen TV.

However, they're built and tested for extra reliability in all high energy circuits. Proved by the surest peak energy capability rating in the business: Pulse Energy Testing.

And right now, they're available in both production and sample quantities.

Why will you want to use the Delco 701 or 702?

For the tough jobs—high inductive load switching or for circuits subject to transients or fault conditions.

For reduction of weight, size and component costs. Circuit complexity and number of components are reduced, so assembly costs go down, too. And fewer components mean higher reliability.

So now you know. The pioneer in high voltage silicon power has done it again.

For prices, samples or complete data, just call us or the nearest Delco Radio distributor listed below.

Now, ready for you in quantity.
I. DTS-701
Collector to emitter voltage ($V_{CE}$) .................. 800V
Sustaining voltage ($V_{CEO (SUS)}$) ................. 600V min.
Emitter to base voltage ($V_{EBO}$) ..................... 5V
Collector current ($I_C$) ................................ 500mA
Base current ($I_B$) ..................................... 100mA
Power dissipation ($P_T$) ......................... 25W

II. DTS-702
Collector to emitter voltage ($V_{CE}$) .................. 1200V
Collector to emitter voltage ($V_{CEO}$) ............... 1000V
Sustaining voltage ($V_{CEO (SUS)}$) ............... 750V min.
Emitter to base voltage ($V_{EBO}$) ..................... 5V
Collector current ($I_C$) ................................ 3A
Base current ($I_B$) ..................................... 1A
Power dissipation ($P_T$) ......................... 50W

Available in solid copper. JEDEC TO-3 package.

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DELCO RADIO
DIVISION OF GENERAL MOTORS
KOKOMO, INDIANA
Pack our new SSPI PIC100 AC Switch. Lightning-fast gate trigger action... "inherent transient immunity" (dv/dt 50 volts/µ sec.) that keeps it from turning on when the supply voltage suddenly changes. In action, it's the quickest AC Switch on-the-draw at high frequencies (up to 20,000 Hertz), and it's got that cool sure-fire dependability at low load currents (1.5 milliamps). It stops 400 volts cold at temperatures up to 150°C. Sighted for a "narrow range of gate control", providing the highest triggering reliability possible.

You can pack this beauty for use in Servo mechanisms, guidance and control, and process controls. So, if you want to marshal the best AC control, call or write Peter Jenner at:

SOLID STATE PRODUCTS (SSP)
DIVISION OF UNITRODE CORPORATION
1 Pingree Street, Salem, Massachusetts 01970
Tel: (617) 745-2900
The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

**A word of caution**

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

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

### INSTRUMENTS

#### Counters

<table>
<thead>
<tr>
<th>Monsanto 1500A</th>
<th>Eldorado 1615</th>
<th>Nonosc. Systems 1721 (scaier)</th>
<th>Beckman 6380</th>
<th>CMC 901</th>
<th>H-P 5360A</th>
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<td>200</td>
<td>320</td>
<td>400 500</td>
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Eldorado 1650

Fairchild 8220 with FM01

G. Radio 11918 with I157

Monsanto 1500 with I10IA

#### General-purpose oscilloscopes

H-P 180A

Tektronix 454

Iwatsu SS2II

Real-time bandwidth MHz

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<td>50</td>
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<tr>
<td>100</td>
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<tr>
<td>150</td>
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<td>200</td>
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#### Pulse generators

E-H Research 122

Datapulse II2

Datapulse II3

E-H Research 129

Chronetics PG-13

H-P 214A

E-H Research 5112

Highest PRF MHz

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<td>100</td>
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<tr>
<td>125</td>
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<tr>
<td>200</td>
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<tr>
<td>250</td>
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<tr>
<td>500</td>
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Output pulse amplitude Volts (across 50Ω)

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<tr>
<th>Volts</th>
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<tbody>
<tr>
<td>±50</td>
</tr>
<tr>
<td>±15</td>
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#### CHIP CAPACITORS

**Ceramic**

Monolithic Dielectrics K1200

Capacitance μF

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**Tantalum**

Kemet D336

Kemet D107

Capacitance μF

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<td>(10V dcw)</td>
<td>(2V dcw)</td>
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### Integrated Circuits

#### Operational Amplifiers

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<th>Fairchild</th>
<th>National</th>
<th>Radiation</th>
<th>Union Carbide</th>
<th>Transistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>μA741C</td>
<td>LM101</td>
<td>RA909</td>
<td>UC4000</td>
<td>TOA7709</td>
</tr>
</tbody>
</table>

**Input bias current** (typical): nA

<table>
<thead>
<tr>
<th>Voltage Regulators</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPC LA100</td>
</tr>
<tr>
<td>National LM100</td>
</tr>
<tr>
<td>Fairchild μA723</td>
</tr>
<tr>
<td>Transistor TVR2000</td>
</tr>
</tbody>
</table>

**Output current** mA

<table>
<thead>
<tr>
<th>Power Amplifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampex TAA300</td>
</tr>
<tr>
<td>G.Electric PA234</td>
</tr>
<tr>
<td>Motorola MC554</td>
</tr>
<tr>
<td>RCA 3020A</td>
</tr>
<tr>
<td>Transistor TTI</td>
</tr>
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</table>

**Power output** Watts

<table>
<thead>
<tr>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Power Transistors (nPN)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Westinghouse 1441</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Power dissipation Watts</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dual Bipolar Transistors</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Union Carbide UCX2910</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Frequency ( f_1 ) MHz</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Microwave Semiconductors (Power)</th>
</tr>
</thead>
</table>

| H-P 39143A                     |

<table>
<thead>
<tr>
<th>Frequency GHz</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Junction FETs</th>
</tr>
</thead>
</table>

| Siliconix 2N5397 |

<table>
<thead>
<tr>
<th>Noise figure dB</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Zener Diodes</th>
</tr>
</thead>
</table>

| Motorola M24614 |

<table>
<thead>
<tr>
<th>Noise level ( \mu V/\sqrt{Hz} )</th>
</tr>
</thead>
</table>

---

The Electronic Engineer • June 1969
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UNITRODE invents the 12 amp UCR - the industry's first fused-in-glass SCR.

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And their size and shape meet your high density packaging requirements.

2. WHAT TRADE-OFFS YOU HAVE TO LIVE WITH...

With wirewounds, inductive and capacitive effects rule out use at high frequencies. With conventional film, you can get the speed but can't approach Vishay's absolute tolerance or almost-zero TC.

The totally new Vishay design eliminates these trade-offs... there just aren't any.

3. WHAT SUCH COMPLETE PERFORMANCE MUST COST...

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If you want or must have precision resistors, in your system or instruments, Vishay offers a precision package no other production resistor can come close to matching.

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An apple isn't a pear

Sir:

You recently carried a new-product feature story on the Hewlett-Packard computing counter [THE ELECTRONIC ENGINEER, March 1969, p. 99]. We were surprised, and not too happy, to find a paragraph in the middle of that article dealing
with CMC's Model 901. We don't believe that one manufacturer's product should be used as an expendable buffer to promote another's, especially when you are comparing apples and pears. So let's set the record straight.

The mistake you made in your mentioning the 901 was to omit its price. It sells for only $2475, as compared with H-P's $6500 plus. Now, once that is established, it becomes clear that the H-P product should indeed have some performance advantages over any conventional counter selling for about a third of its price. (And you can be sure that for $4000 on top of our base price, we would be prepared to offer Model 901 buyers a pot full of extras, too! Maybe we'd even throw in a computing module.)

We have no beef against H-P or the concept of a computing counter. But we believe you would have done your readers a greater service had you simply introduced the H-P model as a new, $6500, special-purpose computing and measuring instrument, rather than billing it as some kind of a counter comparable with conventional counters in the medium- to low-price range.

Let us hope that your hapless reference to the CMC 901 has not confused your readers. The fact remains that at $2475, the 901 still delivers the best performance-per-dollar of any comparable instrument available today. So perhaps those readers who aren't willing to spend $6500 for special performance they may not need will want to refer back to that Hewlett-Packard article for CMC's telephone number.

Leslie B. Arnold
President and General Manager
Computer Measurements Co.
San Fernando, California.

EDITOR'S NOTE: The H-P instrument was billed as a counter because it is a counter, first and foremost. But a non-conventional design, plus some clever applications of side-benefits of that design, let you use the instrument as a computer also.

On the other hand, we must agree with Mr. Arnold's suggestion that it's unfair to compare the H-P item with a conventional counter, at least on a price basis. And no such comparison was intended. We brought in the CMC 901 simply as an example to show our readers what they could expect, in terms of direct-frequency count and resolution, from even such an outstanding example of a conventional counter as the 901.

The gentlemen at CMC will be delighted to discuss these points further, dear reader, if you'll call them at (213) 367-2161.
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JUNE

8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30


JULY

1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
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JUNE


AUGUST

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'69 Conference Highlights

WESCON—Western Electric Show and Conv., August 19-22; San Francisco, Calif.

NEREM — Northeast Electronics Research and Eng'g Meeting, Nov. 5-7; Boston, Mass.

Call for Papers


Dec. 4-5, 1969: Vehicular Technology Conf., Columbus, Ohio. Submit a 50-word abstract and an 800-1000 word abridgement before August 1, 1969 to Dr. Robert E. Fenton, Dept. of Electrical Eng'g, Ohio State Univ., Columbus, Ohio 43210.

The Electronic Engineer • June 1969
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A case history

Project management accomplishes "impossible" mission

The mission was to verify the structural integrity of the Apollo short stack—a task estimated to take at least a year—in four months. Project management techniques helped get the job done on time.

By Joan Segal, Assistant Editor

A project is usually defined as a “unique, well-defined effort to produce certain specified results at a particular point in time,” and by all terms of the definition the short stack testing program qualifies. It was an unprecedented testing effort (representing a significant advance in ground testing for space vehicles). It had a specific objective (to confirm that the short stack, as an assembly, was capable of withstanding the rigors of flight). And it certainly had a specified time span (four months).

To handle this complex project, with its very compressed and urgent schedule, Wyle top management immediately assigned a program manager with the full responsibility for administering the contract. It was his responsibility to establish program objectives, budgets, and schedules, and to assure the performance of all services provided under the contract.

People power

When Wyle was awarded the short stack testing project, David R. Reese—who had managed the proposal effort—became the program manager. His first task was to assemble a project staff, and there was no time to waste because of the tremendous schedule requirements. What made his job easier was the company's policy for staffing a project: When it commits itself to getting a job done, it gives the program manager the freedom to pick senior individuals for each of the identified tasks from virtually any of the cor-
The procurement panic

Because of the program deadline, one of Reese's most urgent tasks was to identify those items he knew he had to order immediately—or the whole schedule would blow up. But there was a more basic problem, and that was to bring together all the responsible parties from NASA, North American, Grumman, IBM, and McDonnell and get an agreement as to what the test parameters really were. Naturally, you need this kind of information before you can set the design of your test hardware, and thus before you can begin procuring needed materials and equipment. As the program manager recalls, "The original meetings to get this settled would involve some 65 to 70 people. The pains and agonies of getting enough of an agreement so that we could at least order long lead items was in itself a major undertaking."

In many cases, what he had to do was analyze the minimum-maximum requirements and try to order on this basis. For example, steel was a very tough item to get, but the exact requirements were not set immediately. Since he knew that the Saturn rocket during boost is in the range of 4 to 5 g, Reese felt that he would be safe in sizing the steel for the fixtures based upon a maximum of 5 g. As it turned out, the final test parameters were based on something a little over 4 g; but by estimating his needs rather than waiting for the exact parameters to be decided, he assured himself of obtaining the hard-to-get item—on time.

Another critical supply was wire. To connect the test set-up's 1300 strain gauges to the data system, a million feet of insulated wire was required. To fulfill this need, Wyle purchased nearly every foot of suitable wire available in the entire country.

In a normal program, the manager can allow a week or two for a shipment getting lost or for somebody in the receiving department "goofing up." But in this program a single day could be critical. Recognizing this, Reese and his staff sat down and, based upon their previous experience, tried to predict everything that could go wrong in the whole procurement cycle. Then, to make sure nothing did go wrong, they organized a purchasing staff to follow up every purchase order that was significant. And to do this, they had to put together a complex schedule that listed when you had to have what item to keep up to date.

To illustrate the enormity of this expediting job (which is usually only a minor problem for most major programs), in only 43 days purchase orders totaling $1,300,000 had been placed and filled.

Making what you can't buy

The program's procurement problem went further than just selecting a supplier and watching over him to ensure that he delivered on time. In some cases, the needed item could not be purchased from any subcontractor within the allotted time span. For example, a major problem was how to apply the aerodynamic forces to the skin of the SLA (Spacecraft Lunar Module Adapter) and the SIV-B. The normal way for doing this is with a mechanical attachment, which affects the dynamic response of the structure. Since the short stack program involved dynamic tests, the forces had to be applied without affecting the dynamics. To do this, program engineers devised a method which called for the use of many specially formed air bags made from the same type of material that goes into the manufacture of a dirigible.

The big problem was finding a rubber company that could meet the delivery requirements for the nearly 200 air bags—ranging up to 20 ft long. Unfortunately, Reese discovered that although he could get the raw material, no plant would build these things in the allotted time. So, he lured an ex-Goodyear specialist out of retirement, had him set up a manufacturing area for air bags, hired platoons of vacationing college students, and got the job done.

As Reese summarizes, "Running a program like this is a continual evaluation of where you stand and where you have to put more strength, more engineering talent. We didn't particularly want to get into the manufacturing business but we had to—there were no two ways about it."

Coordinating the test effort

Aside from the technology involved, perhaps the most unique feature of the program was the smoothness with which Reese was able to get all the people from the various stage manufacturers and NASA to work together. After all, NASA, McDonnell Douglas, IBM, and Grumman had no real contractual relation-
New Miniature Power Supplies for Op-Amps and IC Logic Circuits

Now at new low prices

(Model 904)
±15V @ 50mA ... $39

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The circuit designer's best friend these days is the packaged circuit module. Engineers everywhere have discovered the convenience and economy of "plug-in" building blocks... op-amps, logic cards, miniature D/A converters, etc. Relatively new on the scene are power supply modules. The only problem, until now, has been the cost.

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We're so sure that once you see one of these great little supplies you won't want to part with it that we're prepared to send one to you for a free 30 day trial. At the end of the trial period you simply return the unit or send your purchase order. No risk to you and no obligation to buy, of course. USE THE INSTANT ACTION CARD.
<table>
<thead>
<tr>
<th>MODEL 902</th>
<th>MODEL 904</th>
<th>MODEL 903</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INPUT VOLTAGE</strong></td>
<td>105 to 125VAC^1</td>
<td>105 to 125VAC^1</td>
</tr>
<tr>
<td>50 to 400Hz</td>
<td>50 to 400Hz</td>
<td>50 to 400Hz</td>
</tr>
<tr>
<td>17VA max</td>
<td>9VA max</td>
<td>17VA max</td>
</tr>
<tr>
<td><strong>OUTPUT VOLTAGE (fixed)</strong></td>
<td>±15V @ 0 to 100mA</td>
<td>±15V @ 0 to 50mA</td>
</tr>
<tr>
<td><strong>ACCURACY</strong></td>
<td>±(15.0 to 15.3V)</td>
<td>±(15.0 to 15.2V)</td>
</tr>
<tr>
<td>±15V within ±1% of +15V</td>
<td>±15V within ±3% of +15V</td>
<td></td>
</tr>
<tr>
<td><strong>TEMP COEFFICIENT</strong></td>
<td>0.015%/°C max</td>
<td>0.03%/°C max</td>
</tr>
<tr>
<td><strong>REGULATION</strong></td>
<td>0.05% max</td>
<td>0.1% max</td>
</tr>
<tr>
<td>Line (105 to 125VAC)</td>
<td>0.1% max</td>
<td>0.3% max</td>
</tr>
<tr>
<td>Load (0 to 100%)</td>
<td>0.05% max</td>
<td>0.1% max</td>
</tr>
<tr>
<td>0.1% max</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WARM UP DRIFT</strong></td>
<td>±0.3% (45mV)</td>
<td>±0.25% (37mV)</td>
</tr>
<tr>
<td><strong>RIPPLE</strong></td>
<td>0.5mV rms, 2mVp-p max</td>
<td>0.5mV rms, 2mVp-p max</td>
</tr>
<tr>
<td><strong>OUTPUT IMPEDANCE</strong></td>
<td>2 ohms @ 10kHz</td>
<td>0.2 ohms @ 10kHz</td>
</tr>
<tr>
<td><strong>SHORT CIRCUIT PROTECTION</strong></td>
<td>Either output to common indefinitely</td>
<td>Any combination of output pins indefinitely</td>
</tr>
<tr>
<td><strong>OVERVOLTAGE PROTECTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OPERATING TEMPERATURE</strong></td>
<td>0 to 71°C</td>
<td>0 to 71°C</td>
</tr>
<tr>
<td>derate 5mA/°C</td>
<td>derate 2mA/°C</td>
<td>derate 12mA/°C</td>
</tr>
<tr>
<td>above 60°C</td>
<td>above 55°C</td>
<td>above 50°C</td>
</tr>
<tr>
<td>derate 1mA/°C</td>
<td>derate 0.5mA/°C</td>
<td>derate 10mA/°C</td>
</tr>
<tr>
<td>below 10°C</td>
<td>below 10°C</td>
<td>below 15°C</td>
</tr>
<tr>
<td><strong>STORAGE TEMPERATURE</strong></td>
<td>−25 to +85°C</td>
<td>−25 to +85°C</td>
</tr>
<tr>
<td><strong>SURFACE TEMPERATURE RISE</strong></td>
<td>20°C above ambient @ full load</td>
<td>25°C above ambient @ full load</td>
</tr>
<tr>
<td><strong>INPUT ISOLATION</strong></td>
<td>50 Megohms</td>
<td>500 MΩ</td>
</tr>
<tr>
<td><strong>WEIGHT</strong></td>
<td>16 oz.</td>
<td>10 oz.</td>
</tr>
<tr>
<td><strong>PRICE</strong></td>
<td>$49.</td>
<td>$39.</td>
</tr>
<tr>
<td>1-9</td>
<td>$47.</td>
<td>$38.</td>
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<tr>
<td>10-24</td>
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</tbody>
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1. Input voltage of 205 to 240VAC available. Specify Model 907. Mating Socket AC1013 $3.75

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Please send the following units for 30 day free trial:

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My interest is for:
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- [ ] Information only
- [ ] Send OEM Quantity prices
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Problem and solution

Early in 1968 NASA's budget for space exploration was radically cut and the agency was thus forced to reduce the number of Saturn/Apollo test flights. Then on April 5, 1968, Saturn/Apollo 6 preceding the manned Apollo 7 began to shed pieces of the Spacecraft Lunar Module Adapter (SLA) shortly after blastoff.

These two events presaged a long delay of the moon shot landing, a radical disruption of the United States space schedule, and a consequent problem for space contractors.

That June, NASA and the Space Division of North American Rockwell Corp., prime contractor, concluded a series of analyses with the decision that a multi-environmental test program was feasible—although the problem was compounded by the nearness of the next manned flight, scheduled for the fall of '68.

A contract was awarded to Wyle Laboratories, Huntsville, Ala. Wyle's task: to conduct an environmental testing program to simulate launch conditions of the Saturn/Apollo modified "short stack," an assembly which stands 60 ft high, is 22 ft in diameter at the base, and weighs close to 22 tons. It includes the Apollo Service Module and the Spacecraft Lunar Module Adapter (North American), the Lunar Module (Grumman), the Saturn Instrument Unit (IBM), and the S-IVB (Saturn third stage) Forward Skirt (McDonnell Douglas).

At Wyle, the short stack was tested for its stamina under worst flight conditions—Max Q Alpha (that point in launch when the vehicle is subjected to the worst possible combination of static and dynamic loads), and End of Boost (that point in launch when the vehicle sees maximum acceleration and highest aerodynamic heating from air friction).

Although the program was initially estimated to take from ten to 14 months to complete, Wyle was contracted to finish testing in 20 weeks. Under further pressure from NASA and its contractors, the company accelerated the program and completed it in only 16 weeks. The result: the structural integrity of the short stack was confirmed and NASA was able to stay on its flight schedule.

As in most success stories, more than one "hero" is involved. But a major reason for Wyle's success can be discovered if you look at its project management system, and at the tools and techniques that it uses to implement this approach to managing large, complex, and critical programs.
JDT Series Dry Reed Relay

An entirely new magnetic structure makes possible an exceptionally low seated height of only 0.275 inch for high density board packaging. Circuit boards employing JDT relays may be spaced on 0.5 inch centers. This design minimizes magnetic flux dispersion, resulting in a very efficient magnetic circuit. This decreases coil power requirements and often permits direct operation of JDT relays in low-power semiconductor logic circuits. An interfacing amplifier may be eliminated in many applications.

Terminals are similar to those on IC packages, permitting spot testing on either side of a circuit board. The dual in-line terminals on 0.1 inch centers simplify circuit board design. The reed switches are rated at 10 watts maximum resistive (50V or 0.5A DC maximum) switching.

A solid state time delay circuit may be incorporated in this small package. Or a Darlington amplifier can be included to compensate for low current applications. However, the number of available poles for switching is reduced by the addition of either of these circuits.

The JDT is completely encapsulated in epoxy, giving protection against environmental contamination. The Series is presently available in many combinations of Forms of A, B and C.


SPECIFICATIONS

Power:
JOT 4000 Series: 310 mw nominal
JOT 8000 Series: 600 mw nominal

Operate Time:
4 milliseconds maximum (6 nominal voltage (6°C, including bounce

Temperature Range:
-50°C to +85°C

Expected Life:
Approximately 20 million operations (resistive)
Introducing Potter & Brumfield's unique dual thin-line dry reed relays

mounted height is only 0.275”

power requirements: only 75mw per pole

combinations of Forms A, B and C are available

Single lot prices are as low as $7.65 for 4-pole version (JDT 4000 Series) with 6 or 12-volt coils. The 8-pole relays (JDT 8000 Series) start at $12.95. Quantity discounts apply. Order sample quantities today for evaluation in your most sophisticated design.
From the very beginning, the program went on a 24-hour, seven-day-week schedule. And when testing finally began, the schedule was extremely rugged. There were many times when the team was continuously testing for periods exceeding 24 hours.

"The very critical thing was the complete cooperation of all the people involved in the testing effort," comments the program manager. "They, of course, had the motivation to get the job done, and to get it done properly, but sometimes we asked for cooperation beyond the call of duty . . . . when you phoned everybody up at one or two in the morning and said, 'We're going to test in an hour . . .' It was a function to some extent of program management and planning and trying to make life easier every way we could, and having good meetings where everybody was fully informed."

Reese established a complete open-door communications policy, as well as very rigorous criteria for briefings. Originally, he had one of his assistants conduct weekly briefings; but then as all the hardware started to come in, daily briefings were held at 8:00 a.m. Everybody was invited and the "book was opened," so that everyone involved knew exactly what had happened in the past 24 hours. If there were any communications problems, personnel conflicts, or bottlenecks, these were solved right then. No problem was permitted to drift over into the next day. If something could not get resolved, Reese himself was called into the meeting to make the decision.

This "open-door" communications policy instilled in all the participants that sense of complete involvement. Moreover, it served to continually reinforce morale and helped keep everyone on schedule.

Indeed, Reese feels that as a program manager his main job is communication (see *The Electronic Engineer*, May 1968, page 24). "Ten years ago," he comments, "I used to get my hands dirty. Five years ago I used to at least draw something. But in the last two or three years, I cannot think of one thing I've done which has resulted in anything other than communication . . . . It came as a shock to me because, if you're in instrumentation or electronics as I started out, you like to be able to turn a knob and see something happening."

The check-and-balance organization

One reason Wyle was able to short-cycle the testing program is that it has built-in management procedures. When it is awarded a contract, Wyle uses its existing procedures, which are very flexible, and adapts the program the best way it can to fit the procedures. These procedures, outlined in a series of formalized operational memorandums, describe how you set up a management program. The memorandums define the responsibilities of three key organizational groups—the program manager, the contracts administrator, and the task supervisors (who are responsible for the performance of a specific increment of work)—and outlines the interfaces among them.

