AUDIO TRANSFORMERS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DO-T44</td>
<td>120 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>9.8</td>
<td>11.5</td>
<td>500</td>
<td>DI-T44*</td>
</tr>
<tr>
<td>DO-T29</td>
<td>100 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>9.0</td>
<td>10</td>
<td>500</td>
<td>DO-T29*</td>
</tr>
<tr>
<td>DO-T12</td>
<td>90 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>8.5</td>
<td>10</td>
<td>500</td>
<td>DO-T12*</td>
</tr>
<tr>
<td>DO-T13</td>
<td>80 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>8.0</td>
<td>10</td>
<td>500</td>
<td>DO-T13*</td>
</tr>
<tr>
<td>DO-T19</td>
<td>70 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>7.0</td>
<td>10</td>
<td>500</td>
<td>DO-T19*</td>
</tr>
<tr>
<td>DO-T30</td>
<td>60 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>6.0</td>
<td>10</td>
<td>500</td>
<td>DO-T30*</td>
</tr>
<tr>
<td>DO-T43</td>
<td>50 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>5.0</td>
<td>10</td>
<td>500</td>
<td>DO-T43*</td>
</tr>
<tr>
<td>DO-T42</td>
<td>40 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>4.0</td>
<td>10</td>
<td>500</td>
<td>DO-T42*</td>
</tr>
<tr>
<td>DO-T41</td>
<td>30 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>3.0</td>
<td>10</td>
<td>500</td>
<td>DO-T41*</td>
</tr>
<tr>
<td>DO-T2</td>
<td>20 CT</td>
<td>50 split</td>
<td>32/32</td>
<td>2.0</td>
<td>10</td>
<td>500</td>
<td>DO-T2*</td>
</tr>
<tr>
<td>DO-T20</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T20</td>
</tr>
<tr>
<td>DO-T4</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T20</td>
</tr>
<tr>
<td>DO-T14</td>
<td>500 CT</td>
<td>5</td>
<td>75</td>
<td>43</td>
<td>50</td>
<td>500</td>
<td>DO-T14*</td>
</tr>
<tr>
<td>DO-T31</td>
<td>400 CT</td>
<td>5</td>
<td>60</td>
<td>43</td>
<td>50</td>
<td>500</td>
<td>DO-T31*</td>
</tr>
<tr>
<td>DO-T32</td>
<td>300 CT</td>
<td>5</td>
<td>60</td>
<td>51</td>
<td>50</td>
<td>500</td>
<td>DO-T32*</td>
</tr>
<tr>
<td>DO-T15</td>
<td>200 CT</td>
<td>5</td>
<td>60</td>
<td>51</td>
<td>50</td>
<td>500</td>
<td>DO-T15*</td>
</tr>
<tr>
<td>DO-T21</td>
<td>100 CT</td>
<td>5</td>
<td>60</td>
<td>53</td>
<td>53</td>
<td>500</td>
<td>DT-T21</td>
</tr>
<tr>
<td>DO-T3</td>
<td>100 CT</td>
<td>5</td>
<td>60</td>
<td>53</td>
<td>53</td>
<td>500</td>
<td>DT-T21</td>
</tr>
<tr>
<td>DO-T45</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T16</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T33</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T5</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T17</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T22</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DO-T34</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DI-T3</td>
</tr>
<tr>
<td>DT-T51</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T51*</td>
</tr>
<tr>
<td>DT-T37</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T37*</td>
</tr>
<tr>
<td>DT-T52</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T16</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T35</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T48</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T47</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T4</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T9</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T10</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T25</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T38</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T11</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T36</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T2</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T23</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T39</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T40</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T46</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T27</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
<tr>
<td>DT-T24</td>
<td>1000 CT</td>
<td>5.5</td>
<td>600</td>
<td>31</td>
<td>32</td>
<td>500</td>
<td>DT-T52*</td>
</tr>
</tbody>
</table>

Write for catalog of over 1,300 UTC HIGH RELIABILITY STOCK ITEMS IMMEDIATELY AVAILABLE from your local distributor.
Find Coax Cable Faults FAST!

Use the hp 140A Oscilloscope and 1415A Time Domain Reflectometer Plug-in!

Quickly find and identify such problems as water in cables, crushed cables, damage caused by flex and bends in cables, transmission difficulties in buried or hard-to-reach cables, cables damaged by temperature extremes, and bad connectors joining cables.

With the 140A/1415A combination, you can instantly locate problems in cables up to 600 ft. (to 3000 ft. with Option 14), and you can identify their exact nature—opens, shorts, resistive or reactive discontinuities. You can separate, on the scope crt, discontinuities as close as one inch—making Time Domain Reflectometry (TDR) ideal for analyzing connectors and checking coax switches and attenuators.

The 140A/1415A is calibrated directly in distance for air and polyethylene dielectric cables, and a special slide-rule furnished permits quick conversion for other dielectrics. With the scope and TDR plug-in you can measure characteristic impedance and dielectric constant of unknown cables, and recorder outputs permit recordings on any x-y recorder, for applications such as studies of cable degradation with age.

The 140A costs $575, the 1415A TDR Plug-in $1050. Besides accepting double-size special-purpose plug-ins, such as the 1415A, the 140A is useful as a general-purpose oscilloscope, accepting both vertical and horizontal plug-ins. Five vertical and two time base plug-ins provide maximum versatility. Performance includes sensitivities to 10 µV/cm, bandwidths to 20 MHz.

Contact your Hewlett-Packard field engineer for more information on the versatile 140A General-Purpose Scope... and especially on the 1415A Time Domain Reflectometer. A technical discussion of TDR techniques and their application is available, for the asking, in Application Note 67, “Cable Testing With Time Domain Reflectometry.”

You can get a copy from your hp field engineer or by writing Hewlett-Packard, Palo Alto, California 94304, Telephone (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Prices f.o.b. factory.
NEW wideband DC data amplifier for $495

including integral power supply

**SOLID-STATE  ★ DC—75 KC  ★ GAIN OF 1000  ★ NO CHOPPER**

Precisely measure thermocouple, strain gage and similar low level dc outputs with this high performance new Model 8875A Data Amplifier. Use it with modern data acquisition systems employing analog-to-digital converters, digital printers, magnetic data recorders, oscillographs, digital voltmeters, and other readout instrumentation. The new 8875A is a solid-state wideband dc amplifier with an output of ±10 v, 100 ma and features dc — 75 kc bandwidth, 1000x amplification, ± 0.1% gain accuracy, ± 0.01% gain stability, and 120 db common mode rejection — at $495 including power supply.

This new Sanborn amplifier measures just 4-3/4" high by 1-9/16" wide by 15" deep, weighs 3.5 lbs., including integral power supply. For multi-channel use, ten units can be mounted in a 5" x 19" modular cabinet which contains input and output connections, power cable, on-off switch, cooling, fuse, and mating connectors for ten amplifiers. These modules can be stacked, or equipped with tilt stands for bench-top use. When used individually, the completely enclosed amplifier requires no cooling.

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth:</td>
<td>dc to 75 kc within 3 db.</td>
</tr>
<tr>
<td>Gain:</td>
<td>from 1 to 1000 in seven fixed steps</td>
</tr>
<tr>
<td>Gain Accuracy:</td>
<td>±0.1%</td>
</tr>
<tr>
<td>Gain Stability:</td>
<td>±0.01%</td>
</tr>
<tr>
<td>Vernier Gain:</td>
<td>continuously adjustable between fixed steps.</td>
</tr>
<tr>
<td>Gain Trim:</td>
<td>±3% with sufficient resolution for setting any one gain to ±0.01%.</td>
</tr>
<tr>
<td>Common Mode Rejection:</td>
<td>120 db from dc to 60 cps, 40v p-p tolerance.</td>
</tr>
<tr>
<td>Output Circuit:</td>
<td>±10 volts across 100 ohms and 0.2 ohms max. output impedance at dc.</td>
</tr>
<tr>
<td>Drift:</td>
<td>±3 µv referred to input, ±0.2 mv referred to output.</td>
</tr>
<tr>
<td>Non-Linearity:</td>
<td>Less than 0.01% full scale value, 10 volts.</td>
</tr>
<tr>
<td>Overload Recovery Time:</td>
<td>recovers to within 10 µv R.T.O, ±10 mv R.T.O in 10 msec. for 10 v overload.</td>
</tr>
<tr>
<td>Power:</td>
<td>115/230 volts ±10%, 50-400 cps, 6 watts.</td>
</tr>
<tr>
<td>Available options:</td>
<td>Switch-selected filtering, dual output (±10v, ±10ma; ±10v, ±100ma; a short on one output has negligible effect on the other output).</td>
</tr>
</tbody>
</table>

For complete specifications and application assistance, call your local HP/Sanborn field engineering office, or write: Sanborn Division, Hewlett-Packard Company, 175 Wyman Street, Waltham, Mass. 02154.
Electronics Review

Page 39 Designed by computer 42 Fewer errors in Apollo data
40 Spending more for computers 44 ZIPping the mail
41 Faster, denser memory 46 TV camera on a block
41 3-D by vibration 48 Lighting up with scr’s

Probing the News

133 The 1967 budget: a blockbuster
133 Lion’s share to defense
134 A review and a forecast
138 Slowdown for NASA
141 Brakes applied in avionics
145 Gains on the home front
148 Factories of the future

Electronics Abroad

197 Are Russians scuttling Seacom? Controlling nuclear power
198 Color on demand Composition by computer

Technical Articles

I. Design

Microwave 72 Using strip transmission line to design microwave circuits
Part one of a survey examines design procedures for multipliers, filters and diode switches
J. R. Dangl and K. P. Steele, Sylvania Electronics Systems

Circuit design 84 Designer’s casebook
■ FET converts transducer for use in a-c bridge
■ Charge feedback increases pulse-rate meter accuracy
■ Low-cost emitter-follower extends voltmeter’s range

Instrumentation 88 Phase-locked marker improves spectrum analyzer’s accuracy
New approach overcomes the limitations of conventional spectrum analyzers
Charles W. Wilson, Georgia Institute of Technology

Components 95 Putting superconductors to work
New materials are expanding applications for superconductors
Donald K. Fox, Westinghouse Electric Corp.

II. Application

Communications 103 Automated ground station will check out Saturn
Computer-controlled telemetry is installed as the quantity of data received explodes
G. D. Shollenberger, Defense Electronics, Inc.

III. Manufacturing

Packaging 109 Simpler designs for complex systems
Two-sided boards simplify the organization of complex digital systems built of integrated circuits
Rex Rice, Fairchild Semiconductor Division
Readers Comment

Impossible may be possible

To the Editor:

I read with interest your article on the PAL Television system [Jan. 10, p. 239]. I wish to bring to your attention that J. Y. Roy, an employee of the Canadian Broadcasting Co., has done interesting theoretical work on a color-television system called PICS. His system is used in the receiver only to receive a standard NTSC signal, and some of the things you mention in your article as being impossible appear possible in the PICS system.

For example, equifand vestigial sideband is possible without crosstalk. It has been said that PICS will eliminate phase errors and no hue control is necessary on the receiver. Differential-phase errors are changed to desaturation without loss of resolution, vertical or horizontal.

I have heard that the system is simple and would cost little.

P. Herbert-Dupont
Mount Royal, Canada

A reader's tolerance

To the Editor:

The article by A. J. Talamini Jr. and E. C. Farnett of the Radio Corp. of America about optical radar data processing [Dec. 27, 1965, p. 58], states that a closed loop servo was used to hold the speed to one part in 10 million. I wonder if this is an error. This would seem to be an extremely close tolerance. I'd also like more details.

Donald Breslow
Itc Corp.
Lexington, Mass.

• Reader Breslow is right. It should have been one part in a million.

Counter recounted

To the Editor:

The logical arrangement of a BCD counter shown in the note by P. Ward of Texas Instruments [Dec. 13, 1965, p. 74] is not new. A decade counter using this design has been available from the Ger-
New from Sprague!

METANET® TRUE METAL-FILM PRECISION RESISTOR NETWORKS

Save Space, Time, and Money

- High packaging density—4 to 8 times that of individual components.
- Fewer components to stock, handle, inspect, install. Entire module can be hand-inserted faster than one axial-lead component.
- Permit substantial savings over equipment assembled with individual components.
- Epoxy terminal board keeps pin terminals free of resin coating, unlike conventional dipped components, and provides uniform lead spacing.
- Stand-off bosses permit efficient flux removal after soldering. Also prevent dirt and moisture traps around leads.
- Extremely stable and reliable. Meet performance requirements of MIL-R-10509E. Resistance tolerances to ±1%.
- Ceramic capacitors can be incorporated for further savings and size advantages over individual components.

For complete information write to Integrated Circuit Application Engineering Dept., Sprague Electric Company, 35 Marshall St., North Adams, Massachusetts 01248

SPRAGUE COMPONENTS

RESISTORS
CAPACITORS
TRANSISTORS
INTEGRATED CIRCUITS
THIN-FILM MICROCIRCUITS
PULSE TRANSFORMERS
INTERFERENCE FILTERS
PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS
CERAMIC-BASE PRINTED NETWORKS
PACKAGED COMPONENT ASSEMBLIES
BOBBIN and TAPE WOUND MAGNETIC CORES
SILICON RECTIFIER GATE CONTROLS
FUNCTIONAL DIGITAL CIRCUITS

S P R A G U E
THE MARK OF RELIABILITY

'Sprague' and '@' are registered trademarks of the Sprague Electric Co.
**Completely Automatic**

**CAPACITANCE BRIDGE**

*Just Insert a Capacitor... and Read the Answer*

---

**Direct Reading**... C and D (or G) indicated with decimal point and correct unit of measurement.

**Fast**... measuring rates up to 2 per second... works with scanner-type inputs.

**Accurate**... ±0.1% of reading for C and G; 1% ±0.001 of reading for D.

**Stable**...a true bridge whose accuracy depends only on passive standards and fixed transformer ratios and is independent of generator voltage variations and phase-sensitive-detector errors. Three-terminal configuration permits accurate remote measurements.

**BCD Output**... BCD (1-2-4-2 code) for data processing and recording.

---

**Wide Range**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>120c/s</th>
<th>400c/s</th>
<th>1kc/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitance</td>
<td>0.0001µF to 100µF</td>
<td>0.01µF to 1000µF</td>
<td>0.1µF to 10µF</td>
</tr>
<tr>
<td>Conductance</td>
<td>1µS to 1µS</td>
<td>0.1µS to 1µS</td>
<td>0.01µS to 1µS</td>
</tr>
</tbody>
</table>

Dissipation Factor: 0.0001 to 1.0 in one range

---

**Automatic Capacitance Bridge Assembly**

Type 1680-A... $4850 in U.S.A.

If you think a 1680 Automatic Capacitance Bridge can save you time and money and improve accuracy, why not write or call us for a demonstration?

---

**RCA Aerospace Systems Division**, Burlington, Massachusetts, has responded to the Department of Defense’s challenge to industry to attain new levels of product quality by instituting a company-wide Zero Defects program. For example, in their Purchased Materials Inspection Department, new test equipment has been installed to upgrade measurement techniques and accuracy. A GR Type 1680 Automatic Capacitance Bridge and Type 1137 Data Printer are now used for incoming inspection of capacitors, whereas a manually balanced bridge was previously used. Capacitance measurements were not only tedious and time-consuming, but were also subject to a considerable amount of human error. With the installation of the Type 1680 Automatic Bridge, a thirty-percent saving in time has been realized; accuracy has been increased ten times; and data is automatically and permanently recorded.
Nothing new department

To the Editor:

I was rather surprised to read about the "new" storage oscilloscope with a variable persistence facility [Nov. 29, 1965, p. 66]. The instrument very closely resembles the one developed by my company in 1956. The initial work was done for the Atomic Research Establishment at Harwell, the equipment being used during thermonuclear fusion experiments. An oscilloscope called the Remscope came into general use in 1958.

The equipment embodied early Hughes Memotron tubes, and later the English Electric E-702 half-tone direct-view storage tube, and for data transmission the Raytheon QK-685 "electrical - in electrical - out" tube.

The only difference between Kolar's equipment and the Cawkell 1958 Remscope appears to be in his use of a tube with two flood guns; this of course improves writing linearity and possibly collimation; the older tubes had one flood gun and an offset writing gun.

All of the facilities described by Kolar, including variable persistence achieved by variable duty cycle pulsing of the backing electrode, were included in the 1958 instrument.

It would have been very interesting had the author discussed writing speeds because this is a well known limitation of storage tubes. The English Electric tube would write at about 5 cm/µs, while 20 cm/µs was achieved on some later tubes. The CSE TEI-603 would write at about 30 cm/µs. It is believed that they have still not been exceeded.

In conclusion, the Cawkell instrument was probably the first storage oscilloscope in the world embodying the features mentioned; another version of the instrument is now being manufactured by Dawe Instruments, Ltd.

A. E. Cawkell
Middlesex, England

-The author replies:
While we were aware of specialized radar cathode-ray-tube displays which function in much the same way as our new variable persistence scope, we did not know of any other laboratory oscilloscope which made this feature available.

Reader Cawkell's comments on writing speed are also appreciated. We recognized this limitation and continued development. Model 141-A scopes now being delivered incorporate new circuits, added since the article appeared, to maximize this characteristic. For single shot transient storage, specified writing rate is one cm per microsecond. We believe this is conservative since all instruments observed to this time will easily produce a usable trace at 5 cm per microsecond. Ten cm per microsecond has been displayed on some. Among production storage scopes, this appears to be unusually good.

Bob Kolar
Applications engineer
Hewlett-Packard Co.
Colorado Springs, Colo.
how to convert resolver and synchro angles to digits
(and vice versa)

North Atlantic now brings you a new family of solid-state analog-to-digital and
digital-to-analog converters for resolver and synchro data. They offer a major advance
in conversion accuracy in modern navigation, simulation, data processing and
measurement systems.

Typical of these new instruments is the Model API-5450 shown here. It provides
both continuous and command conversion of both resolver and synchro angles,
accommodates all line-to-line voltages from 11.8 to 90 volts at 400 cps. Output data
is in decimal digits and is presented both as a Nixie-tube display and a five-digit
printer output with supplementary print command. Accuracy is 0.01° and update
time is less than 1 second.

All instruments in this family are designed to MIL-T-21200 and feature all solid­
state circuitry and precision transformers—there are no motors, gears, or relays.
Their flexible plug-in modular circuit design permits a wide range of variations to
suit your specific requirements. For example:

- 18 bit or 10 second accuracy
- binary, BCD, or decimal
- and resolution
- inputs/outputs
- multiplexed channels
- high conversion speeds
- multi-speed inputs/outputs
- other signal frequencies

Your North Atlantic representative has complete application information. He'll be
glad to help you solve interface problems in measurement and data
conversion. Simply call or write.

NORTH ATLANTIC industries, inc.
TERMINAL DRIVE, PLAINVIEW, L. I., NEW YORK • OVerbrook 1-8600

People

The North American Philips Co. has appointed John S. Auld general
manager of its Studio Equipment
division. He will
guide two moves by the
division: expansion of produc-
tion of the Nor­
elco Plumbicon
color television
camera and ex-
pansion into
other broadcast products areas.

Demand for the color tv camera, which was introduced last March,
was unexpectedly high, explains
Auld. The effort now is to step up
output to meet the surge in buying;
the division already has an order
backlog that will keep production
at full speed until the summer of
1967.

Both these goals fit Auld's back-
ground, which includes engineer­
ing, production and marketing. He
came to North American Philips
from the Fairchild Camera & Instru­
ment Corp., where he was gen­
eral manager of the Instrumenta­
tion division.

North American Philips' parent
company is Philips Gloeilampenfa-
bricken, N. V., of the Netherlands.

B. E. Simmons, a physicist who
heads the new
lab at the Syra­
cuse University
Research Corp.,
explains: “The
name does give a hint of the sci­
entific approach we'll be taking; it
will be a systems approach.” The
lab will try to synthesize the work
of a dozen or more specialties and
try to come up with an entire under­
water package. The package, for
example, could be an entire mil­
tary base on the floor of the ocean
says Simmons.

He explains that there's still
much development work to be per­
Looking for rugged 3 amp transistors?

Prabodh Shah speaks your language.

Prabodh Shah is one of our applications engineers. We call him Pete. Customers call him just plain great, because he's made available both 3 amp germanium DAP and alloy power PNP transistors. Over 60 types in all. All competitively priced. Available in TO-5, TO-37, stud nut MT-27 and hexagonal nut MT-28 packages.

You can use our DAP® (Diffused Alloy Power) transistors for audio amplifiers, pulse amplifiers, relay drivers and switching. Featured are switching times in microseconds without worry of secondary breakdown; high collector-to-base voltage $V_{CBO}$ to $-200$ V; high DC current gain: $\beta_{FE}=30$ to $90$ at $V_{CE}=-1$ V, $I_C=-0.5$ A; low collector cutoff current: $I_{CBO}=-3$ mA maximum at $+85^\circ$C; low saturation voltage: $V_{CE(sat)}=-0.2$ V typical with $I_C=-1$ A, $I_B=-0.5$ mA; excellent frequency response: $f_{T}>2.5$ MHz. All are SOAR (Safe Operating Area) specified.

Use our Alloy power transistors for solenoid drivers, small power supplies (inverter/converter), audio amplifiers and control circuits. They feature $V_{CBO}$ to $-100$ V, $V_{CBO}$ to $-60$ V, $I_C=-3$ to $-3.5$ A, $V_{CE(sat)}=-0.25$ V maximum with $I_C=-1$ A, $I_B=-0.1$ A; high DC current gain: $\beta_{FE}=20$ to $60$ at $-3$ A; $f_{T}>0.25$ MHz. All Bendix 3 amp Alloy transistors are SOAR specified.

Ten types are now available meeting military specifications. In addition, our commercial DAP and Alloy lines offer packages that meet MIL-S-19500, MIL-STD-750 and MIL-STD-202 environmental and mechanical requirements.

More information? Just phone or write our nearest sales office. If it's a particularly tough application, we'll have Prabodh Shah translate it into easy terms for you.

<table>
<thead>
<tr>
<th>TYPE NUMBER</th>
<th>$I_C$ (Amps)</th>
<th>$V_1$ (Volts)</th>
<th>$V_2$ (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAPS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N2282-2N2284</td>
<td>3</td>
<td>30 to 70</td>
<td>70 to 110</td>
</tr>
<tr>
<td>2N2467-2N2469</td>
<td>3</td>
<td>30 to 60</td>
<td>60 to 90</td>
</tr>
<tr>
<td>ALLOYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2N1038-2N1045</td>
<td>3.5</td>
<td>60 to 90</td>
<td></td>
</tr>
<tr>
<td>2N2552-2N2567</td>
<td>3.5</td>
<td>60 to 90</td>
<td></td>
</tr>
</tbody>
</table>

Bendix Semiconductor Division
HOLMDEL, NEW JERSEY

Baltimore, Md.—(301) 828-6877; Chicago—(312) 637-6929; Dallas—(214) 357-1972; Detroit—(313) 6-1420; Holmdel, N. J.—(201) 747-5400; Los Angeles—(213) 776-4100; Miami—(305) 887-5521; Minneapolis—(612) 926-4633; Redwood City, Calif.—James S. Heath Co., (415) 369-4671; Seattle—Ray Johnston Co., Inc., (206) LA 4-5170; Syracuse, N. Y.—(315) 474-7517; Waltham, Mass.—(617) 899-0770; Export—(212) 974-2121, Cable: "Bendixint," 605 Third Ave., N. Y.; Ottawa, Ont.—Computing Devices of Canada, P.O. Box 508—(613) TA 8-2711.
Did You Know Sprague Makes 32 Types of Foil Tantalum Capacitors?

100 C TUBULAR TANTALEX® CAPACITORS
Type 100D polarized plain-foil
Type 101D non-polarized plain-foil
Type 102D polarized etched-foil
Type 103D non-polarized etched-foil
ASK FOR BULLETIN 3602C
Circle 332 on reader service card

85 C TUBULAR TANTALEX® CAPACITORS
Type 110D polarized plain-foil
Type 111D non-polarized plain-foil
Type 112D polarized etched-foil
Type 113D non-polarized etched-foil
ASK FOR BULLETIN 3601C
Circle 333 on reader service card

RECTANGULAR TANTALEX® CAPACITORS TO MIL-C-3965C
Type 300D polarized plain-foil
Type 301D non-polarized plain-foil
Type 302D polarized etched-foil
Type 303D non-polarized etched-foil
ASK FOR BULLETIN 3650
Circle 334 on reader service card

TUBULAR TANTALUM CAPACITORS TO MIL-C-3965C
CL20, CL21 125 C polarized etched-foil
CL22, CL23 125 C non-polarized etched-foil
CL24, CL25 85 C polarized etched-foil
CL26, CL27 85 C non-polarized etched-foil
CL28, CL29 125 C polarized plain-foil
CL32, CL33 125 C non-polarized plain-foil
CL34, CL35 85 C polarized plain-foil
CL36, CL37 85 C non-polarized plain-foil
Circle 335 on reader service card

For comprehensive engineering bulletins on the capacitor types in which you are interested, write to:
Technical Literature Service
Sprague Electric Company
35 Marshall Street
North Adams, Mass. 01248

People

formed before the sea can be exploited. Some of the work will be building basic hardware—power sources, communications gear, transportation equipment; and some of it will involve "the social aspect of having man in the sea"—politics, economics and psychology.

"We'll be able to draw on the expertise of some 250 people" who work at the not-for-profit company, he says. And if needed, he can turn to members of the staff at Syracuse University, through which the company is chartered. The lab staff is made up of six senior scientists.

Enjoys building. Simmons describes himself as a "physicist with a little bit of the engineer in me. I don't like to limit myself to theory. Hardware is a means to an end, and I enjoy building."

"Look at it this way: it often takes longer to get from downtown New York to Kennedy Airport than from the airport to Washington," says Robert J. Shank, the newly named vice president of Cutler-Hammer, Inc.'s Airborne Instruments Laboratory division. It was with this problem in mind that Cutler-Hammer named Shank, a former associate administrator of the Federal Aviation Agency, to a post that will guide the division in the broad field of transportation.

"We'll be interested in all kinds of transportation, including high-speed trains," says the 51-year-old executive-engineer. The job will be to translate Cutler-Hammer's experience in such fields as avionics and materials handling to the task of transporting people. This move will mean a "shift in emphasis" for the company, explains Shank.

One project that Shank hopes to convince the company to pursue is the development of all-weather automatic controls for helicopters. "We're developing such gear for fixed-wing craft," he says, "but so far nothing has been done for the helicopter." Stabilization equipment for helicopters would have to be tailor-made because they are very unstable when flown on instruments, Shank adds.
200 kW power output with .7 kW drive from magnetically beamed Machlett triode

ML-8618, Machlett's new magnetically beamed water-cooled triode, provides high power gain, high plate efficiency and maximum cathode utilization. Electron trajectory from cathode to plate is magnetically controlled to greatly reduce electron interception by the grid... and therefore decrease grid current and heating and allow significantly higher performance levels.

Result: the ML-8618 delivers a typical 200 kW power output with .7 kW drive as a Class C rf amplifier or oscillator. As a switch tube in pulse modulators, it is capable of a maximum 8 Mw high duty pulse. For full operating details, write to The Machlett Laboratories, Inc., Springdale, Conn. 06879.
Planar II is the purest manufacturing process ever put into mass production.
By 1970 every semiconductor manufacturer will use it. You can wait. Or get it now from Fairchild.

Planar is a patented Fairchild process.
±1% tracking plus taut-band in 20 models, 9 styles—-with many in stock

API offers 1 percent tracking, at no extra cost, in virtually every popular DC panel meter style, size and sensitivity—clear plastic, black phenolic, or ruggedized-sealed.

As long as you specify taut-band construction, you'll automatically get ±1 per cent tracking—in all but the smallest and most sensitive API meters.

Taut-band is a bonus in sensitive meters

You don't even have to specify taut-band if you order meters in ranges from 0-3 to 0-50 microamperes and from 0-3 to 0-25 millivolts. These meters just naturally come with taut-band. Besides responding best to exceptionally small signals, this friction-less design is much more resistant to damage from shock and vibration.

(Taut-band costs a little extra for less sensitive meters than those named above. There's also a slight charge for 1 per cent tracking in sensitive ranges of 0-10 µa or 0-3 mv, or better.)

Immediate delivery for 10 models

Ten API panel meter models, in the most popular taut-band ranges, are now being stocked for off-the-shelf delivery.

New Bulletin 47 has full information on all API panel meters and pyrometers

Meetings


National Meeting on Space Applications, Communications, and Environment, American Astronautical Society; San Diego, Calif., Feb. 21-23.


International Fair for Electronics, Automation and Instruments, Danish Electronics Industry; Exhibition Hall, Copenhagen, Denmark, Feb. 25-March 6.

Conference on Nondestructive Testing, Society for Nondestructive Testing; Biltmore Hotel, Los Angeles, March 7-10.


International Convention and Exhibition of the IEEE; New York Hilton Hotel and the Coliseum, New York City, March 21-25.


National Association of Broadcasters Convention, NAB; Conrad Hilton Hotel, Chicago, March 27-30.


Digital Electronics Seminar, RCA Institutes, Inc.; Hotel New Yorker, N. Y., March 28-April 1.


Conference on Analysis and Synthesis of Networks, IEEE-NTG; Stuttgart, West Germany, March 31-April 1.

Industrial Engineering Conference, AIIE; Hotel Pontchartrain, Detroit, March 31-April 1.


Symposium on Electron and Laser Beam Technology, IEEE, University of Michigan; Ann Arbor, April 8.

IEEE Region III Convention, IEEE; Mariott Motor Inn, Atlanta, April 11-13.

National Telemetering Conference and Exhibit, ISA, AIAA, IEEE; Prudential Center, Boston, May 10-12.

Call for papers


International Telemetering Conference, International Foundation for Telemetering; Ambassador Hotel, Los Angeles, Oct. 18-20. June 1 is deadline for submission of completed manuscripts on theory and technological advances of telemetry in the fields of aerospace, military, earth sciences, life sciences, and industry to J. E. Hinde, 9231, Program Chairman, ITC/66, Sandia Corp., P. O. Box 5800, Albuquerque, N. M. 87115.

* Meeting preview on page 16
and watch Astrodata's new PAM/PDM Decommutator start a revolution in set-up and performance

Just blink once and you could miss all the set-up procedures necessary for Astrodata's new telemetry decommutator. It takes less than a second to hit the AUTO-SET button. The Model 603 Decommutator does the rest unattended, adjusting the level and gain of the input amplifier automatically.

**ABSOLUTELY NO RATE PLUG-INS**

Model 603 does away completely with rate plug-ins. Thumbwheel switches are centralized around the front panel for entire selection of frame length (up to 128 channels), rate (1 pps through 10,000 pps), and reference channels. Touch AUTO-SET and away you go. Calibrated, synchronized and ready to unscramble the noisiest signal, extracting good data from what would have been otherwise useless data in any other decommutator.

**HOW MUCH NOISE IMMUNITY?**

We are prepared to demonstrate that the Model 603 Decommutator offers the most noise immune PAM-NRZ performance ever available. For example, synchroniza-
Nine AUTOMATIC operations with this Cat-Whisker Welding Machine

by KÄHLE

This KÄHLE machine is fully automatic. It flattens the lead wire; then the whisker wire is fed, cut, transferred and welded to the flat with a synchronous electronic timer insuring a uniform weld. Finally, it forms to the required configuration. PRODUCTION RATE 3,000 TO 4,000 PER HOUR!

KAHLE Servos and Feedbacks detect rejects prior to completion of assembly

Instrumentation feedbacks and servos can be supplied that will reject faulty parts prior to assembly and product finishing... saving materials and time in production.

KAHLE Machines are Customer-approved under actual operating conditions

Your equipment is run in our factory, using your materials in the presence of your engineers; the machine is not shipped to you unless you approve it!

CONSULT KAHLE—Save time and money by letting professionals build your specialty production equipment for automation!

Kahle Engineering Company

3324 HUDSON AVE., UNION CITY, N. J.
Telephone: UNION 7-6500 (Area Code 201)

Meeting preview
Telemetry in Boston

Technical details of the European Space Research Organization (ESRO) satellite program will be described at the National Telemetering Conference in Boston May 10 to 12. Representatives from European industry and ESRO will discuss the over-all status of telemetry in Europe.

Three of the 22 technical sessions will be devoted exclusively to industrial application. A highlight will be the description of a new economical long-distance telemetry system for oil, gas, and railway companies. The San Francisco Bay Area Rapid Transit System's telemetry methods will be described. In the industrial sessions the Army Corps of Engineers will tell about a novel battery-powered telemetering device that can be dropped from an aircraft to provide terrain information to aid in deciding whether aircraft can land there.

In a panel session moderated by H. A. French of Trans-Canada Pipe Lines, Ltd., manufacturers and users will consider which characteristics in industrial telemetry equipment have to be defined more accurately to prevent confusion.

Many topics. The United States space programs will provoke many topics for the aerospace-telemetry sessions. System design concepts which suggest the laser's promise to compete with r-f in wideband deep-space communications will be assessed in a paper by a team of scientists from the Raytheon Co. Equipment used in the successful Mariner flight past Mars and planned for use in the Apollo lunar mission will be discussed. A panel on the clinical aspects of biotelemetry and two other sessions will describe the uses of telemetry in medicine. Dr. E. B. Johnson of ITT Federal Laboratories in California, a subsidiary of the International Telephone and Telegraph Corp., will present a paper on stimulating the brain with remote telemetry. A team of researchers from the Veterans Administration Clinic in Boston will discuss the advantages of telemetering medical data from a patient's home over testing in a laboratory.
ON YOUR MARK...

Kay 154: 50 KHz to 100 MHz
Kay 159: 1 MHz to 300 MHz

PM 7650 Plug-in:
Pulse Markers
0.5 to 100 MHz

PM 7660 Plug-in:
Harmonic & CW Markers
1 to 300 MHz

These solid-state sweep and marker generators cover the range in a single sweep; provide a continuously-variable narrow sweep.

Performance characteristics include line-lock, cw, manual and variable sweep rates, and external input.

PM 7650 and PM 7660 plug-in marker heads offer up to eight optional, individually-switched crystal plug-in markers per head.

A variable birdie marker provision is standard. All plug-in marker heads may be changed or added as required.

External modulation from dc up to more than 15 KHz, a built-in detector and switched attenuator are standard features. Sweep high-to-low or low-to-high.

For literature and prices write:

KAY ELECTRIC COMPANY
Pine Brook, Morris County, New Jersey • (201) 227-2000

Visit Kay at the IEEE Show, Booths 3C11 - 3C17
Tough Recorder Environments:
Kid Stuff!

Try leaving a couple of kids alone for ten minutes with a brand new toy. Result: the kind of chaotic environment Leach recorders thrive on. Like in-flight testing, automotive torture tests, hydrofoil recordings, etc. . . . if you can keep a transducer on it, we'll monitor the output.

Take the MTR-3200 for example. For a modest power input of as little as 50 watts at 28vdc, this compact 44 pound package records, stores and reproduces data under the toughest conditions. Conditions like 10g shock with less than a 3% peak to peak flutter. 10g vibration with less than a 6% peak to peak flutter. 25g acceleration. –40° to 71°C operating temperatures. 95% humidity. 150,000 foot altitude. Check these specs against any other recorder/reproducer and see if they'll operate through conditions like that.

And the MTR-3200 is versatile, too. Plug in electronic modules provide up to 14 analog and FM or 16 digital channels usable in any combination. Six tape speeds are selectable in speed pairs. Even data bandwidths are extended beyond IRIG standards, and the entire unit is compatible with IRIG standard data reduction equipment. For those special applications, Leach offers a wide range of little luxuries such as analog to digital, serial to parallel and parallel to serial conversion equipment.

If these specs meet your immediate requirements, or if you have a highly improbable environmental situation to be challenged and accommodated, write us. No one knows more about high environmental tape recorders than Leach Corporation, Controls Division. 717 North Coney Avenue, Azusa, California Phone: (213) 334-8211. Export: Leach International, S.A.
An industry first from IRC... PAR
metal film resistors
meet 3 assured
reliability levels

published prices for PAR
(Program for Assured Reliability)
.1%, .01% or .001% levels

Up to now, assured registered reliability could only be obtained through negotiations for screening or additional lot testing.

Now IRC eliminates the need for negotiation and offers a truly low-cost approach to established reliability. For the first time in the industry, users of standard evaporated metal film resistors can specify one of three assured failure rate levels at established published prices.

PUBLISHED SPECIFICATION
IRC has published a specification covering three established reliability levels for its standard evaporated metal film resistors—.1%, .01% and .001%. These failure rates are per 1000 hours, full rated load at 125°C, to 60% confidence.

This Program for Assured Reliability marries the high stability performance requirements of MIL-R-55182. It also defines the requirements to prove failure rate levels as well as necessary control procedures to assure continuing compliance.

LOWEST PUBLISHED PRICES
IRC is the first to publish a price schedule for a predetermined level of resistor reliability. And, only IRC can offer such assured reliability at these low prices.

<table>
<thead>
<tr>
<th>FAILURE RATE LEVEL</th>
<th>IRC TYPE</th>
<th>T.C. (°C)</th>
<th>COST (250 LOT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1%</td>
<td>CCA</td>
<td>± 100ppm</td>
<td>.21</td>
</tr>
<tr>
<td>.01%</td>
<td>CCA</td>
<td>± 50ppm</td>
<td>.57</td>
</tr>
<tr>
<td>.001%</td>
<td>CCA</td>
<td>± 25ppm</td>
<td>3.32</td>
</tr>
</tbody>
</table>

Above prices are excerpted from IRC’s published price schedule.
ESTABLISHED RELIABILITY IN A STANDARD PRODUCT LINE

All evaporated metal film resistors covered by IRC's Program for Assured Reliability meet MIL-R-10509, characteristics C and E, with the added benefits of assured reliability at the lowest cost. These types are immediately available.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MIL-R-10509 CHAPS.</th>
<th>WATTAGE</th>
<th>TOLERANCE</th>
<th>TEMPERATURE</th>
<th>RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRC</td>
<td>M K</td>
<td>@ 10°C @ 100°C @ 125°C</td>
<td>± 1%</td>
<td>± 0.5%</td>
<td>± 25ppm</td>
</tr>
<tr>
<td>MMC RN50</td>
<td>E</td>
<td>1/8 1/10 1/20</td>
<td>± 1%</td>
<td>± 0.5%</td>
<td>± 25ppm</td>
</tr>
<tr>
<td>CCM RN55</td>
<td>E</td>
<td>1/8 1/10 1/20</td>
<td>± 0.5%</td>
<td>± 0.5%</td>
<td>± 50ppm</td>
</tr>
<tr>
<td>CCA RN60</td>
<td>E</td>
<td>1/4 1/8 1/20</td>
<td>± 1%</td>
<td>± 0.5%</td>
<td>± 25ppm</td>
</tr>
<tr>
<td>CCB RN65</td>
<td>E</td>
<td>1/2 1/4 1/20</td>
<td>± 0.5%</td>
<td>± 0.5%</td>
<td>± 25ppm</td>
</tr>
</tbody>
</table>

*Summarized. Standard values fully described in PAR Specification.
IN LINE REGULATED ADJUSTABLE DC POWER SUPPLIES

KEPCO'S DESIGN SIMPLICITY

MAKES THE DIFFERENCE!

The FLUX-O-TRAN® is the heart of Kepco's PR GROUP of DC Power Supplies. By delivering a square-wave-form to the rectifier, the FLUX-O-TRAN increases rectifier utilization and improves the loading characteristics of the filter capacitors. This characteristic provides a relatively low intrinsic source impedance, improving load regulation and affording a low ripple content. The result is a simple, highly reliable and efficient source of regulated DC power in minimum space and at minimum cost.