According to these memorandums, once a contract is received the responsibilities of the program manager are fourfold:  

- to prepare a Program Plan for the performance of work  
- to issue work orders in accordance with the Program Plan  
- to monitor the performance of all work including the technical approach, results, expenditures, and schedules  
- to review and transmit all documentation, including progress, financial, and test reports, to the Contracts Administrator

In short, he is in charge of every aspect of the program.

In setting up his organization, the program manager follows a stylized procedure. He generally assigns three key people to work with him, the first being a project engineer. This man knows the technical aspects of the job. He is a good organizer. He is able to take all the engineering tasks and make sure that the right people are assigned to each task, that they interface properly, and that they know the objectives. The important thing is that the project engineer himself have both technical capabilities and capabilities for leading engineers.

On the other hand, he does not have to be a recognized technical expert in one specific line, and he does not have to be a genius at accounting. "We see him as a very straightforward organizer of our engineering effort," comments Mr. Reese.

The second key individual is the program administrator. Although he doesn't have to be an engineer, he has to talk engineering language and he has to understand the fundamental engineering problems. It is his job to make sure that the accounting and progress reports are accomplished, and that the contractual obligations are satisfied.

He also has to be able to spot problems. For example, let's say task number 22 is costing more money than was projected. It's the program administrator's job to call this to the attention of the task supervisor and the project engineer, so that they can focus their attention on it. The earlier such problems are discovered the easier they are to solve.

The third individual in this system of checks and balances is the purest of technical types—the perfectionist engineer. This individual (or individuals) does not care whether the program gets done on time. He does not care whether it gets done within budget. The only thing he is interested in is that the best possible job is done technically. "Of course," adds Reese, "there is nothing that can ruin a project more than to put a perfectionist in charge of it, because you'll never get the job done and you'll spend an ultimate amount of money."

The perfectionist is expected to look over the shoulder of the working level engineer. When he is given a job, this working level engineer is also made very aware of the fact that it has to be done on schedule and within the budget—and thus he sometimes is forced into compromises. In the event that his compromises lean too heavily towards schedule or budget limitations, the perfectionist is there to uphold the technical aspect of the task.

Conflict or balance?

With the three assigned individuals—project engineer, program administrator, and perfectionist—you
"Ten years ago I used to get my hands dirty... But in the last two or three years, I can't think of a thing I've done which has resulted in anything other than communication."

get a balance between schedule, budget limitations, and technical competence. But inevitably a conflict will result. When it does, the program manager takes charge and makes sure that a decision is made. But the important thing is that if these individuals are competent, the conflict comes up early enough so that you can satisfy the technical requirements and still get the budget and schedule control that you need.

Planning and operating procedures

As stated previously, Wyle has its program procedures mapped out in what it calls "Operational Memorandums," and simply adapts the individual programs to fit the procedures. One of the program manager's first tasks is to develop a Program Plan, which divides the total program into a series of logical, identifiable tasks, and assigns budgets, schedules, and controls on the performance of the tasks. This includes determining the equipment, facility, and manpower requirements as well as establishing the requirements for technical, financial and progress reports.

For operating the program there is a system of time cards and charge numbers. These charge numbers are assigned to correspond with a logical breakdown of project tasks, or work breakdowns, which is part of the initial planning. Each person that works on the program uses the proper task number for the job he's working on, and the information is stuffed into the accounting system. The program manager can then get computer dumps daily or weekly—in almost any format he desires.

The computer (the CDC3300) is also "trained" to take this information and give x/y plots, which show projected expenditures versus actual. "In many cases," says Dave Reese, "the raw accounting numbers leave much to be desired, because most engineers are more apt to see a problem if the data is in the form of a plot."

Reports and more reports

Several other types of reports are required. PERT charts, however, are not one of them, although Wyle can handle PERT if the customer requests it. As Reese points out, "PERT is useful to a large company that is dealing with a program that has tremendously variable elements. If you're working with 20 different subcontractors, guidance equipment, ground support equipment, and so forth, PERT makes sense. But in most test programs it's not necessary."

For organizing and running the short stack program, Reese used Milestone Charts, an elaborate system of bars and symbols, arranged to give him total program visibility. These Milestone Charts have two main functions:

- to chronologically identify the tasks to be performed and emphasize critical events which may constrain completion of the program or another event
- to provide a means for clearly identifying work progress during the period of performance and to identify problem areas which may need special attention
INTRODUCING

THE DIP REED RELAY

AN IC COMPATIBLE REED RELAY
IN A DUAL INLINE PACKAGE

The DIP RELAY can be driven directly from your IC.
• draws 10 milliamps from 5 volt logic
• switches up to 10 watts, .5 amp. max., 100 VDC max.
• fits directly into a standard 14 pin DIP receptacle
• switches in less than 500 µ seconds
• tested to 500 million operations
• available with 1 form A contact and 5, 6, 12 and 24 VDC coils

This totally encapsulated relay meets military environmental specifications with a temperature range from –55°C to +85°C.

Automated testing and production with 100% inspection from the individual contacts through the completed relay assures quality performance at low cost.

ELEC-TROL FILLS THE GAP...

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INFORMATION RETRIEVAL

Careers, Project management

40

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MILITARY GRADE T-POTS

600 Series: Mil. Equiv. RT-10; 10Ω to 100KΩ, ±5%; 1 watt at 70°C, derated to 0 at 175°C, .18 H x .32 W x 1.00 L.

1200 Series: Mil. Equiv. RT-11; 10Ω to 100KΩ, ±5%; 1 watt at 70°C, derated to 0 at 175°C, .28 H x .31 W x 1.25 L.

1600 Series: Mil. Equiv. RT-12; 10Ω to 100KΩ, ±5%; 1 watt at 70°C, derated to 0 at 175°C, .19 H x .32 W x 1.25 L.

5000 Series: Mil. Equiv. RT-22; 10Ω to 50KΩ, ±5%; 1 watt at 70°C, derated to 0 at 175°C, .15 or .22 H x .50 W x .50 L.

5800 Series: Mil. Equiv. RT-24; 10Ω to 50KΩ, ±5%; 1 watt at 70°C, derated to 0 at 175°C, .145 or .150 H x .375 W x .375 L.

COMMERCIAL GRADE ECONO-TRIM T-POTS

WIREWOUND ELEMENT

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

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

FILM ELEMENT

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

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

INDUSTRIAL GRADE T-POTS

WIREWOUND ELEMENT

100, 200, 300 Series: 10Ω to 100KΩ.

100 Series: ±5%; 0.8 watt at 70°C, derated to 0 at 135°C.

200 Series: ±10%; 0.5 watt at 70°C, derated to 0 at 105°C.

300 Series: ±15%; 0.25 watt at 70°C, derated to 0 at 85°C.

Dimensions: .22 H x .31 W x 1.25 L (also 1.32 L for 100, 200).

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

2100 Series: Industrial counterpart RT-11; 10Ω to 100KΩ, ±10%; 1 watt at 70°C, derated to 0 at 125°C, .26 H x .31 W x 1.25 L.

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

FILM ELEMENT

8100 Series: Industrial counterpart RJ-11; 10Ω to 2 Meg., ±10%; 10Ω to 500KΩ, ±20%; all other values; 75 watt at 70°C, derated to 0 at 125°C, .26 H x .31 W x 1.25 L.

Call 402-564-3131 for complete information or write for Catalog B

DALE ELECTRONICS, INC., 1304 28th Ave., Columbus, Nebraska 68601
In Canada, Dale Electronics Canada, Ltd. • A subsidiary of The Lionel Corporation
It is said that Leonardo Da Vinci had a special little bump on his head—a "sixth brain lobe" which permitted him to make extraordinary logical leaps into future technological ages. Thus he invented such things as a machine to wind bobbin thread evenly, centuries before the sewing machine was invented. And versions of airplanes, helicopters, the parachute, etc.

Engineers at Motorola must have an accurate idea of how Leonardo felt, because they have the "sixth lobe," too. Working with electronic computers, they can span the gulf that often separate men from tomorrow. And the product of this remarkable synergism is the product of Motorola: Thinking and working beyond the present to prepare for the future.

It takes good men with good brains—often two each—to do what has to be done. It will be done at Motorola.

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- Space Communications
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- Digital Multiplex
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- Readout
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- Project Test

Write: Paul Ahler, Recruitment Manager, Dept. 69, Box 1417, Scottsdale, Arizona 85252
An Equal Opportunity Employer M/F

Nico H. Roos
Chief application engineer
Motorola Instrumentation and Control, known in the industry as an applications-conscious firm, has appointed Nico H. Roos as a chief application engineer for process systems.

In his new post, Roos will concentrate on applications research for the newly-developed Veritrak® performance optimizing controller, a device that contains many of the capabilities of a computer control system. He will also be involved with the entire line of Veritrak process control instrumentation.

Prior to this responsibility, Mr. Roos was a senior systems engineer in digital computer products at the Foxboro Co., where he worked on control systems. At Motorola he will put increased emphasis on digital methods for process control instruments.

His background—a mix of process control, analytical concepts, solid-state equipment, and logic systems—should enable him to accelerate application projects where the performance optimizing controller and Motorola's new MDP-1000 data processor will be major elements.

Nico Roos feels that a prime function of any applications engineer is trying to determine what the customer really needs, as opposed to what he says he needs. "My background in science and math has helped me tremendously in being able to solve this dilemma," he says. "It's necessary to read between the lines, solve the problem, and communicate the solution to the user. There are pitfalls," he adds. "But with the proper approach, communication with the customer does not become insurmountable."

Mr. Roos holds an honors degree in physics from Michigan State and has done graduate work in physics and math at Massachusetts Institute of Technology.

The Electronic Engineer • June 1969
Here we welcome new companies or divisions in the electronics industry. For more details, circle the appropriate numbers on the reader service card.

Communications: From black box to systems. Nardcom Corp., a new subsidiary of Narda Microwave Corp., is entering the microwave communications subsystems and satellite ground station field, and will be introducing three products this year.

The first is a unique up and down frequency conversion system whose special feature is its dual-conversion design. The up converter (Model UC-5000) can be used to convert any message or video carrier at the 70-MHz intermediate frequency to an rf carrier in the 5925- to 6425-MHz range. The down converter (Model DC-5000) can convert any rf message or video carrier in the 3700- to 4200-MHz range to an intermediate frequency of 70 MHz without signal returning. Both converters are now available.

The firm's second product, to be available around September, is a threshold extension demodulator for use in communications systems where a very sensitive receiver is needed. The third product line—high-power amplifiers (3-kW output klystron amplifiers)—will be introduced by year's end.

Although Nardcom is now only building the boxes, it eventually plans to integrate them into one system. And "on a long term basis," says Fred Kornberg, the vice-president and general manager, "we are interested in producing microwave data transmission terminals." Located in Plainview, N.Y., Nardcom is not an internal Narda development, but rather was formed separately and staffed by outside engineers.

Circle 399 on Inquiry Card
A partner for Sprague. Pirgo Electronics, Inc., located in Farmingdale, N.Y., is a corporation in its own right and a partner of Sprague as well. When Sprague consulted with New Business Resources, a company formed last year by Richard Hanschen and Dr. Richard Petritz (formerly of Texas Instruments), the result was the union of the two firms to form Pirgo.

As a manufacturer of power semiconductors, including transistors and thyristors, Pirgo hopes to attract computer, power supply, and industrial control houses, as well as the military.

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Do you measure up?

If you are an Electronic and/or Simulation Specialist, you're invited to "measure" your talents against our needs...

Aerodynamics • Circuit design
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Electronic components
of proven reliability

Aluminum Electrolytic Capacitors

The rugged CAPACITORS by West-Cap that have built-in reliability and durability. Because of their all-welded construction they will withstand more vibration and shock. The elements are made from 99.99% pure etched aluminum foil sealed in high grade aluminum cases.

SERIES WHC Computer Grade Electrolytic.

A superior line of energy storage and filter electrolytics which meet all the specifications set by MIL-C-62. In addition, this series will meet all the standard telephone quality standards set by the telephone industry. This electrolytic will meet the most exacting ripple standards.

Ratings: 200 mfd to 100,000 mfd from 5 VDC to 150 VDC
Voltages in excess of 150 VDC to 500 VDC on special order

SERIES MAC Axial Lead Electrolytic.

They are available in miniature size with 1⁄4" x 1⁄8" case and larger.

Ratings: 2 mfd to 70,000 mfd from 3 VDC to 150 VDC

The manufacturing process is completely quality-controlled in West-Cap’s modern new facility in the Tucson International Airport Industrial Park. This facility was designed and equipped primarily for the manufacture of high quality electrolytic capacitors at competitive prices.

Call your representative of West-Cap high reliability components, or contact West-Cap Arizona, where service and quality count.

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Circle 26 on Inquiry Card

PRODUCT SEMINARS

This new column lists product seminars that electronic companies offer to users of their products. For more details, circle the appropriate reader service number on the inquiry card.

21-110 Mass Spectrometer: June 16-20, Monrovia, Calif., $225. Intended for those responsible for operation and maintenance of a CEC Type 21-110B or 21-110C gas ion source mass spectrometer. Coordinator of Training and Technical Publications, Bell & Howell, 1500 S. Shamrock Ave., Monrovia, Calif. 91106.

Circle 401 on Inquiry Card


Circle 402 on Inquiry Card


Circle 403 on Inquiry Card

RGA Spectra Interpretation: Aug. 18-20, Monrovia, Calif., $150. Emphasis is on the spectra of materials found in vacuum systems; for users of residual gas analyzers. Coordinator of Training and Technical Publications, Bell & Howell, 1500 S. Shamrock Ave., Monrovia, Calif. 91106.

Circle 404 on Inquiry Card


Circle 405 on Inquiry Card


Circle 406 on Inquiry Card

Circle 27 on Inquiry Card
Get sine, square and triangle functions—and positive and negative going pulses, positive and negative going ramps—in the new HP 3310A. And there's more! You'll have these seven functions over a decade of decades—0.0005 Hz to 5 MHz.

All this capability is packed into a package only 7½" wide, 4½" high, 8" deep! With the 3310A Function Generator performing many of the functions of the pulse generator, ramp generator, bias box and amplifier on your bench—think about the clutter you eliminate...the instant access you'll have to all these signals.

With the dc offset capability of the 3310A, you can put any of the functions where you want them—easily and without biasing. And, with the choice of high or low level output, you can get clean low level signals without an external attenuator. You get a maximum of 15 V peak-to-peak into 50 Ω—and that's plenty of power to eliminate most needs for external amplification.

Add to this the external frequency control capability which allows you to sweep over a 50 to 1 range or tie the 3310A into a system—the price of only $575—solid-state reliability—and you know the HP 3310A is more than a function generator!

Order your HP 3310A today from your nearest HP Sales Office. For full specifications, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

**This One Is More Than A Function Generator!**
LEVERWHEEL SWITCH a brand new concept...

Since when does Cherry make rotary thumbwheel switches? Since we figured out how to make them better. Which is right now with the new Cherry "Leverwheel" Thumbwheel Lever-Action switches that set in half the time of conventional thumbwheels.

THE SLOW PLUNK VS. THE FAST SET
A single movement of the Leverwheel lever through its 60° arc is all that’s necessary for a complete 10-position cycle. (Compare that to plunking through the 360° rotation on conventional thumbwheels!)

EVERYTHING’S COMING UP ZERO
There’s instant reset at no extra cost. A simple sweep with the hand and all levers return to home position with every switch in the bank returned to “zero”.

From the makers of famous, dependable precision Snap-Action Switches...
so new you can’t look it up in your Funk & Wagnalls

...Thumbwheel Lever-Action by CHERRY...

SEND TODAY for a free copy of the new eight-page brochure describing the complete line of Cherry Leverwheel and Thumbwheel Switches. For immediate action phone: 312/831-5024

CHERRY ELECTRICAL PRODUCTS CORP. 1655 Old Deerfield Road, Highland Park, Illinois 60035

Circle 28 on Inquiry Card
### DTL DIGITAL LOGIC CHART

<table>
<thead>
<tr>
<th>Manufacturer/Type</th>
<th>Acronym</th>
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<tbody>
<tr>
<td>Amperex FCI</td>
<td>FCI</td>
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<tr>
<td>Philco-Ford</td>
<td>MEL</td>
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<tr>
<td>Motorola MRTL</td>
<td>MRTL</td>
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<tr>
<td>Texas Instruments</td>
<td>ITL</td>
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<td>Stromberg</td>
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### TTL DIGITAL LOGIC CHART

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<td>54L</td>
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<tr>
<td>Texas Instruments</td>
<td>54L/74L</td>
</tr>
<tr>
<td>Philco-Ford</td>
<td>211</td>
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<tr>
<td>Motorola MRTL</td>
<td>MC808</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>54H/74H</td>
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<td>Stromberg</td>
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### ECL DIGITAL LOGIC CHART

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<td>Motorola MECL</td>
<td>MECL</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>54H/74H</td>
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</tbody>
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### Special Logic

- **CCSL** Compatible Current-Sinking Logic
- **CML** Counting Logic
- **CML** Complementary Transistor Logic
- **DCTL** Direct-Coupled Transistor Logic
- **DTL** Diode-Transistor Logic
- **DTL** Diode-Transistor Logic
- **ECCSL** (EC1/S1) Emitter-Coupled Logic
- **ECL** Emitter-Coupled Logic
- **EEL** Emitter-Coupled Logic
- **HLT** High-Level Transistor-Transistor Logic
- **HNL** High Noise Immunity Logic
- **LDPL** Low-Power Diode-Transistor Logic
- **LPCFL** Low-Power Complementary Logic
- **LPCFL** Low-Power Complementary Logic
- **MCM** Micro Energy Logic
- **MDTL** Motorola Diode-Transistor Logic
- **MCML** Motorola Emitter-Coupled Logic
- **MEL** Micro Energy Logic
- **MHTL** Motorola High-Threshold Logic
- **MTRL** Motorola Transistor-Transistor Logic
- **MTML** Motorola Transistor-Transistor Logic
- **MVTL** Motorola Variable-Threshold Logic
- **MW** Milliwatt Logic
- **MVW** Milliwatt Logic
- **OMIC** Optimized Micrcircuits
- **RCTL** Resistor-Capacitor-Transistor Logic
- **RTL** Resistor-Transistor Logic
- **RTL** Resistor-Transistor Micrologic
- **SUHL** Sylvania Universal High-Level Logic
- **TTL** Transistor-Transistor Logic
- **VHL** Variable-Threshold Logic
- **Ulogic** Utility Logic

The following list represents the individual ICs shown on the chart. The number next to the manufacturer corresponds to the number of a circuit configuration shown on the chart. Also shown below is a list of circuit type names and their acronyms, including most of the better known types.

**Speed/power chart for digital ICs**

Compiled by the staff of *The Electronic Engineer*

The specifying chart on the facing page is a new edition for the past two years. It allows you to make a ballpark selection of those digital integrated circuits that are best suited to your application.

The chart shows typical propagation delay in nanoseconds plotted against average power dissipation (usually for a 50% duty cycle) in milliwatts per gate. Over 100 catalogued commercial ICs are listed, including all generic forms as well as some specials. These circuits are all silicon monolithics—most hybrid devices have been excluded—and represent about 70 different circuit configurations.

Each circuit configuration is indicated on the chart by a color dot. The larger dots indicate those popular circuits, made by several manufacturers, that have the same or nearly the same speed/power parameters.

If you compare the 1969 chart to that of 1968 or 1967, you can note some interesting changes in the digital IC market. The DTL circuits, previously the most common type made, have lost their popularity rating to the faster TTL circuits. And while RTL has made no advances, ECL is definitely finding wider use. Of all circuit configurations shown, those made by most manufacturers are the TTL 54/74 variety (12 sources), and the DTL 930 (nine sources).

The following list represents the individual ICs shown on the chart. The number next to the manufacturer corresponds to the number of a circuit configuration shown on the chart. Also shown below is a list of circuit type names and their acronyms, including most of the better known types.
A view through the window of the "white room" where MB pressure cells are assembled.

**Cost/Pressure/Accuracy**

**Optimum combination achieved through precision manufacture in Series 500 pressure cells**

Low cost Series 500 pressure cells are an outgrowth of many years of work in developing production facilities for the manufacture of highly specialized transducers intended for applications requiring extreme accuracy, or severe environments, as in cryogenics.

These 5-volt output cells were designed to take advantage of Alinco foil strain gages bonded directly to the sensing element in a four-active arm Wheatstone Bridge. The inherent ruggedness of the design makes it possible to withstand very high over-pressures—up to 400%—without mechanical damage.

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The Electronic Engineer • June 1969
Analysis and Synthesis of Linear Active Networks

This book provides a comprehensive introduction to the important branch of network theory indicated by the title. It satisfies a twofold purpose: to provide a text for a first year graduate level course in active networks, and, to provide the practicing engineer with a reference book or a text for self instruction.

To fully appreciate this book, the reader should have a knowledge of complex variables and matrix algebra. As well, he should be familiar with passive one-port and two-port network analysis and synthesis.

To increase the usefulness of the book, extensive lists of references are supplied at the end of each chapter. Mathematical rigor has been kept to a minimum, while examples are given extensively. A complete set of problems augments the text, but unfortunately no solutions are included.

Control Engineering

Here is a book for both the practicing engineer or one who is new to the field of control systems. This volume is both practical and comprehensive, and includes the latest information on techniques used in day-to-day control systems installation.

Since this is not a mathematically sophisticated text, it is particularly suited for those who are primarily concerned with installation of equipment. Its academic level is equivalent to the final year of a technicians course. Basic material on feedback amplifier theory and closed-loop systems are presented, but the major emphasis is on modern applications and physical operation. Thermionic, gas-, and vapor-filled tubes and semiconductor devices are treated throughout.

Principles of Linear Circuits

Analysis and Simulation of Multiport Systems
By Dean Karnopp and Ronald C. Rosenberg. Published 1968 by The MIT Press, 50 Amers St., Cambridge, Mass. 02142. Price $10.00. 221 pages.

CATV System Engineering, Second Edition

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MICROWORLD

IC Op Amp Selection Charts

Whether monolithic or hybrid, you’ll find all commercial op amps here, classified by five important parameters.

Compiled by the staff of The Electronic Engineer

On the next five pages you’ll find a new set of charts that graphically illustrate the relation between price and the five most important parameters used in specifying op amps. The five charts are:

1. Differential voltage amplification vs Price
2. Input bias current vs Price
3. Bandwidth (at rated load) vs Price
4. Slew rate vs Price
5. Input offset voltage temp. sensitivity vs Price

In all, 227 different devices are represented with a complete listing, shown on the following page, which is divided into two categories—hybrid and monolithic. Each device listed has a number next to it, and is represented by this device number on all five graphs. This listing also shows the price per unit to simplify the job of finding a particular device on the charts.

To help you better understand these charts, a set of definitions of the five op amp parameters is listed below. These agree with the op amp parameter definitions being drawn up by the EIA Industry Committee MED-20 under the chairmanship of Richard Lindner of Bell Labs.

Since these charts are a first for us as well as for you, we look forward to hearing your reactions and suggestions.

Op amp parameter definitions

The op amp parameters used on the charts and their definitions given below are the most recent available. A few of these parameters are known by simpler (if less accurate) names, which will be indicated for those of you who still call kilohertz by kilocycles.

Differential voltage amplification ($A_{VD}$ or $A_{ii}$), previously called open-loop gain.

The ratio of the change in output voltage to change in differential input voltage (or current) in the linear range. For amplifiers with only one output terminal, it is the ratio of the change in output voltage with respect to ground to the change in differential input voltage.

Input bias current ($I_{Ib}$)

One-half the sum of the separate bias currents entering into the two-input terminals of a balanced amplifier, or, the bias current entering the input terminal of a single-ended amplifier.