The PR GROUP offers a wide choice of adjustable output voltage and output ratings with:

- typical ripple values 0.5 to 3%
- overcurrent protection
- no voltage overshoot
- power efficiency typically 50-70%
- reliable, efficient silicon full-wave rectification
- output essentially free of line voltage variations
- isolation of line transients
- current limiting protection from current overloads and external short-circuit

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DC OUTPUT VOLTS</th>
<th>RANGE AMPS</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR 15-10M</td>
<td>0-7.5-15</td>
<td>0-10</td>
<td>$360.00</td>
</tr>
<tr>
<td>PR 15-30M</td>
<td>0-15</td>
<td>0-30</td>
<td>$525.00</td>
</tr>
<tr>
<td>PR 38-5M</td>
<td>0-38-78</td>
<td>0-5</td>
<td>$340.00</td>
</tr>
<tr>
<td>PR 38-15M</td>
<td>0-38</td>
<td>0-15</td>
<td>$495.00</td>
</tr>
<tr>
<td>PR 80-2.5M</td>
<td>0-40-80</td>
<td>0-2.5</td>
<td>$340.00</td>
</tr>
<tr>
<td>PR 80-8M</td>
<td>0-80</td>
<td>0-8</td>
<td>$475.00</td>
</tr>
<tr>
<td>PR 155-1M</td>
<td>0-78-155</td>
<td>0-1</td>
<td>$340.00</td>
</tr>
<tr>
<td>PR 155-4M</td>
<td>0-155</td>
<td>0-4</td>
<td>$450.00</td>
</tr>
<tr>
<td>PR 220-3M</td>
<td>0-220</td>
<td>0-3</td>
<td>$450.00</td>
</tr>
<tr>
<td>PR 310-0.6M</td>
<td>0-165-310</td>
<td>0-0.6</td>
<td>$360.00</td>
</tr>
<tr>
<td>PR 310-2M</td>
<td>0-310</td>
<td>0-2</td>
<td>$450.00</td>
</tr>
</tbody>
</table>

Applicable Patent Nos. furnished on request

± 1% LINE REGULATION

105-125 V AC, 60 CPS ± 5%° – SINGLE PHASE

± 2% LINE REGULATION

208/230 V AC ± 10%, 60 CPS ± 5%° – 3-PHASE

*For models to operate at 104 ± 9V AC; 115 ± 10 V AC; 208 ± 18V AC or 230 ± 20V AC, 50 cps ± 5%, add suffix "−50" to model no. and derate output voltage by 20%.
Federal budget: the prime mover

In Washington every year, the end of January is a time of nervous anticipation and nagging worry for government officials waiting for the President to finish polishing the federal budget. This year, the waiting and worrying were intensified because everybody feared that the cost of the fighting in Vietnam would take money away from other projects. It was not until Jan. 21, when government officials got their first advance look at the completed budget, that many officials heard which of their projects had been approved, killed or postponed.

Clearly this year’s budget, examined in detail on pages 133 to 145, is a military one. It is the biggest in our history, calling for $112.8 billion, with $61.4 billion earmarked for national defense.

For the first time since hostilities started in Vietnam, Congress is being asked to program money for that war. Previously, the Defense Department had kept the forces supplied by shifting matériel from bases around the world and by juggling budget accounts. The Pentagon’s fiscal experts finally ran out of ways to shift funds. In fact, at the same time President Johnson presented the $112.8 billion budget with $61.4 billion slated for the military, he asked for an additional $12.3 billion for fiscal 1966, the current year. In August, the Administration had asked for $1.7 billion more for Vietnam. Incidentally, Defense Secretary Robert S. McNamara, who until May of last year had been denying that the Pentagon needed more money for Vietnam, has now told a congressional committee in closed hearings that he was wrong—his first admission that he might not be infallible.

The great expenditures for Vietnam are changing the character of defense spending. There is far less money going into strategic weapons and far more into what the foot soldier can see and carry: helicopters, radars and radios. Even more important, some money has been directed away from civilian expen-
ditures. Spending plans of the Federal Aviation Agency for air-traffic control will need a drastic new look because of a $22-million cut (p. 141).

Many plans for the Great Society will not be realized in fiscal 1967 because not enough new money was authorized. Although health and education agencies were disappointed that plans will have to be curtailed for at least a year, many officials breathed a sigh of relief that their budgets are about the same size as last year’s. Little of the work already started will have to be cut back.

A close examination of the federal budget is likely to alarm those interested in research and development. Federal expenditures for R&D are plateauing and may slide in the future.

At the Pentagon, research-and-development spending has leveled off after a spectacular rise in the early 1960’s. One reason: the big strategic projects are nearly completed, and although there are more R&D projects under way, the new ones cost less. One Pentagon expert opined, “It takes a lot less money to develop a radio than a missile.”

At the National Aeronautics and Space Administration, officials are also worried about a leveling off of R&D funds. Advanced projects, like the Voyager mission to land instruments on Mars, have been postponed. And the agency has no big specific program to follow Apollo, the moon shot, which is now moving rapidly into the hardware phase.

Unfortunately for electronics engineers and business men, the official budget carries no breakdowns of electronics spending. These figures are buried in gross numbers for departments or big projects. Only a veteran government employee can supply the details that help industry people estimate how much of the $112.8 billion will end up in engineers’ paychecks and company coffers. To obtain this kind of information, Electronics sent three editors from New York to work with six members of McGraw-Hill’s Washington Bureau the week before the President delivered his message.

This task force attended advance budget briefings over the weekend and interviewed scores of department and agency controllers and contract officers.

The story, starting on page 133, spells out how the budget will affect the electronics industry. The federal budget, earmarking about $10 billion in calendar 1966 for electronic systems, equipment and hardware, accounts for more than one-half of all the business of the U.S. electronics industry—supplying the prime power behind the industry and the fuel for much of its technology.
Here's why engineers have specified this heavy duty 25 amp relay by P&B for over 30 years

This is the granddaddy of all P&B relays. Our very first design. Many millions are in use throughout the world... starting motors, controlling elevators, switching high current and voltage loads, doing a multitude of heavy duty jobs, reliably. Year after year, the PR Series remains high on our best-seller list. Here are some reasons why.

EXCELLENT CONTACT WIPE ACHIEVED WITH FLOATING CONTACT CARRIER

PR relays are designed with a full floating carrier for the movable contacts. Beside providing sufficient contact pressures, the floating carrier builds-in an abundance of wipe to keep the contacts scrubbed on every operation. Large, \( \frac{5}{8} \)" diameter contacts switch 25 amperes non-inductive loads or 1 HP at 115/230 VAC, single phase. A phenolic barrier between the contacts of multipole relays prevent flash-over between contacts.

SELECT FROM A VARIETY OF CONTACT ARRANGEMENTS

PR reliability is available in relays having the following contact arrangements: SPST-NO, SPST-NC, SPST-NO-DB, SPST-NC-DB, SPDT, DPST-NO, DPST-NC, and DPDT. Coil voltages range from 6 to 440 volts A.C., and 6 to 110 volts D.C. A vast number of special variations of these standard parameters have been engineered over the years.

AUXILIARY CONTACTS ADD TO VERSATILITY OF PR RELAYS

A single set of auxiliary contacts (Form A, B or C) can be supplied when the application demands. They are rated at 5 amperes at 115 VAC, 60 cycle resistive. Standard models of PR relays with auxiliary contacts are available from leading electronic parts distributors.

MANY STANDARD RELAYS ARE LISTED BY U.L. AND CSA

A wide range of standard PR relays is listed by Underwriters' Laboratories (File E22575) and Canadian Standards Association (File 15704). CSA listing covers AC relays only. These listings can often save you time and extra expense when obtaining UL or CSA qualification for your products.

MAGNETIC ARC-QUENCHERS FURNISHED ON SOME MODELS

For DC loads over 28 VDC, PR relays with normally open contacts can be furnished with permanent magnets to quench arcs. These magnets increase the DC voltage rating to 220 volts resistive... and often increase the life of contacts handling DC inductive loads.

PR SERIES SPECIFICATIONS

GENERAL:

Mechanical Life: Single-pole, 1,000,000 (cycles); double-pole 10,000,000 (cycles).
Contact life increases at smaller loads or with appropriate arc suppression.
Breakdown Voltage: 1,500 volts rms minimum between all elements and ground.
Ambient Temperature Range:
DC: -55 to +80° C.
AC: -55 to +45° C.
Weight: Approximately 10 ozs.
Pull-In:
DC: 75% of nominal voltage (approx.)
AC: 75% of nominal voltage (approx.)
Terminals: Heavy-duty screw type terminals are standard for coil and contacts. Available with printed circuit, plug-in, \( \frac{1}{4} \)" quick connect and terminals for rear panel wiring.
Enclosure: PR dust cover.

CONTACTS:

Arrangements: Up to 2 Form C (DPDT.)
Material: \( \frac{1}{4} \)" dia. silver standard. Other materials available for special applications.
Load: 25 amps non-inductive or 1 HP @ 115/230 volts AC, single phase. Special version - 30 amp. non-inductive at 115/230 VAC; single phase available. (Consult factory)

COIL:

Voltage: AC: 6 to 440 volts.
DC: 6 to 110 volts.
Power: DC: 2.0 watts nominal.
AC: 9.8 volt-amps.
Resistance: 63,800 ohms maximum.
Duty: Continuous, AC or DC (DC coils will withstand 8 watts @ +25° C.
Mounting: Two \( \frac{5}{16} \)" diameter holes on \( \frac{3}{4} \)" centers.

LEADING ELECTRONIC PARTS DISTRIBUTORS STOCK 44 DIFFERENT PR RELAYS

Immediate delivery at factory prices.
Ask your distributor for a copy of Stock Catalog 100

POTTER & BRUMFIELD
Division of American Machine & Foundry Company, Princeton, Indiana
Export: AMF International, 261 Madison Avenue, New York, N.Y.
Contrary to what every electronics engineering student is told as a freshman, a d-c transformer is possible, says a scientist at the General Electric Co.'s laboratories in Schenectady, N. Y. The only catch is that the transformer he built operates at cryogenic temperatures and, so far, can only raise and lower voltages in the millivolt range, with efficiencies of 10%.

The developer, Ivar Giaever, says two thin films made of tin, separated by a thin layer of silicon oxide, form the transformer. It has a transformation ratio of 1-to-1. The bottom thin film is the primary and the top film is the secondary. If two thin films are deposited in either layer and connected in series, the transformation ratio becomes 2-to-1 or 1-to-2.

Most materials at low temperatures are not penetrated by magnetic fields. But tin at $-450^\circ$ F is an example of a Type II superconductor that is penetrated at certain magnetic flux spots. When a direct current passes through the tin, the magnetic flux spots move along with it. If another thin tin film is placed nearby—within 0.000001 inch—these spots will penetrate it, too, and their motion will generate a direct current in the second film.

The Radio Corp. of America has become the first manufacturer to use integrated circuits in its television sets. RCA bypassed transistorization in going to the IC's, which are now being built into selected models scheduled for marketing in the early spring. Each IC will replace 26 components in the sound circuits.

RCA says it will eventually use the IC's in all sound circuits in its TV receivers and in radios and stereo sets; but initially they will only be in selected TV models—black-and-white and color, transistorized and tube. In its present TV line, RCA has one transistorized receiver—a 12-inch black-and-white; but its 15-inch color set, due late this year, will be at least partially transistorized and will presumably use IC's as well.

Last year it was learned that the Admiral Corp. planned to produce a hybrid 15-inch color TV set with an integrated circuit [Electronics, Dec. 27, 1965, p. 103]. Production is to begin late this year.

By the time the North American Air Defense Command (Norad) opens its Combat Operations Center in April, the electronics complex will already be five to seven years behind the state of the art. It will have less speed and reliability than are possible with the newest equipment.

The $142$-million facility is buried in 1,400 feet of granite in Cheyenne Mountain, near Colorado Springs, Colo., safe from even a direct hit by a nuclear bomb. Because the complex was designed about seven years ago, its computers aren't the fastest, reliability isn't the best and none of the information-display systems operate in real time.

The role of the center is to detect—with the help of a radar network—the approach of enemy missiles or planes to North America and then to assess the danger and methods of defense and counterattack. With the present equipment, it takes 11 seconds for the computers to grind out an analysis of an attack, but Norad officials are considering revamping the electronic gear so it will work in real time.

Also under consideration is a sharp boost in reliability. "We've had
to buy a multiredundancy system because we have to work with mean
time between failures of about 20 hours," says a Norad official. The
goal, he adds, is equipment with a mean-time rate of up to 300 hours.

Manufacturers are already preparing proposals for faster, more ver­
satile and more reliable equipment. The Burroughs Corp., prime con­
tractor for the electronic gear, is proposing its new B-8500 computer
system.

Norad officials are also interested in simplifying computer language;
ideally, the military wants its computers to understand ordinary English.
Work along these lines is already under way at several research centers.

Encouraged by the latest reliability tests on the Interplanetary Moni­
toring Platform (IMP) that will be orbited this summer, the National
Aeronautics and Space Administration is planning wide use of metal­
oxide-semiconductor (MOS) integrated circuits for space applications.
IMP, a package of scientific experiments that will orbit the moon, is
the first use of MOS IC’s in a space vehicle. NASA turned to them
because of their low-power requirements.

NASA says it has continuously tested an IMP subsystem containing
360 MOS integrated circuits for more than 9,500 hours without a failure;
the test is continuing.

During the next two weeks, NASA plans to award a contract to Honey­
well, Inc., to build a plated-wire nondestructive memory driven by MOS
integrated circuits. Beryllium-copper wire coated with Permalloy—a
nickel-iron alloy—will be used for the memory. The contract price,
still being negotiated, is expected to be about $50,000. Delivery of a
working model by Honeywell to NASA is planned for November.

Honeywell recently installed a facility for building MOS IC’s at St.
Petersburg, Fla. The company plans to use high-current linear IC’s in
the memory-drive circuitry. The IMP scientific satellite uses low-current
digital MOS IC’s.

A NASA spokesman indicated that several other contracts also involv­
ing the use of MOS IC’s in computers were being considered.

Germanium power-output transistors are back in fashion for high-fidelity
equipment produced by the Harmon-Kardon division of the Jerrold
Corp. Harmon-Kardon had switched from germanium to silicon power
transistors about three years ago.

Engineers at Harmon-Kardon say they made the change because
silicon power devices were suffering from secondary breakdown caused
by high transient currents; this kind of failure doesn’t occur with the
germanium single-diffused power transistors, they say.

A French laboratory is understood to have built a carbon dioxide-nitro­
gen laser with an output of one kilowatt, continuous wave. The efficiency
of the laser is said to be about 10%. . . . Motorola, Inc., hoping to main­
tain a price differential between silicon and germanium transistors, has
sharply reduced the price of its premium germanium transistor line by
between 14% and 91%. The price cuts affect 29 high-speed switching
transistors, low-noise radio-frequency amplifiers and transistors for tele­
vision and a-m and f-m receivers. Prices for the low-cost germanium line
and the power germanium line aren’t affected.
Almost everyone who's had occasion to specify germanium point contact diodes knows the 1N541. And those specifiers may also know that the 1N542, commonly used in FM ratio detector and discriminator circuits, is actually the same diode. But, and here it begins to get confusing, two 1N541s become one 1N542 when they're supplied as a matched pair. Now, take one unit from one 1N542 matched pair and one unit from another 1N542 and what have you got? Right, two 1N541s. Here's how Sylvania puts an end to this confusion while, more importantly, announcing a greatly improved diode.

There is no longer a need for the 1N542 germanium point contact specification.

Sylvania has just sampled the electronic manufacturing industry with a greatly advanced version of the standard 1N541. Results show that the new 1N541 is so uniform from diode to diode that any two Sylvania 1N541s will give satisfactory performance in a ratio detector application, which up until now required the 1N542.

To insure this uniformity of the 1N541, the forward voltage and the reverse current characteristics are both specified at several levels. In addition to these static characteristics, tight control is maintained on 10.7 mc rectification efficiency.

Sylvania developed the new 1N541 especially to meet the demands of manufacturers of ratio detectors who need two things: an improved 1N542 and the ability to avoid the added expense of handling individual matched pairs.

This issue in capsule

Readouts—a new EL panel design of special interest to aerospace display designers.

Integrated Circuits—how a new sense amplifier may solve your memory systems problem.

CRTs—a high-sensitivity, electrostatic tube especially for compact, portable equipment.

Microwave Diodes—new silicon mixer diode operates over the 50 to 90 GHz range.

Receiving Tubes—rugged 10,000-hour premium tubes for new designs or upgrading equipment.

Television—how new small-neck 12" CRTs lead to economy and TV set compactness.
Tests on random samples show that the advanced 1N541 exhibits a greatly improved forward capacitance characteristic (see Figure 1). The narrow spread between capacitance and voltage indicates Sylvania's close control during the manufacturing process. The same control also results in narrow spreads in capacitance vs. reverse voltage, an especially important diode parameter.

If the spread shown in Figure 1 were not narrow, it would indicate that the forward capacitance change with signal voltage would be radically different from one diode to another, and performance characteristics of a ratio detector would be less than desirable. Under these conditions the characteristic detection curve of the detector becomes highly distorted. This is due to the detuning of one of the secondary circuits which in turn causes an unwanted output from the detector.

TYPICAL PARAMETER SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Voltage</td>
<td>$I_F = 1.0 \text{ ma}$</td>
<td>0.45 v</td>
<td>0.50 v</td>
</tr>
<tr>
<td>Forward Voltage</td>
<td>$I_F = 10 \text{ ma}$</td>
<td>1.5 v</td>
<td>1.75 v</td>
</tr>
<tr>
<td>Forward Voltage</td>
<td>$I_F = 30 \text{ ma}$</td>
<td>3.8 v</td>
<td>4.25 v</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>$V_R = 2.0 \text{ v}$</td>
<td>3.5 ηA</td>
<td>20 ηA</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>$V_R = 30 \text{ v}$</td>
<td>150 ηA</td>
<td>200 ηA</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>$V_R = 45 \text{ v}$</td>
<td>350 ηA</td>
<td>450 ηA</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>$V_R = 60 \text{ v}$</td>
<td>650 ηA</td>
<td>1000 ηA</td>
</tr>
<tr>
<td>Dynamic Resistance</td>
<td>$I_F = 10 \text{ ma}$</td>
<td>40 Ω</td>
<td>80 Ω</td>
</tr>
<tr>
<td>Rectification Efficiency</td>
<td>1.0 V eff</td>
<td>76 %</td>
<td>80 %</td>
</tr>
<tr>
<td>Rectification Efficiency</td>
<td>3.0 V eff</td>
<td>83 %</td>
<td>89 %</td>
</tr>
</tbody>
</table>

DIODES

How a versatile new diode improves discriminator and ratio detector circuits

The advanced Sylvania 1N541 germanium point contact diode has found wide usage in discriminator and ratio detector circuits. A circuit diagram of a typical ratio detector circuit is shown here. The AM rejection characteristic, which is a major parameter in judging ratio detector performance, is greater than 25 db with a 10 mv input signal. 1N541 diodes, picked at random, have performed satisfactorily in this circuit.

Another application for the 1N541 is the balanced modulator, also shown below. This modulator is currently incorporated in the National Radio Company's NCX-5 single side band transceiver. This circuit provides an overall carrier suppression of 50 db under extreme environmental conditions. The stability of this circuit eliminates the need for an external balance control in this transceiver.

Here are two typical applications for the 1N541. The imaginative engineer will find many more instances where this point contact diode saves time while improving performance.
A high-sensitivity, electrostatic tube designed for compact, portable equipment

Characteristics such as portable, lightweight, transistorized and battery-powered are closely associated with today's consumer demands in television sets. But there's also a large demand for these very same features in industrial and military equipment. Cathode ray tubes are built to fit the bill in both cases. Here's an instance where just such a tube was perfect for an unusual test instrument.

Now a Sylvania CRT helps measure pipe wall thicknesses, detect corrosion in ship hulls and find fatigue cracks in jetliners. The electrostatically focused and deflected SC-3511 tube is a vital part of the Sonoray model 301 ultrasonic flaw/thickness tester, developed by Branson Instruments Inc.

The entire unit weighs only 16 pounds and is battery-operated. Since the tester is easily portable, it can be carried into such difficult areas as manholes, catwalks and scaffolds.

Accurate readings are directly viewed on the tube's $2\frac{1}{2}''\times 2\frac{1}{2}''$ screen in the face of the tester. No calculations are required. Since a feature of the tube is its low heater power, the readings are always instantaneous.

Sylvania designed the SC-3511 as a part of a CRT product line to suit compact portable equipment such as the Branson model 301. The tube has helical-resistor post-deflection acceleration to achieve a high writing rate, high deflection sensitivity, and a distortion-free pattern. And the tube itself weighs just a pound and a half.

The CRT receives its information from a dual transducer which detects reflecting surfaces .030" below a front surface. Transmitting and receiving crystals are contained in single housings sized as small as $\frac{3}{4}''$ in diameter.

Other Sylvania CRTs for compact equipment include the round SC-3802 as well as the square SC-3377 and SC-3551. These tubes all have clear faceplates, very high deflection sensitivity, low heater power and helical-resistor post-deflection acceleration.

**CIRCLE NUMBER 301**

**SC-3511 CHARACTERISTICS**

- Heater Voltage: 1.5 volts
- Heater Current: 0.14 ± 10% amperes
- Focusing Method: electrostatic
- Deflection Method: electrostatic
- Minimum Useful Screen: $2\frac{1}{2}''\times 2\frac{1}{2}''$
- Useful Scan: $2\frac{1}{2}''$ max.
- Weight: 1½ pounds
- Overall Length: 13½ inches

---

**SC-3511, SC-3377, and SC-3551 Outlines**

---
Compactness and economy built-in with new small-neck 12" CRTs

Historically, black-and-white picture tubes have been among Sylvania's important products. Over the past several months consumer demands have been spiralling for smaller, more portable sets. Sylvania is playing a leading role in improving and broadening its CRT line to keep pace with set manufacturer demands. Here's news on two picture tubes designed especially to meet small-set requirements.

Television circuit designers will be especially interested in two significant features of Sylvania's newest line of 12" monochrome picture tubes: small-neck size (for compact set design) and resultant production economies.

With the new ST-4133A and the recently announced ST-4132A, designers now have the opportunity of specifying CRTs with overall lengths of just 9.021" and 10.814" respectively. Substantial savings in component costs as well as reduction of weight in the overall set can now be realized.

The ST-4133A has 110° magnetic deflection, while the ST-4132A has 90° deflection. Both types are 12" direct viewed rectangular glass tubes with aluminized screens and gray filter glass.
These tubes have the added safety factor of T-Band implosion protection. Neck length is only 3/4" with a small neck diameter of .788".

Other features include a straight electron gun which requires no ion trap, a 150 milliampere 12.6 volt filament, and 100 volt G2 for cathode or grid drive.

Both of these CRTs are equally suited to solid-state as well as tube sets. Light weight and compact size make them perfect for portable and battery-operated sets.

**READOUTS**

**New solid-state EL panels perfect for 115-volt aerospace display usage**

The line of hermetically sealed Electroluminescent (EL) readout panels developed by Sylvania has been presented in recent issues of IDEAS. Now this line is complemented with a new panel design that permits even lower operating voltages, while meeting the stringent environmental and performance requirements of the aerospace industry.

Solid-state EL is now offered in a wider range of operating conditions. In addition to operating at a lower voltage, the newest panel design has increased brightness and effective life comparable to the higher voltage units. Operating typically at 115 volts rms, 400 hertz (see graph), the new readout has an initial brightness of 15 footlamberts and a minimum brightness of 6 footlamberts, even after 1200 hours operation.

The device's low power requirement, an outstanding feature of EL, is shown in the table below. This low power aspect is of special interest to aerospace system designers. (The values given in the table are with all segments lighted and 5-digit, 7-segment numeric panels with half-inch characters).

The new design was developed by Sylvania in conjunction with the GT&E Laboratories as a result of efforts to develop an EL readout which would operate at a lower voltage, but with brightness and life comparable to, or better than, existing units.

Because of the solid-state nature of the EL readout panel and its construction features, stable performance is assured under conditions of temperature and pressure extremes. The true hermetic seal assures maximum protection to phosphors that are sensitive to moisture. With proper mounting the panels withstand severe shock and vibration.

With its sandwich panel-type compactness, EL readout panels take up minimal space. They are light in weight, an important aerospace consideration also.

Inherent advantages in all EL units are the wide (almost 180°) viewing angle, rapid information display, and a pleasingly readable blue-green presentation.

**TYPICAL OPERATING CHARACTERISTICS AND MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Operating Characteristics</th>
<th>ST-4132A</th>
<th>ST-4133A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Output (Initial Brightness)</td>
<td>12-18 FL</td>
<td>9 - 12 FL</td>
</tr>
<tr>
<td>Wavelength</td>
<td>5100 Angstroms</td>
<td>5100 Angstroms</td>
</tr>
<tr>
<td>Voltage</td>
<td>115 V AC, RMS</td>
<td>115 V AC, RMS</td>
</tr>
<tr>
<td>Frequency</td>
<td>400 Hertz</td>
<td>400 Hertz</td>
</tr>
<tr>
<td>Current (Max.)</td>
<td>11 mA</td>
<td>10 mA</td>
</tr>
<tr>
<td>Power (Max.)</td>
<td>110 W</td>
<td>110 W</td>
</tr>
<tr>
<td>Power Factor (PF)</td>
<td>.80</td>
<td>.80</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>300 V</td>
<td>300 V</td>
</tr>
<tr>
<td>RMS Voltage</td>
<td>130 V</td>
<td>130 V</td>
</tr>
<tr>
<td>Peak Transient Voltage</td>
<td>400 V</td>
<td>400 V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-55 to +71 °C</td>
<td>-55 to +71 °C</td>
</tr>
</tbody>
</table>
100mc linear amplifier for high-gain wide bandwidth information transmission

CORRECTION
If we've succeeded in keeping you puzzled all month, let's admit now that the January issue of IDEAS contained a very obvious error. The input and output traces shown on page 1 (under this same headline) were mislabeled. The scope trace is shown here in its correct form.

Now there's a linear amplifier with 20 db typical gain that has broad problem-solving versatility. Whether the problem is in driving low impedance loads, avoiding large signal clipping or cross-talk, or in achieving a broad frequency response with flat gain, Sylvania's SA-20 can well be the logical solution.

The strong capabilities of this wideband linear amplifier lie in the device's outstanding combination of features. These include -65 db intermodulation (harmonic) distortion, externally variable gain-bandwidth and phase shift, 1.6k input impedance, output voltage 14Vp-p swing, and less than 10ns pulse response.

CIRCLE NUMBER 304

How this sense amplifier can solve your memory systems problem

Here's some useful information on practical applications of Sylvania's SA-10 sense amplifier. This is the device announced in IDEAS last November which showed an unusual combination of high sensitivity, minimum offset, and high common mode rejection.

The applications diagramed here again show the SA-10's versatility. This is in large part the result of the aforementioned favorable characteristics, plus monolithic silicon epitaxial construction, a differential amplifier, and an externally variable threshold detector.

Still another advantage of this sense amplifier is that it can be used with any digital logic family including the entire SUHL (Sylvania Universal High-level Logic) line of ICs. Its high speed, fast response time and a wired ORd capability are other performance features.

Available in the standard 14-lead flat package, the SA-10 will operate effectively over a -55°C to +125°C temperature range.

CIRCLE NUMBER 305
RECEIVING TUBES

10,000-hour ruggedized premium tubes available from Sylvania distributors

Now, an exceptional line of premium tubes, available from Sylvania Industrial Distributors, can do a high performance job at extreme environmental conditions.

A line of tubes that withstands 500-g impact shocks and has 10,000-hour life is often the answer to problems of both new designs and upgraded equipment. Sylvania GB Gold Brand tubes also show exceptional stability, maximum uniformity and extreme physical ruggedness.

All tubes in the extensive GB product line are engineered to the specific requirements of critical commercial and industrial service. Their many qualities add up to built-in reliability.

Assurance that these tubes do a better job than any others is found in both their proven performance record as well as in the stringent tests and quality controls that Sylvania applies. These include: Multiple Life Tests at high temperature and room temperature conditions; 500-g Shock and 10-g Vibration Tests; Thermal Shock Tests (Glass Strain); Low Pressure Breakdown (High Altitude); Basic Tube Parameters—controlled to 0.65% AQL; Noise and Vibration to 2.5% AQL; and Continuity and Shorts to 0.4% AQL.

In a recent issue of IDEAS we explained how such features as bonded grid design, improved heater design, and increased cathode stability were built into the GB line. Here are more technological reasons why these tubes are proving themselves as problem solvers:

HIGH DISSIPATION SAFETY FACTOR PLATES

...laminated plate construction to conduct heat more uniformly and radiate it more efficiently—provides 10% to 20% safety factor in heat dissipation.

...uniform heat dissipation of laminated construction—to eliminate hot spots, often the cause of gassing that hastens early replacement.

...multilayer laminated construction (combination of as many as five different metals) to optimize the heat transfer characteristics of the plate.

OTHER STRUCTURAL FEATURES

...isolation mica—to improve insulation resistance between elements by containing getter flash.

...double top and bottom micas with more contact points—to support elements more securely.

...U-bolt construction of supports between top and bottom micas—to clamp and lock elements in rigid mount cage.

...controlled atmosphere welding—to reduce weld splash and minimize loose and dangling particles.

...controlled annealing of glass—to eliminate strain, cracking and chipping.

CIRCLE NUMBER 306

HOT LINE INQUIRY SERVICE

Use Sylvania's “Hot Line” inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information almost by return mail.
What price IC reliability?

Pity the poor inspector! Consider his steady parade of products, packages, tests, specifications, etc. But now his existence is complicated even more by products that require test equipment that he may not even have.

Users of integrated circuits, for instance, face the complex problem of having to establish virtually an entirely new incoming inspection department capable of testing the huge variety of IC types now on the market. Look at the package styles alone -8-, 10- and 12-pin TO-5's; 10-, 12- and 14-pin flat packs; 14-pin plug-ins; oversize packages of 16 pins, and even more styles.

The user must invest in the development, production and maintenance of highly specialized test equipment. The installation cost of such equipment runs into the hundreds of thousands of dollars and, in addition, there is the manpower/maintenance cost to keep it running. These investment costs must be weighed against constantly changing system programs.

But on the other hand, IC manufacturers like Sylvania can justify their own test equipment costs on the basis of reduced device costs. And they can plan the utilization of this equipment far better than a user can.

A recommended solution, then, is to use the established facilities of the suppliers. Review their standard quality control (both on-line and outgoing) procedures and equipment. Establish a monitoring program based on your needs (and compatible with the supplier's procedures) which will assure continuity of testing and also will allow the supplier to do full testing for you. Establish correlation samples from each lot, together with the detailed parameter readings on this control sample. These correlation samples can then be checked by incoming inspection and filed with test data for review against subsystem assembly and overall system field performance. Approval of the vendor's facilities, procedures and the correlation samples would result in automatic lot releases. This type of program enables users to cut inspection costs. It frees the user's Q.C. engineers for reliability analysis and specification analysis programs.

Where such procedures have been used they have generally resulted in appreciable savings without increasing component cost! (Typical of the type of IC testing done at Sylvania is 100% testing, at temperature, of all DC parameters.) Further, the manufacturer is not required to do anything incompatible with his established Q.C. procedures. This type of cooperative program will lead to improvements in test procedures, device analysis and failure analysis (with shorter feedback loops to improve product performance). It can also improve communications between user and supplier resulting from more efficient use of Q.C. engineering talent.

And it can reduce equipment costs, equipment maintenance costs, reliability costs, and costs resulting from order lead times.

With the advent of multiple circuit functions in complex packages, (e.g. integrated scratchpad memories, full adders, multi-bit shift registers and frequency synthesizers); the cost of 100% testing in an incoming inspection department is prohibitive to most. Based on cost savings alone, the adoption of cooperative quality assurance programs will be mandatory.

Since establishing such programs requires adherence to a detailed review procedure and the establishment of good communications between user and supplier, it seems desirable for all systems manufacturers who plan extensive use of integrated circuits to initiate a program to develop experience in this area.

Harry Luhrs

H. M. LUHRS
If you want to capture signals from way way out,

record them on the tape with total recall

MEMOREX
PRECISION MAGNETIC TAPE

When you put a reel of Memorex instrumentation tape on
your transport, you can expect the most reliable perfor-

mance, both from the tape and from your recorder. Because
Memorex coating formulations are highly uniform, you'll
find fewer dropouts; because they are extremely durable,
you'll find significantly less oxide shedding, and freedom
from head build-up or gap smear. The result is multi-pass

stability of performance unequalled by any other tape.

If you write Memorex Corporation at 410 Memorex Park,
Santa Clara, California 95052, we will send you instrumen-
tation tape specification data and a bibliography of tech-
nical information available without obligation from the
Memorex library of reprints.


Electronics | February 7, 1966
Frequency Stability

50 KC to 455 MC

2 parts in $10^7/10$ minutes

with a new synchronizer and improved signal generators

- Unique sampling phase-lock: stabilize at any frequency
- Frequency or phase modulation capability: better than 1% linearity
- Low-distortion amplitude modulation: less than 3% at 80% AM
- Constant power, constant modulation with frequency change: time-saving and easier operation

Electronics | February 7, 1966
The new 8708A Synchronizer lets you add unprecedented stability to improved 606B and 608F Signal Generators. It offers $2 \times 10^{-11}/10$ minutes frequency stability in the important and universally used 50 kc-455 mc range. This represents a 250-time improvement in frequency stability over earlier signal generator performance. The 8708A can lock at any frequency, rather than at discrete points only. Lock is automatically re-established after changing frequencies. The stabilized rf signal has high spectral purity and highly linear frequency/phase modulation capability.

The improved 606B and 608F are MOPA-type signal generators that can be synchronized with the 8708A while retaining their own full performance flexibility. This means you can AM or pulse modulate the instruments and utilize the full output level range while stabilized. You also can use, simultaneously, a 5245L Electronic Counter to achieve highest frequency accuracy along with the high stability.

Application Note 71, "Advances in RF Measurements, Using Modern Signal Generators", describes measurement techniques for HF and VHF receivers, amplifiers, filters, etc., with special emphasis on test equipment performance criteria. A call to your Hewlett-Packard field engineer will provide you with assistance in meeting your requirements. Or you can get the application note and complete specifications on all models with a letter to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

### MAJOR SPECIFICATIONS

<table>
<thead>
<tr>
<th><strong>hp 8708A Synchronizer</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency range:</strong></td>
<td>50 kc - 500 mc (uses aux. rf output from 606B/608F Generators)</td>
</tr>
<tr>
<td><strong>Frequency stability:</strong></td>
<td>$5 \times 10^{-10}$ per minute</td>
</tr>
<tr>
<td></td>
<td>$2 \times 10^{-10}$ per 10 minutes</td>
</tr>
<tr>
<td></td>
<td>$2 \times 10^{-10}$ per day</td>
</tr>
<tr>
<td></td>
<td>$2 \times 10^{-10}/^\circ C$ ($0^\circ$ to $55^\circ C$)</td>
</tr>
<tr>
<td></td>
<td>$2 \times 10^{-11}$ for 10% line voltage change</td>
</tr>
<tr>
<td><strong>Price:</strong></td>
<td>$1800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>hp 606B Signal Generator</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency range:</strong></td>
<td>50 kc - 65 mc ($\pm 1%$ accuracy)</td>
</tr>
<tr>
<td><strong>Output:</strong></td>
<td>0.1 $\mu V$ - 3 v into $50 \Omega$ ($\pm 1$ db accuracy); aux. cw output, 100 mv min.</td>
</tr>
<tr>
<td><strong>AM modulation:</strong></td>
<td>0 - 95%, (Internal, 400 and 1000 cps; External, dc - 20 kc)</td>
</tr>
<tr>
<td><strong>FM modulation:</strong></td>
<td>Typically 0.2% min. deviation</td>
</tr>
<tr>
<td><strong>Price:</strong></td>
<td>$1550</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>hp 608F Signal Generator</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency range:</strong></td>
<td>10 mc - 455 mc ($\pm 1%$ accuracy)</td>
</tr>
<tr>
<td><strong>Output:</strong></td>
<td>0.1 $\mu V$ - 0.5 v into $50 \Omega$ ($\pm 1$ db accuracy); aux. cw output, 180 mv min.</td>
</tr>
<tr>
<td><strong>AM modulation:</strong></td>
<td>0 - 95%, (Internal, 400 and 1000 cps; External, 20 cps to 20 kc; also external pulse modulation)</td>
</tr>
<tr>
<td><strong>FM modulation:</strong></td>
<td>Typically 0.2% min. deviation</td>
</tr>
<tr>
<td><strong>Price:</strong></td>
<td>$1600</td>
</tr>
</tbody>
</table>

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT PACKARD

An extra measure of quality

For applications not requiring the synchronizer:

New 608E with major improvements over popular 608C and 608D

10 mc to 480 mc frequency coverage with 0.005%/10 minutes frequency stability

Output 1 v into 50 ohms with rf buffer stage for lowest incidental FM (<1000 cps pk at 50% AM)

Feedback circuit in rf amplifier results in low envelope distortion (<1% at 50% AM, <3% at 80% AM) and constant output level with rf frequency change.

Auxiliary rf output (cw) for frequency check with a counter, or other external applications

Crystal calibrator for frequency checks

The broad frequency coverage, high power output and high degree of low distortion modulation make the 608E an ideal signal generator for driving bridges, antennas, etc. and for receiver and filter measurements. Price, $1450.
NEW:
Digital Thermometer/Temperature Controller
0.1°C accuracy* from -192.0°C to +999.9°C

features:
• High absolute accuracy
• Direct reading
• Easily calibrated
• Fully automatic operation
• Outputs for control, recording, or telemetry
• Modular construction
• High reliability

The PAR Model DTS-1 offers a new order of reliability, convenience, and accuracy in laboratory and process control thermometry. The unit operates by comparing the resistance of a sensor element of platinum (the material whose characteristics define the International Temperature Scale) with an internally generated reference function which employs a unique resistance analog network** that precisely duplicates the temperature-versus-resistance change of platinum. This method allows an absolute accuracy* of 0.1°C to be achieved. A modified self-balancing Kelvin bridge eliminates sensor lead resistance errors, permitting precise remote temperature monitoring.

In addition to the direct visual readout, measured temperature information is available in binary coded or 10-line decimal form for printer or computer input as well as in pulse code modulated form for telemetry applications. For temperature control or strip-chart recording applications, an analog signal is provided which is proportional to the difference between the measured temperature and the desired temperature selected by front panel thumbwheel switches.

All circuits use solid state components except the comparator amplifier where two miniature nuvistor tubes are used to obtain high input impedance and the reference function generator where mercury-wetted relays are used. The entire Kelvin bridge, including the resistance analog network, is isothermally enclosed to assure a high degree of accuracy and good long-term stability. Rugged modular construction, utilizing printed circuit boards, contributes to reliable performance and extended service-free life.

Price: $3,950.00 (excluding probe). Write for Bulletin #118.

*Subject to operating range of actual sensor used.
**Patent Pending

PRINCETON APPLIED RESEARCH CORP.
DEPT. D
Box 565, Princeton, N. J., Tel. (609) 799-1222
Advanced technology

Designing circuits

Circuit designing will soon be taken over by time-shared computers, researchers at the Massachusetts Institute of Technology believe.

The principles of computer-aided design—or CAD as the men who work with it call it—were outlined last week in Los Angeles by Prof. J. Francis Reintjes at the Winter Convention on Aerospace and Electric Systems. Reintjes is director of the MIT Electronics Systems Laboratory, where he heads a CAD project.

**In concert.** The essence of CAD is on-line, real-time design of circuits by man and machine in concert. The designer need not know how to program a computer.

“Computer modeling,” says Reintjes, “will let the engineer know how the circuit will vary with environmental changes, and enable him to be more precise in his design by taking into account effects which were formerly ignored or just approximated.”

Adds Assistant Prof. Michael Dertouzos, who’s also working on the CAD project: jobs that now take days could be performed in seconds. “In fact,” he points out, “computer-aided design could eliminate bread-boarding altogether.”

The MIT team is convinced that only through time-shared computers will the process be inexpensive enough to be widely used. The group has access to a time-sharing system at MIT known as Project MAC [Electronics, Nov. 29, 1965, p. 83].

**Uses a ‘pen.’** To use CAD, a designer points with a light pen to a desired position on a graphical input and presses appropriate computer buttons for the type of electrical element he wishes to introduce and its orientation or direction. The element appears on the cathode-ray tube in conventional schematic form and the user types into the computer relevant information about the element, such as its value and type. By repeating this process for each component, the user gradually composes the entire network, including sources of excitation, on the crt.

On command, the computer can analyze and store the dynamic response at all points of the network. It can present a display of voltages between nodes or the waveform of the network under a given excitation. The designer can then

change the network or modify some parameters until he is satisfied with the results. He can also introduce environmental factors and watch performance vary.