Bandwidth (small signal) (BW)

The range of frequencies within which the small-signal voltage (or current) amplification of the amplifier is more than $1/\sqrt{2}$ the value of the midband amplification.

This parameter was sometimes called the 3 dB bandwidth to differentiate it from the 0 dB or unity-gain bandwidth. Despite the newly accepted definitions, our chart shows the unity-gain bandwidth (or frequency) of the open-loop amplifier when operating into its rated load. All this causes a lot of confusion which we are the first to admit. However, we feel that the information presented is still valuable within the constraints imposed by the definitions.

Slew rate (SR)

The time rate of change of the closed-loop amplifier output voltage for a maximum-step signal input (a maximum-step signal input is the largest input voltage step for which the amplifier performance remains linear).

Since the value of closed-loop amplification is not specified in the definition, we have taken the value of slew rate at unity amplification.

Input offset voltage temperature sensitivity (no symbol specified at this time)

The ratio of the change in input offset voltage ($V_{10}$) to the change of circuit temperature for a constant output voltage.

Temperature sensitivity = $\frac{\Delta V_{10}}{\Delta T}$ for constant $V_{out}$

The use of the terms drift or coefficient have been replaced by the term sensitivity.

For a copy of this article circle #420 on Inquiry Card.
Differential Voltage Amplification vs Price

- Hybrid
- Monolithic
- Hybrid & Monolithic

Hybrid: 1-97
Monolithic: 101-230

Price per unit (quantities of 100)
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Input Bias Current vs Price

Hybrid
Hybrid & Monolithic

Hybrid: 1-97
Monolithic: 101-230

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Bandwidth (unity gain at rated load) vs Price

- Hybrid
- Monolithic
- Hybrid & Monolithic

Hybrid: 1-97
Monolithic: 101-230

Price per unit (quantities of 100)
Miniature, subminiature connectors, yes.

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Slew Rate vs Price

Price per unit (quantities of 100)

Hybrid
Monolithic
Hybrid & Monolithic

Hybrid: 1-97
Monolithic: 101-230

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Digital data: play it like it is

Distortion and noise in tape-playback amplifiers often give you false data. An improved peak detector for NRZI amps rejects both low- and high-level noise, and responds only to the true peak of the playback signal.

By Frank C. Marino, Sr. Dev. Engr.
Digitronics Corp., Albertson, N. Y.

In high density NRZI (nonreturn-to-zero inverted) data recording systems, playback signal amplitude variations of 20 to 30 dB are not uncommon. Thus, the peak detector in the playback amplifier of such systems must respond to full-wave rectified signals that range from a few tenths to several volts peak amplitude.

The sensitivity of such a detector poses two problems. One is that at low levels, you must prevent noise signals from reaching the detector. You usually do this by mixing a dc voltage with the rectified input, so that only signals exceeding this threshold-voltage level reach the peak detector.

The second problem is that of high-level noise signals, which the detector must also reject. Most peak detectors consist of a differentiator followed by a nonlinear amplifier. Now, a differentiator is a high-pass network. So unwanted high-frequency noise that exceeds the dc voltage level mixed with the rectified input signal will be passed along by the peak detector.

To prevent this, first remember that most unwanted high-frequency noise—which may be larger in amplitude than wanted low-level signals—is narrower in width than the desired signals. This fact tells you that if you place a pulse-width discriminator after the peak-detector stage, you can get high-level noise rejection.

The pulse-width discriminator usually takes the form of an integrator at the input of a shaper amplifier such as a Schmitt-trigger.

Signal distortions

A peak detector made of a differentiator followed by an amplifier is, basically, a zero-slope detector. Such a detector will work properly only for good NRZI playback signals as shown in Fig. 1a, where the signal peaks, P, are the only points at which \(\frac{dv}{dt}=0\). The detector will have difficulty with the distorted waveforms of Fig. 1b. Here, a distorted signal shows additional points of zero-slope, or near zero-slope, at points A of the waveform.

At unconventional tape speeds (under 3 ips), mechanical vibrations caused by vacuum motors, rotating pulleys, idlers, and so forth, become significant. They move along the tape to the playback head and help produce the distortions shown in the figure. Such
Digital data and magnetic tape

There are several formats for recording digital data on magnetic tape. And a feature common to all such recording modes is that the recording head produces sufficient flux to saturate the tape's magnetic oxide. The direction of magnetization depends upon the direction of the write current, and the length (on the tape) of a particular magnetized section is a function of the tape speed and the write-current time.

Because the tape's oxide is saturated, the playback head gives you an output only at those times that the tape magnetization changes direction.

The various recording modes use the playback head's output pulses to represent the one's and zeroes of digital data. Some common recording formats are shown.

The nonreturn-to-zero inverted (NRZI) mode is one of the most common formats. It has a high packing density (you can put lots of data in a small length of tape); it is the least demanding format with respect to the frequency response of the tape and transport mechanism; and accidental polarity reversals do not affect the accuracy of the data (because the flux direction is of no significance: a 1 is represented by a transition in either direction).

To recover the recorded data, you must linearly amplify the playback signal, full-wave rectify it (because in the NRZI mode, binary ones are bipolar), and peak-detect it. Peak detection is desirable because the peak of the playback signal is least affected by pulse crowding and dropout on the tape.

Obviously, proper operation of the peak detector is important to the accuracy of the recovered data. One vital aspect of detector performance is its ability to generate an output that corresponds in time to the true peak of the rectified playback signal. Another is the detector's ability to accurately peak-detect signals in the presence of noise and large input-amplitude variations.

If you satisfy these criteria, you'll have a good detection system. This article describes one way of doing it.

Distortions are also common with relatively inexpensive IBM-compatible read/write heads, where write-to-read and read-to-read crosstalk levels are greater than 3%.

The effects of crosstalk are especially noticeable at the base of the waveforms, where signal-to-noise ratios are low. But because it is desirable to use dc threshold voltage levels much less than 15% during playback (to recover extreme dropout signals), the peak detector must tolerate the type of waveform distortion shown in Fig. 1b.

A close look at these waveforms shows you that the peak-points, P, are distinguished from the distortion points, A, by the first derivative of the waveforms. The derivative changes polarity only at the points P, the desired peaks of the waveform. An improved peak detector, therefore, is one which is responsive only to a change in the polarity of the first derivative of the playback signal. Such a peak detector consists of a differentiator, followed by a bistable amplifier.
An op amp to the rescue

Figure 2b shows you how a conventional peak detector fails when presented with a distorted waveform. Another type of failure, not shown, is that of an oscillatory or unstable amplifier output that occurs at the point of distortion which approaches zero-slope. This happens because the resulting input-voltage to the amplifier, $RCdv/dt$, may be in the region of uncertainty common to all amplifiers because of their inherent lack of hysteresis.

The combination of any bistable amplifier preceded by an ordinary $RC$ differentiator gives you improved peak-detection. That is, the circuit will respond only to a change in the polarity of the first derivative of the input waveform. But the improved detector of Fig. 3 goes one step further. Its bistable amplifier is a Fairchild µA702C op amp arranged in the form of a comparator with pre-determined hysteresis.

In Fig. 3a, the total differentiator resistance $R$ includes the non-linear resistance of the two diodes. These diodes protect the comparator from the excessive input voltages of signals with large peak amplitudes (say, 5 V), and with sharp rising and decaying slopes. Conversely, for very weak input signals (100 mV) most of the differentiated voltage appears across the now relatively-large diode resistances. Consequently, the peak detector operates accurately with input signal variations greater than 30 dB.

Some analysis

If you assume the rectified input signal approximates a sine wave, you can write this first-order differential equation for the differentiator:

$$RC \frac{dv}{dt} + V = E \sin \omega t$$  \hspace{1cm} (1)

The general solution for the voltage $V$ developed across the capacitor is:

$$V = \epsilon \int \frac{dt}{RC} \left[ \frac{E}{RC} \int \epsilon \frac{dt}{RC} \sin \omega t \, dt + K \right]$$  \hspace{1cm} (2)

From which,

$$V = \epsilon \frac{E}{RC} \left[ \frac{\sin \omega t - \omega RC \cos \omega t}{(\omega RC)^2 + 1} \right] + K$$  \hspace{1cm} (3)

Since $V = 0$ at $t = 0$, $K = \frac{\omega RC E}{(\omega RC)^2 + 1}$

and the particular solution of eq. (1) is:

$$V = \frac{E}{(\omega RC)^2 + 1} \left[ \sin \omega t + \frac{\omega RC (\epsilon - \frac{\epsilon}{RC} - \cos \omega t)}{(\omega RC)^2 + 1} \right]$$  \hspace{1cm} (4)
Since \( \frac{Cdv}{dt} = \frac{e_i}{R_d} \), you can rewrite eq. 1 as

\[
V = E \sin \omega t - \frac{e_i}{R_d} R,
\]

where \( R = R_s + R_d \). (5)

Now combine eqs. (4) and (5):

\[
\frac{e_i}{R_d} = \frac{\omega CE}{(\omega RC)^2 + 1} \left[ \omega RC \sin \omega t + \cos \omega t - \frac{1}{R} \right].
\]

You must solve equation (6) graphically for values of capacitance as a function of the fundamental frequency of the input signal. In the final analysis, you must apply a single value of the ratio \( \frac{e_i}{R_d} \) to the graphical results, to find the optimum values of capacitance for given values of the fundamental frequency.

If you differentiate eq. (5) with respect to time, assuming \( \frac{e_i}{R_d} \) is constant at a specific point on the input waveform, you can evaluate the resulting equation at that point:

\[
\frac{\partial V}{\partial t} \frac{e_i R}{R_d} = \omega E \cos \omega t.
\]

Then,

\[
\frac{\partial V}{\partial t} C = \frac{e_i}{R_d} = \omega CE \cos \omega t
\]

from which \( C = \frac{e_i}{\omega R_d E \cos \omega t} \). (9)

The forward diode-resistance, \( R_d \), is a non-linear function of the voltage, \( e_i \) developed across it. To ensure that a minimum input-signal peak amplitude of \( E = 100 \) mV will exceed the hysteresis level of 30 mV needed to switch the bistable amplifier, choose \( e_i = 50 \) mV. The germanium diodes used in the circuit have an \( R_d \) of 50 kΩ at this signal level.

A practical point at which to use these results is at \( \frac{1}{4} \) cycle. Thus, \( \omega t = \pi / 4 \) and \( \cos \omega t = 0.707. \) Putting

Fig. 4. The complete NRZI amplifier. It features the improved peak detector, with low- and high-level noise rejection. Fairchild µA702C op amps are used throughout, and the output signal will drive DTL logic circuits.

Fig. 5. High-level noise rejection in the improved peak detector. An op amp arranged as a comparator has predetermined hysteresis levels. Note that even though the unwanted noise signal is initially peak detected, the Schmitt trigger does not allow an output to occur.
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these values into eq. (9), you can approximate the capacitance as a function of frequency:

$$C_{Pf} = \frac{2250}{f_{Full}}$$

For example, at 800 bpi and a tape speed of 40 ips, $$f = \frac{(1/2)(800)(40)}{16} = 16 \text{ kHz},$$ and $$C = \frac{2250}{16} = 140 \text{ pF}.$$ At 556 bpi and the same tape speed, $$C = 203 \text{ pF}.$$ Because it is impractical to change the value of this capacitor to compensate for a change between these two popular packing densities (556 and 800 bpi), you can choose 180 pF as a compromise value for the tape speed. You should pick a value for $$R_s$$ that is relatively small compared to $$R_z$$ for weak input signals, but large enough to avoid dynamic overloading of the driving stage during nominal strength input signals.

A complete amplifier

Figure 4 shows a playback amplifier for tape speeds from 10 to 40 ips and packing densities of 556 and 800 bpi. At 40 ips, the best value of the peak detector's differentiator capacitor is 180 pF. At 10 ips, you should increase its value by the factor of 40/10, to about 750 pF.

The first-stage linear amplifier has a balanced input for common-mode rejection, and a closed-loop gain of 40 dB. The second-stage linear amplifier gives you the needed phase-splitting function, and an additional gain of about 20 dB. A full-wave, balanced bridge rectifies the playback signals. The overall frequency response of the linear portions of the amplifier is flat to about 33 kHz, and rolls-off at 12 dB/oct. from this point. Note that the dc voltage that sets the low-level noise is added at the bridge, through $$D_3.$$

Following the improved peak-detector circuit are the integrator and Schmitt-trigger stages. These two circuits comprise a pulse-width discriminator for high-level noise rejection. Figure 5 shows how it works. The Schmitt-trigger is, again, an op amp arranged as a comparator with pre-determined hysteresis threshold levels.

You can apply the general amplifier configuration of Fig. 4 to high-density NRZI tape systems with tape speeds from one to more than 100 ips. But at speeds below 10 ips, you must add linear gain. At speeds above 40 ips, you must appropriately extend the upper-corner frequencies by lowering the capacitor values of the various lag networks. And you must also modify the RC time constant in the integrator, as a function of the tape speed.

During read-only operations, you can safely use low-level noise-threshold voltages as low as 3%. This is due mainly to the improved peak detector circuit. And the added use of pulse-width discrimination following the detector eliminates high-frequency noise that exceeds this low threshold-level. Further, the improved detector lets this amplifier perform reliably with less expensive IBM-compatible read/write heads, because it can tolerate increased levels of write-to-read and read-to-read crosstalk.
Introducing new GAF Industrial “A” Polyrapid™ X-Ray film on a tough polyester base. It’s especially designed for short-cycle processing.

Now you don't have to trade time for image quality. In fact, you can get better contrast and definition in your radiographs than you’re getting now... in half the time.

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What is more, our film has significant processing advantages over the other films in fixing, washing and drying, whether processed manually or in conventional automatic processing systems. These advances were maintained over processing times varying from 5 to 13 minutes.

Suggestions: If you’ve been thinking about buying a second processor to beat the “waiting game,” why not call in a GAF representative. He’ll be glad to assist you to step up your present processor to double time or any time you choose and demonstrate the fast processing speed and superior radiographic properties of Industrial “A” Polyrapid film. If you’re not satisfied, he’ll set your processor back for you. Just fill in the coupon.

Circle 37 on Inquiry Card
Torture tests improve equipment reliability

You can vibrate it, accelerate it, shock it, heat it, and chill it yourself, or you can send it out to be done, but the result will be the same—an improved product.

By Smedley B. Ruth, Associate Editor

The current testing philosophy is to simulate, as closely as possible, the environment which the equipment will see in actual use, or in transit. To perform this simulation you will need environmental test equipment. Since ordering and using this equipment is not always as easy as it may seem, particularly if you are new to the game, let's discuss some general guidelines you can follow when purchasing and using environmental test equipment:

- Study your needs before you call the manufacturer. At least know the characteristics of the equipment you will be testing.
- Plan several years ahead if possible. Don't purchase equipment that will meet today's need and then have to upgrade it to meet tomorrow's need.
- Know the vendor. Make certain he is reputable. Visit his plant if possible.
- Don't overspecify. Don't ask for a lot of extras that you will seldom, if ever use. If you specify too much you may be tying the manufacturer's hand and raising the price unnecessarily.
- Make certain that you have a knowledgeable operator. Poorly run tests give poor results.
- Be sure that your test apparatus is accurate—have it checked periodically.
- Compare the costs of buying and testing with your own equipment or sending the items out to a commercial test lab. A general rule of thumb is that if you can amortize the cost of the equipment over 2-4 years you should buy. (But keep in mind the other considerations such as maintenance costs, convenience and so forth.)

Now, let's discuss the various types of tests and the equipment needed to perform them.

Vibration

Technically, the vehicle that does the vibration is called a vibration exciter, but it's generally referred to as a vibrator, head, shaker, or just plain exciter, and these terms are interchangeable.

The four main types of shakers are classified according to the source of vibration producing energy—electromechanical, electrohydraulic, mechanical, and pneumatic. Which type you select depends upon its intended use.

Electrohydraulic and electrodynamic (electromechanical) exciters are the ones most commonly used to test electronic equipment. However, electrodynamic types tend to be used for vibration tests while electrohydraulic shakers tend to be used for fatigue tests—although both can be performed on either shaker.

The electrohydraulic exciter is basically a simple hydraulic cylinder where the crucial element is a servo valve, which regulates the flow of pressurized fluid. The electrodynamic system consists of basically three components: an oscillator, which acts as a signal source, an amplifier, and an exciter. A wide range of input signals (sinusoidal, complex, random, and tape recording) can be converted to mechanical vibration.

When do you use an electrodynamic and when an electrohydraulic shaker? For testing lightweight components at high frequencies, the electrodynamic type is best. For testing heavy components at low frequencies, on the other hand, you are probably going to want the electrohydraulic type. You will seldom see anything less.
than a 100-lb payload on an electrohydraulic shaker because of the economics involved.

Where the breakpoint is depends on frequency, force levels, and so forth. Electrodynamic types have hf capability that electrohydraulic types don't have, and electrohydraulic types have a long stroke capability (probably 80% have 5-10 in. of stroke) that the electrodynamic (great majority are for only 1 in. of stroke) don't have. Fortunately, the requirements tend to go together. That is, in general, with heavy payloads you are mainly interested in the lower frequencies, and with light items you are mainly interested in the higher frequencies. You won't hurt a small electronic component with 5 Hz—it just doesn't react to it. And, there is no reason to put 1000 Hz to a large heavy console, because by the time the vibration gets a few inches off the base, it has been absorbed.

For most electronic applications, therefore, electrodynamic shakers will usually be specified. These range from a 25 force lb unit to a 35,000 force lb unit.

Force rating of the exciter doesn't change as the weight of the test specimen changes; rather, it is the amount of acceleration you can get that changes. The equation \( F = Wg \) is used to calculate how much you can accelerate different loads. The force capability of the exciter is defined by \( F = BIL \), a physical equation for an air gap where \( B \) = flux density of the air gap, \( I \) is the current through the conductor, and \( L \) is the length of the conductor in the gap. Thus the force capability depends upon the construction of the exciter and not upon the weight of the test specimen.

The equation \( F = Wg \) tells you how much you can get out of the exciter for a given payload.

Take, for example, a 1200 force lb exciter. It can take a 102 lb payload to 10 g acceleration (the reason payload weight is not more is that you must also consider the weight of the moving element in the exciter). For a 20 g acceleration test, the 102-lb payload would have to be derated to about 42 lb. So you are limited by the 1200 force, which is the fixed factor. Weight and acceleration are the variables, but you can trade them off, one for the other; the higher the rate, the higher the acceleration and vice versa.

To get the system best suited to your requirements, you should be able to tell the manufacturer as much of the following as possible:

- type, size and weight of the package to be tested
- intended use in the actual environment
- acceleration level needed
- vibration levels that must be reproduced
- operating frequency range
- in which axis the motion is to be produced (horizontal, vertical, etc.)
- actuator stroke required
- number of exciters needed (it can be a single or a multi-head system)
- fixture weight
- how test is to be controlled (Will the input signal be sinusoidal, random or complex?)
- instrumentation required

Any background information or Mil Specs that you will be testing to would also be helpful.

Many people who purchase the smaller systems don't need a signal source—they probably already have one of their own (an oscillator) that can do the job. The
higher force rating exciters will also include a cooling package (amplifier output tubes are water-cooled and the exciter is usually either water- or oil-cooled). This will probably be included in the system price, but accelerometers and other instrumentation won't be included. Instrumentation is a subject that should definitely be discussed with the manufacturer. He is the one to advise you on what is needed and how it should be used.

Fixturing is a critical step in vibration testing. It's really an art because every test object requires its own peculiar fixture—it's almost a cut and try process. Without proper fixturing and instrumentation placement the test won't truly represent the specimen's performance under the specified environment. In placing the accelerometer you must know the purpose of the test and what you are trying to simulate—you then place the instrumentation at the points that will most closely duplicate it. Also, tests are repeatable only if they are performed in the same way with the same fixturing and drive source, and only if the instrumentation is placed at the same points.

Another factor you will have to discuss with the manufacturer is the possible need to isolate the exciter. Most exciters have some sort of built-in isolation system that is adequate, but occasionally you will need an auxiliary system.

You can upgrade your exciter to some extent as new amplifiers become available, but when you select a system, try to look ahead—what will your needs be next year, or five years from now?

Portions of a shaker such as suspension and other parts associated with the moving element will wear out. But, even with the larger shakers almost all such parts can be replaced in a day assuming they are "available."

And finally, you might consider using a multi-shaker setup. Systems with up to eight shakers have been built. The advantage is flexibility—you can apply the vibration in more than one place.

**Acceleration**

Acceleration tests are performed on components that will be subjected to this condition during their lifetime. But they also serve another function—to spot weak points in a component. For example, let's consider the effects acceleration might have on the IC. A potential weak spot is the gold bond on the lead. Acceleration checks the bonding procedures. If an IC is overbonded or underbonded, if the pressure applied on the bond is not exactly right, or if the loop that the lead has is too much or not enough, the stress put on it when accelerated will make it pull out.

Another point is that since the chip sits on a glass substrate, it has to be flat. If it isn't flat, you'll get a lever effect. The acceleration force will then crack it and you will actually destroy the chip.

Acceleration may also damage the glass-to-metal seal that exists on the package, if it is not a reliable seal. And finally, the external leads will have a tendency to pull away or break the seal they have with the glass. Temperature cycling or thermal shock does much the same, but to a lesser degree.

To simulate acceleration environments you need a rotary accelerator, which can take small components to levels over 250,000 g. The basic unit is a centrifuge that generally has a variable speed drive, operator controls, a rotating arm for mounting test specimens, and slip rings for connecting power and instruments to the test objects.

You may often want to subject a test object to a controlled environment while it is being accelerated, since certain failures will occur under a combination of environments but not under one or the other alone. For such tests, you can either mount an environmental chamber at the end of the accelerator's rotating arm or enclose the entire centrifuge chamber with insulation and provide means for high and low temperature, vacuum, humidity, and so forth.

If you decide to buy a rotary accelerator, you should know the following before contacting a manufacturer.

- the amount of g (1g = 32.2 ft/s² needed
- physical dimensions (l, w, h) of the test package and fixture (6 in. cube, 8 in. cube, etc.)
- location of the package's center of gravity
- package weight
- how closely you want the acceleration controlled
- accessory equipment needed
- type of speed indication—tachometer (2% acc.) or counter (0.01% acc.)
- acceleration gradient
- speed regulation and acceleration accuracy needed

It's important to remember that acceleration is proportional to the distance from nominal radius. For example, if the g rating for a 23 in. package at a 10 in. radius is 100, then at 9 in. it will be 90 and at 11 in. it will be 110 g (g gradient is then ±10%). Thus, the farther out on the arm you have the package mounted, the higher the rating.

This could affect your test considerably. Let's say that you have a package that must be tested to 100 g at the center. Somewhere in that package is a component that is marginal at, say 110 g, and you have a 25% g gradient—giving you 125 g at the outside. If, when you mount the package, that component is on the outside (away from the center of the centrifuge), you will be subjecting it to 125 g and it may well fail. However, if you mount the package such that the component is on the inside (toward the center of the centrifuge), it will be subjected to only 75 g's and will not fail.

Many specs will state just how the package is to be oriented so you needn't be concerned, but if they don't, be careful. In general, the greater the g gradient, the cheaper the machine.

One way to eliminate g gradient entirely is to mount two smaller centrifuges on a larger one. If these satellite tables are locked to ground (or are motor-driven), you can have the main table going one way and the satellite tables going the opposite way at exactly the same speed. At any point on the satellite table you have the same acceleration. Thus, if a test requires that the test object have the same acceleration all across it (even if it were only an inch), you could use this setup. Another feature of the satellite setup is that you can apply sinusoidal changes in acceleration at very low frequencies. By controlling the satellites, you can make the sine wave anything you want.