The project is still in the research stage, and the present system is limited to 20 network elements. The researchers are building on earlier work done at MIT on numerical control of machine tools and on graphical construction programs like Sketchpad [Electronics, May 16, 1963, p. 16].

**Beyond CAD.** Extensions of CAD are already envisioned. After the design process is finished, numerical controlled tools or production lines could be instructed to convert the computer design into hardware. The system could store catalogues supplied by manufacturers on tape; and the computer, by searching these files, could determine how a circuit could be built most satisfactorily and inexpensively.

The MIT group is already at work on another extension, called “nesting.” Once the designer and machine have created a circuit, this information could be stored in the computer. Subsequently, it can be called out of the memory as a “black box” and then put into a network.

Also under study is the possibility of creating new devices. The designer might crank into a computer the electrical characteristics needed in a certain part of the network. Even though no such device exists, the computer could spell out what the device should do. “Then perhaps you could go in the back room and build such a device,” suggests Dertouzos.

The MIT researchers plan to extend the technique from electronic networks to digital systems, treat-
ing logic gates as components. They will also apply it to distributed systems, transmission and acoustic lines.

Set up blocks. CAD includes a unique circuit analysis technique called Circal, a computer program developed by an MIT graduate student, Charles Therrien.

"Circal is more simulation than analysis," says Therrien. "We set up blocks within the computer memory for each branch element, and interconnect them so that the circuit equilibrium laws—Kirchhoff's laws and the voltage-current relationships—are satisfied."

Thus it does not—like most analysis techniques—convert the circuits to equations and analyze the equations.

"Throughout Circal," says Therrien, "the internal computer model or data structure is established in almost one-to-one correspondence with the actual network. Thus, resistors, inductors, capacitors and other elements are represented within the computer with computational blocks that carry all the relevant information about their corresponding real elements. These blocks are in turn interconnected through a convenient addressing system in correspondence with real element interconnection of the given network. So, additions, deletions or modifications of elements in the network correspond to identical operations on the computational blocks."

For example, Therrien's program sets up a block of words, or locations, in the core memory. Each of these words, also called registers, represents an element of the network, and they are interconnected through a referencing system. The computer solves the network—finds out what it will do under a given excitation—by a mathematical technique called relaxation. The computer guesses at a solution. If the guess is wrong, the equilibrium constraints will not be satisfied. The computer will then repeatedly modify its guess until all the network equilibrium conditions are met.

Programs like Circal are best written in a language like MIT's Automated Engineering Design.

Computers

Growing numbers

Washington will spend more on computers next year than on defense against air and missile attack. Its computer inventory will exceed its stock of intercontinental missiles and strategic bombers combined.

From almost a standing start in 1956, when only 90 computers were serving the government, the number has skyrocketed to about 7,575—more than 30% of the computers in the United States. The figures include machines that Washington owns, leases or controls through arrangement with contractors.

The percentage may have reached a peak, however; the total is expected to be unchanged next year. The leveling off does not reflect any decrease in agencies' reliance on computers for tasks as varied as guiding rockets and controlling generating plants in the Tennessee Valley. Rather, it reflects a shift from many small computers to fewer large ones, and better management of the government's computer operations.

Fewer but bigger. Through increased computer sharing, round-the-clock operations, and more reliance on computers of the caliber of the System 360 made by the International Business Machines Corp., agencies will reduce their computer purchases next year to $115 million from $125 million in fiscal 1966. Only 50 machines will be bought, at an estimated cost of $50 million; replacement costs are down to $34 million for 32 machines, compared with $73 million for 132 machines this year. Conversion from lease to purchase will cost $45 million for 64 machines, compared with $12 million for 21 machines this year.

These figures are for computers working for the government, except those in secret military operations and those operated for Washington by contractors. Similar trends are anticipated in those two areas, but data is unavailable.

More tasks. Computer applications in government are constantly expanding. An official in the Bureau of the Budget describes the situation as one where agency managers are exploring additional applications of the computer inventory.

The Battelle Memorial Institute is studying the Monte-Carlo digital-computer simulation techniques developed at the University of California at Los Angeles. The goal is to find ways to calculate freight rates and to set traffic-control patterns quickly and accurately.

The Tennessee Valley Authority is controlling the balance of hydroelectric and steam-fed power systems with computers and auto-
matic monitoring equipment.

The National Institutes of Health is installing a remote-console IBM system for use by researchers at its various facilities.

The Department of Justice is exploring a retrieval system for crime data and legal precedents. A similar system already in operation at the Air Force, may be expanded to some other agencies.

At the National Bureau of Standards, specialists in data processing are seeking guidelines for standardizing computer hardware and programs. One goal is to encourage agencies to share them.

Administrative coordination by the General Services Administration is also being beefed up. The GSA soon will begin to offer the services of procurement specialists to help agencies negotiate for computers with the industry. One effect may be an increase in dicker-

ing between agencies and suppliers. A specialist in the Budget Bureau notes that, as costs of associated software soar to more than one-half the cost of computer equipment, and as competition among suppliers intensifies, more suppliers are becoming eager to bargain over the more flexible costs of computer software as leverage into the market.

Think faster

International Business Machines Corp. has developed an experimental thin-film computer memory that has a 120-nanosecond cycle time, a 589,824-bit capacity and fits in a frame 68 by 42 by 7 inches—including the electronic circuits for driving and sensing.

Other thin-film memories—experimental or commercial—are perhaps a bit faster, but none can hold nearly as much data.

The move toward faster and faster memories is taking other talks at IBM, also. For example, IBM is working on a ferrite-core memory with a cycle time of 250 nsec that holds 8,192 words [Electronics, Dec. 27, 1965, p. 36].

The thin-film memory (with a capacity of 8,192 words of 72 bits each) is made of permalloy rectang-
gles 0.030 inch long, 0.025 inch wide and 0.000003 inch (500 angstroms) thick. There are 4,128 of these rectangles on a silicon-monoxide-coated copper plate three inches square; two arrays of 72 plates each are mounted in a frame 68 by 42 by 7 inches. [The reader who checks the arithmetic will find that the number of rectangles is greater than the number of bits. Thirty-two rectangles on each copper plate are not used; it was convenient to place them in an array 86 by 48.]

The frame is about the same size as the ones in conventional computers.

Stacking the bits. Electrically conducting thin-film lines are deposited, in sequence, on top of the thin-film rectangles. The first layer to be deposited has one line for each word in the memory. Then an insulating layer is applied above these word lines. Finally the bit and sense lines corresponding to the bits in each word are deposited alternately atop the insulating layer; these lines are at right angles to the word lines. A ferrite keeper on top of the bit and sense lines partially closes the magnetic path around the lines.

This thin-film memory, like most others, takes advantage of the anisotropy of thin magnetic film—their tendency to be magnetized in certain directions more easily than in others. The easy magnetic axis of the thin films can be magnetized in either of two directions, 180° apart—one corresponding to a stored “1” and the other to a “0.”

The easy axis in IBM’s experimental memory is parallel to the word lines. A current on the word line then rotes the magnetization toward the hard axis; this rotation generates a voltage pulse on the sense line. When reading, the data is taken from the sense lines in this way. When writing, the combination of a large word current and a small bit current creates a resultant magnetic vector that points a few degrees to one side or the other of the hard axis, depending on the direction of the bit current. First, the word current is turned off, then the bit current; this order allows the magnetization to “flip” to the easy axis in one direction or the other, depending on the bit being stored.

Noise a problem. The memory’s designer, Q. William Simkins, had to find a way to distinguish between signals and noise, one of the major problems in thin-film memory design. Read noise is of approximately the same magnitude as the signal and is caused by capacitive coupling between the word line and the sense line. It is canceled by differentially sensing the voltage pulses on the sense line and a dummy sense line.

Write noise can be several times larger than the signal and can carry over into the next read cycle; it is caused by capacitive and inductive coupling between the bit line and the sense line. Capacitive and inductive noise reinforce one another at one end of the line and tend to cancel one another at the other end.

Simkins put the bit driver and sense amplifier at opposite sides of the array and thus eliminated much of the write noise. When writing, two of the bit drivers are turned on at once—one in each of the two arrays—but only one word line is turned on; differential sensing of pulses from the two arrays distinguishes between noise and signal.

Instrumentation

3-D by vibration

A researcher at the Mitre Corp. of Bedford, Mass., has developed a technique to make a three-dimen-
sional display with mirrors and an off-the-shelf loudspeaker.

For the mirror, physicist Alan C. Traub stretches a sheet of Mylar—a flexible, half-mil-diameter plastic membrane coated with a thin film of metal—over the loudspeaker.

As the flexible mirror vibrates, becoming alternately concave and convex under the influence of the speaker’s pneumatic drive, the change in curvature causes a re-
Faster than the eye. The mirror vibrates so quickly—too quickly for the human eye to resolve—that the eye sees a steady, solid figure in three dimensions instead of a series of discrete, two-dimensional images advancing and receding.

When the source of the image is the periodic pattern of an oscilloscope, or similar time-varying display, the source can be electronically synchronized with the mirror, and display depth.

The technique also permits the introduction of phase changes between an oscilloscope tube face and the mirror motions, permitting images in the shape of circles of ellipses. These are similar to the Lissajous figures produced on the screen of a cathode-ray tube for frequency and phase measurements. But Traub's display can add up to periodic motions along the Z—or depth—axis as well as the X and Y axes.

One of the potential applications of the research project is in air traffic control for displaying airspace in three dimensions: range, azimuth and elevation. The pattern could be generated by a computer at the same rate as the vibrating mirror, and the distance between altitude levels might be calibrated in a grid.

Tracking in 3-D. Other potential applications are in missile trajectory display during the early moments of a launch. In a truly graphic display the missile could be represented as traveling within a 3-D "tube" whose boundaries represent safe paths.

Applications are also seen in analysis of radar signals, and of human speech signals, to display time as well as frequency and amplitude.

As part of his research program, Traub is trying to combine the flexible mirror technique with a bank of Nixie tubes to generate an array of numerals at different depths within the image space.

For wall-size displays beyond the diameter of loudspeakers, Traub says, a membrane mirror acting like a giant capacitor could be vibrated electrostatically. In fact, a study is already being made of an electrostatically driven mirror as an alternative to an acoustically driven one.

In depth. Traub, a member of the technical staff in the Applied Science Laboratories of the Mitre Corp., says the technique could also be used as a psychology laboratory tool for measuring human depth perception.

Looking at much longer-range possibilities, he adds educational and entertainment applications such as 3-D television and moving pictures. "As of today, however, it would be an expensive process, since a lot of bandwidth would be required," Traub says.

The technique of varying the focal length of the mirror gives an effect similar to existing displays of the oscillating or rotating screen type. But Traub says the varifocal mirror technique is simpler, lighter and more reliable. "The amount of motion required to vibrate the mirror is very little," he says. "Only milliwatts of power are put into the speaker, and noise levels are quite tolerable."

"Compared with the depth achieved in the image," Traub says, "the mirror motion is very small. For a seven-inch diameter mirror, the center of the taut Mylar moves less than 1/10 of an inch."

In contrast to some stereoscopic techniques, Traub points out, this mirror display has the property of parallax, permitting an observer to move around and from each vantage point to see a different angle of the image, much as in holography [Electronics, Nov. 30, 1964, p. 86].

For the record

Used separately, the techniques of predetection recording and diversity combining have worked adequately in cutting down the data bit errors that plague telemetry-receiving systems. But then the systems have never been faced with a tough test. Now, however, that test is coming up: during the Apollo moon mission, the spacecraft will often be near the outer limit of a ground receiving station's range. To be sure that valuable data isn't lost in space, engineers at the National Aeronautics and Space Administration decided to combine the two recording techniques, hoping for a further reduction in the error-bit rate. The test results were beyond their fondest hopes: errors of threshold signals were reduced by a factor of at least 1,000—and with some improvements ranging as high as a factor of 100,000.

Costs are cut. The NASA engineers were delighted, not only because of the sharp decline in errors but also because of huge money savings. By adapting the dual techniques, the space agency realized it wouldn't have to scrap its existing receiving gear; it would simply have to modify it and add some processing equipment in the laboratories where all the data tapes are studied.

Predetection recording [Electronics, Sept. 13, 1963, p. 30] is a method of universal recording, capable of operating with any modulation technique. Any telemetered data is received and recorded with conventional equipment, without regard to the modulation techniques.

Once the data is recorded—without any attempt to demodulate—the tape is processed by telemetry experts in a lab under ideal conditions. With conventional receiving systems, special demodulating cir-

3-D image created by physicist Alan Traub uses an off-the-shelf loudspeaker and a Mylar mirror.
Up to 72% smaller than MIL-C-25C paper capacitors!

MIL-C-19978B/2 reduces capacitor size drastically—down to 0.125" diameter by 1/4" long. At the same time electrical characteristics are upgraded sharply.

MIL-C-19978B/2 hermetically sealed mylar* capacitors are available now from TRW with immediate delivery in production quantities.

These capacitors—when designated TRW Type 693—are available to high reliability specifications, and in custom capacitances and tolerances beyond the range of MIL-C-19978B/2.

*Du Pont registered trademark
cuits reduce the telemetered information to usable data—occasionally resulting in the loss of some valuable data.

Diversity combining is a technique in which the signals from two oppositely polarized antennas are combined. The two input signals are converted into a single signal in a combiner; the result is a signal with a signal-to-noise ratio that is as much as three decibels better than either of the two original signals.

**Order is increased.** The space agency is buying the equipment—called pre-d combiners—from the Vitro Corp. of America's Vitro Electronics division. The agency had planned to buy five pre-d combiners; now, however, based on the optimistic results, NASA plans to acquire seven.

In its search for accurate data-receiving equipment, NASA wasn't limited to the pre-d combiner gear. It could have selected the type of receiving system that has been developed for such deep-space missions as the Mariner's Mars fly-by. The gear would probably have worked equally well, space engineers concede, but the price would have been many times higher.

For example, to overcome the problem of low-signal threshold levels on Mariner, NASA fitted a special antenna with a narrow-band, pulse-modulation and phase-locked demodulator. But to install such gear on a worldwide network of antennas—which it would have had to do to get full-time data from Apollo—the cost for ground-station telemetering gear would have skyrocketed.

---

**Industrial electronics**

**ZIPping the mail**

After a decade or more of experimenting with electronic equipment, the Post Office Department has settled on a program for automating its operations. The initial price tag is nearly $100 million.

In a year or so, the department will purchase $65 million of automatic-mail sorting equipment for 100 post offices and a $30-million electronic data-processing system to serve 75 major post offices.

"This is the first step in a nationwide program to improve operating conditions," says Postmaster General Lawrence F. O'Brien. "It will be followed up with a systematic effort to modernize the entire postal complex within the coming few years."

The automation depends primarily on an alphanumeric optical scanner for reading addresses—printed either by hand or machine. The scanner was developed by the Philco Corp. and proved out in tests at the Post Office laboratories in Washington and in operational tests at the Detroit Post Office [Electronics, Jan. 11, 1965, p. 130]. The equipment can sort mail at speeds up to 36,000 pieces an hour. Additional scanners are due in the next year in Buffalo, Boston, Houston, Minneapolis, San Francisco, Seattle and Portland, Ore.

**In the bag.** Though bids will be sought for the alphanumeric scanners, Philco almost certainly will get the contract. Scanners that can read only zip code numbers have been developed by Rabinow Electronics, Inc., now a subsidiary of the Control Data Corp., and the National Cash Register Co. These will be installed later in smaller post offices.

The $30-million data-processing complex will be based on a system undergoing tests in Milwaukee and Minneapolis since 1964; in that time the Post Office estimates it has saved more than 20 man-years of work. The International Business Machines Corp. built the computers and Control Data installed the input stations.

These corporations presumably will have the inside track for a system that will serve 75 major post offices from Portland, Maine, to Los Angeles. Installation begins next November, with a target date in mid-1968 for full operation.

At first, the complex will be used to gather information such as mail volume, workload, manpower fluctuation and attendance records, and will transmit the data to high-speed computers for analysis and evaluation. Results will be flashed to postmasters, with the aim of moving the mail more effectively.

**Early bugs.** Most of the equipment in the $65-million order—contracts will be awarded by June 30—was developed as a result of experience with Project Turnkey at Providence, R. I., an experimental automated post office. For the first six months, this operation proved something of a fiasco. But the bugs since have been worked out and postal officials now class Providence as "one of our very best operations."

In addition to the optical scanners, bids will be sought on:

- Letter sorters that can be operated with or without the use of

---

**Optical scanner developed by the Philco Corp. can sort 30,000 pieces of mail an hour. The Post Office Department will soon order nearly $100 million of equipment to automate its operations.**

Electronics | February 7, 1966
The digital instrumentation you create!

This new and imaginative application of the building block concept enables you to specify the exact digital instrumentation you need — and you pay only for the functions you require! The new Beckman Berkeley modular 6000 Series permits packaging standard off-the-shelf circuit elements into a variety of instrument configurations ... without the high engineering costs required for custom instruments.

Here are some examples of 2-mc 6000 Series instruments: Accumulators, Preset Accumulators, Reversing Accumulators, Preset Reversing Accumulators, Preset Frequency Meters, Time Interval Meters, Gated Counters, Limit Frequency Meters, Deviation Frequency Meters, Preset Pulse Generators, Digital Clocks ... all are provided to your specifications.

And these are only a few examples. You can have one- to six-digit display, remote control, storage for visual display and BCD data, or you name it! So why not start now to solve your digital measurement problems ... just call your Beckman Berkeley representative.

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

INTERNATIONAL SUBSIDIARIES: GENEVA; MUNICH; GLENROTHES, SCOTLAND; TOKYO; PARIS; CAPE TOWN; LONDON
the electronic scanner;
- Facing and canceling machines with photoelectric cells that can search out and cancel stamps at 30,000 per hour;
- Machines that stack mail, remove odd-sized mail and stack letters for automatic canceling machines;
- Semiautomatic sack and parcel post sorting machines; and
- Overhead closed-circuit detection monitoring systems to help regulate the flow of mail.

Solid state

Tv camera on a block

Both the Air Force and the National Aeronautics and Space Administration agree that the best way to develop a smaller, lighter, more rugged television camera is to build a solid state image sensor. But they disagree on what kind of sensor is needed.

So the Air Force and NASA are independently funding efforts to build different kinds of solid state sensors capable of providing pictures with resolution at least equal to that of commercial television systems.

Dual approach. The military is backing the Radio Corp. of America's effort at its Princeton, N. J., research laboratories, and the space agency is backing the Westinghouse Electric Corp.'s work at its Aerospace division in Baltimore.

RCA's plan is to put a large array of evaporated antimony-trisulfide photoconductors on a substrate, with each photconductor in series with a diode. But Westinghouse prefers to use silicon phototransistors in its "mosaic" sensor.

When RCA's photoconductor samples light, its resistance changes and a signal is sent to an address strip. The company has built a working model that has 32,400 photoconductor elements arranged in a 180-by-180 array.

"The picture quality is not as good yet as that obtained with tubos," concedes Paul K. Weimer, who heads the project, "but we've just scratched the surface. We're learning every day but we still need to know more about solid state scanning."

The RCA system uses two 180-stage scan generators. The horizontal generator moves from one element to another 180 times faster than the vertical generator. Each generator has 1,050 components: 540 cadmium-selenide thin-film transistors, 360 nichrome resistors and 180 silicon-monoxide capacitors.

Weimer says the next step is to build a 129,600-photoconductor array with elements arranged in a 300-by-300 square and with a distance of one mill between element centers.

In the 180-by-180 array, the distances between element centers is two mills.

The other way. Westinghouse built two cameras, each using a 2,500-element sensor (a 50-by-50 array measuring 0.6 by 0.6 inch), which produces a crude picture. Now, Westinghouse is working on a 12,800-element sensor (a 100-by-128 array measuring 0.6 by 0.7 inch). William List, program manager, expects the new sensor to sharply improve the camera's resolution.

Delivery to NASA is scheduled for April.

Although this will still leave the company behind RCA as far as resolution capability is concerned, Westinghouse plans to catch up quickly. If NASA approves, Westinghouse will start to work on a 51,200-element sensor (200-by-256 array) in the spring and follow that one with a 160,000-element sensor (400-by-400 array) later this year.

In the Westinghouse camera, the current output of each phototransistor is determined by the light hitting the phototransistor. Conventional monolithic integrated circuits are used in the readout circuitry.

Contact prints can be made with both the RCA and the Westinghouse cameras. This is not practical with present vidicon-tube cameras because of the thick glass.
wall needed to maintain the vacuum.

**Consumer electronics**

**Lighting up with scr's**

An electronic "match" that uses a silicon controlled rectifier will replace the familiar pilot light on several gas appliances to be introduced this year. The electronic pilot light was developed by the Wilcolator Co. of Elizabeth, N. J.

The first appliance to incorporate the new pilot light is a gas range that Sears Roebuck & Co. will market this month.

Wilcolator — a subsidiary of Ranco, Inc., which produces home and industrial appliances — says the electronic match costs between $10 and $20, pending on the complexity of the model. Other appliance makers also plan to incorporate the unit soon, Wilcolator adds.

**See a flame.** Two types of electronic pilots were designed: one for ranges, where the flame can be seen by the user, and the other for such appliances as ovens, where the flame can't be seen.

To light a range electronically, a burner control knob is first set to the "light" position; this opens a gas valve and turns on the electronic match circuit. The circuit consists of a neon lamp oscillator that triggers an scr. During the "on" cycle, a capacitor is charged to a peak voltage. When the scr is off, the capacitor is discharged into the primary of a transformer. The high voltage from the transformer secondary creates a spark across a gap and lights the burner. Once the flame is lighted, the control knob is placed on the regular "on" position, deactivating the electronic match.

In the model where the flame is out of view, the problem of lighting the gas is different. Usually these appliances are thermostatically controlled, such as in an oven; hence, the gas flame is turned on and off automatically to maintain the proper temperature.

**Safety factor.** But to prevent an
To make or buy a power supply... let SOLA quote you both ways

Make the decision a realistic one. Let SOLA quote you on a custom built CV transformer and CVDC power supply. You will then have the costs and specifics to make the right decision.

Building your own d-c supply?
Start with the SOLA CV, custom built to match your power supply's outputs, exactly. Save extra component costs in your design. Get short circuit protection, regulation within ±1% for line variations to ±15%. Send output power and circuit requirements, we'll return price of CV and values of circuit components.

Buying a complete d-c supply?
Choose the SOLA CVDC, custom built to your specified output requirements. Get a high watts-per-pound package combining the CV's tight regulation, low forward voltage drop of the rectifier and low output impedance of the capacity filter.

Let SOLA quote both ways. Send us your specs for custom-built CV's and CVDC's, or call your distributor and ask about his line of standard CV's and CVDC's.

Sola Electric Division, Solo Basic Industries, 1717 Busse Road, Elk Grove Village, Illinois 60007 (312) 439-2800.

---

Electronics Review

explosion, there must be a way of insuring that a large quantity of gas will not seep into the oven before the electronic match is lighted. To solve the problem, Wilcolator uses, in addition to the electronic match, a conventional gas-operated pilot light that is lighted only when the oven is in use.

The electronic match is activated when the oven is turned on; this lights the temporary gas pilot. The flame from this pilot then heats a "flame switch"—a tube of mercury that is vaporized by the heat—which opens a solenoid valve that allows the gas to enter the oven. If the temporary pilot should go out during the oven's cooking cycle, the memory switch will return to its liquid state, closing the gas valve.

Although the electronic match adds a few extra dollars to the price of an appliance, Wilcolator claims that the savings in fuel costs—because the pilot isn't on continuously—pays for the unit in a few years.

Wilcolator cites another advantage for the electronic match that would make it an attractive feature in warm climates: a pilot light burning continuously can raise the temperature to an uncomfortable point in a poorly ventilated room.

Electronic notes

- **Nike X computer.** The Sperry Rand Corp.'s Univac division has received a $24-million contract from Bell Telephone Laboratories for the development of computers and high-speed thin-film memory models for the Army's Nike X anti-missile system.

- **Rechargeable battery.** Cultron Industries, Inc., has developed a prototype of a rechargeable lithium cell. Lithium is more efficient for storing electricity than nickel-cadmium, but can't be stored in air or water. The new battery is hermetically sealed and uses a nonaqueous electrolyte. The test model has a capacity of 100 watt-hours per pound, compared with 26 for nickel-cadmium.
Now—Bourns Gives You a Complete Choice Of 7/8" Precision Potentiometers

Take your pick from the industry's finest, most extensive 7/8"-diameter precision potentiometer line:

<table>
<thead>
<tr>
<th>BUSHING MOUNT</th>
<th>SERVO MOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 3500, 10-turn</td>
<td>Model 3550, 10-turn</td>
</tr>
<tr>
<td>Model 3507, commercial 10-turn</td>
<td>Model 3560, 3-turn</td>
</tr>
<tr>
<td>Model 3510, 3-turn</td>
<td>Model 3570, 5-turn</td>
</tr>
<tr>
<td>Model 3520, 5-turn</td>
<td>Model 3580, single-turn*</td>
</tr>
<tr>
<td>Model 3530, single-turn</td>
<td></td>
</tr>
</tbody>
</table>

*SILVERWELD® multi-wire termination eliminates the chief cause of potentiometer failure. All-sealed construction insures MIL-Spec humidity performance (cycling and steady state). One hundred per cent inspection and the double-check follow-through of the Bourns Reliability Assurance Program are your final quality guarantees.

In quantity and quality, this line is unmatched. Exclusive SILVERWELD® multi-wire termination eliminates the chief cause of potentiometer failure. All-sealed construction insures MIL-Spec humidity performance (cycling and steady state). One hundred per cent inspection and the double-check follow-through of the Bourns Reliability Assurance Program are your final quality guarantees.

No matter what your requirements in precision potentiometers, you will find the answer at Bourns—the complete source. Write for technical data on our entire line of bushing- and servo-mount models, KNOBPOT® potentiometers, and turns-counting dials.
INTERNATIONAL RECTIFIER PROUDLY PRESENTS
A CONTROLLED RECTIFIER FAMILY
WITH RATINGS UP TO

350 AMPS*

UP TO 1200 VOLTS PRV

EPITAXIAL SCR

1,000,000 TO 1 RATIO, FIRING POWER TO RATED POWER

Proven performance backed by years of intensive research and environmental testing.

World’s most advanced line of HIGH POWER EPITAXIAL SCRs UP TO 1200 VOLTS PRV

- 350 Amps epitaxial SCR
- 300 Amps epitaxial SCR (standard)
- 300 Amps epitaxial SCR (fast switching)
- 250 Amps epitaxial SCR

IR opens new vistas in the field of power control and conversion with these compact SCRs. They are indispensable tools of the engineer in meeting demanding design requirements for higher performance. Increased efficiency, increased reliability, reduced size and reduced weight are merely a few of the advantages engineered into IR’s high power SCR line.

The inherent capabilities in the design of these devices, combined with the application experience of our engineering staff offers you an opportunity to utilize the most advanced SCR technology available today in the design of your high power equipment.

350 Amps—Bulletin A-116  
300 Amps (standard)—Bulletin A-114  
300 Amps (fast switching)—Bulletin A-115  
250 Amps—Bulletin A-113

CALL MR. RECTIFIER

He is your Sales Engineer. He’s experienced. Understands your problems. Has the answers. Works closely with you. You can deal in confidence with “Mr. Rectifier”—your rectifier specialist. Call him.

*Average DC amperes

WORLD’S LARGEST RECTIFIER SPECIALISTS

INTERNATIONAL RECTIFIER

INTERNATIONAL RECTIFIER, EL SEGUNDO, CALIF. PHONE (213) 68-6281 • CABLE RECTUSA • REGIONAL OFFICES IN NEW YORK CITY, (212) CH 4-0748 • FORT LEE, N.J. (201) W 7-3334 • SYRACUSE, N.Y. (315) HE 7-8495 • CAMBRIDGE, MASS. (617) LN 4-6520 • ARDMORE, PA. (215) MI 9-3666 • BERKELEY, MO. (314) GJ 9-3305 • MIAMI, FL. (305) 445-5201 • CHICAGO, ILL. (312) 640-6000 • CLEVELAND, OHIO, (216) 744-4101 • DAYTON, OHIO, (513) 723-2394 • HUNTINGTON WOODS, MICH. (313) 8-1144 • ST. LOUIS, MO. (314) TE 6-6333 • MINNEAPOLIS, MN. (612) 920-1200 • RICHARDSON, TEX. (214) AD 1-9504 • SAN MATEO, CALIF. (415) 349-2373 • LOS ANGELES, CALIF. (213) 678-2181 • IN CANADA: TORONTO, ONT. (416) 421-5970 • MONTREAL, QUEBEC (514) 861-0562

EUROPEAN GENERAL SALES OFFICE: 38 AVENUE DES ARTS, BRUSSELS, 4, BELGIUM • TELEPHONE 111774

Circle 50 on reader service card
China's atom threat gets more attention on new evidence...

The United States may take a new look at its missile-defense system, a result of reports indicating that Communist China is much further along in the development of missiles than Pentagon planners had suspected.

The reports also indicate a big push by the Chinese to develop a missile-carrying submarine fleet. The growing evidence of China's offensive potential will produce new pressure this year for:

- **Speeding up developments of the Nike X antimissile missile system to allow deployment of at least a limited array of missiles to counter a crude Chinese attack.**
- **Intensifying development and deployment of antisubmarine-warfare systems, already second only to missiles in the defense budget.**

This new information intensifies the Pentagon's concern over China's nuclear capability. China's exploding of a nuclear bomb last year was serious, but U.S. military officials emphasized that the Chinese lacked an effective way to deliver atomic bombs onto a target. This was a major argument for delaying deployment of the Nike X. This year the Pentagon has allocated more than $400 million for further development of the antimissile system, holding off decisions on when and how to deploy it.

The Defense Department is weighing two broad approaches to the Nike X: a $6-billion system of defense against crude Chinese missiles, and one costing $20 billion for defense against sophisticated Soviet missiles.

Some of the evidence of the growing missile-submarine threat from China came last week from several authoritative sources:

- Ralph *., Powell of the Far Eastern Studies Department at American University in Washington told a House Foreign Affairs subcommittee that China's first deployment of missiles would be ready by 1975.
- Defense Secretary Robert S. McNamara, agreeing with Powell's timetable, told the House Armed Services Committee that submarine defenses would have to be beefed up, even while missile-killer deployment and manned-bomber development is held back; it fills a gap, he said, in defenses against both Soviet and Chinese missile threats.
- It was learned also that defense officials are taking very seriously reports that China already has in operation submarines equipped with short-range—300 miles or so—missiles, unequipped yet with nuclear warheads, and that she could have intermediate-range—1,500 miles—missiles for deployment on submarines before 1970.

Despite gains in missiles and shipbuilding, China remains far behind the United States in over-all scientific and engineering abilities, concludes Chu-Yuan Cheng in a report for the National Science Foundation. The author, former research director of Hong Kong's Union Research Institute, reports that China will miss, by 20 to 30 years, its goal of reaching scientific and engineering parity with the West by 1967. Older, Western-trained scientists are still distrusted and placed under political management of Communist party members, he says. And economic and political pressures often force specialists into fields with which they are unfamiliar and inefficient, he adds. Cheng teaches at the University of Michigan.
Panel opposes automation curbs

The President’s Commission on the Impact of Automation advises against raising barriers to the natural growth of automation, though it concedes that the threat to employment today is greater than in recent years. To offset automation’s effects on the United States economy, the commission recommends the government consider an active manpower retraining policy, tax breaks for low-income groups, extension of free education through junior college and federal works programs for the unemployed.

First total-package buy for the Army: avionics for LOH

The Army has awarded the avionics contract for the light observation helicopter (LOH) to Sylvania Electric Products, Inc., making use for the first time of a “total package” procurement technique pioneered by the Air Force. Sylvania, a subsidiary of the General Telephone and Electronics Corp., received a $3.5-million installment on what eventually will be a $16-million contract.

Under total-package buying, development and follow-on production of military equipment are combined into a single contract, let competitively. The Air Force used this technique first with the award of a $1-billion contract to the Lockheed Aircraft Corp. for development and production of the C-5A transport plane. And the Navy will soon seek bids on a new class of cargo vessels called fast-deployment logistics ships.

The principal components of the LOH system include a-m and f-m very-high-frequency transceivers, ultrahigh-frequency a-m and f-m auxiliary transceivers, a communications control package and an automatic direction finder.

Surge in orders slows Pentagon’s drive for economy

The Pentagon is trying to avoid sloppy buying habits resulting from the surge in military orders for the war in Vietnam. But so far, figures for fiscal 1966—ending June 30—indicate that the Defense Department is losing ground in its efforts. Although cost reductions in fiscal 1966 are still expected to exceed the Pentagon’s goal, as they have since the program began four years ago, the level will be below that of 1965. But this is the first year in which the total reduction is expected to be lower than the previous year’s level.

The Defense Department estimates that such programs as competitive buying and cost effectiveness will result in savings of $2.99 billion in fiscal 1966, down $71 million from the $3.7-billion reductions of 1965.

The biggest dollar setback occurred in the area of competitive buying. Pentagon officials estimate that reductions from competitive buying will decline 35% this year to $414 million. Increased competition has been credited with reducing purchase prices an average of 25%. In one move to tighten purchasing policy, Defense Secretary McNamara has ordered that any procurement officer who wants to switch an order from a competitive to sole-source basis must first obtain authorization from McNamara himself, or from his second in command, Deputy Secretary Cyrus Vance.

According to the Pentagon, cost reductions from the elimination of “goldplating” will total $83 million this year, down substantially from $204 million last year; reductions from the use of excess inventory, rather than new buying, will total $78 million, against $181 million in 1965.
What cleans parts 20 times faster?

Consolidated Electrodynamics says:

FREON® Solvents and a Baron-Blakeslee degreaser

Consolidated Electrodynamics' Transducer Division in Monrovia, Calif., cleans with FREON TMC solvent in a Baron-Blakeslee Model M degreaser. FREON TMC is a patented azeotrope of FREON TF and methylene chloride... another tailored solvent from Du Pont. All kinds of components—from transistors to terminal boards, from subassemblies to complete chassis—are cleaned faster, better, at lower cost than ever before. For example, hand-cleaning one part used to take more than an hour. With FREON it takes just three minutes!

Besides requiring high labor costs, hand cleaning failed to do the job completely. Hidden corners and crevices went untouched. Solvent residues remained after drying. Brushes damaged delicate components. But FREON is a selective solvent—it cleans entire assemblies without harming commonly used components. And FREON has low surface tension to penetrate the smallest pores... high density to float away even microscopic particles. It dries quickly, leaving no residue.

Because FREON can be used over and over again, it helped cut CEC's solvent costs in half. And because FREON is nonflammable and relatively nontoxic, no special exhaust systems are needed.

FREON solvents are used for cleaning in many of CEC's divisions. Chances are FREON can give you faster, better, less costly cleaning, too. For more information, write Du Pont Co., Room 3630, Wilmington, Delaware 19898.

(In Europe, write: Du Pont de Nemours International S.A., FREON Products Div., 81 Route de l'Aire, 1211 Geneva 24, Switzerland.)
FAST-SWITCHING FREQUENCY SYNTHESIS TO MATCH YOUR REQUIREMENT:

JUST CHOOSE FROM THREE HEWLETT-PACKARD SYNTHESIZERS, DC TO 50 MHz, WITH THESE PERFORMANCE CHARACTERISTICS:

- 20 µsec switching time, the fastest available
- Small frequency increments, as small as 0.01 Hz
- Digital pushbutton and remote frequency selection
- Internal search oscillator for continuous tuning, sweep capability
- Low spurious signals
- High stability
- High spectral purity
- Solid-state, modular construction for high reliability
Your selection from three Hewlett-Packard frequency synthesizers gives you the broadest source of spectrally pure, stable test signals especially useful for their fast switching capability, digital pushbutton and remote programmability with random access, as well as superior signal-to-noise performance.

Signals are derived from a stable (3x10^-9/24 hrs.) internal frequency standard, or you can use an external 1 MHz or 5 MHz standard. Each instrument employs a direct synthesizing technique, using arithmetic operations instead of phase-locked techniques. The stability of the source standard is preserved, and unknown variations caused by loss of phase lock are eliminated. Any significant column may be continuously "searched" over a discrete range.

Relate the brief specifications of the three hp synthesizers to your specific application, then call your hp field engineer for a demonstration or write for complete specs to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice. Prices f.o.b. factory.

5100A/5110A Synthesizer—DC to 50 MHz (mc) selectable in steps as small as 0.01 Hz. The 5110A Driver generates 22 spectrally pure signals from the standard; these signals are fed to the 5100A Synthesizer, with arithmetic operations used to synthesize the variable output. Spurious signals 90 db down. Output 1 v rms ±1 db, 100 kHz to 50 MHz; 1 v rms +2 db, -4 db, 50 Hz to 100 kHz. Price: 5100A, $8150; 5110A, $4350.

5102A Synthesizer—Dual-range, dc to 100 kHz (kc) with increments as small as 0.01 Hz (cps) and dc to 1 MHz (increments as small as 0.1 Hz). Spurious signals 90 db down (70 db down in 1 MHz range). Output 300 mv to 1 v rms; rear-panel auxiliary outputs include a dc to 1 MHz + 30 MHz signal. Price $6500.

5103A Synthesizer—Dual-range, dc to 1 MHz (mc) increments as small as 0.1 Hz (cps) and dc to 10 MHz (increments as small as 1 Hz). Spurious signals 70 db down (50 db down in 10 MHz range). Output 300 mv to 1 v rms; rear-panel auxiliary outputs include a dc to 1 MHz + 30 MHz signal. Price $7100.

The outstanding performance of hp synthesizers has opened the door for solutions to many unusual problems. A special team of engineers assigned to synthesizer applications is at your service. Also available: The 10514A Double-Balanced Mixer, which extracts the sum or difference of two input frequencies with high efficiency, low intermodulation, input 200 kHz (kc) to 500 MHz (mc), output dc to 500 MHz; price $250. The 10515A Frequency Doubler, which extends the usable frequency range of the synthesizers, input 500 kHz to 500 MHz, output 1 MHz to 1 GHz; price $120.

Electronics | February 7, 1966
MILITARY RTL
MC900G SERIES

...for the most critical
design jobs!

Designed for low-power
military applications in which
wide environmental extremes may
be encountered in normal application, the series
is specified for -55°C to +125°C operation.

INDUSTRIAL RTL
MC800G SERIES

...for broad applications
of all types!

Specially intended for
reliable operation in indus­
trial logic applications, this series
operates over a temperature range from 0 to
+100°C. Priced for economical use in areas where
wider temperature of operation is not required.

Both Offer These Key Performance Features...

- 12 nsec Propagation Delay
- Fan-out Capability Up to 5
- 15 mW/Node Dissipation
- For System Clock Rates to 8 mc

...and this wide range of circuit functions:

Buffer ............... MC900G / MC800G
Counter Adapter .......... MC901G / MC801G
Flip-Flop .......... MC902G / MC802G
3-Input Gate .......... MC903G / MC803G
Half-Adder .......... MC904G / MC804G
Half-Shift Register .......... MC905G / MC805G
Half-Shift Register (W/O Inv.) ........ MC906G / MC806G
4-Input Gate .......... MC907G / MC807G
Dual 2-Input Gate .......... MC914G / MC814G
Dual 3-Input Gate .......... MC915G / MC815G
J-K Flip-Flop ......... MC916G / MC816G
J-K Flip-Flop .......... MC926G / MC826G
Quad Inverter .......... MC927G / MC827G

THere's a
MOTOROLA
RTL
INTEGRATED
CIRCUIT
TO FIT YOUR
EXACT
PERFORMANCE
AND COST
REQUIREMENT!

...you can choose from
4 different RTL complements
for your design.
LOW-COST COMMERCIAL RTL
MC700G SERIES

...combining RTL & mWRTL circuits for utmost versatility!

Designed and priced for a wide variety of commercial applications (as low as $2.55 for a 3-input gate circuit in quantities of 100 or more), this low-cost series offers a combination of mWRTL and RTL circuits including some 22 circuit functions from which to choose. They open the door to new economical integrated circuit applications in such areas as instrumentation, industrial controls, test equipment, and many commercial computer designs.

COMPARE THESE LOW, LOW PRICES!