Another factor is the center of gravity of the test object. The cg of the test object and the counterbalance (or another test object) must be dynamically balanced. Generally, in something like a centrifuge where the horizontal distance to each package is great and the cg's are
Selecting a vibration exciter.*

Basic physical formula (Newton's Law) is

\[ F = ma \]

Related to vibration testing it is

\[ F = (W \text{ wt. in lb}) \times \text{acceleration level in g units} \]

or \[ F = W_T g \]

where,

- \( F \) = force rating of exciter
- \( W_T \) = total dynamic wt
  \[ W_T = W_{ME} + W_F + W_S \]
  - \( W_{ME} \) = specimen wt
  - \( W_F \) = fixed wt
  - \( W_S \) = moving element wt
- \( g \) = acceleration level of test
  \[ g = \frac{32.2 \text{ ft/s}^2}{1 \text{ g}} \]

Let's take a hypothetical case:

Let specimen wt = 175 lb
(say it's a guidance control) and
\( g = 20 \)

The fixture designer requires 238 lb of aluminum to construct a suitable fixture.

Acceleration*

To order a centrifuge you must know the centrifugal capacity and acceleration gradient that you will need. Here's how to calculate them:

**Centrifugal capacity** = package wt. + fixture wt. \times acceleration level.

For example, 200 lb. (pkg. wt. + fix. wt.) \times 100 g (acceleration test level) = 20,000 g•lb.

Thus you would need a centrifuge with a capacity of at least 20,000 g•lb.

**Acceleration gradient**

If a gradient is specified, will greater acceleration load beyond the nominal radius adversely affect the chances of meeting the spec?

\*Courtesy John Magdziak, Schaeavitz Engineering.
close to the same plane, if they are in static balance, they will be in reasonable dynamic balance.

The center of gravity relative to the instrument base could also affect radius. Other conditions that could well affect radius are distance from mounting base to center of spindle, dihedral angle of the mounting base, variations in eccentricity, and temperature.

**Temperature-humidity-altitude**

One of the main problems with these chambers is that users tend to overspecify. It's easy to do because there are so many types and combinations available, but it can be avoided.

Let's take a typical example of what happens when an engineer overspecifies. If he has a Mil Spec that calls for testing to $-65^\circ F$, he will specify $-100^\circ F$ feeling that it will guarantee that he will get $-65^\circ F$. What he doesn't realize is that reputable manufacturers take a safety factor and bottom it out to $-110^\circ$ or $-115^\circ F$. Thus, the safety factors have been compounded—the fellow that wrote the spec took one and the customer took one, and the manufacturer also took one to compensate for wear factors and so forth. The manufacturer suggests taking the worst condition you'll find in your Mil Specs, and this should be sufficient.

This is particularly true with the lower temperatures. Cooling costs money (compressors, coils, refrigerants, instruments, and maintenance), while heat is relatively inexpensive. Even with heat, however, overspecifying can be costly—there is a breakpoint in cost.

Heater elements are cheap—up to about $300^\circ C$, but above that you start to complicate chamber construction. Your common gasket materials such as neoprene don't work much above $300^\circ F$. Another problem is that you have to use the more exotic sealing materials—silicone rubber, Teflon and so forth. The refrigeration coils also present a problem (most chambers combine high and low temperatures). Copper above about $400^\circ F$ begins to oxidize, so you may need stainless steel coils, and SS is expensive.

Let's consider some of the factors you must consider before you decide on a chamber:

- **Do you need combination or separate chambers?**
- **How high do you want to go in temperature and how quickly do you want to get there from ambient?**
- **How cold do you want to go in temperature and how quickly do you want to get there from ambient?**
- **What control tolerance do you need?** (Not more than you need—it's costly.)
- **What is your specimen? Does it radiate heat, and if so, how much?** (When you have a test package that is operating while in the chamber, remember that it will generate heat. If you don't take this into consideration, you'll soon find that the chamber isn't operating up to capacity.)
- **What is the size and weight of the specimen and how is it going to be distributed in the chamber?** (Rule of thumb is that a test specimen must not occupy more than 50% of the chamber volume. However, it's best if it doesn't occupy more than 25%.)
- **What is the rate of heatup and rate of pulldown?**
- **What humidity range do you want and over what range do you want to control?**
- **What power is available—single or three-phase? This is very important as it can affect the instrumentation and control circuitry to a great extent.**
- **Do you want a window and if so do you want a wiper (for a humidity chamber)?**
- **Do you want a water or air-cooled condenser in the refrigeration system?** (For very large rigs a water-cooled unit is better, but local regulations may prohibit the use of large amounts of water.)

Note that instrumentation wasn't mentioned above. As in other environmental test equipment, instrumentation is something you should discuss with the manufacturer. But, make certain that what you get will give you a true idea of what you are measuring. If you purchase cheap instrumentation, you'll get cheap results.

Do you want combination or separate chambers? It sometimes pays to buy two chambers instead of one combination chamber—that is, if your requirements don't call for a combination. It doesn't cost that much more to buy two and it increases your flexibility. For example, humidity is typically a long run test, possibly weeks or a month, and while it is running, it is tying up the chamber.

If you have a temperature-altitude chamber and operate it at high or low temperature, you have to derate it as you go to higher altitudes—the gradients get very high because there is no longer any air to pump around. You can minimize these effects somewhat with a two-speed fan, or maybe even with an infinitely variable fan that you can run very fast at high altitudes to minimize the gradient. Or, possibly you can request an air-operated switch that will cut the heaters back at high altitude and can even cut them off above 100,000 ft. You may run into a similar problem with refrigeration—you begin to get blackbody radiation from the coils, although not below 50,000 ft.

Specifying very rapid pulldown rate can be costly. It means that you are specifying a big compressor and coil—in other words a big refrigeration system, which doesn't give you a lower temperature capability. Some people order a chamber with very low temperature capability because they want to pull down very fast from ambient to zero, but this doesn't hold true. A single stage made to do the job will pull down a lot faster than a cascade system made to keep going down. What they should have ordered was a chamber that will pull down from ambient to zero in, say, 10 minutes, and then let the manufacturer decide how to do it.

The advantage of a cascade system is that it can go to a lower temperature (increases the temperature range). It's common to go down to $-40^\circ F$ with a single stage, down to $-120^\circ F$ and even lower with a cascaded system. Three-stage cascade systems have gone to $-200^\circ F$ and below in the lab, I'm told. Most electronic testing is not below $-100^\circ F$.

The mechanical refrigeration system is the most common, but you may want to use CO$_2$ or LN$_2$ systems to get to a lower temperature very quickly. They are also useful if you need cold for only a short time or if you test only occasionally, but they aren't economical for prolonged use. They can be used to supplement mechanical refrigeration too. Thus, to get down to temperature fast you can inject CO$_2$ or LN$_2$ to help reach the desired temperature and then shut them off.
Do you really need that window? They are nice to have but you probably don't need to see what is happening (your instrumentation will tell you). Glass viewing ports are a potential source of air and heat leakage, and glass is transparent to radiant heat. (This brings up another point—make certain that your heat sensing element is never optically exposed to the heating element—it will pick up radiant heat.)

One last point. It's a good idea to make a thermal survey of the equipment when you receive it. Set up a dummy load or simulated test specimen in the chamber. Then try various heating and cooling powers to determine heat-up and pull-down rates as well as required holding power. The data you obtain will help you to set your controls for later tests.

Thermal shock

Thermal shock chambers allow you to test the effect that sudden, severe temperature changes will have on components. Generally, the thermal shock is created by transferring the test specimen between a hot and cold chamber, but it is occasionally done by heating and cooling the item in one chamber. The transfer between chambers can be automated. The top chamber is heated and the bottom one is cooled.

Another type of chamber has three compartments. Here, a third or ambient-temperature station is placed between the other two chambers so that the test item can be exposed to an ambient temperature for a specified length of time during the transfer between hot and cold stations.

Each chamber automatically seals tightly after the basket carrying the test specimen enters or leaves. Transfer is usually via a pneumatically operated "dumb waiter".

Shock

With shock machines you can accurately reproduce shock parameters found in the equipments' actual use. It may require specially designed setups but you can duplicate the exact pulse shape, acceleration, and duration needed.

However, the most common pulses called for are \( \frac{1}{2} \) sine, sawtooth, and square wave. Various shaping devices are used to obtain these pulses. For example, to get the \( \frac{1}{2} \) sine pulse, drop an anvil on a rubber pad of known thickness and hardness. To duplicate the sawtooth drop the anvil on a conically-shaped lead pellet or use a hydraulic self-recovering programmer. Varying the pellet's form factor will enable you to obtain various pulse amplitudes and widths. The lead pellets, which are expendable, can be made in molds by the user.

The three most common types of shock machines used are—pendulum, pneumatic and drop or gravity types. The latter two are frequently used for testing smaller items while the pendulum machine is generally used to produce very large and powerful pulses.

The pneumatic, or compressed air operated, machines have capacities in the hundreds or thousands of pounds, and need much less drop height than is needed by the gravity machines.

Gravity machines, which have load capacities into the hundreds of pounds, have carriages that are raised to a pre-selected height and then fall on a decelerating device chosen to produce a shock pulse of specific wave...
shape, acceleration, and duration. They can be recycled automatically or operated for single shock pulses.

Before you contact the manufacturer, you'll want to know:

- size and weight of your load
- height of cg above mounting surface
- percentage of load supported on shock mounts
- direction in which shock pulse must be produced
- axes of specimen through which shock must be applied
- shock pulse characteristics (waveshape, peak acceleration, pulse duration, load, and drop height)
- applicable specs
- repeatability desired

You should also advise the manufacturer of any possible installation problems such as ceiling clearance, whether or not shocks must be isolated from the building, and construction of the floor.

You can use the following formulas to find the free fall distance or velocity needed to produce a given shock pulse.

For ½ sine pulses

\[ S = 19.6 \, \text{g}^2 \text{t}^2 \]
\[ V = 123 \, \text{ft} \]

For terminal peak sawtooth

\[ S = 48.3 \, \text{g}^2 \text{t}^2 \]
\[ V = 192 \, \text{ft} \]

Square wave (non rebound)

\[ S = 192 \, \text{g}^2 \text{t}^2 \]
\[ V = 386 \, \text{g}t \]

where

- \( S \) = Equivalent free fall height in in.
- \( V \) = Velocity at impact in in./s
- \( g \) = Peak pulse acceleration in multiples of acceleration due to gravity.
- \( t \) = Time in seconds.

Where \( S \) is known and you must find velocity use:

\[ V = \sqrt{2gS} \]

To do it yourself or to send it out . . .?

The commercial test lab will help you to prepare technical proposals or detailed test procedures. They will perform all phases of your test programs, including simulation and measurement of environmental conditions and measurement of equipment performance parameters. They will supply you with detailed test reports and analysis of results.

These labs can be particularly valuable to those of you who have never done any environmental testing, and to the occasional tester. All you need to know is the spec and the paragraph number that you must test to. However, if you plan to use a commercial lab it will pay to contact them before you bid on a contract so that they can suggest methods whereby the test program can be made easier and less expensive.

If you can't contact them before you make your bid, they suggest that you let them write the test procedure for complex programs because they know their equipment and it will make the program go much smoother. They would, of course, test to your spec.

Occasionally they will have the test equipment needed, but not the instrumentation. Here they will conduct the test and the customer will operate the instruments and equipment.

If you are considering setting up your own environmental test lab you might call one of the commercial labs and ask to see their facility—they tell me they would be glad to discuss it with you. Why the beneficent attitude? Because they feel that even if you set up your own lab you will always have overflow or scheduling problems, and hence you will come to them.

Even companies with good in-house capabilities go out to test labs on occasion for several reasons. One, is that they may have to schedule a test on fairly short notice and their own lab is “booked solid”. Although the commercial labs would like at least two or three days notice, they can often handle a request immediately. (Some tests require more notice.) It's interesting to note that when they have a slack period, many of these company labs will "go commercial" and perform tests for others—it helps pay the overhead.

And another advantage to the commercial lab is the “third man theme”. A report from an independent testing lab has much more impact on a prospective customer than does an in-house report, since the independent lab is unbiased and has no axe to grind.

On the “con” side

There are four common reasons given for not using a test lab—cost, availability, convenience and control.

Cost can be fairly high for certain tests, but you pay for what you get—experience, wear and tear on equipment, and so forth. Also, even though the basic test may be inexpensive, the related equipment (recorders, instrumentation) you insist must be used, will run up the cost.

Availability may be a valid reason for not using the commercial lab if your company has a large enough facility and enough equipment to insure that it won't become overloaded. Keep in mind that whereas your lab may have, say, one or two chambers or exciters, the commercial lab may have tens or hundreds of them.

Convenience could also be a valid reason—it's easier to carry your equipment down the hall than it is to ship it off to a lab. However, convenience is contingent upon availability.

The final reason is control, but if this is a concern you can always send an engineer to the commercial lab to monitor the tests.

Maintenance: What the users say

Maintenance of any equipment is very important, and this is particularly true of equipment that uses pumps, refrigeration lines and so forth. Without proper preventive maintenance and careful servicing the equipment would see little use. And this points out a serious complaint I have heard from users; that chambers and other equipment are not designed for service—that parts which must be serviced are difficult if not impossible to reach.

For example, I've heard of cases where a part that required periodic servicing was positioned behind a structural member. Since this member was welded in place, the manufacturer had to send workmen to the customer's plant to modify the equipment.

The point here is that service should be a serious consideration. If possible, check the equipment before it
leaves the manufacturer's plant. If this isn't possible, then do a thorough checkout or dry run in your plant before putting the unit in operation.

Even the manufacturers will admit that equipment, and especially chambers, are sometimes a "little" difficult to service. But they argue that a great deal of plumbing and controls must, of necessity, be placed in a chamber, and that they try to make these accessible. Also, many of these chambers are either custom or standard units that have been "customized" so there is always the possibility that the manufacturer has made a mistake. However, if he knows his business and is reputable, he will be happy to rectify the error.

Thus, the old cliché "choose a reputable supplier" is particularly appropriate when choosing environmental test equipment. Make certain that he is knowledgeable and has experience in the field. He doesn't necessarily have to be a large manufacturer (there are many relatively small ones in this field), but he should be experienced. A look at his plant will help—see how he operates.

Some users claim that their equipment is down or inoperative 50% of the time. This figure includes both periodic maintenance time and time down due to breakdowns.

What the makers say

To be fair to the manufacturers we must give them "equal time." They say that some users are careless about their maintenance programs, and when the unit fails, they wonder why. Those who have a regular program of preventive maintenance have little trouble with the equipment. The majority of breakdowns are due to neglect or misuse.

Users take a chamber and place it in a confined space where the condenser (which is air cooled) doesn't receive any fresh air—then they wonder why it fails or why its efficiency is affected. They also let dust and dirt accumulate around the condenser coil, which affects efficiency.

Lightweight power lines or extension cords are other sources of inefficiency. Also, customers will operate a combination chamber at a low temperature, shut it down for the night, and then the next morning wonder why there is condensation present. With a little forethought they would have heated the chamber to at least room temperature before shutdown, preventing this condition.

Another point—don't expect to get an instruction manual with a chamber comparable to that of electronic equipment. Most are really inadequate because there are few standard units. Even many of the off-the-shelf units are very different because of the many options.

Ingenuity sometimes pays off

Another point raised by users is that they can't always get equipment that will meet their requirements, or that it is sometimes too costly. Some have solved it by improvising and/or building their own units. Some are very professional and some are disasters.

I know of one enterprising company where packages were tested for contaminants in a fish tank. And some attempt to use a deep freeze to perform their temperature tests. I've also seen a bell jar placed in an expensive temperature chamber to simulate a temperature altitude test; and the product qualified. Rotary accelerators and shock machines are other "home brews" I have seen. But even the people who have made them don't usually recommend them, particularly if you are not very experienced. Some tests with these units are useful in design and to the maker as self-proof that his design works, but they can't be used for qualification testing.

Another factor to consider when building the equipment yourself is "How much will it cost to properly instrument the unit?" This can be a significant amount.

Acknowledgements

I'd like to thank those people who took time from their busy schedules to see me. I'd particularly like to thank Thomas Freedom, AMP Incorporated; John Latour and Richard Hassett, Associated Testing Laboratories; H. L. Banton, Richard Sipfle, and Bruce Thompson, EMR Div. of Weston Instruments; Michael Maher, General Testing Laboratories; Fred Mohr and Jack Dennis, Harowe Servo Controls, Inc.; Robert Morse and John Zamparo, MB Electronics; John Magdziak, Schaevitz Engineering; Robert Norton, Standard Cabinet Co.; George Butler, Jim Quigley, and Al Silverman, Tele-Dynamics Div. of AMBAC Industries Inc.; and Conrad Miller, Tenney Engineering.
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Here's how you voted
The winning Idea for the January 1969 issue is, "Digital filter replaces bulky components."

Mario Humberto Acuña, our prizewinning author, is a Supervisor in the Engineering Research and Development section of Fairchild Hiller, in Riverdale, Md. Mr. Acuña chose the Simpson 270 tester.
Fault monitor checks for circulating logic bit

Robert Serody
Raytheon, Bedford, Mass.

This circuit monitors the operation of a ring counter to determine that only one bit is circulating. When this condition does not occur, the monitor sends a reset pulse to correct the counter and register a fault condition.

Previously, you had to use separate test/monitoring circuits to sense the presence of the circulating logic bit. A typical way would be to sum every state of the counter with a summing amplifier, and compare that output with two comparators that define the acceptable voltage range. If the counter states fall outside this range, the monitor resets the counter. Such a method needs a circuit with precision components, usually mounted on a separate module, with several power supplies necessary to operate it.

The new ring counter/fault monitor combines the counter and monitor into one circuit that checks periodically for proper operation. This is possible because the monitor checks for the presence of only one state of the ring counter.

As an example, consider the 3-state counter/monitor shown here. A NAND gate, HY-1, monitors the first state. (One input to HY-1 is a Q output; the other inputs are Q.) The absence of this state shows that either all outputs of the counter are 0, or that more than one logic 1 is circulating. In either case, the output of HY-1 stays HIGH, and C1 charges to the supply voltage via HY-2's pull-up resistor.

When the voltage across C1 reaches the logic threshold level, HY-2 sends a logic 0 through HY-3 and HY-4 to reset the counter. This, in turn, forces HY-1's output to drop to a 0 and discharge C1 through D1. The input to HY-2 thus drops below threshold, removing the reset pulse.

A time lag set by C2 ensures that the reset pulse does not disappear before the flip-flops can reset. Gates HY-3 and HY-4 decrease the transition times of the reset pulse. Diode D1 isolates C1 from HY-1 during the recharge interval.

The circuit doesn't need precision components because the time constant set by C1 and the pull-up resistor in HY-2 need be only long enough to prevent C1 from reaching the threshold voltage between discharge times. The time between each discharge is the period of the ring counter. The fault monitor will reset the counter at turn-on, or when any extra bits are generated by noise spikes, or when the counter becomes defective.

You can use the monitor in a timing system by connecting the fault output of HY-3 to a register which is reset periodically. Connecting the register to trigger an alarm warns you if too many faults occur in a given time.

The ring counter may have any number of states. But the fault monitor always retains its basic simplicity of design because it need monitor only one of the states. In general, you can use the monitor to check the operation of many other circuits which involve a change of state in their operation.
921 Shape pulses for RTL circuit use

Charles Ervin Cohn
Argonne National Laboratory,
Argonne, Ill.

This circuit accepts either positive or negative pulses with amplitudes of 1 V or more, and shapes them to a form suitable for use with RTL logic.

In the quiescent state, the 2N3904 transistor is OFF, and the inverter following it is ON. But when a pulse appears, the transistor receives base drive and starts to conduct. As the inverter comes out of saturation, the transistor receives more drive. Such regenerative action rapidly turns the transistor ON and the inverter OFF. When the input pulse terminates the inverse action occurs.

The output has sharp transitions even if the input pulse has very long rise and fall times because of hysteresis in the regenerative loop.

922 Counter counts to find faults

J. J. Hoefer
Bendix, Kansas City, Mo.

Suppose you must monitor a large number of remotely-located, low impedance loads connected in parallel (a bank of squib switches, for example). For such situations, this circuit tells you if a load is open-circuited, and if so, which one.

The circuit uses a 6.3-V filament transformer at each load station. The low-voltage winding, wired in series with the load, applies an oscillator signal to the load during test. Thus, the presence of ac in the transformer secondary shows that the load is not open-circuited.

After detection, the signal from the secondary is applied to one input of the first gate. Now, if there is also an output at point A from the preceding stage, the first gate sets the latch circuit output (point B) to a 1 state, putting a pulse on the counter bus.

The other side of the latch circuit (point C) drives the output gate. A 0.47-μF capacitor delays this signal (A'), and thus determines the pulse separation time. The counter runs until it detects the first open load (a missing pulse), or until it counts all the loads.

The Electronic Engineer • June 1969
Taylorclad FIREBAN 1011E is a premium glass-epoxy copper clad for critical circuit needs. It combines all of the basic properties of NEMA G-10, G-11, FR-4, and FR-5 grades. Heat resistant, flame retardant, it meets MIL-P-13949 and takes precision drilling, punching and shearing.

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Feature article abstracts

Published information is vital to your job. To save time in finding this information, we have abstracted the important technical features from eight electronic engineering publications.

Should any of these articles interest you, contact the magazine—names and addresses are listed below. Reprints of articles with an asterisk are available free. Save this section for future reference.

Amplifiers

*Digital data: play it like it is, Frank C. Marino, Distriptech, "The Electronic Engineer," Vol. 29, No. 6, June 1969, pp. 74-78. Data processing by computer is expected to expand into scientific or military uses; it is already part of our personal activities (monthly bank statements, charge accounts, bills, and so forth). How is more and more data handled with fewer and fewer errors? By constant improvement of each element in the processing chain. One such element is the "playback amplifier," in which the raw digital information is shaped to perform electronic functions. This article tells of an improvement in the signal-processing mechanism of such an amplifier, one that further reduces the possibility of error in the digital data stream.

Stabilize your op amp experimentally, Karl Huecke, Motorola Semiconductor, "Electronic Design," Vol. 17, No. 9, April 26, 1969, pp. 50-56. A quick way to calculate the correct values for amplifier compensation capacitors is described. This method uses five simple scope measurements taken under actual operating conditions.

*Operational amplifier charts, Staff Report, "The Electronic Engineer," Vol. 29, No. 6, June 1969, pp. 67-71. Manufacturers of both monolithic and hybrid operational amplifiers offer a complete line of products at prices that make it uneconomical for most designers to calculate and build their own op amps. To simplify the reader's job, the Electronic Engineer has classified 200 commercial operational amplifiers (split about evenly between monolithic and hybrids) by their six most important parameters, one of them being the all-important price. This group of five charts, published for the first time, will constitute the most useful specifying reference that the user has ever had available to him.

High-frequency characteristics of wide-band invertor op-amps, Heinrich Krose, Zettel, "EEE," Vol. 17, No. 4, April 1969, pp. 74-78. Both theoretically and graphically, the author explains the significance of, and how to calculate and how to improve frequency response, settling time, slew rate, and loop gain.

Circuit Design

Specify your trap filter the easy way, Jerome H. Howitz, Bunker-Ramo, "Electronic Design," Vol. 17, No. 9, April 26, 1969, pp. 58-64. Computer tables are provided for quickly establishing the Q, notch depth, and group delay of trap filters once the desired attenuation and center frequency are specified.

Cut differential-amplifier design time, Sidney A. Friedman, Cardian Electronics, "Electronic Design," Vol. 17, No. 10, May 10, 1969, pp. 114-117. Reference tables of equations are given that enable differential-amplifiers to be designed quickly if their fall into one of several commonly used configurations.

Design and match op-amps, Gunnor Richwell, Reflections Electronics, "Electronic Design," Vol. 17, No. 10, May 10, 1969, pp. 106-111. Two Quick programs are provided for device analysis and matching network selection. Inputs to the first are the stability factor and y-parameters of a two port device. The outputs are admittances, transducer and unilateralized gain, stability, sensitivity and input and output impedances. The second program uses source and load impedances, frequency, and Q to determine the components of 28 possible matching networks.