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer</td>
<td>MC700G</td>
<td>$2.55</td>
</tr>
<tr>
<td>Counter Adapter</td>
<td>MC701G</td>
<td>3.80</td>
</tr>
<tr>
<td>Flip-Flop</td>
<td>MC702G</td>
<td>3.20</td>
</tr>
<tr>
<td>3-Input Gate</td>
<td>MC703G</td>
<td>2.55</td>
</tr>
<tr>
<td>Half-Adder</td>
<td>MC704G</td>
<td>2.65</td>
</tr>
<tr>
<td>Half-Shift Register</td>
<td>MC705G</td>
<td>4.35</td>
</tr>
<tr>
<td>Half-Shift Register (W/O Inv.)</td>
<td>MC706G</td>
<td>3.65</td>
</tr>
<tr>
<td>4-Input Gate</td>
<td>MC707G</td>
<td>2.65</td>
</tr>
<tr>
<td>Adder</td>
<td>MC708G</td>
<td>3.75</td>
</tr>
<tr>
<td>Buffer</td>
<td>MC709G</td>
<td>2.55</td>
</tr>
<tr>
<td>Dual 2-Input Gate</td>
<td>MC710G</td>
<td>2.65</td>
</tr>
<tr>
<td>4-Input Gate</td>
<td>MC711G</td>
<td>2.65</td>
</tr>
<tr>
<td>Half-Adder</td>
<td>MC712G</td>
<td>3.65</td>
</tr>
<tr>
<td>Type D Flip-Flop</td>
<td>MC713G</td>
<td>6.35</td>
</tr>
<tr>
<td>Dual 2-Input Gate</td>
<td>MC714G</td>
<td>2.65</td>
</tr>
<tr>
<td>Dual 3-Input Gate</td>
<td>MC715G</td>
<td>3.20</td>
</tr>
<tr>
<td>Dual 3-Input Gate</td>
<td>MC718G</td>
<td>3.20</td>
</tr>
<tr>
<td>J-K Flip-Flop</td>
<td>MC720G</td>
<td>6.35</td>
</tr>
<tr>
<td>Expander</td>
<td>MC721G</td>
<td>2.65</td>
</tr>
<tr>
<td>J-K Flip-Flop</td>
<td>MC723G</td>
<td>6.35</td>
</tr>
<tr>
<td>J-K Flip-Flop</td>
<td>MC726G</td>
<td>6.35</td>
</tr>
<tr>
<td>Quad Inverter</td>
<td>MC727G</td>
<td>4.60</td>
</tr>
</tbody>
</table>

LOW-POWER MILLIWATT RTL
MC908G SERIES

...where minimum operating power level is required!

- 2.5 mW/Node Power Dissipation
- 40 nsec Propagation Delay
- Full Military Temperature Range — −55°C to +125°C

The low-operating power requirements of this Motorola RTL circuit series (only 2.5 mW/node) makes this logic complement especially attractive to military and space users. To meet the requirements of this market, the series is designed for operation throughout the full military operating temperature range from −55°C to +125°C.

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adder</td>
<td>MC908G</td>
<td></td>
</tr>
<tr>
<td>Buffer</td>
<td>MC909G</td>
<td></td>
</tr>
<tr>
<td>Dual 2-Input Gate</td>
<td>MC910G</td>
<td></td>
</tr>
<tr>
<td>4-Input Gate</td>
<td>MC911G</td>
<td></td>
</tr>
<tr>
<td>Half Adder</td>
<td>MC912G</td>
<td></td>
</tr>
<tr>
<td>Type D Flip-Flop</td>
<td>MC913G</td>
<td></td>
</tr>
<tr>
<td>Dual 3-Input Gate</td>
<td>MC918G</td>
<td></td>
</tr>
<tr>
<td>J-K Flip-Flop</td>
<td>MC920G</td>
<td></td>
</tr>
<tr>
<td>Gate Expander</td>
<td>MC921G</td>
<td></td>
</tr>
</tbody>
</table>

See your local Motorola semiconductor distributor for the Motorola RTL integrated circuit type which fits your immediate need. For production quantity requirements, call your nearest Motorola district office — or write Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.
μ-PAC Integrated Circuit Logic

OD-335 OCTAL/DECIMAL DECODER PAC contains a prewired binary-to-octal decoder and two additional independent NAND gates to expand the matrix for BCD-to-decimal decoding.

BC-337 FAST CARRY COUNTER PAC contains an eight-stage prewired counter which can be easily converted to a binary counter or BCD counter by using jumper connections.

BC-336 BINARY COUNTER PAC contains between 8 and 20 prewired binary counter stages; number of stages is determined by user. Can be used for counting and frequency division.

BC-335 COUNTER PAC contains six independent flip-flops with appropriate inputs for operation as binary counters; may also be employed individually as complementing flip-flops.

EO-335 EXCLUSIVE OR PAC contains five independent functional gate structures and one independent NAND gate; each contains 3 two-input NAND gates and performs AND-OR and AND-OR-INVERT functions.

BR-335 BUFFER REGISTER PAC contains six flip-flops with independent set-reset capability for parallel loading of information. Common clock reset inputs make possible simultaneous operations on all stages.

XD-335 TRANSMISSION LINE DRIVER PAC contains 6 two-input driver circuits. Each circuit is capable of driving standard 50 ohm, 75 ohm and 93 ohm coaxial cables at repetition rates up to 5 megacycles.

LD-330 LAMP DRIVER PAC contains twelve identical independent lamp driver circuits. Each circuit is capable of switching 70 milliamps of current at any positive voltage up to 20 volts, at a maximum frequency of 1 mc.

BP-330 BLANK PAC — standard card with etched buses for +6V, -6V and ground — facilitates mounting special circuits using standard component lugs and point-to-point wiring. Also available: standard copper clad PAC kit for custom etching.

DL-335 NAND TYPE 2 PAC contains 6 four-input NAND gates; two have disconnected collector load resistors brought out on separate terminals. By tying the gate outputs to a single load circuit a number of gates can be connected in parallel without reducing output drive capability.

DN-335 EXPANDABLE NAND PAC contains 6 three-input NAND gates with nodes; two have disconnected load resistors which are brought out on separate terminals. Gate node input allows for expansion of the number of gate inputs by attachment of diode clusters.

DI-335 NAND PAC contains 10 two-input NAND gates; two have collector loads separate from the collector outputs. By tying the gate outputs to a single load circuit, a number of gates can be connected in parallel without reducing output drive capability.

DG-335 SELECTION GATE TYPE 2 PAC contains two independent functional gate structures; each has 4 three-input NAND gates and performs the AND-OR-INVERT function.

DG-335 SELECTION GATE TYPE 1 PAC contains four independent functional gate structures. Each has 3 two-input NAND gates and performs the AND-OR-INVERT function.

MOUNTING HARDWARE is available with PAC capacities between 24 and 144 modules, and a choice of wire-wrap or taper pin connectors. Power supplies are offered in plug-in or rack-mount models. Accessories include auxiliary wire wrap kits, wire wrapping tools, taper pin insertion tools, extender PACS, jumper lead sets, instruction manuals and logic symbol sticker kits.
Modules

FA-335 GATED FLIP-FLOP PAC contains four independent flip-flops, each with AC and DC inputs and a common reset; allows for control of the flip-flop from a variety of level and pulse inputs.

UF-335 UNIVERSAL FLIP-FLOP PAC contains three independent flip-flops each with AC and DC input gating and a common reset; can perform all functions of other µ-PAC flip-flops plus many additional logic operations.

FF-335 BASIC FLIP-FLOP PAC contains eight independent flip-flops. Each stage has a DC set and reset input and a set and reset output. Circuit consists of two NAND gates internally wired back-to-back.

DC-335 MULTI-INPUT NAND PAC contains 2 six-input NAND gates with nodes and 4 three-diode clusters. Gate node input allows for diode cluster expansion of the number of gate inputs.

DM-335 DELAY MULTIVIBRATOR PAC contains two independent monostable multivibrators capable of generating assertion and negation pulses in a variety of widths. Each circuit has two NANO inputs, an Enable and three discrete variable delay taps.

MC-335 MASTER CLOCK PAC contains a crystal controlled oscillator, a pulse shaper and a pulse amplifier. The oscillator operates between 200 kc and 5 mc. The pulse shaper section can vary pulse width between 50 and 150 nanoseconds.

ST-335 SCHMITT TRIGGER PAC contains two independent trigger circuits capable of converting various shaped inputs to a µ-PAC output. Switching levels can be varied from +2.5 volts to −2.5 volts by making appropriate pin connections.

PA-335 POWER AMPLIFIER PAC contains 6 three-input high-drive NAND gates, each capable of driving 25 unit loads and 250 picofarads stray capacitance. Each gate has two electrically common outputs to reduce load distribution current.

MV-335 MULTIVIBRATOR CLOCK PAC contains a free-running variable frequency multivibrator, a pulse shaper and a pulse amplifier. The multivibrator operates between 200 kc and 5 mc; frequency and pulse widths can be varied by means of potentiometer–capacitor networks.

TG-335 TRANSFER GATE PAC contains four independent functional gate structures. Two of the structures have 4 two-input NAND gates, one input on each gate being common to the four gates. The remaining two structures have 3 two-input NAND gates, one input being common to the three gates.

LC-335 NEGATIVE LOGIC LEVEL CONVERTER PAC contains 10 independent two-input circuits. Each circuit accepts signals at ground and −4 to −15 volts and provides a µ-PAC output. Also available is the S-PAC LC-35 Positive Logic Level Converter PAC which mates µ-PAC signals with 3C’s S-PAC.

SD-330 SOLENOID DRIVER PAC contains three independent circuits for driving heavy resistive, capacitive or inductive loads. Each circuit has two NAND inputs and is capable of switching up to one amperes of current at 500 cycles per second from a positive supply of up to 28 volts. One independent two-input NAND gate is also included.

COMPUTER CONTROL COMPANY, INC.
OLD CONNECTICUT PATH, FRAMINGHAM, MASSACHUSETTS 01702

Electronics | February 7, 1966

Circle 59 on reader service card 59
Six Semiconductor Innovations Help

1. New tetrode FET attains 8000 µmhos

Very high transconductance, frequency capability into the uhf range — these are the major advantages you get with TI's new TIXS35 N-channel tetrode field-effect transistors. These represent a two-to-one improvement over currently available tetrode FETs.

Transconductance is typically 8000 µmhos with substrate gate connected to source, and 10,000 µmhos minimum with gates connected together. Other characteristics: $V_{BB,GBS} = 30$ V min; $C_{iss} = 1.4$ pF max; $C_{iss} = 8$ pF max.

Isolation between gates minimizes "pulling" in mixer applications and greatly reduces skewing problems in AGC applications at IF. In autodyne mixer circuits like the one at left, the TIXS35 reduces circuit components. Circle 71 on Reader Service card for data sheet.

2. New N-channel FET features 60 ohms $R_{DS}$ (ON)

TI's new TIXS33 field-effect transistor features a very low drain-source resistance of 60 ohms maximum. This makes it ideal for a wide range of switching applications such as low-level choppers and commutators as well as low- and medium-frequency amplifiers.

This planar epitaxial device offers high transconductance ($Y_{cs} > 12,000 \mu \text{mhos}$), high drain current (> 25 mA), low leakage ($I_{ss} < 1 \text{nA}$), and low capacitance ($C_{gs} < 5 \text{pF}$ and $C_{gs} < 20 \text{pF}$).

Symmetrical geometry makes drain and source leads interchangeable. This permits use in multiplex and sample-hold circuits and allows replacement of older devices with non-standard lead configurations. Package is the TO-72 (four-lead version of the TO-18). Circle 72 on Reader Service Card for data sheet.

3. High-density diode arrays save space, improve product

Custom monolithic and discrete diode arrays, combining up to 20 diodes in standard flat-pack, low-profile TO-5 and TO-18 packages, are available from TI.

Benefits include high-density packaging, compatibility with integrated circuits, uniformity of parameters, and close thermal tracking. Core drivers, diode AND gates, common-anode and common-cathode arrays are typical of devices that are available. Circle 75 on Reader Service Card for information.

TI cannot assume any responsibility for any circuit shown or represent that they are free from patent infringement.
4. New diodes employ oven for high stability, low cost

TIKD746-759 temperature-compensated reference diodes offer temperature coefficients as low as 0.001%/°C and voltage ratings from 3.3 to 33 volts. Cost is less than conventional multijunction reference diodes.

The unique unit comprises a Moly/G® diode within a self-regulating polycrystalline semiconductor oven as shown at right. The oven holds 120°C within ±8°C from −55°C to +100°C and within ±2°C from −10°C to +50°C. Temperature is held within 1°C over a 10% voltage change. The oven operates on 24 V ac or dc.

Typical applications include regulated power supplies, high-frequency crystals, differential amplifiers, and instruments requiring voltage reference. Circle 73 on Reader Service Card for data sheet.

5. Simplify assembly with TI customized light sensor arrays

Now you can reduce manufacturing costs, increase reliability, improve performance, and minimize optical crosstalk with PC-board light sensor and light emitter arrays from TI.

You can reduce assembly, testing and inventory costs because TI arrays are preassembled and pretested units ready for installation. Reliability is improved because PC-board design is inherently more rugged than individually wired sensing devices. All components are hermetically sealed for long life.

LS600 planar light sensors give high, uniform sensitivity. Typical output is 1 mA light, and 0.01 µA, dark, at 25°C. Sensitivity can be matched to ±20% across arrays. Lens confines admission angle to 10° off axis, minimizing optical crosstalk with close sensor spacing. Circle 74 on Reader Service Card for information.

6. 400 V power transistors permit simplified circuitry

TIP04 NPN silicon transistors offer 400 volt minimum VCEO(CBO) — permitting simplified circuitry for high-power line-operated equipment and circuits with inductive or capacitive loads.

Low saturation voltage (1V max at 2A) gives high efficiency. Low leakage (Ieek = 10 mA max at 400 V and 100°C TC) permits high-impedance bias circuitry for high gain. Other features include an f of 3 MHz and fast switching speed. Circle 76 on Service Card for data sheet.
How Amphenol’s 108 microminiature connectors help you hatch new ideas

They give engineers the complete selection needed to break out of the shell... to innovate... to design smaller, cheaper and more reliable equipment.

Now, you can choose from the most complete line of standard microminiature connectors in the industry. Amphenol builds connectors for printed circuit board, rack and panel and modular applications; mni-
ature circuitry and thin film networks; cable-to-cable and cable-to-chassis connections. Many of which meet unusual environmental requirements.

Amphenol builds specials, too. Some are variations of standards. Others were hatched to solve one-of-a-kind interconnection problems.

For instance, Amphenol designed and built a new high density micro-miniature "Multi-Mod" connector with environmental seals, removable contacts and full modular construction. You can program both the contacts and the modules.

Amphenol's tiny Micro-Med bipolar probes are helping medical technicians make inexpensive brain implantations in laboratory animals.

And a modification of our 74 Series Micro-Min® connector is delivering new cost and reliability advantages in a high-volume communication handset.

Ask an Amphenol Sales Engineer to show you how we can help you hatch a new idea in microelectronics and microminiature interconnection techniques. Call your distributor for off-the-shelf delivery. Amphenol Microelectronics, 2837 S. 25th Ave., Broadview, Illinois 60155.
A design advance

Broader line of standard silicon modular power supplies for fixed voltage applications

UP TO 60 VDC • UP TO 90 AMPS

Features and Data
Meet Mil. Environment Specs.

- RFI: MIL-T-16910
- Vibration: MIL-T-4807A
- Shock: MIL-E-4970A • Proc 1 & 2
- Humidity: MIL-STD-810 • Meth. 507
- Temp. Shock: MIL-E-5272C • (ASG) Proc. 1
- Altitude: MIL-E-4970A • (ASG) Proc. 1
- Marking: MIL-STD-130
- Quality: MIL-Q-9858

Convection cooled — no heat sinking or forced air required

Wide input voltage and frequency range — 105-132 VAC, 45-440 cps

Regulation (line) 0.05% plus 4MV
(ground) 0.03% plus 3MV

Ripple and Noise — 1MV rms, 3MV p to p

Patents Pending

Circle 64 on reader service card

RACK ADAPTERS

LRA-5—3½” height by 2½” depth.
Mounts up to 4 A package sizes; 3 B or C package sizes; or 2 A and 1 B or C package sizes. Price $35.00

LRA-4—3½” height by 14” depth.
(For use with chassis slides)
Mounts up to 4 A package sizes; 3 B or C package sizes; or 2 A and 1 B or C package sizes. Price $55.00

LRA-3—5¼” height by 2½” depth.
Mounts up to 4 A, B or C package sizes; 2 D or 2 E package sizes; or 2 A, B or C and 1 D or 1 E package sizes. Price $35.00

LRA-6—5¼” height by 14” depth.
(For use with chassis slides)
Mounts up to 4 A, B or C package sizes; 2 D or 2 E package sizes; or 2 A, B or C and 1 D or 1 E package sizes. Price $60.00

Lambda Electronics Corp.
515 Broad Hollow Road • Melville, L.I., New York • 516 Myrtle 4-4200
## Ordering Information

### METERS—1½ Metered panel MP-3 is used with rack adaptors LRA-4, LRA-5 and packages A, B, and C.

5½" Metered panel MP-5 is used with rack adaptors LRA-6, LRA-3 and packages A, B, C, D, and E.

To order these accessory meters, specify panel number which must BE FOLLOWED BY THE MODEL NUMBER of the power supply with which it will be used.

### Examples

For Lambda Panel Model No. Metered Panels Model 1, 3, and Price

- MP-3 LMA-24 LMA-36 LMA-4 $40.00
- MP-5 LMA-20 LMA-28 LMA-40 $40.00

Note—G and LM Packages are full rack power supplies available metered or non-metered. For metered models, add suffix M to the Model No. and $30 to the non-metered price.

### OVERVOLTAGE PROTECTION—Externally mounted adjustable crowbar type overvoltage protection accessory for use with A, B, C and D packages—$25.

E, F, and G packages available with built-in overvoltage protection. To order crowbar type overvoltage protection for E, F, and G packages, add suffix OV to the model no. and $60 to the E package price and $90 to the F and G package price.

### FIXED VOLTAGES—In addition to the fixed voltages listed, any fixed voltage is available up to 65 VDC at moderate surcharge.

### Current rating applies for input voltage 105-132 VAC 55-65 cps.

For operation at 45-55 cps and 360-440 cps derate current rating 10%.
Now there are 2 \textit{split-screen} bistable storage oscilloscopes on the market!

(Tektronix developed both of them)

The exclusive Tektronix split-screen, bistable storage feature is now available in two oscilloscopes, the new DC-to-30 MHz Type 549 and the familiar DC-to-15 MHz Type 564.

Both offer the unique capability for simultaneous storage and conventional oscilloscope operation, plus general purpose convenience and plug-in versatility. These features and new, reduced prices for the Type 564/RM564 add up to the kind of value you can expect from Tektronix.

Tektronix Bistable Storage Offers

- **Contrast of a stored trace independent of viewing time**
- **Brightness of a stored trace independent of viewing time**
- **Brightness of a stored trace independent of writing speed**

<table>
<thead>
<tr>
<th>Storage Scope</th>
<th>Type 549</th>
<th>Type 564</th>
<th>Type 564 Mod 08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness</td>
<td>2.5 ft. L</td>
<td>6 ft. L</td>
<td>2 ft. L</td>
</tr>
<tr>
<td>Writing Speed</td>
<td>Normal</td>
<td>0.5 cm/µs</td>
<td>25 cm/ms</td>
</tr>
<tr>
<td></td>
<td>Enhanced</td>
<td>&gt; 5 cm/µs</td>
<td>&gt; 125 cm/ms</td>
</tr>
<tr>
<td>Contrast Ratio</td>
<td>&gt; 4:1</td>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>Erasure</td>
<td>split screen</td>
<td>split screen</td>
<td>split screen</td>
</tr>
<tr>
<td></td>
<td>remote/Auto</td>
<td>full screen</td>
<td>full screen</td>
</tr>
<tr>
<td>Display Area</td>
<td>6 cm x 10 cm</td>
<td>8 cm x 10 cm</td>
<td>8 cm x 10 cm</td>
</tr>
</tbody>
</table>

- **3 display modes**—(1) split-screen combination of storage/conventional displays, (2) full-screen storage, or (3) full-screen conventional displays.
- **Saves film**—extended viewing times of stored displays permit detailed waveform analysis in many instances without photography.
- **Simplifies trace photography**—once initial camera setting has been determined, no further camera adjustments are necessary, regardless of conditions under which future stored traces are obtained.
- **Beam locate**—locate pushbutton offsets beam into a non-store area on left edge of display, permitting precise vertical positioning of beam before signal is stored.
- **Adapts easily to various applications**—accepts major plug-in lines for such applications as multi-trace, low-level differential, sampling, spectrum analysis, others.
- **Type 549 automatic erase**—can be selected for periodic or after sweep operation with selectable viewing times from 0.5 second to 5 seconds. In addition, Erase-and-Reset pushbutton—which permits erasing display and rearming single sweep—can be controlled remotely, if desired.
**TYPE 564**

**DC-to-15 MHz**
accepts 2 and 3 series vertical and time-base plug-ins

**Storage time** — Bistable Storage provides a stored display for up to one hour.

**Erase time** — 250 ms full cycle at normal operating level.

Type 564 Storage Oscilloscope $875
Size is 13$\frac{3}{4}$" high by 9$\frac{3}{4}$" wide by 21$\frac{1}{2}$" deep; net weight is 33 pounds. Uses 2-series and 3-series plug-ins.