Communications

Frequency-spectrum dilemma—critic or opportunity? James E. Klug, Sr., Ed. "EDN," Vol. 14, No. 9, May 1, 1969, pp. 33-45. Radio spectrum congestion is very bad between 25 and 920 Mhz. FM and TV bands occupy 60% of this region, and land-mobile services (railroads, utilities, police and fire departments, etc.) less than 5%. Crowding of the land-mobile services spectrum already endangers public safety. A similar congestion is building in the microwave spectrum, where data and video transmissions are increasing. Sharing parts of the UHF TV band with the land-mobile services, and extending the usable spectrum to the millimeter and optical ranges seem to be possible solutions. A detailed analysis of the land-mobile services problem, something to give, by Wm. H. Detwiler of Radio Specialists Co., pp. 46-52, immediately follows Mr. Klug's article.

Design bias circuits with nomographs, M. G. Golden, 3M Research Center, "Electronic Design," Vol. 17, No. 9, April 25, 1969, pp. 66-71. A series of nomographs is provided for rapidly designing transistor bias circuits once the operating point is defined in terms of Vce and IC.

Magazine publishers and their addresses

EDN
Gannett Publishing Company
3375 S. Bannock Street
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EE ABSTRACTS

Data communication: The medium and the means. Donald E. Scott, "Electronic Design," Vol. 17, No. 9, April 26, 1969, pp. 52-57. The author defines a standard, the "Electronic Design," Vol. 17, No. 4, April 1969, pp. 57-61. This article describes the technology of digital transmission, concluding in favor of digital. Part 3 outlines the problems of selecting both tape and photo equalizing components that can be switched in and out with a trigger amplifier with wide control.

Components

Picking and working with a hybrid lab shop, Jon Van Hise, Bell & Howell, "Electronic Products," Vol. 11, No. 13, April 1969, pp. 124-127. This guide will help you to decide whether or not to use the hybrid approach in your circuit construction. Prime factors in any such decision are area, size, cost, and reliability. Should you decide to use the hybrid, the article also tells you how to select a lab shop.

Digital panel meters, Bill Segalits, Western Ed., "Electronic Products," Vol. 11, No. 13, April 1969, pp. 109-110. The same split memory operates with stable waves moving along a structure and integrating with magnetic films on the cathode plane, which is still present. Features of a non-destructive readout are non-volatile, and has no mechanical linkages.

Digital Design

Applying off-the-shelf MOS logic to digital systems, J. J. Kibane, National Semiconductor, "Electronic Products," Vol. 11, No. 13, April 1969, pp. 44-45. The author writes that making MOS and bipolar ICs makes sense, if you use the bipolar for fast performance and the MOS for memories. He shows you how to eliminate hybridized bipolar circuits, and how MOS logic eliminates interfaces, and the complexities of DTL systems.

The crystal resonator—a digital transducer, Donald L. Hammond and Albert Benjamin, Hewlett-Packard Co., "Electronic Design," Vol. 6, No. 10, April 4, 1969, pp. 53-58. Temperature and pressure transducers are not digital devices in the strictest sense. However, electronic devices, including quartz, crystal transducers, can convert information from analog to digital, including the analog parameter of frequency, which is turned into a standardized form.

Integrated Circuits

Jock of all-trades: monolithic I-F is a universal subsystem, Robert A. Hinckley, National Semiconductor, "Electronic Design," Vol. 6, No. 13, June 1969, pp. 97-102. Each class of two-way broadcast radio service (land, mobile, marine, and so forth) has its own standard mode of transmission (e.g., FM, CB, and so forth). This diversity has discouraged wide use of IC'd subsystems, since each such subsystem is peculiar to its own transmission mode. The article describes how this can be overcome by a microprocessor. The IC, the main idea in this system, also has a change for reducing the number of parts used in the system.

Phase-locking: Integrated tuned circuits made easy, Hans R. Cameron and A. B. Grahe, Santomics, "Electronics," Vol. 47, No. 9, April 28, 1969, pp. 100-101. This module is designed to provide an easy way to generate resonant frequencies accurately. This old method is a simple way to get resonant frequencies accurately.

Designing with diff-amp and op-amp ICs, Ralph Seeger, "Electronic Products," Vol. 17, No. 4, April 1969, pp. 59-61. This article describes "Signetics 516 amplifier" and two for the Signetics 519 operational amplifier. Oscillograms show the two op-amp multivibrator, with a long time constant, to provide ramp with slow build-up (0.1 to 1 seconds), and a trigger amplifier with wide control.

*Speed/power chart for digital ICs, Staff Report, "The Electronic Engineer," Vol. 29, No. 6, June 1969, pp. 48-49. This chart allows the reader to make a "ballpark" selection of those digital integrated circuits that are best suited for his application. Organized by the two most important parameters—power dissipation and propagation delay, the chart can be used easily by the engineer, the relative performance of the circuit family is discussed. The chart includes both DTL and MOS technology.

MOS integrated circuit directory, Raymond D. Speer, Microwave Electronics, "Electronic Design," Vol. 17, No. 10, May 10, 1969, pp. 75-103. Twenty-seven pages of standard MOS circuits are tabulated. Manufacturers, characteristics, and availability of data sheets, application notes, and price lists are included.

Single building block proves logical choice, for custom I-C's, Donald K. Lauffer, National Cash Register, "Electronics," Vol. 42, No. 9, April 29, 1969, pp. 86-93. For special-purpose systems, a multipurpose building block gives you more stability against transients, variations in power supply voltages, and changes that can affect stock devices. While the price may seem high for these custom circuits, volume usage will offset most of the added cost.

Microwaves and microwave products

Designing lumped elements into microwave amplifiers, Martin Coulton and Walter E. Poole, RCA, "Electronic Design," Vol. 17, No. 13, April 1969, pp. 100-110. Because thin-film inducers, capacitors, and resistors can be made so small, lumped passive elements used in microwaves without distributed reactive effects. The hybrid microwave units are potentially cheaper and much smaller than those made with microstrip techniques. Manufacturing methods are based on the photorest methods developed for transistors.

Reliability

*Ftube tests improve equipment reliability, Sigourney R. Robb, Associate Editor, "The Electronic Engineer," Vol. 29, No. 6, June 1969, pp. 50-52. The current testing philosophy is to simulate as closely as possible the environment that the equipment will see in use or in transit. To perform this simulation requires environmental test equipment, and since many engineers are not too familiar with this equipment, they find ordering and using environmental testing equipment is a time-consuming process. The article describes a system that not only eliminates the problem but also speeds up the testing process.

Test and Measurement

PRBS can fool the system, J. A. Martin, Solartron, "Electronics," Vol. 42, No. 9, April 28, 1969, pp. 89-91. PRBS—pseudo-random binary sequence—is periodic and can be precisely generated. Hence, it can be very useful as an input test signal. The article describes in detail what response to random inputs. From these signals an engineer can learn how a system will function under random noise conditions.

How to extend sampling-oscilloscope versatility, H. Allen Zimmermann, Tektronix, "Electronic Products," Vol. 11, No. 14, April 1969, pp. 37-39. Many measurement problems, some of which have been corrected, are solved by using a sampling-oscilloscope system. This system consists of a 20 different types of zero, including plug-in, and self-contained instruments, which can be used together in a wide variety of functional configurations. The article describes the specific applications which can be achieved by using this system.

Ultrasonic instrumentation in industry, Erwin H. Stork, Asst. Ed., "Electronic Design," Vol. 6, No. 13, April 1969, pp. 108-113. New techniques, in particular, have increased the demand for ultrasonic equipment. The article describes the specific applications which can be achieved by using this system.

Miscellaneous

Conversion revisited, Timothy J. Kealy, Univ. of Santa Clara, "IEEE Spectrum," Vol. 6, No. 4, April 1969, pp. 87-93. There are few mathematical operations more important to engineers. The article presents a new method of conversion and transformation. This article describes the mathematical operations, which are based on discrete convolution, continuous convolution, and transform analysis. In addition, the article presents a new method of conversion and transformation analysis techniques lead to the same solution.

What's a "systems" approach? It's just the name of the game, Ralph Kestenbaum, Asst. Editor, "Electronic Design," Vol. 47, No. 9, April 27, 1969, pp. 89-91. A systems approach can mean many things to many engineers. The article describes the way that a program must be done when there is a systems approach. The article presents a continuous planning throughout the project. The article describes what this article discusses with the different views presented.

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The Electronic Engineer • June 1969
Jack-of-all-trades: monolithic i-f is a universal subsystem

A single chip serves a multitude of transmission modes, and lets you switch economically from one to another, within a single receiver.


Because of differing user needs, each class of broadcast and two-way radio service has evolved its own standard mode of transmission (a-m, fm, nbfm, cw, ssb, and so forth). This diversity has heretofore discouraged widespread use of IC i-f subsystems. But now a single microcircuit can serve nearly all radio users. National Semiconductor’s LM373 incorporates those subsystem functions which may be changed, by a few external connections, from the duties required of one mode to those of another.

The 373 is for a-m, fm, and ssb i-f applications, and for broadband video amplification as well—even though the reception of these modes requires contradictory performance parameters. For example, a-m and ssb receivers must have linear amplitude-response, and agc (automatic gain control) to help maintain that linearity. On the other hand, fm reception is basically nonlinear: you need limiters to remove all amplitude variations from the signal. And fm detection systems differ radically from those needed in a-m or ssb systems.

An a-m i-f strip

Figure 1 (top) shows a block diagram of an a-m i-f strip. A high-performance age stage (80-dB range) is preceded by one gain stage and followed by another. The gain stages isolate input and output circuitry from y-parameter shifts as age-stage gain varies.

Balanced construction on the chip gives you a dc output voltage that is constant with varying gain. This means that you can have a fast attack or pulsed age and not induce ringing in high-Q tuned-interstages. Output from the second gain stage couples externally to the third-stage input via a lumped bandpass filter (or a single capacitor, for broadband applications).

Putting the selectivity in the middle of the strip’s total gain reduces the noise bandwidth of signals reaching the detector, as compared to strips in which selectivity precedes all gain. Similarly, placing the agc section after the first-stage gain gives less fixed gain between age and

*Fig. 1. The LM373 connected as an a-m i-f strip with agc.*
detector, and thus less output noise at higher input signal levels than when age precedes all gain.

An active detector follows a total of four gain stages. It not only detects, but also gives you some audio gain and an age output. The age voltage is externally filtered and fed back to the age-stage control input.

Each gain stage is an emitter-coupled limiter which, for a-m, operates in its linear region. Because such stages limit without saturating, large impulse-noise spikes superimposed on a constant-carrier a-m signal cause the first and second stages to limit momentarily. This action reduces both spike amplitude and ringing in any high-Q, lumped, bandpass filter that may follow stage two. Limiting in the last gain stage reduces the effect of spikes upon the active detector, allowing fast recovery.

The bottom sketch in Fig. 1 shows a circuit realization of the block diagram. It is useable in a-m receivers at all standard intermediate frequencies up to 12 MHz. Because the output impedance at pin 9 is about 70Ω, you need a series resistor for any high-Q filters whose shape factor deteriorates when driven from other than the manufacturer's recommended source impedance.

Only a small amount of unbalance in the balanced mixer gives you maximum gain in the fourth stage. The 10-kΩ resistor from pin 6 to ground does this, because it acts as a voltage divider with the internal 3-kΩ biasing resistance at that point. Do not ground pin 6 directly, since this will forward-bias the junction capacitor (used only for fm), and the strip will draw excessive supply current.

A 0.1-μF capacitor at pin 8 smooths the active-detector output. An RC network consisting of a 10-kΩ resistor to pin 1 bypassed by a 1-μF capacitor (or larger, for slower age action), operates the age loop. The optional resistance to ground lets you externally adjust the age threshold.

The dc feedback loop at pin 3 must be carefully bypassed. You need a large capacitor to prevent unwanted feedback from distorting the audio modulation envelope, and a small rf bypass to make the loop ineffective at the desired i-f. Lead length is important, since inductance in either pin 3 or 5 makes bypassing ineffective, and may cause oscillation.

For 455 kHz, assuming a bandpass with negligible loss at the center frequency, the strip's useful input-voltage range (pin 2) is from 50 μV to 200 mV rms—an age range of 72 dB. Signals 100%-modulated produce about 700 mV pk-pk of audio output.

Meanwhile, back in the fm section . . .

The block diagram of Fig. 2 shows an fm i-f strip. For this purpose, the age is defeated and each emitter-coupled gain stage becomes a symmetrical, non-saturating limiter. An external bandpass filter between the second and third stages provides nearly all of the needed receiver selectivity. The balanced quadrature-detector needs only a single external phase-shift element; this may be a parallel-LC filter for wideband fm or a quartz crystal for narrowband applications.

A crystal quadrature-detector is attractive for vhf fm receivers because it allows single conversion to a high i-f, where images aren't a problem, while giving large audio-outputs for very small deviations. Present nb fm vhf receivers must use double conversion to retrieve audio at a low i-f, where the ratio of deviation to center frequency is larger. The crystal quadrature-detector eliminates many components in such systems, and gives a detector with a center frequency as stable as the crystal itself.

Except for bandwidth differences, the input and bandpass circuitry of the fm i-f is similar to that of the a-m and ssb (Fig. 3) strips, with the same requirements of dc biasing, impedance matching, and quality of bypass elements. Grounding pin 1 simultaneously defeats the age and closes the internal switch to the junction quadrature capacitor on the chip. Thus, a 90° phase-shifted signal appears at the quadrature input, pin 6.

The wideband quadrature-element shown in the figure is a conventional parallel-LC network, with dc decoupling from pin 6. The narrowband element is a fundamental-mode quartz crystal.

Bypassing pin 7 removes i-f components from the audio output, and another bypass stabilizes pin 8.

At 10.7 MHz, with a bandpass filter of negligible loss, the strip begins to limit at 600 μV rms; first-stage overload occurs above 500 mV. With the narrowband quadrature element, you get 300 mV pk-pk audio for ±3 kHz deviations. The wideband element produces the same output for ±75 kHz deviations.

Because its gain stages are broadbanded, the LM-373's limiting and a-m rejection characteristics cannot equal those of a tuned emitter-coupled strip made of an equal number of single-stage amplifiers. For fm, limiting must occur not only in the fourth gain stage, but also in the third, since the third-stage output drives the quadrature port of the balanced mixer.

Practical receivers, therefore, may require more limiting gain ahead of the 373. If another 373 precedes the fm i-f strip of Fig. 2, it may be either a limiter/amplifier, with output (not bypassed) from its pin 7, or an fm age amplifier. This latter scheme has merit in its ability to hold a constant drive level to the limiting amplifier's input, resulting in constant bandpass-filter phase and shape factors for varying signals. Certain crystal filters exhibit variations in these parameters as a function of drive level.

The configuration of the fm age amplifier is that of the a-m strip of Fig. 1, with output taken from pin 7 to drive the limiting amplifier, while the age loop operates exactly as it would for an a-m signal. Thus, in a-m/fm equipment, you can use the first (age) strip for a-m and both strips for fm with relatively little component switching when you change modes.
For cw/ssb buffs

Connected for single- or double-sideband (suppressed carrier) operation as in Fig. 3, the first stages operate linearly, as for a-m, and use the same age and bandpass-shaping arrangement. A doubly-balanced product detector follows the gain stages, and gives an audio output proportional to the product of the received signal with an externally-injected local oscillator signal.

Because the product detector is balanced with respect to both input and local oscillator signals, only a small amount of these signals appears at the audio output (pin 7), where such rf is bypassed with a small capacitor.

Since there is no carrier present, you create age action by peak detecting the audio output of the i-f strip. With appropriate external capacitance, this produces an age with fast attack and slow release. Gain is maximum up to about 2.1 Vdc at pin 1, and full attenuation is reached at about 2.4 V. You use the same system to receive cw signals, where you also need local oscillator (beat-frequency oscillator, or BFO) injection to produce an audible beat note. For cw rf gain control, you can use a manually-controlled dc age voltage at pin 1. The age system has a large audio-smoothing capacitor at pin 8 and an rf bypass at pin 1 to prevent instability.

The residual rf voltage at pin 7 is, ideally, the sum of the local oscillator and incoming signal frequencies (assuming that the audio is the difference). Practically, however, a slight unbalance in the mixer could allow the signal, the local oscillator, or both to leak through. If only the signal leaked through, it would help in operating the age detector. But if the constant, large-amplitude LO predominated, the age would act as if too large an audio signal were present, and reduce the system gain to an unwarranted low level. Bypassing at pin 7 is effective in solving this problem; however, you must be careful in using very low i-f’s, which must be distinguished from audio by the bypass capacitor.

Some applications may require precisely-nulled mixing. Figure 3 shows how you can inject (or draw) nulling currents into (or from) either pin 6 to balance the signal, or pin 3 to balance the local oscillator port. The injection at pin 3 is an error signal that drives the dc feedback loop in one direction or the other, letting you critically balance the collector currents in differential gain-stage four. Injection at pin 6 places a dc offset voltage across the LO port, nulling incidental dc offsets that may arise from unit to unit.

Because the mixer has conversion gain, the ssb system can operate with inputs somewhat below those possible for a-m. At 10.7 MHz, 40- to 50-µV signals operate the age loop, while max. input level, limited by the linear input range of gain-stage one, is still about 200 mV rms.
The whole is the sum of its parts

The circuitry between pins 2 and 9 of the pin connection diagram consists of the first-gain, agc, and second-gain stages, as shown here. A low dc input, such as a transformer secondary or a small shunt resistor, drives the differential input-stage single-ended, so that the rf input is dc-biased at the same voltage as that of the fixed input. The 50-Ω degeneration resistance that separates the differential emitters extends the 373’s agc range; it lets larger input signals be handled linearly in a and ssb applications.

Each side of the input differential-pair is the common-emitter first stage of a cascode amplifier. These stages drive the two common-base stages of the agc section which have their emitters tied together. One CB stage of each half drives a 1-kΩ resistor, but the other does not. If output, the transistors with loads are biased from 4V... Thus when the other two, which are driven from the agc CONTROL input, are held OFF by a control voltage more than 200 mV below 3V... (about 1.9 V), signal current flows through the loads and gives maximum first-stage gain, about 13 dB.

When the control voltage rises to 3V... it biases the common-base stages equally, and half of the signal current (as well as half of the dc current from the input stage) is shunted away from the signal-carrying devices. Gain falls about 6 dB. Further increase in the control voltage diverts all current away from the amplifying pair, so that any remaining gain arises from stray-capacitance coupling.

This circuit has a gain control range of more than 80 dB, and can handle large signals with little distortion. The dc current through the amplifying common-base stages goes to zero at minimum gain, so that the common-mode output voltage at their collectors rises. With good monolithic matching, the circuit stays balanced, so that a gain change does not cause a differential dc voltage.

The 20-dB second-gain stage has differential inputs, and responds only to a differential signal. Its single-ended output has a dc operating point which is unaffected by agc. The emitter-follower output stage gives a 70-Ω source impedance for driving interstage networks, and prevents load capacitance from degrading the second-stage bandwidth.

This balanced mixer serves as a quadrature detector for fm and a product detector for ssb reception. It is a cross-coupled version of the agc circuit. If all parts of the circuit are in dc balance, a differential signal from the collectors of stage four cancels at the output, as does a differential signal across the local oscillator or quadrature inputs. When balanced, the output is proportional to the algebraic product of the two input signals.

For any operation, you balance the mixer by a dc voltage at the LO input. More than 200 mV of unbalancing voltage turns one group of CB stages completely OFF, leaving only one side of differential gain-stage four connected to the load resistance. If you unbalance the mixer in the opposite direction, the phase of signals reaching the load will reverse.

To get quadrature detection for fm, drive one port of the balanced mixer with amplitude-limited fm signals, and drive the other port (the quadrature terminal) with the same signal, phase-shifted 90° at the center frequency. The phase shifter is an RC network made up of 3 kΩ in parallel with the real part of the quadrature impedance (externally connected to the quadrature input), and a small junction capacitor, part of the LM373 chip. Stage three’s output drives the capacitor when a switching arrangement, internally connected to the agc control pin, senses that agc has been defeated for fm operation. Otherwise, the internal quadrature capacitor is disconnected.

An output pulse train appears as a result of the 90° phase shift. Ideally, it is a 50% duty-cycle square wave, and its dc value is halfway between its positive and negative peak voltages. A resonant circuit attached to the quadrature input gives a 90° phase difference between the input and quadrature ports, at the tuned circuit’s resonant frequency. On one side of resonance, quadrature phase lags the input phase; on the other side, it leads. This gives the variations in output duty cycle shown in the figure.

Integration of these pulses gives an audio output proportional to duty cycle, and hence to frequency deviation. Because the pulse train’s amplitude is constant, the maximum peak-to-peak output is the same for any quadrature element. Positive and negative peaks occur at the element’s 3-dB points, and are the peaks of the fm detector S-curve.

You can see that the detector’s sensitivity to deviation, for a given tuned circuit, is adjustable by resistive loading of the quadrature terminal. This decreases Q and increases separation of the 3-dB points. Because of its very high Q a quartz crystal causes a large phase shift for very small deviations.

SSB operation also requires that you operate the mixer at its balance point. Since agc is operating, the built-in junction capacitor is automatically disconnected, and you inject the local oscillator, via a capacitor, into the same terminal used for fm quadrature elements. Mixing action is linear for small local-oscillator injection levels. Since the LO and signal frequencies are generally high, and since they cancel, only sum and difference frequencies appear at the output. Generally, one of the two will be nearly twice the signal frequency, while the other is audio, so that a simple bypass capacitor at the output completes the product detection process.
The third and fourth gain-stages, shown at the right, are conventional emitter-coupled amplifiers, each with 20 dB of gain. An emitter-follower between them reduces third-stage loading. A dc feedback loop, derived from several common-base stages in the balanced mixer following gain-stage four, sets the base voltage of one side of stage three to 2Vbc (1.4 V). The input of stage three is already biased at 2Vbc, so the dc feedback loop automatically balances stages three, four, and the balanced mixer. The regulated feedback voltage simultaneously provides base bias for stage one.

The last section of the LM373 is the peak detector, an op amp type feedback circuit. For a-m, its external output smoothing capacitor bypasses rf, but passes audio. As an audio detector, to provide agc voltage in ssb use it needs a larger capacitor, one that can't follow rapid audio variations. Using an emitter-follower to charge the larger capacitor gives true peak detection; that is, a rapid charge on peaks, and a relatively slow discharge between peaks, so that the audio detector constitutes a fast-attack, slow-release system for ssb.

The complete schematic of the LM373 shows the techniques used to hold the total number of pins to only ten. Pins 2, 4, 5, 9, and 10 serve the single functions shown. But all other pins perform multiple functions. For example, pin 3 connects a large external capacitor that makes the feedback loop ineffective at high frequencies. But it also provides dc bias for pin 2, and you can use it to inject an external dc current to manually trim the mixer balance.

Pin 1 is an agc control input; it also controls the internal switch that connects the quadrature capacitor in the fm mode.

Pin 6 can be used for LO/BFO input for ssb and cw reception, for connection of the fm quadrature element, as a terminal for the deliberate unbalancing of the mixer in the a-m mode, and for injection of an external dc current to balance manually the upper part of the mixer.

Pin 7 serves for audio output in the fm and ssb modes. You can also short it with an external parallel-tuned circuit for added selectivity on a-m, or use it as a video or rf output in either broadband or first i-f applications.

Pin 8 is the audio output for a-m, and also provides the agc voltage in both a-m and ssb modes.

A string of reference diodes and emitter-followers provide power supply decoupling and dc bias, so that you need only one power-supply pin for the entire if strip. You don't need individual stage decoupling capacitors; and each stage operates essentially from a regulated supply, reducing performance variations as the main supply voltage changes.

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**Fig. 4.** Here's the LM373 connected as a first i-f amplifier and a second mixer, for use in double-conversion systems. The configuration is similar to that of the ssb i-f strip of Fig. 3, with these exceptions: agc operates from a carrier (in this example); output isn't audio, but the lower i-f of agc may, instead, be controlled by the detector of the second i-f strip (when, for example, you need ssb audio-operated agc). System requirements may make it necessary to trap out the small amount of LO leakage at pin 7.

**Fig. 5.** Constant-amplitude/amplitude-modulated oscillator. Use the agc section of the 373 as an oscillator, and sense the rf output level with the fixed-gain/detector portion. This reduces the open-loop gain of the agc section to the minimum value to sustain oscillation at a fixed amplitude. You can use many types of frequency-determining networks in the oscillator feedback loop. Output is stabilized at that level where there is about 0.7 V pk-pk at pin 7. Since such an a-m agc circuit constitutes a closed-loop feedback system, you can inject an error voltage that disturbs the output amplitude by a proportional amount. The audio modulating voltage does just this; the result is an amplitude-modulated oscillator with closed-loop system a-m characteristics, and with distortion set by that of the 373's peak detector.

**TV, too**

With broadband, RC interstage components, the LM373 can handle video signals with bandwidths up to 12 MHz. Peak detection gives an agc determined by either the positive or negative peak value of the input signal, depending on stage four phasing. (Stage four is either inverting or non-inverting, depending on whether pin 6 is unbalanced by injecting or withdrawing a current from it.) You can gate the signal by applying ordinary 5-V logic levels to pin 1, or you can use a dc voltage at the same pin for remote, manual gain control.

Medium level, wide bandwidth video may be picked up at pins 9 or 4, while the agc is operated by the third and fourth gain stages, driving the peak detector. Pin 7 gives a higher gain, lower bandwidth output.

You can use the first, second, and age stages as an amplifier with about 32 dB gain and a 57-MHz bandwidth, if pins 9 and 4 are not connected together. With about 36 dB gain and a 15-MHz bandwidth, stages three and four can be used as a completely separate amplifier. If agc is not used in the first section, don't ground pin 1, as this will switch-in the quadrature capacitor. Instead, bias pin 1 from about 1.8 V, slightly below the region where attenuation starts but above the turn-on point of the quadrature capacitor switching section.

**Tomorrow's systems**

The 373 is a powerful tool for communications systems designers—one that will help convert existing discrete-component systems to microcircuit systems. It should also stimulate the realization of new system concepts which would otherwise be impractical or too costly.

And speaking of cost, these devices are modestly priced. The LM373, which operates from 0° to 70°C, sells for $4.73 each in quantities of 1-24, $3.73 ea. for 25-99, and $2.73 ea. for 100-999. The LM273, an industrial version for -25° to 75°C, and the LM173, a military version for -55° to 125°C, are somewhat higher in price. All versions will be in distributor stock by late summer.

**References**


Capacitor Problems That Require A Lot Of Self-Control...Chemically Speaking

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New material makes a better relay

In a standard reed relay, if you apply enough coil current the reed will close. Any additional current increases the magnetic force but doesn't influence the contact. If you decrease the current, the force is reduced and the reed will drop out at some point below the initial closure point.

To obtain a bi-stable or latching reed, you can put a small permanent magnet near the reed capsule. This magnet provides enough force to keep the switch closed after it has been operated by an external field. Much less coil current is needed than for the non-latching version.

The magnet force keeps the reed closed even if the coil current is decreased, because of the increased flux through the closed contacts. To release the relay, you reduce the permanent magnetic force below the levels needed to hold the switch closed. This is done by causing an opposing magnetic field which will subtract from the permanent's field.

Unfortunately, with this method, variations in reed configurations and in placement of the permanent magnet within the reed cluster create manufacturing problems.

In the new Hystereed, a saturable core material replaces the biasing magnets. This material's hysteresis characteristic is such that it can be magnetized by the current applied to the operate coil. Thus, when you apply current to the operate winding the reed closes and at the same time a magnetic field builds in the core. If the current is increased no further than point A of the illustration, the magnetic material will not be saturated, and reducing the coil current will drop the magnetic force back towards zero and the reed switch will drop out. Thus far, Hystereed operation is identical to that of a standard non-latching reed relay. However, if you increase coil current beyond point A, the core will saturate and when you reduce or remove coil current, the resultant residual magnetic force will keep the reed latched. As shown, this field is much greater than the force needed to keep the reed switch closed and any number of reeds can be added to the assembly without jeopardizing the dropout point of the individual switches.

You can unlatch the Hystereed by reversing current in the operate coil and demagnetizing the core material, or by using a second winding to produce the demagnetizing effect. When you apply current to such a release coil, and limit the excursion to point B, the magnetic force generated destroys the residual magnetic force. However, the coil current is enough to keep the reed closed until the release current decreases below the dropout point of the reed switch. The magnetic force now present in the core material is virtually zero and with continued operation of the release coil, the relay will behave as a standard relay.

The Hystereed can be operated as a non-latching relay on either the operate or release windings by limiting offset voltage is ±3 mV max. (A 10-kΩ balance pot in your circuit takes this down to zero.) The input bias current is ±40 pA max.

You can use power supply voltages between ±10 and ±18 V. Rated voltage is ±15 V, which gives an 8-mA max. quiescent current. Short-circuit protection is built into the device.

The ADO-101B has an 800-kHz typ. (400-kHz min.) gain-bandwidth product, with a straight-from-the-shoulders 6-dB/oct. gain roll-off, and a 0.6-V/µs min. slew rate. Open-loop dc voltage gain into a 2-kΩ load is 112 dB min. The common-mode rejection competes for attention with a very high 88 dB min. and a 10¹¹Ω min. cm input impedance. Differential input impedance is the same value, while

Op amp likes the military life

Protected by its hermetically-sealed metal case, and with its long-term performance assured by thin-film construction, this op amp stands ready to work for you in a wide range of environmental conditions.

The ADO-101B has terminal connections identical to those of the popular µA741 monolithic op amp, except for pin 2. The 101B's designers have wired its pin 2 to the metal case. This connection turns the case into an electrostatic shield which you may either ground or drive as a guard to enhance the amplifier's noise performance. The case, by the way, is a metal version of the 14-pin, dual in-line package; its 0.875-in. long, 0.55-in. wide (that's about 0.5 in.² of board area), and 0.17-in. high.
the current. Under these conditions, it will behave like a standard reed relay whenever there is current in the coil. By increasing the current in the operate coil, the reed can be made to latch; it remains closed after coil current is decreased to zero.

The new relay has been built with up to six form A reed capsules within a single package. In addition to form A contacts, form C and combinations of form A and form C have been packaged and operated successfully.

Because of the pre-biasing condition of the magnet in the ordinary latching reed relay, it takes very little coil current to close the reed switch. Result is a sensitive system where as little as a 1 V pulse causes closure in a nominally rated 24 V relay.

As the new relay doesn't have the permanent magnet pre-bias it takes a voltage of over half the nominal operating voltage to latch the reed switch. Once latched, it takes a 150 g shock to unlatch the relay. Shock, vibration or electrical transients can't close and latch the switch.

The relay can be pulsed and latched with a minimum of a 1½ ms pulse at nominal voltage. Cunningham Corp. Subs., of Gleason Works, Honeoye Falls, N.Y. 14472. (716) 624-2000.

Circle 252 on Inquiry Card

the 20-Hz, open-loop, output impedance is about 500 Ω. Into a 2-kΩ load, the output current can swing ±5 mA min.

Let's not forget that the 101B sports a FET input stage. This contributes not only to the input impedance specs, but also to the amp's noise performance. From 0.1 to 10 Hz, the equivalent input noise with a 50-Ω source is 3 μV pk-pk max., while from 10 Hz to 1 kHz the figure is 3 μV rms max. Typical numbers run half as large.

You can buy the ADO-101B for $95 apiece in 1-24 pc. quantities. It's made by Fairchild Controls, 423 National Ave., Mountain View, Calif. 94040. (415) 962-3833.

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The 3990 is a high-speed, computer-programmed, random-access, 2-D reed relay matrix. It has program input storage registers for direct interface to TTL positive or negative logic levels. Complete guarding permits high CMR in system uses. Instrument Products, 3M Co., 300 S. Lewis Rd., Camarillo, Calif. 93010. (805) 482-1911.
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This 1024 word by 8 bit/word ferrite core system is built on five interconnected circuit cards. The 4 µs random access system (FI-2) contains all decoding, drive, data and timing circuits. All I/O lines are terminated at a single connector. Ferroxcube Systems Div., Englewood, Colo. 80110. (303) 771-2000.
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DISPLAY TERMINAL
To replace keyboard/printers.

This self-contained, alphanumeric display comes in formats of 480, 512, 960 or 1,024 ASCII characters, displaying the complete set of 96 characters, including upper and lower case alphabets. The Uniscope 100 can operate as either a data entry or display device. Sperry Rand Corp., Univac Div., Box 8100, Philadelphia, Pa. 19101
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SURVEILLANCE RECEIVER
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WR-550 receiver covers from 3 kHz to 100 GHz in a single 1.2 ft³ assembly. It has demodulation for AM, FM, CW, and FM/FM signals. It will also demodulate SSB and other narrowband signals. A feature is an automatic search and track capability. Micro-Tel Corp., 1406 Shoemaker Rd., Baltimore, Md. 21209. (301) 823-6227.
Circle 204 on Inquiry Card

TONE CALLING TERMINAL
Expands touch calling system use.

Datatone RTCT (Receiver Tone Calling Terminal), lets any tone-button telephone location be used for control or computer input functions over any commercial or private communications link. No special line matching equipment is needed. Trepac Corp. of America, 30 W. Hamilton Ave., Englewood, N.J. 07631.
Circle 205 on Inquiry Card

DATAREED MATRIX
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This high speed signal routing instrument is capable of sequential operation at 250 ns intervals without waiting for actual contact closure. It has computer compatible logic levels to allow remote programming. Analog Digital Data Systems, Inc., 830 Linden Ave., Rochester, N.Y. 14625. (716) 381-2370.
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SIDEBAND RECEIVER
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The RF-505 is a freq. synthesized, digitally tuned, two independent sideband receiver, operating from 1.6000 to 29.9999 MHz. Tuning is in 100 Hz increments. Continuous tuning is available in the 1 kHz tuning control. Frequency stab. is ±1.0 ppm. RF Communications Inc., 1680 University Ave., Rochester, N.Y. 14610.

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Optical Electronics, Inc., P. O. Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

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OP AMP
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This hybrid op amp features a 5-μV/°C offset voltage drift. The OA104 has a FET input, and is housed in a dual in-line package. According to the maker, the latest techniques of hybrid technology, together with optimal selection of thin-film resistor networks and active devices, produced this stable, balanced circuit. The OA104's initial offset voltage is internally trimmed to better than 1 mV. The device is internally frequency compensated and short-circuit proofed. $50 ea., 100-pc. lots. Quantum Devices Corp., 15 W. Main St., Box 294, Bergenfield, N. J. 07621. (201) 385-9600.

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AUTOMATIC PROBE
For LSI wafers.

According to the manufacturer, this is the industry's first fully operational probe machine. An automatic system, it represents nearly two years of on-line testing. The 64 adjustable probes have less than 1-pF point to point capacitance. A probe head with a 7-ms inker mounts on a Model CE high-speed automatic probe machine. Drive and logic sections mount in a pull-out rear drawer. The machine can test 3-in. wafers, and may be had with 5-pitch, 10-pitch, or metric lead screws. Pacific Western Systems, Inc., 855 W. Maude Ave., Mountain View, Calif. 94040. (415) 961-8855.

Circle 260 on Inquiry Card

COPPER-BASED CONDUCTIVE INK
For thick-film circuits.

This ink costs 30 to 40% less than silver based inks, and, according to its maker, has excellent printing qualities. Patterns dry in about five minutes at 80°C. The ink's resistance range is from 15 to 40 milliohms per square mil. Adherence to alumina is excellent, and solderability is good. The ink's frit melts at 750°C. Firing should be in a protective nitrogen (or other inert gas) atmosphere with an oxygen content of 0.01% or less so that the copper doesn't oxidize. General Electric Co., Lamp Metals and Components Dept., 21800 Tungsten Rd., Cleveland, Ohio 44117. (216) 266-2451.

Circle 261 on Inquiry Card
Suffering from Pot Core tolerance pain?

(Take a powder and control it all the way).

Ferroxcube pot cores offer the magnetics designer extra performance and value because every step from powder formulation to final machining is under strait-jacket-tight control. And there are a lot of steps to be controlled: particle size, uniformity of properties, pressing, firing, grinding, testing. It takes precision all the way to give you pot cores with electrical tolerances that are the tightest in the business. That's why our pot cores are the choice of hard-nosed design engineers. Ferroxcube pioneered ferrite materials. Out of this experience have come some proprietary contributions to the art of mass producing pot cores. These are reflected both in a wide variety of pot core sizes and a range of bobbins and hardware accessories. All with prices you can live with.

Ferroxcube pot cores are stocked by distributors in your area. If you haven't yet designed around them and would like to experiment a bit before you buy, write for Bulletin 220-D. A quick scan will tell you which free sample pot core to ask us for.

Ferroxcube

Saugerties, New York
PORTABLE INSTRUMENTATION RECORDER
Four channels, three speeds, very low flutter.

A crystal-controlled, phase-lock servo drive gives a tape-limited speed accuracy of ±0.2% and minimum flutter. Model 3960A uses any four-channel combination of fm or direct record/reproduce electronics. FM mode signal-to-noise ratio is 46 dB min. at 15/16 ips, 48 dB min. at higher speeds (3/4 and 15 ips). At 15 ips, direct recording response goes to 60 kHz, fm to 5 kHz. The recorder uses 1/4-in. tape on standard 7-in. reels, and has built-in calibration circuitry for the fm mode. With four fm channels, the 3960A costs $4285. Inquiries Mgr., Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

PORTABLE SPECTRUM ANALYZER
Battery/AC powered; bright display; 10 Hz to 50 kHz.

Calibrated functions include: scan width, 10 Hz/cm to 5 kHz/cm; i-f bandwidth, 10 Hz and 100 Hz; sweep time, 3 ms/cm to 10 s/cm; vertical display, 30 nV/cm to 3 V/cm linear, 10 dB/cm (60 dB on screen) log. Sensitivity as a low-noise receiver is better than -140 dBm. Switch-selectable 50-Ω to 1-MΩ input impedances. Recording outputs and controls; 4-digit digital frequency readout. Called the 710-800, it consists of a Model 710 display unit and a Model 800 analyzer module. $2495. Microwave Div., Systron-Donner Corp., 14844 Oxnard St., Van Nuys, Calif. 91409. (213) 786-1760.

PUNCHED-CARD RESISTANCE DECADES
Digitally programmed with a hand punch.

Use this panel-mounted card reader to automate resistively-controlled equipment. It translates a punched digital number to an equivalent analog resistance function. Available in accuracies from ±0.1% to ±0.01%, the programmed-resistance repeatability is ±0.0025%. Operating temperature range is 10° to 40°C, with a TC of 25 ppm/°C. Needs 2 x 4.25 in. on panel, 6 in. behind panel. Model P413, ±0.1% accurate, six cards and a punch, $99. Model P413M, militarized for -55° to 125°C, $137.25. Program Electronics Co., 1733 West End Ave., New Hyde Park, N.Y. 11040. (212) 991-7484.

LOW-FREQUENCY COUNTERS
Tachometry, crystal checking, production testing, etc.

These counters offer a useful combination of features for the low-cost, low-frequency market. There is a full set of input conditioning controls; a 10-s time base position for resolution and accuracy to 0.1 Hz; BCD output; remote programming of all functions; and push-button operation. Input conditioning controls include a trigger level control, switch-selectable slope, and a two-position attenuator. You can use the counters for most waveforms. Three units can fit side by side in a 19-in. panel. Time Systems Corp., 265 Whisman Rd., Mountain View, Calif. 94040. (415) 961-9321.
Hi-Reliability from Weston is no put on.

When we say Hi-Reliability, we mean it! Weston offers units designed, manufactured and tested in complete conformance with MIL-R-39015. You'll find a designator stamped on every Weston Squaretrim® Hi-Rel pot in the 200 ohm to 20K range. This number verifies its failure rate and confidence level at full ¾ watt operating power. Design, materials and workmanship must be tops. Not to mention Weston's 45 to 1 adjustment ratio, patented wire-in-the-groove construction, and slip clutch mechanical protection which are standard features of these pedigreed models. Insist on the genuine item—Squaretrim Hi-Rel Model 313-160HS with flexible leads or 318-160HS with pins—in all critical applications. Contact the factory about other Hi-Rel values available, or see your local distributor. Daystrom potentiometers are another product of WESTON COMPONENTS DIVISION, Archbald, Pa. 18403, Weston Instruments, Inc. a Schlumberger company.
NEW LAB INSTRUMENTS

DUAL CONVERSION UP-CONVERTER
Covers communications satellite band without retuning.

This unit converts any 70-MHz i-f carrier to an rf signal between 5925 and 6425 MHz. Simply change the frequency of the local oscillator signal to the second up-conversion mixer, to change the converter's output frequency. Output level is -20 dBm (0 dBm, optional); 70-MHz input level, -10 to 0 dBm. Frequency repeatability, better than 5 ppm over a 5-yr. period; stability better than 2 ppm/month. Less than -125 dBW rf noise in any 4-kHz band. Model UC-5000 meets CCIR and ICSC requirements. Narcom Corp., 75 Commercial St., Plainview, N. Y. 11803. (516) 433-9000.

Circle 266 on Inquiry Card

AUTO-RANGING DIGITAL MULTIMETER
Reads to 10 µV and 10 pA; teleprinter/recorder outputs.

Push-button select a basic measuring range, and this instrument automatically selects one of three sub-ranges to display a best-resolution reading. The PM-2421 reads 10 µV to 1000 Vdc; to 500 Vac max. rms; dc/ac currents from 10 pA to 1.4 A; resistances from 0.01 Ω to 1400 MΩ. Maximum resolution is 10 pA in the 14-nA range, 0.01 Ω in the 14-Ω range, and 10 µV in the 14-mVdc range. DC voltage readings are accurate to 0.1% ±1 digit. Model 94430 accepts cables to 34-in. dia. Standard connector is BNC; TNC on request, but miniature connectors must be special-ordered. Operates 20 Hz to 250 MHz with your specified transfer impedance of 0.05, 0.1, 1.0, or 7.00. Rated output load is 50Ω. Model 94456 accepts 4-in. cables, has type-N connector, operates from 10 Hz to 100 MHz. Transfer impedances are 0.06, 0.1, 1.0, or 5.0Ω. Output load, 50Ω. Probes hinge open, clamp shut, and are available with other transfer impedances. Stoddart Electro Systems, 2045 W. Rosecrans Ave., Gardena, Calif. 90249. (213) 770-0270.

Circle 267 on Inquiry Card

HIGH-SPEED MINIVERTERS™
Throughput rates to 180 kHz; 12-bit format.

Three instruments each combine a multiplexer, sample-and-hold amplifier, and A-to-D converter for throughput rates of 90, 135, and 180 kHz. A short-cycle mode gives higher rates at fewer bits resolution. Capable of sequential and random address operation, the units handle up to 64 input channels in 8-channel plug-in increments. Input range, ±10 V. Sample-and-hold amplifier aperture time, 50 ns max. Overall accuracy of multiplexed units, 0.065% ±1 LSB. Optional control and indicator panel. $5800 to $8200 ea. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. (714) 546-7160.

Circle 268 on Inquiry Card

RF CURRENT PROBES
For measurements of conducted interference in cables.

Model 94430 accepts cables to ¾-in. dia. Standard connector is BNC; TNC on request, but miniature connectors must be special-ordered. Operates 20 Hz to 250 MHz with your specified transfer impedance of 0.05, 0.1, 1.0, or 7.0Ω. Rated output load is 50Ω. Model 94456 accepts 4-in. cables, has type-N connector, operates from 10 Hz to 100 MHz. Transfer impedances are 0.06, 0.1, 1.0, or 5.0Ω. Output load, 50Ω. Probes hinge open, clamp shut, and are available with other transfer impedances. Stoddart Electro Systems, 2045 W. Rosecrans Ave., Gardena, Calif. 90249. (213) 770-0270.

Circle 269 on Inquiry Card
Amco takes the sting out of styling with 33 new styling approaches that can be quickly and inexpensively applied to Amco stock modular enclosures.

Here's how the Amco INTERFACE-33 styling system works:

There are at least 33 different combinations of horizontal and vertical trim that can be added to Amco Custom & Semi-custom frames. In certain cases, these frames can also be interfaced with Amco Heavy-Duty Aluminum frames. The trim style works as well for one enclosure as it does for multiple-bay consoles. Different basic enclosure systems may be combined to take advantage of their particular features while still maintaining a unitized, custom appearance for the entire system.

INTERFACE-33 is versatile...

- 33 distinctly different styling combinations.
- 3 structurally different console systems... 2 in steel... 1 in aluminum.
- 10 different textured and semi-gloss finishes in two-tone combinations with high scuff and chemical resistance epoxy finishes.
- 12 different colors, including two neutral metallic finishes.
- 3 different pressure sensitive adhesive vinyl trims.

INTERFACE-33 is easy to use...

It looks different and it looks like it belongs. For example, the enclosure shown utilizes INTERFACE-33 style approach #14 which consists of horizontal trim and vertical trim:

A wood grain effect on the horizontal trim was also specified to enhance the styling effect.

You're not limited to the standard INTERFACE-33 styling combinations. Many different styling effects can be achieved through the use of various colors or vinyls on the enclosure panels or trim. Amco styling engineers will gladly assist in selecting your own protected styling approach.

The complete versatility of the Amco INTERFACE-33 system makes protected styling feasible.
NEW PRODUCTS

CONTROLLED INDICATOR
IC compatible.

This MTLED series indicator consists of a light emitting diode (L.E.D.) controlled by integral SS logic. It interfaces directly with RTL, DTL and TTL and operates from +5.0 V supply. The light source is a GaAs phosphide diode. Transistor Electronics Corp., Box 6191, Minneapolis, Minn. 55424.

Circle 210 on Inquiry Card

PHOTOVOLTAIC CELLS
Fast response time.

These silicon cells (Ultra-Cells) feature typical leakage of 2 µA –5.0 Vdc and 25°C. Typically an Ultra-Cell is two to three times faster than normal sensors with higher values possible under certain operating conditions. Sensor Technology, Inc., 7118 Gerald Ave., Van Nuys, Calif. 91406. (213) 873-1533.

Circle 213 on Inquiry Card

Si BRIDGE RECTIFIERS
For PC boards.

Miniature, single phase rectifier units in this series will accept inputs to 700 V rms and withstand PIVs to 1000 V. Maximum dc current is 2 A in amb. temps. to 30°C. However, the rectifiers are capable of reduced output current up to 130°C. Sarkes Tarzian Semiconductor Div., 415 N. College Ave., Bloomington, Ind. 47401.

Circle 216 on Inquiry Card

FLAT PACK SOCKETS
Provide low profile.

New 14 and 16 contact receptacles provide high density DIP packaging. Connectors are soldered into a circuit board giving mounting centers as close as 0.400 in. Installed it projects only 0.255 in. from board surface. Advanced Packaging, Inc., 1357 E. Edinger Ave., Santa Ana, Calif. 92707. (714) 547-3935.

Circle 211 on Inquiry Card

MODULAR POWER SUPPLY
With current limit foldback.

Model ACF supply has current limit foldback to protect both load and power supply from overloads. All models provide for 115/230 V input. Nominal vol. is adjustable ±10%. Load reg. is 0.03% and line reg. 0.01%. Scintillonics, Inc., 600 Fort Collins Ind. Park, Fort Collins, Colo. 80521. (303) 482-4752.

Circle 214 on Inquiry Card

DECODER/DISPLAY
Decoding done with readout head.

With the Midgi-Coder-Lite, Model M6-IC, you don’t need a separate decoder package to translate from 8-4-2-1 BCD code to seven segment displays. It is done within the readout head; with a total combined depth of only 3/16 in. Pinliters Inc., 1275 Bloomfield Ave., Fairfield, N.J. 07006. (201) 226-7724.

Circle 217 on Inquiry Card

BALUN TRANSFORMERS
Reduce noise in memory circuits.

The balun transformer series comes in a four transformer module compatible with 1cs as well as in discrete miniature cases. They feature ratios of primary ind. to leakage ind. as high as 6600:1. Balun transformers with primary ind. of 20 µH to 2000 µH are available. Pulse Engineering Inc., 560 Robert Ave., Santa Clara, Calif. 95050. (408) 248-6040.

Circle 212 on Inquiry Card

VHF/UHF FETs
Have a low noise figure.

These devices (2N3823, 2N4416 and 2N4416A) provide 18 dB pwr. gain at 100 MHz or 10 dB gain at 400 MHz. Noise fig. is 2.0 dB at 100 MHz or 4.0 dB at 400 MHz. They also have low capacitance (0.8 pF) and high gain (4500 µmhos). National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051. (408) 245-4320.

Circle 215 on Inquiry Card

CIRCUIT PROTECTOR
Senses and deflects transients.

Transtector® Circuit Protector can sense and deflect damaging transient voltages and currents in < 50 ns. It will then return the transient to nominal line voltage in < 500 ns. It also protects against sudden losses of voltage below acceptable operating levels. Transtector Systems of M & T Chemicals Inc., 3025 W. Mission Rd., Alhambra, Calif. 91803.

Circle 218 on Inquiry Card
Meet JR.
The world's first Guaranteed Forever miniaturized power supply.
Five times smaller. 50% better efficiency.
Competitively priced.
Write for complete catalog.
acdc electronics, inc.
2979 North Ontario St.,
Burbank, Calif. 91504.
NEW PRODUCTS

CRYSTAL FILTER
Center freq. is 40 MHz.

New 40 MHz crystal filter (Model P4012 AA) has a 3 dB bandwidth of 10 Hz, 20 Hz, 30 Hz, 40 Hz and 200 Hz. The 60 dB to 3 dB bandwidth ratio is 2.0 with a spurious rejection of 60 dB for narrow bands and 50 dB for wide bands. Microsonics, 60 Winter St., Weymouth, Mass. 02188.

Circle 219 on Inquiry Card

RF SWITCHES
For transient-free switching.

These rf switches cover from 0.2 to 500 MHz. High freq. components of the switching signal are suppressed 30 dB or greater. Schottky barrier diodes permit fast switching speeds. Less than 1 ns switching speeds and "on-off" ratios > 80 dB are specified. Relcom, 2329 Charleston Rd., Mountain View, Calif. 94040. (415) 961-6265.

Circle 220 on Inquiry Card

DESOLEDGER TOOL
For PCs and microcircuits.

Model 67-1 De-soldermaster draws unwanted solder into an asbestos trap by using a precision built continuous duty diaphragm pump. It allows the operator to desolder multi-contacts without damaging adjacent components. Scientific Industries, Inc., 55 Madison Ave., Hempstead, N.Y. 11550.

Circle 223 on Inquiry Card

OP AMP
Minimum output is 5.5 mA at ±11 V.

These low cost D-2 series devices feature input overvoltage and output short-circuit protection. Typical stability is 10 µV/°C voltage and 0.2 nA/°C current drift. DC open loop gain at rated load is 90 dB and freq. for full output is 50 kHz. Frequency for unit gain is 1.5 MHz. Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801. (516) 433-5330.

Circle 221 on Inquiry Card

PLASTIC SOLDER
Can be cured at room temp.

Eccobond 72-C is a two component electrically conductive adhesive that effectively replaces hot solders. Its price is one-fourth that of silver filled plastic solders, while the vol. res. is five times (0.01Ω cm). Emerson & Cuming, Inc., Canton, Mass. 02021. (617) 828-3300.

Circle 222 on Inquiry Card

COAXIAL SWITCH
In a subminiature package.

New SPDT switch combines good rf performance with broad bandwidth. Series 09-53 switches have excellent VSWR (e.g. at 12.4 GHz it = 1.25:1), and high inter-channel isolation to 18 GHz (e.g., 60 dB min. at 11 GHz and 55 dB to 18 GHz). Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles, Calif. 90030. (213) 246-6761.

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Circle 224 on Inquiry Card

DIGITAL READOUT
Meets Mil Specs.

Series 30 Digicator® modules have a character size of about 0.3 x 0.2 in. Maximum current per lamp is 20 mA max. at 5 Vdc. Rated life is 50,000 hrs. Light output is from 10 to 200 FL with standard lamps, and up to 1000 FL with higher current lamps. Discon Corp., 1150 Northwest 70th St., Ft. Lauderdale, Fla., 33309 (305) 933-4551.

Circle 227 on Inquiry Card

FLATPACK LEAD CUTTER
Trims individual leads.

The Model 1018 narrow end cutter has a tip width of 0.062 in., allowing adequate clearance of adjacent leads. Stop screw in shank prevents possible overpressure. Rated for cutting capacity of 0.006 x 0.020 in. maximum lead dimensions. ETM Corp., Monrovia, Calif. 91016.

Circle 226 on Inquiry Card

NPN DUAL TRANSISTORS
Low noise figure.

Series 2N2913-20 transistors have a NF of 3.0 dB max. at 1.0 kHz, breakdown voltages as high as 60 V, VBE matching of ±3.0 mV max., and VBE tracking accuracy of 10 µV°C at 100 µA. A high current gain of 150 min. is provided at 10 µA. Qualidyne Corp., 3699 Tahoe Way, Santa Clara, Calif. 95051. (408) 738-0120.

Circle 226 on Inquiry Card

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Circle 227 on Inquiry Card

The Electronic Engineer • June 1969
I've been itching for a FORUM on molded cable assemblies. I say you can't beat the solder or screw connected assemblies when it comes to fast repairs in the field.

How about less repairs to begin with? Failure incident rates have proven to be less with molded cable assemblies. Pull tests show why molded assemblies are 50%-100% stronger than soldered plugs. Solder types, like the one shown in fig. 1 (bottom) broke at forces as low as 24 lbs. In fact, in the tests we’ve run, the cable itself broke before it would pull out of the molded plug.

But when it does break, you're finished. That could mean expensive equipment down-time unless it can be quickly repaired.

Let’s say the molded assembly does break. If you clip off the damaged plug and replace it, you’re still better off than with solder or screw type connectors. You want better aspirin: we say, eliminate the headache in the first place.

Repair costs can be expensive, too. Especially, if the connection is poorly soldered and shows up as an intermittent defect. Add this to the possibility of non-molded plug handles coming loose from vibration, poor shielding from moisture and contaminants, or excessive strain due to plug and cable size mis-matches and you’ve got yourself a potential profit-killer.

O.K., I’ll have to concede your point as far as the cable-plug connection is concerned. But, you’ll have to admit that when the molding holds the plug parts together, plastic cold flow can loosen the plug tip and kill reliability.

You’re right. That’s why Switchcraft doesn’t mold the plug components together.

Fig. 2. shows how we start with a one-piece tip rod, connector and insulators, with the rod solidly staked into the tip terminal. After soldering the center conductor, a bridge sleeve is crimped around the cable and connector flange prior to molding. No tip loosening, no cable strain.

I’m almost convinced. Now give me the bad news about the cost of molded cable assemblies vs. solder or screw types.

Brace yourself. Think of what it costs your company to order, stock, assemble and test the cable assemblies you’re now using. Compare your total costs with the price we’ll quote for a comparable molded cable assembly, and you’ll be money ahead. And that doesn’t even include the cost-savings you’ll get from the added reliability of our molded cable assemblies.

That’s great for phone and phono plugs, but we often get into some pretty oddball applications where we need a different type of connection.

You name it, we can produce it. Most of the time, one of our standard straight or right angle phone or phono plugs, microphone connectors or extension jacks will do the job. If not, Switchcraft has the know-how and high production machinery to run an economical, custom-molded unit to your specs. Just circle the reader service number for more info on these standard and custom made molded cable assemblies.

Sounds good, but how can my staff get further technical details on specific applications that back up what you’ve just told me?

Simple. Have them join the FORUM by writing their questions or comments on your company letterhead. We’ll send our “Forumfacts on Molded Cable Assemblies” handbook, and also add their name to our TECH-TOPICS mailing list. Every other month, they’ll receive this engineering application magazine that we’re sure will be useful and interesting to them. 10,000 design engineers can’t be wrong!!
NEW PRODUCTS

PARAMETRIC AMPLIFIER
For dc to 1 kHz ranges.

Model RA-12 If amplifier is for use where min. system noise, indiscernible input noise current, high input impedance and high common mode rejection are desired. Gain, adjustable through ext. feedback resistors, normally is from 60 to 100 dB. Amplifier input is fully differential and floating and is completely separated from the feedback circuitry, preventing the possibility of any ground loops between sensor elements and recording equipment. Texas Instruments Incorporated, Box 5621, M.S. 938, Dallas, Tex. 75222.

Circle 228 on Inquiry Card

VARIABLE ATTENUATOR
Weighs less than 6 oz.

Voltage variable attenuator Model AM7000A can also be used as a switch or modulator in systems where low VSWR and system accuracy are critical requirements. This device is available with standard PIN diodes or optional PN types for greater switching speed. Specs. include: Freq. range: 1-4 GHz; insertion loss (0 mA): 2 dB max.; dynamic range (50 mA): 40 dB min. from 1-2 GHz, 50 dB min from 2-4 GHz and VSWR: 2.0 max. Alpha Industries, Inc., 381 Elliot St., Newton Upper Falls, Mass. 02164 (617) 969-6480.

Circle 229 on Inquiry Card

COAXIAL CONNECTOR
Solderless SMA type.

Until now, all Mil-C-39012 Type SMA connectors have been the solder type. However, these new connectors are mechanically terminated to the cable, avoiding any possibility of heat damage to cable dielectric during assembly. They can be salvaged for reapplication to another cable if necessary, and are intermateable with existing Type SMA connectors. This 50Ω subminiature unit is usable up to 12 GHz with a VSWR < 1.02 + 0.0067 (f in GHz). Rf leakage is -78 dB at 2.5 GHz. AMP Incorporated, Harrisburg, Pa. 17105. (717) 564-0101.

Circle 230 on Inquiry Card

New from IGC: sintered form of the industry’s best alnico 8.

You might be able to get sintered alnico 8 somewhere else—but not like this. Our HyCo 8 has the greatest coercive force of all sintered alnicos. Typically, 1500 oersted for HyCo 8B, and 1800 oersted for 8H.

Sintered alnico 8 is well suited for miniaturized applications requiring a high coercive force. Typical uses include motors, TWTs, polarized relays, reed switches, pick-up cartridges, core meters, and holding and torque transmitting devices. And sintered has it all over cast alnicos when it comes to smoother surfaces, closer tolerances, physical strength, and flexibility of shapes.

For the complete characteristics and further details on sintered HyCo Alnico 8B and 8H, write Mr. C. H. Repenn, Manager of Sales, Indiana General Corporation, Magnet Division, Valparaiso, Indiana.

INDIANA GENERAL
We make it easy for the design engineer.

120 Circle 54 on Inquiry Card

ELROY

"Who cares who lowered the temperature... What's he doing in there in the first place?"
increase ic yield


Coors Porcelain Company
Golden, Colorado 80401

Circle 55 on Inquiry Card
NEW PRODUCTS

REED RELAY
Only 0.43 in. long by 0.2 in. dia.

This microminiature relay has a 0.1 A contact current, 150 mW sensitivity, up to 28 Vdc coils, −65°C to +130°C, shock 50 g/11 ms, vibration 30 g up to 300 Hz, approximate weight 0.7 grams (0.02 oz.) type SM. Amec, c/o Nortec, Box 246, Thomaston, Conn. 06787. Circle 231 on Inquiry Card

CIRCULATOR/ISOLATOR
Operates from 1 GHz to 2 GHz.

Miniature junction circulator can be used as an isolator by terminating one of its ports with a 50Ω load. It has 19 dB isolation, 0.5 dB insertion loss and 1.3:1 VSWR. Addington Laboratories, Inc., 1043 DeGiulio Ave., Santa Clara, Calif. 95050. (408) 248-5511. Circle 234 on Inquiry Card

SWITCH BANKS
Only 3/4 in. high

Available non-illuminated or illuminated with color coding. Switches are on 1/2 in. centers. Up to 12 stations in multiples of two. Contacts are rated at both 11/2 and 10 A at 115 Vac resistive. Up to 4PDT/station. Guardian Electric Mfg. Co., 1550 W. Carroll Ave., Chicago, Ill. 60607. Circle 237 on Inquiry Card

VHF/UHF PREAMP
Frequency range is 150 kHz - 1 GHz.

Type 1237 is a low-noise, low-level, transistorized amplifier for use as a general-purpose amp., preamp., and isolator. It consists of a 3-stage amp., a 30 MHz stop-band filter, and an ac power supply. General Radio Co., 300 Baker Ave., West Concord, Mass. 01781. (617) 369-4400. Circle 232 on Inquiry Card

MODULAR PC CONNECTOR
For array-mounting on motherboard.

Mojo™ card-edge receptacle has a completely new contact that eliminates soldering when contact tails are press-fitted into plated-through holes in the board. Two module sizes are available: connector and modules use 4 dual-readout contacts (two 0.150 in.—center card positions) and one molded-in card guide. Center modules use six contacts (3 card positions) and are open-ended. Elco Corp., Willow Grove, Pa. 19090. (215) 659-7000. Circle 233 on Inquiry Card

CHIP THERMISTORS
TC at 25°C is −4.4%/°C.

These inexpensive thermistors come in sizes ranging from 0.04 to 0.15 in.² with thicknesses from 0.012 to 0.035 in. They have values of 1200 to 20,000Ω. Max. op. temp. is 130°C. Standard res. tol. ±10%. National Lead Co., TAM Div., Hyde Park Blvd., Niagara Falls, N.Y. 14305. Circle 235 on Inquiry Card

SUBCARRIER VCO
Uses hybrid ICs.

Model 870, microminiature VCO offers freq. stab. to within ±1% of the ±7.5% deviation band (1-18) or ±0.5% of the ±15% deviation band (A-E) and linearity better than ±0.1% (BSL) of the deviation band. Individual units cover bands 1-18 and A-E and are compatible with IRIG telemetry stds. Multitech Microelectronics, 583 Monterey Pass Rd., Monterey Park, Calif. 91754. (213) 282-3161. Circle 236 on Inquiry Card

THUMBWHEEL SWITCH
It's only 5/16 in. wide.

These binary and decimal-coded Model M switches are rated from 0.5 to 50 Vac or dc. They will handle a 0.1 A res. load at rated voltage. Current carrying capacity is 1 A. Contact res., including printed circuitry, is 0.07Ω. Interswitch, 770 Airport Blvd., Burlingame, Calif. 94010. Circle 238 on Inquiry Card

VIBRATION EXCITER
Rated a 1200 force pounds.

High "g" vibration exciters. Model VP-120 meets vibration test requirements on components and sub-systems specified in Mil. Stds. 202, 810, 883, 750. It uses the company's "Link Arm" suspension system for increased reliability. It has a wide freq. range—1.5 to 5000 Hz; large mounting surface—7 in. dia.; low distortion and transverse motion. AGAC-Deirtor Inc., Box 358, Alexandria, Va. 22313. (703) 836-4641. Circle 239 on Inquiry Card

122

The Electronic Engineer • June 1969
When someone keeps telling you to be broad-minded and to get the "big-picture," aren't you often tempted to reply that sometimes a narrow point-of-view can be even more valuable? For example, one of the greatest race horses that ever lived, parlayed a narrow point-of-view into a fortune. By placing blinders on this horse, all extraneous objects were eliminated and he could concentrate on the immediate problem—the finish line and getting there first.

Hewlett-Packard has their own set of "blinders" for engineers who want to take a "narrow look" at individual signals over a wide range of frequencies. We call them wave analyzers.

Let's start with the HP 302A. When a very narrow point-of-view is required, a special 1 Hz bandpass is available. This bandpass, combined with a sensitivity of 3 µV to 300 V, is ideal for differentiating closely spaced signals with wide variations in amplitude. This wave analyzer can be battery operated and covers the frequency range of 20 Hz to 50 kHz. The price, $1900.

Next in line is the HP 310A, a highly selective wave analyzer for the 1 kHz to 1.5 MHz range. 1 µV to 100 V. With selectable bandwidths of 200, 1000 and 3000 Hz, it is well suited for tape transport harmonic measurements, or frequency response and level measurements on carrier and radio systems up to 300 channels. Get direct readouts in volts or dB. All this capability for $2500.

And finally, the HP 3590A—the most automated wave analyzer you can get today. Covering a frequency range of 20 Hz to 620 kHz with built-in autoranging and electronic sweeping, the HP 3590A almost operates itself. With 85 dB dynamic range and 4 selectable bandwidths of 10, 100, 1000 and 3100 Hz you can separate closely spaced signals, characterize distortion, or analyze a frequency spectrum. With its plug-ins the HP 3590A runs from $3280 to $4800.

When a balanced input and selectable impedances are required, just add $150 to the price of a 3590A and get the HP 3591A.

So, if the "big-picture" has become a big pain then it's time to quit "horsing-around" and call your local HP field engineer for more information. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.
LOG PERIODIC ANTENNA
Reduced profile.

AN112F broadband antenna covers 1-12.5 GHz freq. range. Its small profile offers easier storage and handling for portable RFI/EMC surveillance uses. Outline dimensions are 8 x 6½ x 1¾ in., and it weighs under 1 lb. Electro Data, Inc., 3121 Benton St., Garland, Tex. 75040. (214) 276-6167.

Circle 240 on Inquiry Card

DECADE POTENTIOMETER
Terminal linearity is 50 ppm.

DP 310 Dekapot, newest in a series of stacked-decade, coaxial-dial voltage dividers, minimizes space while providing easy in-line readout. It has high resolution (0.0035%) and constant input impedance. Input resis. is 1, 10 and 100 kΩ. Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. 97229. (503) 646-4141.

Circle 241 on Inquiry Card

WIRE MESH
For EMI gaskets.

Higher frequency and magnetic field attenuation is possible with this tri-metallic, narrow wire mesh. It's good for use as the conductive element in EMI gaskets. It consists of a magnetic, ferrous alloy core; a mid-section of high conductivity metal, and an outer, contactor coating. Metex Corp., 970 New Durham Rd., Edison, N.J. 08817. (201) 287-0800.

Circle 242 on Inquiry Card

HV SILICON RECTIFIERS
Working ratings from 1 kV to 20 kV.

Miniature rectifiers in either glass envelopes or molded packages achieve a high power to volume ratio with low leakage currents. For miniature displays, photo-multiplier circuits and many industrial applications. Erie Technological Products, Inc., 644 W. 12th St., Erie, Pa. 16512. (814) 456-8592.

Circle 243 on Inquiry Card

WIDEBAND DC OP AMP
Guaranteed 500 V/µs slew rate.

Model 3260/25 is for D/A conversion, high-speed integration, fast pulse amp., fast sampling, peak detection, and broadband amp. It settles to 1% of final value in 100 ns (0.1% in 1-2 µs). It has an FET input stage with low bias current. Burr-Brown Research Corp., Internat'l Airport Industrial Park, Tucson, Ariz. 85706. (602) 294-1431.

Circle 244 on Inquiry Card

RADIAL LEAD WIREWOUNDS
Cut production time.

These resistors come in 3, 5, and 8 W sizes. Designated PC-58, they are for use where axial lead resistors are manually inserted in PC boards. When mounted in the PC board they reduce the overall length needed as compared to axial lead resistors. Standard range is 0.51 to 7000Ω. Ohmite Mfg. Co., 3601 W. Howard St., Skokie, Ill. 60076.

Circle 245 on Inquiry Card

DIL SOCKET
For PC board or chassis mounting.

This socket is available for 14 and 16 lead DILs with leads on 0.1 in. centers in row and 0.3 in. between rows. Accepts any package with round, square or rectangular leads with a cross section of 0.008 to 0.023 and 0.090 in. min. lead length. Robinson-Nugent, Inc., 800 E. 8th St., Albany, Ind. 47150.

Circle 246 on Inquiry Card

FLAT CABLE PLUG
For 14 conductor cable.

This plug (2P14-1) is for 28 gauge stranded 14 conductor flat cable. It comes unassembled, but it can be installed either at cable ends or at any desired bussing location. Designed for use with the company's 8136 series packaging panels, it plugs into IC pattern without soldering. Augat, Inc., 33 Perry Ave., Attleboro, Mass. 02703. (617) 222-2202.

Circle 247 on Inquiry Card

DECIMAL DISPLAY
Features IC logic.

DM500 series displays are self-contained plug-in units. The DM519 includes a decade counter with BCD outputs available to the connector as well as the decoder/driver circuit. The DM529 accepts BCD inputs for decoding and display. Computer Products, Inc., 2801 E. Oakland Park Blvd., Ft. Lauderdale, Fla. 33306. (305) 565-9565.

Circle 248 on Inquiry Card

The Electronic Engineer • June 1969
HYBRID DRIVER CIRCUIT
Increases current sinking capacity.

High performance lamp and relay driver has a 50 V output and a sinking current of 500 mA at 6 V. The SH2200 provides a combination of four input NAND gates and an inhibit (NOR) input. It can interface with all other current sinking logic circuits. The driver will also serve in display systems, tape readouts, go-no-go testers, and readouts of computer peripheral equipment. Other applications are in solenoid driving and memory and clock driving. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. (415) 962-3563.

Circle 249 on Inquiry Card

WIREWOUND POT
It's only 0.50 x 0.50 x 0.18 in.

Model 3255 Trimpot® is a subminiature 25-turn screwdriver adjustment pot. Specifications are:
- Std. res. range: 10Ω to 50 kΩ
- Res. Tol.: ±5% std.
- Op. Temp. range: -65 to +150°C
- Temp. coeff.: 70 ppm/°C
- Absolute min. res.: 0.5Ω
- Power rating: 1 W at 50°C
- Mech. life: 200 cycles without discontinuity
- Load life: 1000 hrs at rated power

In addition, Model 3255 is rated at 30 g vibration and 100 g shock. Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92507. (714) 684-1700.

Circle 250 on Inquiry Card

NPN POWER TRANSISTORS
Operate at frequencies to 5 MHz.

This family of transistors features:
- If capability (f is rated up to 40 MHz min.), fast switching speeds (typ. storage times from 400 ns at 2 A to 330 ns at 60 A), and HV capability (VCEO(sus) is rated to 200 V). They span a power range from 20 to 150 W and have peak collector current ratings from 10 through 75 A.
- Double epitaxial mesa process provides good gain linearity and low sat. voltages (typ. VCE(sat) ranges from 0.30 V at 2 A to 1.25 V at 60 A), insuring min. losses and increased operating eff.


Circle 251 on Inquiry Card

VARGLAS ACRYLIC SLEEVING
FOR CLASS F APPLICATIONS

Varglas Acrylic Sleev ing by Varflex will not soften, flow or blister—even at 155°C, for as long as 15,000 hours. In fact, it passes the thermal endurance test under MIL-1-3190 (latest revision).

Made of modified acrylic resin on Fiberglas braid, it is compatible with polyester, epoxy, phenolic or formvar coatings and is made to exceed military, IEEE and NEMA standards. Varglas resists acids, solvents, oils, alkalies, fungus and moisture.

Select from a wide range of sizes and coding colors. Immediate off-the-shelf shipment or one week for special production.

Send for free sample of this and 24 other sleevings.
VARFLEX CORPORATION
506 W. Court Street
Rome, New York 13440

Circle 57 on Inquiry Card

NEW LOW COST PROBE

Wentworth Laboratories’ Model PR-0100 Probe Assembly was designed specifically for thick and thin film applications. Features “snap-in” probe point, magnetic base, a 6:1 ratio joystick for fine positioning plus height and pressure adjustment.

Probe points available unwired or with one or two wires. Send for Bulletin 1068.

WENTWORTH LABORATORIES INC.
ROUTE 7, BROOKFIELD, CONN. 06804 — (203) 775-1750

$20 ea.

Circle 58 on Inquiry Card
Logic modules

This 416-page guide should be a useful reference for those who specify, design, manufacture, or apply solid-state logic. Presented in paperback form, the 1969 Logic Handbook covers logic modules and hardware.


RF power instruments

You will find 60 pages of data on a line of instruments for rf power measurement in this product catalog. The company's new rf standard Thru-line® peak wattmeter is one of the many items covered. Bird Electronic Corp., 30303 Aurora Rd., Cleveland (Solon), Ohio 44139.

Microwave products

This 140-page catalog lists a wide range of microwave products, including standard coaxial, waveguide, and millimeter devices. Catalog 20 also contains sections on attenuators, high sensitivity detectors, directional couplers, high power loads, filters, preselectors, and diplexers. Covered too is a complete line of miniature components. Microlab/FXR, 10 Microlab Rd., Livingston, N.J. 07039.

Hybrid microcircuits

Applications for hybrid microcircuits in lightweight and compact packaging designs are the subject of a 24-page guide. The reference explains how hybrid technology can achieve design functions not possible using monolithic ICs. It also explains the hybrid manufacture step by step, and outlines layout procedures for designing custom products. Listed too are 16 off-the-shelf hybrid products. Distribution Services, Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040.

Interface circuits

"Monolithic Interfacing in Computers," a 10-page application report, discusses three types of computer interfacing. It then describes new integrated circuits to serve these three interface areas—line circuits, memory drivers, and sense circuits. Other topics in Bulletin CA-122 are history, tradeoffs between system advantages and problems, and general application examples. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, MS/308, Dallas, Tex. 75222.
This is the world's smallest all-pluggable DPM.

Then there's our less expensive model.

We brought out our 3½-digit compact DPM* just last March. It's the one that plugs into a panel slot only seven inches square, and pulls out for servicing or replacement. If you need the accuracy of 3½ digits, Model 1290 is still your best buy. But if you can settle for a digit less, you can have our new Model 1260 at less than half the price. Don't be fooled by the price tag, though... there's nothing "cheap" about this 2½-digit version. Housed in the very same plug-in case and fully compatible with its more sophisticated brother, Weston Model 1260 offers 0.5% ±1 digit accuracy—with far greater resolution capability than mechanical movements provide. Full scale reading is 199, with 25% over and under-range capability, remote command signal and Weston's usual high rejection characteristics. In addition to the convenience of front panel pluggability and circularly polarized viewing, we've included front panel calibration as a built-in bonus feature on the 1260. Write to the originators of the DPM.

WESTON INSTRUMENTS DIVISION, Weston Instruments, Inc., Newark, N.J. 07104.

WESTON®

*U.S. Pat. 3,051,893 and patents pending.
Operational-amplifier chart
This handy foldout chart lists key parameters for a line of integrated circuit op amps, including both military and commercial types. Product type numbers, physical characteristics, frequency compensation requirements, and specific advantages are included in the op amp guide. National Semiconductor, 2975 San Ysidro Way, Santa Clara, Calif. 95050.
Circle 331 on Inquiry Card

Video-detector nomogram
A laminated nomogram provides a convenient method for computing tangential sensitivity of video detectors. It allows solving for any one of four unknowns—noise figure (ratio), bandwidth, diode figure of merit, or tangential sensitivity—given the other three. The copyrighted nomogram is available from Microphase Corp., Greenwich, Conn. 06830.
Circle 332 on Inquiry Card

Memory systems
"Taking the Mystery Out of the Memory" is the title of an 8-page technical note, which provides basic information on electronic memory system interface. Definitions of terms are given and common memory and digital binary math are discussed. Ferroxcube Corp., Saugerties, N.Y. 12477.
Circle 333 on Inquiry Card

Special purpose tapes
A short-form catalog covers a line of special purpose tapes for a variety of applications. Chemical resistant, electroplating, insulation, and temperature resistant tapes are a few of the types shown. Mystik Tape, Borden, Inc., 1700 Winnetka Ave., Northfield, Ill. 60093.
Circle 334 on Inquiry Card

Electronic stroboscope
A 12-page pocket-size booklet explains the basic concepts of stroboscopy. Topics include how the stroboscope works and how you use it to measure speed. Accessories and applications are also covered in the primer. General Radio Co., 300 Baker Ave., West Concord, Mass. 01781.
Circle 335 on Inquiry Card

Acceleration transducers
A brochure features five different acceleration transducers for aerospace and oceanographic applications. They are available either as single-or multiple-axis sensors, with ranges as low as 0.25 g and as high as 200 g. Humphrey Inc., 2805 Canon St., San Diego, Calif. 92106.
Circle 336 on Inquiry Card

Telemetry components
Circle 337 on Inquiry Card

The Electronic Engineer • June 1969

Custom Wound Bobbins • In 10 Days

Custom wound bobbin samples are available in ten days; production shipments start within three weeks after sample approval.

Special 16 Pi/30 KV windings for oil-filled high voltage transformers ... special coils also are furnished on 10-day sample/3-week production delivery cycle.

Bobbins furnished in wide range of inductance and current ratings. If desired, Miller engineers will make recommendations for optimum performance.

J.W. MILLER COMPANY
P.O. BOX 5825 • COMPTON, CALIFORNIA 90224
Write for your copy of the latest full line catalog

Circle 60 on Inquiry Card
Magnetic shields

"Helpful Information for Designing a Magnetic Shield" is the title and subject of an informative 23-page article. The text is supported by tables of measured shielding ratios. Included too is a list of magnetic shields for CRTs, as well as a list of various brands and types of multiplier tubes and corresponding magnetic shield types. James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass. 02148.

Circle 338 on Inquiry Card

Power supplies

This catalog supplement contains 32 pages of data on the company's new products. Among these are integrated circuit power supplies, standard power supply assembly systems, and so forth. A handy selection guide is included. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746.

Circle 339 on Inquiry Card

Tube caps

A wall guide for a standard tube cap line is intended to help you solve connecting problems. The chart lists integrally molded cap connectors — available in polyethylene, nylon, CTFE, silicone, or phenolic—for high temperature, high voltage, high reliability applications. Insulation, contact, lead, and resistor data is included. Alden Products Co., 117 N. Main St., Brockton, Mass. 02403.

Circle 340 on Inquiry Card

Switches

A 6-page selection guide, No. 2007d, contains data on lighted push-button switches, word indicators, fuse holders, and circuit breakers. Un-

lighted switch assemblies and audio and visual warning and display systems are also covered. Descriptions, characteristics, and application data are given. Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. 92627.

Circle 341 on Inquiry Card

ASK MATHESON...

why $1 + 1 \n
\not\geq 2$

Matheson's understanding of gas technology combined with inherent advantages of gas phase processing make conversion to gas systems pay added dividends.

Consider the considerable advantages of gas phase processing

Contamination is minimized. For one thing, source limiting of impurities significantly reduces diffusion tube contamination. And there are no trace "heavy impurities." Troublesome vaporization processes are also eliminated.

Convenience is maximized. Introduction of vapors in high temperature processes is simplified to merely opening and adjusting a gas flow line. And gas systems are readily and conveniently adapted to automated control.

Matheson gas systems are designed with you in mind

For example, U. H. P. Ammonia for vapor deposition of silicon nitride. This grade of Ammonia has been specifically developed for use by the semiconductor industry. It affords greater reproducibility in dielectric constant of grown layers . . . a degree not normally obtainable with standard Ammonia.

Matheson can also help you with Ammonia systems. For example, High Purity, Stainless Steel Regulators for vacuum or purge systems. Or low cost Stainless Steel Gas Proportioners for blending the desired vapor concentrations in Ammonia systems.

This is just one way Matheson serves the electronics industry. Experienced, confidential, technical service is also offered. And don't worry — we'll help you with the installation.

Ask Matheson now — for our new catalog "Gases and Systems for the Electronics Industry". It contains extensive technical data on epitaxial and doping gases. Address: P. O. Box 85, East Rutherford, N. J. 07073.
mite-size relays with macro-size contacts

Couch 2X relays are true ½-size, yet the contacts are as large or larger than many full and half-size crystal can units. Couch 2X relays meet MIL-R-5757D/19 and 30/specs in ½ of a cu. in. Design simplicity and oversize contacts assure the ultimate in performance. Each relay is fully tested. Ideal for missile and aerospace switching applications or wherever reliability in small space is of prime importance. Available in many terminal styles and a wide choice of mountings.

Write for Data Sheets No. 9 and No. 10 today.

2X (DPDT) 1X (SPDT)

| Size     | 0.2" x 0.4" x 0.5" | same |
| Weight   | 0.1 oz. max.      | same |
| Coil     |                    |      |
| Operating Power | 100 mw or 150 mw | 70 mw or 100 mw |
| Temperature -65°C to 125°C | same |
| Vibration | 2G                 | same |
| Shock    | 75G                | same |

RUGGED ROTARY RELAYS - Dynamically and Statically Balanced

S. H. COUCH DIVISION
ESB INCORPORATED
3 Arlington St., North Quincy, Mass. 02171

Circle 62 on Inquiry Card

Audio amplifier IC

A 6-page condensed catalog highlights a new 1-W audio amplifier integrated circuit. Other products covered are 1.5- and 10-W zener regulators (6.8 to 200 V); 1-, 1.5-, and 3-A silicon single junction rectifiers; and 1.6-A full-wave bridge rectifiers. Trans-Tek, South Plainfield, N.J. 07080.

Circle 344 on Inquiry Card

Quartz crystals

A line of quartz crystals for control of frequency response is described in a 16-page brochure. Product applications, crystal specs, design considerations, and MIL reference tables are included. Also covered is a line of temperature control ovens. Erie Technological Products, Inc., 644 W. 12th St., Erie, Pa. 16512.

Circle 343 on Inquiry Card

Trimmer pots

An expanded trimmer potentiometer line is listed in a 32-page catalog. "Catalog B" describes six new rectilinear and square series film element trimmers, and also contains data on the company's single turn, wire-wound precision pots. Dale Electronics, Inc., Box 609, Columbus, Neb. 68601.

Circle 344 on Inquiry Card

High current SCRs

A line of high current silicon controlled rectifiers covering the range from 55 to 275 A rms are listed in an 8-page catalog. Operating characteristics are given in chart form. KSC Semiconductor Corp., KSC Way (Katrina Rd.), Chelmsford, Mass.

Circle 345 on Inquiry Card

CLASSIFIED ADVERTISING

GROWTH POSITIONS $12,000-$25,000
MANAGEMENT—ENGINEERING—SALES
RESEARCH—MANUFACTURING


Circle 63 on Inquiry Card
Transistors and microcircuits

A 12-page condensed catalog contains product data on a line of silicon transistors and microcircuits. Listed are single and dual n-channel junction FETs, p-channel single and dual MOSFETS, dielectric isolated monolithic npn's, and dual npn and pnp transistors. MOS shift registers, MOS micropower counters, MOS voltage comparators, FET analog gates, and flip chips are also covered. Inter-sil Incorporated, 10900 N. Tantau Ave., Cupertino, Calif. 95014. Circle 346 on Inquiry Card

Voltage regulator

A 25-page brochure discusses the design and application of a monolithic voltage regulator with foldback current limiting. A high-performance, short-circuit-proof regulator with high current capacity is described. Tables of physical and mechanical specs, and schematics that outline the various applications, are included. Transitron Electronic Corp., Wakefield, Mass. 01880. Circle 347 on Inquiry Card

Circular electro adapters

Electro adapters (or backshells) for circular connectors are the subject of a 40-page publication. Catalog EA-2-69 covers four basic product styles: environmental, non-environmental, EMI/RFI shielded, and unshielded. Helpful design, selection, and assembly data are presented. Electro Adapter, Inc., 8217 N. Lankershim Blvd., North Hollywood, Calif. 91605. Circle 348 on Inquiry Card

Switches

Catalog 50e contains about 90 pages of data on precision electrical switches. The source is conveniently arranged in eight product sections: limit switches, enclosed switches, explosion-proof switches, proximity switches, basic switches, small basic switches, mercury switches, and other switches. Also included is a glossary of switch terms, as well as a variety of design and ordering data. Micro Switch, a division of Honeywell, Freeport, Ill. 61032. Circle 349 on Inquiry Card

Designing an Electromagnetic Shield?

Let Magnetic Metals help WITH THIS

A complete reference book for the design, specification and purchase of drawn and fabricated electromagnetic shields. Data is given for both electrical and mechanical design considerations. Custom-made shields as well as standard shields are discussed in detail. Everything you need to know about Electromagnetic Shield Design is presented in clear, precise language. A valuable addition to the design engineer's technical library. Available FREE FROM MAGNETIC METALS. Magnetic Metals Company Hayes Ave. at 21st Street Camden, New Jersey (609) 964-7842 Ext. 321

The Electronic Engineer • June 1969 Circle 64 on Inquiry Card
Rectifier modules
A revised 20-page application note (N-130B) describes how to replace high-voltage, high-current rectifier tubes with stackable Doorbell® rectifier modules. These modules permit direct, plug-in replacement. Data on over 120 rectifier tubes, including maximum ratings and recommended module-type replacements, are given in table form. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172.

Heat-shrinkable polyolefins
A short-form catalog (6 pages) provides information on Insultite®—a family of heat shrinkable irradiated polyolefins. From the mil-spec variety to the new commercial-grade type, these polyolefins are designed to help you wrap up electrical insulation or encapsulation problems. Electronized Chemicals Corp., Burlington, Mass. 01803.

Monolithic linear multiplier
The MC15959, a monolithic, linear four-quadrant multiplier, is designed for applications where the output voltage is a linear product of two input voltages. Features, typical applications, electrical characteristics, and circuit schematics are presented in a 4-page data sheet. Technical Information Center, Motorola Semiconductor Products, Inc., Box 20924, Phoenix, Ariz. 85036.

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Custom-molded, extruded or machined to close tolerances to meet your exact specifications. Prompt delivery at low cost on large or small orders. Over half a century of service is your guarantee of complete satisfaction.

FIND OUT TODAY. Illustrated bulletin with complete technical data will be sent on request.

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West Coast Representative:
Yarbrough Sales Co., 1668 Orange Street, Alhambra, California • 'phone: (213) 283-0666
Microwave components

You will find 132 pages of product data on microwave components and packages in this new catalog. Each major product section is preceded by a technical guide on applications and available engineering options. About 200 new products are listed, including miniature designs in mixers, couplers, hybrids, attenuators, terminations, and video detectors. Sage Laboratories, Inc., 3 Huron Dr., Natick, Mass. 01760.

Circle 353 on Inquiry Card

Magnetic synchronous drives

In this 8-page guide you'll find instructions on how to design ceramic magnet axial gap synchronous drives for transmitting rotary motion through an air gap. Included are 13 sets of design curves relating torque to air gap. Also given is an example which solves an actual coupling design problem using the torque-gap curves. Indiana General Corp., Magnet Div., 405 Elm St., Valparaiso, Ind. 46383.

Circle 354 on Inquiry Card

Relays

A line of power, rf, and signal relays available in over 40 basic types is described in a 36-page design handbook and catalog. Besides product data, the publication contains contact code data for determining relay size, material, and resistive rating, and a relay parameter selection guide. Hart/Advance Relay Div., Oak Electro/Netics Corp., Crystal Lake, Ill. 60014.

Circle 355 on Inquiry Card

Monolithic integrated circuit

Application Report No. S-138 discusses the use of the TAA 300 as a complete audio amplifier. It provides a circuit description of this monolithic device, a discussion of its various properties, application notes, and schematics and graphs. Precautions to take when you use this IC are also listed in the 21-page report. Ampex Electronic Corp., Semiconductor and Microcircuits Div., Slatersville, R.I. 02876.

Circle 356 on Inquiry Card

You can imitate a Digiswitch but you can't duplicate it.

You can't duplicate a Digiswitch® any more than you could duplicate a sculpture by Rodin. Make a fair copy? Sure, but the knowledge, experience and skill that went into the original would be missing.

Digitran pioneered thumbwheel switches, and years of experience and improvement have established Digiswitch as the industry standard. And nobody comes close to duplicating our service organization, application library or scope of product.

Insist on an original. Digiswitch. The switch you can count on.

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The Electronic Engineer • June 1969

Circle 67 on Inquiry Card
More torque, Less weight in moving coil mechanism

Highly stable, linear and accurate mechanism for indicating, control or recording systems. 18-0-18° linearity is 1%. Coil design with over 75% of winding “working” in high energy, uniform field air gap assures greater accuracy. Coil system weighs 0.85 gm, develops 26.4 mmg of torque; 31:1 T/W. Mechanism offers negligible vibration pivots and jewels — custom damping — wide range of sensitivities.

AMMON
AMMON INSTRUMENTS, INC.
345 Kelley St., Manchester, N.H. 03105

Circle 68 on Inquiry Card

Packaged switches

Major reasons why engineers specify hermetically sealed switches are discussed in this 22-pager. Basic control circuits with schematics showing how to apply them are also described. In addition, Catalog B-3252 lists both off-the-shelf stock models and pre-engineered models of hermetically sealed switches, and shows some packaging solutions to complex control problems. Ledex Inc., 123 Webster St., Dayton, Ohio 45402.

Circle 357 on Inquiry Card

Molded inductors

A large product line, including a shielded inductor series, a molded inductor series, variable inductors, and custom devices, is covered in a 32-page booklet. Brochure No. 103068 also includes a handy cross reference list, as well as inductor color code data. San Fernando Electric Mfg. Co., 1501 First St., San Fernando, Calif. 91341.

Circle 358 on Inquiry Card

Numeric instruments

Mechanical, electrical, and electronic instruments and accessories are covered in an 8-page brochure (Form No. 1865). A listing of specs, features, and applications is included for counting, recording, and controlling devices and standard input devices. Veeder-Root, 70 Sargeant St., Hartford, Conn. 06102.

Circle 359 on Inquiry Card

FREE

Model S1301A

Get technical literature on the only totally portable, solid state oscilloscope. Operates from optional internal battery or from 110/220 vac, 50 to 400 Hz line voltage. Features include: 20 MHz bandwidth; 17 nsec rise time; 18 ranges of calibrated sweep speeds; internal voltage calibrator; and triggering stability in excess of 30 MHz.

Write for Bulletin TIC 3316 to Motorola Communications & Electronics Inc., 4501 W. Augusta Blvd., Chicago, Ill. 60651

Circle 70 on Inquiry Card
Regulated power supplies

The 67-pager features application notes and a glossary of terms used to describe regulated power supplies. Detailed specs are also given. Dept. D, Kepco, Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352.

Circle 361 on Inquiry Card

AC power transducers
AC power transducers which are used with graphic recorders, indicating meters, data acquisition and control systems and in telemetry are described in a 12-page catalog. A special feature of most units in the line is constant output current. Esterline Angus, Div. of Esterline Corp., Box 24000, Indianapolis, Ind. 46224.

Circle 360 on Inquiry Card

Voltage relays
Three types of voltage relays for under- and/or over-voltage protection are the subject of a 12-page brochure. Bulletin DB 41-200 discusses relay operation and construction using time curves and internal wire diagrams. Applications, features, and thermal capabilities are also covered. Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230.

Circle 362 on Inquiry Card

MOLDED NYLON, DELRIN & OTHER THERMOPLASTICS DESIGN GUIDE Shows how GRC's special methods for producing tiny, precision parts in all engineering thermoplastics can help you. GRC's exclusive die-cast limited cavity techniques offer quality and accuracy in small parts of diecast zinc alloy, Nylon, Delrin, and other engineering thermoplastics. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletins. Write, wire, phone NOW for samples and detailed bulletin.
A complete standard line of battery holders for use with all type batteries. Available for immediate shipment from stock, single or multiple holders.

- LOW COST
- STURDILY CONSTRUCTED
- LIGHTWEIGHT

Free engineering service for your special custom built holders.

A holder for every application. Also a complete line of Standardized Components or Modification of our Standard Line.

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- TERMINALS
- PLUG-IN HOUSING
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- PRE-PUNCHED BOARDS
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2. EASILY FED AND STAKED WITH EXISTING EQUIPMENT
3. NO COMPLEX, EXPENSIVE TOOLING
4. FLARES WITH ONLY 7 LBS. PRESSURE
5. ELIMINATES P.C. BOARD DAMAGE
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7. ELIMINATES FLUX ENTRAPMENT
8. ASSURES UNIFORM SOLDERING
9. SPEEDS PRODUCTION, ELIMINATES HAND SOLDERING
10. PROVIDES FOR THERMAL SHOCK

11. OFFERED AT THE SAME PRICES AS CONVENTIONAL EYELETS AND THEY ARE AVAILABLE FROM STOCK.

COMPLETE DETAILS ON REQUEST

Electroplating

"Precision Electroplating" is the title of a 10-page brochure which discusses the design and use of NobleCoat electrodes. Typical applications, electrode mechanics, and advantages are covered. Technical Service Dept., Engelhard Minerals & Chemicals Corp., 113 Assor St., Newark, N.J. 07114.

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Ceramic capacitors

This 12-page catalog, (E-1) contains a rundown of the company's subminiature ceramic capacitors. Capacitor types include: molded square, molded tubular, temperature compensating, ribbon lead, general purpose, uhf standoff, and high capacitance monolithic devices, among others. Republic Electronics Corp., 176 E. 7th St., Paterson, N.J. 07524.

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NEW FREE CATALOG ON REQUEST
Switches and accessories

Catalog 89 will give you detailed specs for a line of switches, which include snap-action, push-button, rocker-actuated, and toggle types. Glossaries of general switch terms and snap-action switch terms, along with a table of circuitry abbreviations, are provided. McGill Manufacturing Co., Inc., Electrical Div., Valparaiso, Ind. 46383. Circle 367 on Inquiry Card

Diode test instruments

The D-200 series is a family of automatic test instruments for go/no-go testing, evaluation, and classification of low- to medium-power diodes and rectifiers. A 12-page brochure gives details on these high-speed units, which are for use on production lines and at incoming inspection. Teradyne, Inc., 183 Essex St., Boston, Mass. 02111. Circle 368 on Inquiry Card

Microwave components

Microwave coaxial devices for operation through 18 GHz are the subject of a 12-page brochure. Among the components shown are electromechanical switches, solid state switches, filters, and a variety of directional couplers. Subsystems and assemblies are also covered. Automatic Metal Products Corp., 315 Berry St., Brooklyn, N.Y. 11211. Circle 369 on Inquiry Card

Fluoric cable

- Easy to install
- Self-contained harness
- Permits fast assembly
- Variety of colors for coding

Now you can get Natvar Flotube fluidic tubing in cable design of 7, 14, 21 and special configurations. Perfect for fast assembly and color coding of fluidic circuits. You get tight, leakproof connections that won't kink even on small radii. Available in all sizes for commonly used devices. Select combination of sizes needed and color combinations from 10 colors and clear. Send for technical data and Free samples. Circle 78 on Inquiry Card

New! High-Torque Reversible Synchronous Motor

Here's a newly-developed, low-cost synchronous motor you can use in your timing or drive applications where high torque, reversibility, or low power input are required. You can obtain .75 oz. in. at 300 rpm directly from the rotor, at an input of only 1.5 watts. The motor will operate efficiently with an input as low as 0.2 watt!

You can choose from four standard gearing systems if you need higher torque or lower speed — torque up to 100 oz. in., and speed as slow as one revolution per day. You can use either a single-phase or two-phase supply, and single-phase reversibility is obtained by merely changing one connection. Special models are also available. Send for technical data now.

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- Overload & Short Circuit Protection
- Repeatability 100 ppm
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- Supplied with 50 KV Output Connector

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Ask your local RCA Representative or your RCA Distributor for full details. Or write for technical data to RCA Electronic Components, Commercial Engineering, Section ICJ6, Harrison, N. J. 07029.

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