Rack Mount Model RM564 $960
(same performance specifications, yet occupies only 7" standard rack height)
(Bandwidth DC-to-15 MHz with Type 3A5 Plug-in)

Plug-ins illustrated

Type 3B3 Time-Base Unit $585
(normal and delayed sweeps — 0.5 µs/cm to 1 s/cm, calibrated sweep delay — 0.5 µs to 10 sec, single sweep, 5X Magnifier, full passband triggering, flexible, easy-to-use — simplified trigger logic)

Type 3A6 Dual-Trace Unit $540
(Dual-Trace — 10mV/cm at DC-to-10 MHz, 5 display modes)

**TYPE 549**

**DC-to-30 MHz**
with sweep delay and > 5 cm/µs writing speed; accepts letter and 1-series plug-ins

**Storage time** — Bistable Storage provides a stored display for up to one hour. When applications require maximum writing speed, viewing times of 20 minutes or less are recommended.

**Erase time** — 200 ms maximum, complete cycle.

**Time base features** — Sweep Delay — from 1 microsecond to 10 seconds. Sweep Range — 5 s/cm to 0.1 µs/cm (Time Base A) and 1 s/cm to 2 µs/cm (Time Base B). X5 Magnifier extends fastest sweeps to 20 ns/cm (Time Base A) and to 0.4 µs/cm (Time Base B). Single Sweep — manually, automatically, or remotely. Full Passband Triggering — with flexible, easy-to-use facilities, and Simplified Trigger Logic — with lever control of trigger functions.

Type 549 Storage Oscilloscope $2,375
Size is 17" high x 13" wide x 24" deep; net weight is ≈ 67 pounds. Uses letter and 1-series plug-ins.

Type 1A1 Dual-Trace Plug-In Unit (illustrated) $600
(Dual Trace — 50 mV/cm at DC-to-30 MHz*, 5 mV/cm at DC-to-23 MHz*. Single Trace — 500 µV/cm at 2 Hz-to-14 MHz, 5 Display Modes, front panel signal output)

*When used in Type 549.

For information on how Tektronix can solve your measurement problem with a storage oscilloscope, call your Tektronix field engineer.

Tektronix, Inc.
When 737 Simulators Were Needed

MCDONNELL WAS A NATURAL

United Air Lines and Boeing have picked 737 Simulators built by McDonnell. They had good reasons. Naturally.

They found at McDonnell:

- Simulator design concepts based on efficient application of modern general purpose digital computers.
- Direct conversion of digital outputs to synchro instrument drives, without use of servos.
- All-digital computer inputs.
- Digital accuracy.
- Digital input flexibility.
- Self-test programs.
- Standard parts and solid-state components.
- Design for reliability.

McDonnell’s years of simulation engineering and development experience—from fighter aircraft design evaluation to Gemini mission training—provide the practical know-how both air transport management and air line pilots can depend upon. McDonnell welcomes the tight reliability requirements of the 737 Simulator. We know the penalties of “down time” and we design to avoid them.

McDonnell is also prepared for other simulation problems. Naturally.
Capacitor reliability?
Take Scott's word for it: MYLAR®

H. H. Scott manufactures some of the world's most widely used stereo amplifiers. They are recommended by many leading independent testing organizations. Because this kind of reputation depends on capacitor reliability, engineers at Scott use capacitors of MYLAR® exclusively for audio circuits from .047 to .47 microfarads.

"We don't have to worry about performance with capacitors of MYLAR in our components and consoles," says Chief Engineer Dan von Recklinghausen. "We use capacitors of MYLAR because of their low leakage, extremely long life, excellent capacitance stability and ability to withstand the wide temperature and humidity ranges encountered in high-power hi-fi amplifiers." MYLAR also offers high dielectric strength in thin gauges, so capacitors can be made smaller, leaving space for more circuitry. And, in many cases, capacitors of MYLAR cost less than paper.

Scott components and consoles are known for excellence in quality, performance and reliability. So are capacitors of MYLAR. For complete information write DuPont Co., Room 3370A, Wilmington, Delaware 19898.

(In Canada, write Du Pont of Canada Ltd., P.O. Box 660, Montreal 3, Quebec.)

Electronics | February 7, 1966
This is the BCD decoder that ends make/buy decisions

Many users seem to think so.
We've built our numeric readout (the noteworthy NIXIE® tube, naturally!) into a handsome, compact package that not only gives you dependable low-level BCD-to-decimal conversion, but also enhances your most elegant design.

Most important, our BIP-8211P readout assembly carries a price tag so low that the savings in design, development, production, and testing will convince even the most parsimonious do-it-himselfer to reach for a P. O. instead of a slide rule.

Convenience? The decoder socket packs can be mounted in one of our bezel assemblies that handles up to 15 digits, mounts into your front-panel opening with just two screws, accommodates decimal points and colons.

Flexibility? It's odds-on that your own BCD circuits will drive the BIP-8211P without modification. But we also offer optional versions which accept just about any form of BCD, or one that gives you straight decimal-to-decimal driving, should that be what you need.

Reliability? Continuing environmental and life testing add up to dependable operation in severe environments of temperature, shock and vibration. All this and an enthusiastic Zero Defects Program, too!

Availability? We've tooled up a new production line that's turning out BIP-8211P modules in quantities large enough to make shipment possible in an interval no longer than the time it takes to process the paperwork. Need them even faster for bread-boarding or prototyping? They're priced low enough to order them now, and have them in arm's reach.

Got a BCD-decoding requirement? Leave it to Burroughs! You'll be glad—so will your comptroller — so will the user.

Write or call for full information.

Burroughs Corporation / ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY 07061

Electronics | February 7, 1966
**Technical Articles**

### Using strip transmission lines to design microwave circuits, part I

Though strip transmission lines are not new, many engineers have been reluctant to use them because they don’t understand them. But the pressure to miniaturize microwave equipment—a byproduct of the acceptance of solid state devices—has stimulated their use. One big advantage is the size reduction, shown clearly by this issue’s cover. In the photograph, taken at the Sylvania Electric Products, Inc.’s Williamsville, N.Y., plant, the strip line card does the work of the other hardware.

![Electronics magazine cover](image)

### Phase-locked marker improves spectrum analyzer’s accuracy:

A new instrument allows the rapid identification and accurate measurement of any frequency in the spectrum. This frequency-measuring spectrum analyzer has a phase-locked marker and a modified display to offset the limitations of previous spectrum analyzers. It can aid in analyzing radio-frequency interference.

### Putting superconductors to work:

More than a dozen companies are making superconductor magnets and systems. The discovery of new materials is speeding the use of superconductors in applications as diverse as giant research magnets, masers and magnetohydrodynamic generators.

### The packaging revolution—simpler designs for complex system:

To avoid complicated, expensive interconnection structures, an engineer has to adopt new procedures when designing a complex digital system with integrated circuits. These new practices force the system’s functional organization to be regular and the interconnections simple.

### Coming February 21

- Optoelectronic devices in memories
- Converting to hybrid integrated circuits
- Survey of strip transmission lines: part II
Using strip transmission line to design microwave circuits, part I

The first article in a two-part survey of the characteristics and capabilities of strip transmission line examines tested design procedures for reliable, low-cost multipliers, filters and diode switches

By J. Richard Dangl and Kenneth P. Steele
Sylvania Electronics Systems, Williamsville, N.Y.

Practical design procedures, developed over the last few years, are resulting in the wider use of strip transmission line in miniaturized microwave circuits. Ideally suited for low and medium power applications, strip transmission line is used to design low-cost, solid state circuits with improved electrical characteristics and increased reliability. But design engineers, interested in taking advantage of the line's capabilities, have been hard put to find a broad examination of this invaluable technology.

Strip transmission line consists of a thin rectangular center surrounded by dielectric, and spaced between two highly conducting ground planes, as shown in the diagram on page 73. Printed circuit techniques are used to construct the line. The fundamental propagation mode is a transverse electromagnetic wave.

Components such as semiconductors and ferrites can be embedded in the line, and passive elements such as filters can be formed by chemically etching the center conductor. The low cost of etching passive components means that multiresonant filters can be used to improve the electrical performance of many semiconductor circuits such as varactor multipliers and tunnel-diode amplifiers.

Characteristics

Strip transmission line reduces equipment size because equivalent electrical line lengths are reduced in inverse proportion to \( \sqrt{\epsilon_r} \), where \( \epsilon_r \) is the relative dielectric constant of the material used in the construction of the line. For dielectrics such as the polyolefins, \( \epsilon_r = 2.3 \); thus linear dimensions are reduced by a factor of 1.5. Size reduction by a factor of two or three can be provided by higher dielectric constant materials, but their other physical characteristics, such as brittleness, make them less suitable. An example of size reduction is illustrated in the photograph on page 73.

Uniformity and accuracy of circuits designed in the line depend on the quality of the dielectric material. The development of irradiated polyolefin dielectrics was a major breakthrough because it made available low-loss dielectric materials with desirable electrical and physical characteristics. These materials typically have dielectric constants of about 2.25 to 2.32, and loss tangents as low as 0.0001 into the K, frequency band (12.4 to 18 Gc). Polyolefin is more temperature-stable than previously available low-loss dielectrics, permitting its use in miniature equipment operating at ambient temperatures as high as 85°C.
Comparison of equivalent microwave and strip transmission line circuits shows the reduction in size offered by the latter technique. Girl holds both the basic strip transmission line circuit board and the complete package for a varactor tripler.

when produced in large quantities, the material is extremely homogeneous.

The superiority of strip transmission line over waveguide or coaxial cable can be demonstrated by showing that a solid state frequency source, consisting of a chain of varactor multipliers, can be made to operate more reliably without increasing its cost. To reduce the number of diode stages, each stage should multiply the frequency by a large factor. However, high-order multiplication is less efficient than an equivalent chain of low-order multipliers. To increase the circuit’s efficiency, additional resonators for sustaining idler frequencies must be added. Also, multiple resonator filters with Chebyshev or maximally flat characteristics are needed to increase bandwidth and prevent spurious outputs. When strip transmission line is used, these complex circuits can be produced economically because the additional resonators can be etched at a negligible increase in cost. The increased efficiency permits the use of high-order multiplication, resulting in fewer diode stages. Additionally, the large bandwidths prevent severe physical environments from changing electrical parameters and performance. Both factors increase the circuit’s reliability.

Another distinguishing characteristic of strip transmission line is its compatibility with solid state devices. This feature acquires increased significance now that semiconductor manufacturers are producing devices in sizes to match the line’s thickness and to fit special diode mounts. The ultimate in compatible design—the use of the same semiconductor material as the strip transmission line’s dielectric and as the substrate for active elements such as diodes—is under experimental investigation in a number of laboratories.

I. Synthesis of strip transmission line

The evolution of strip transmission line is illustrated on page 74. The line may be considered as a development of the parallel-wire line. In this line, the two wires carry equal and opposite currents and the field is in the form of a transverse electromagnetic wave (TEM). In a TEM wave, no longitudinal component of field exists, that is, there is no component of field in the direction of propagation. The TEM mode is the principal mode in coaxial cable, but cannot exist in rectangular waveguide.

If a thin, perfectly conducting metal plate that is infinite in extent is placed perpendicular to, and at the midpoint of, the line joining the centers of the wires, the field pattern will not be disturbed if one of the wires is removed. In effect, a virtual image of the remaining wire is produced in the metal plate to maintain the same electric field configuration. This basic concept leads to microstrip—one of the earliest and simplest of lines. In microstrip, the wire conductor is formed into a rectangle and a dielectric material is added as mechanical support for the conductor. The metal plate is called a ground plane.

A major disadvantage of microstrip is the radio-frequency leakage resulting from the use of only one ground plane. This difficulty is overcome by adding a second ground plane as in the three air-dielectric transmission lines in the center panel of the diagram.

Of the three types of line illustrated, only the line with the circular center conductor is still used extensively. This line, called shielded strip line or slab line, is used for breadboard and research
The evolution of strip transmission line . . .

Strip transmission line development starts with the parallel wire line at the upper left. The field around the upper wire is not changed if a metal sheet is inserted between the wires, and the lower wire is removed. This leads to the microstrip configuration. Air dielectric lines in the middle of the diagram reduce r-f radiation but the center conductors are difficult to support. Strip transmission line at the upper right is formed from two copper clad sheets that are sandwiched together to form a rugged, compact package. Both single and double registration are used in circuit design. The coupled strip transmission line is the basic structure for various coupling networks and filters, and is one of many configurations that can be designed.

purposes because it is easy to modify. In addition, short-circuited stubs, which are useful in experimental work, can be built easily in the shielded strip line configuration.

The major problem with the three air-dielectric transmission lines is that the support for the center conductor is too complex and may not be rugged enough for many environmental conditions. The deficiency is overcome by using the strip transmission line shown at the right in the diagram.

Strip transmission line is built using two sheets of copper-clad dielectric. The dielectric is normally 1/16 to 1/8 inch thick and is clad with 1 or 2 ounces of copper per square foot. The center conductor is formed by chemically etching away the copper on one side of a doubly-clad board. Then the two sheets are brought together to form the sandwich structure. To provide rigidity and insure uniformity, the boards are fastened between two light-weight, metal pressure plates.

Because of the thickness of the center conductor, there is an air gap of .0015 to .003 between the dielectrics of the two sheets. This air gap is important only when there is a possibility of peak power breakdown.

Both single and double registration types are shown in the diagram. In double registration, center conductors are etched on each of the dielectric sheets. Double registration is used when the lines are butted together. The additional thick-

Directional coupler may be constructed with the center conductor configuration shown at the left. The coupler supports even and odd modes whose electric fields are shown in the figures at the right. In the odd mode (the lower figure), the direction of the electric field on one side of this axis of symmetry is opposite to the direction on the other side.
The conductor reduces the possibility of discontinuity at the joint and thereby a low voltage standing wave ratios. Single registration can suffice if proper test and processing controls are used.

The coupled strip transmission line, shown in the right hand corner of the panel on page 74, is the basic configuration for many important components such as directional couplers, hybrid couplers and parallel coupled filters.

The center conductor configuration and the four ports of a directional coupler are shown at the left of the diagram at the bottom of page 74. The coupling mechanism may be explained by the electric field distribution for the fundamental TEM modes, shown at the right of the diagram. The even mode results when the currents in the two conductors are both equal and in the same direction. The odd mode results when the currents in the conductors are equal but in opposite directions. It is the odd mode which couples the two conductors.

**Energy flow**

If one superimposes the fields from the two modes, it can be seen that the fields will be additive at one conductor and opposing at the other. Under these conditions, much of the energy is concentrated along one of the conductors and a small coupling field exists between the two conductors. The conductor which supports the larger field is represented by the direct line between ports 1 and 4 in the center conductor. Most of the energy flowing into port 1 will flow out of port 4. Some of the energy will be coupled to the other line and will flow out of port 2. Theoretically, no energy flows out of port 3 if it is properly terminated. The coupling mechanism may also be explained in terms of the capacitance between the two lines. This is a useful viewpoint when the coupled lines are used as filter elements. For maximum coupling to occur, the electrical length of the line is \( \lambda /4 \) where \( \lambda \) is wavelength in the dielectric.

The coupler is theoretically matched at all frequencies if the input impedance of the coupler is equal to the source impedance \( Z_0 \). The input impedance, \( Z_{in} \), and coefficient of coupling, \( k \), of the coupled line is given by

\[
Z_{in} = \sqrt{Z_{00}Z_{oo}}
\]

\[
k = \frac{Z_{ee} - Z_{oo}}{Z_{oo} + Z_{ee}}
\]

where \( Z_{oo} \) is the odd-mode characteristic impedance, which is defined as the characteristic impedance of one line to ground when equal currents are flowing in the two lines; and \( Z_{ee} \) is the even-mode characteristic impedance, defined as the characteristic impedance of one line to ground when equal and opposite currents are flowing in the two lines. The width of each of the coupled conductors and the spacing between them can be found in nomograms in terms of \( Z_{oo} \) and \( Z_{ee} \).2

Although strip transmission line is most accurately represented by distributed impedances, lumped-element circuits may be approximated with lengths of line that are small fractions of a wavelength. Because the line may be represented by lumped constant networks, it is possible in many instances to use low-frequency analysis to design passive microwave circuits such as filters. Illustrated in the diagram shown above are some of the equivalent impedance relationships.3,4 In this diagram the first two figures are end views of the line; the third and fourth figures are top views.

The characteristic impedance of the line is a function of the dimensions of the line and a parameter, \( d_0 \), which is a function of the thickness, \( t \), of the center conductor. The value of \( d_0 \) can be determined from graphs.3 In the second figure, shunt capacitance is seen to be equivalent to a short length of line, \( s \). The total capacitance may be considered to be the sum of the shunt capacitance and the series capacitance.

**Basic impedance relations** and lumped circuit equivalents are indicated. These impedance configurations may be combined in many ways to form different circuits. Only the top view of the center conductor is showing in the diagrams of the series inductance and parallel resonant shunt circuit.

\[
C = 0.9 \varepsilon_r \frac{w_b}{1-1/b} \quad \mathrm{pF}
\]

\[
Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln \left( \frac{4b}{2d_0} \right) \quad \mathrm{OHMS}
\]

\[
\varepsilon_r = \text{RELATIVE DIELECTRIC CONSTANT}
\]

\[
d_0 = \text{DETERMINED FROM GRAPHS}^2
\]

\[
w_b < 0.35
\]
of the capacitance between the center conductor and the ground plane and the fringing capacitance at the edge of the center conductor.

Shunt capacitance may also be obtained with a metal post: one end forming a small gap with the center conductor and the other end shorted to the ground plane. Small machine screws are often used as the metal post.

A series capacitance (not shown) is formed by overlapping lengths of center conductor that are separated by a small piece of dielectric. The technique is useful when large capacitances are required. Smaller values of series capacitance are obtained easily by cutting a small piece of the center conductor. Series inductance is obtained by changing the width of the conductor.

The open-circuited stub—the last figure in the diagram—is equivalent to a series-resonant stub circuit and is very useful, particularly for impedance matching and for low-pass filters. To permit tuning with a variable capacitor, capacitively loaded open-circuited stubs are also used. The circuit may be made to appear primarily capacitive or inductive depending on whether the stub is shorter or longer than \( \lambda/4 \).

II. Varactor multiplier frequency sources

Varactor multipliers use the nonlinear voltage-variable capacitance characteristics of a diode to generate microwave frequencies from a stable source.

A simple form of varactor multiplier is the doubler, which contains most of the elements that are common to all other multipliers. The shunt-type circuit at the top of the diagram shown below can be easily fabricated in strip transmission line. The low-pass filter matches the 50-ohm source impedance of the external generator. The filter prevents higher frequencies generated by the varactor from appearing at the input. The input frequency is applied to the diode through the low-pass filter and the matching network. The nonlinear reactance of the diode generates the second and higher harmonics and the mixing products of the input frequency. The desired second harmonic is selected by the bandpass filter at the output.

The matching networks are usually quarter-wave transformers that match the real part of the diode impedance to the characteristic impedance of the line. Line lengths between the diode and the two

Multiplier circuits use various filters and matching networks to increase the bandwidth and provide conduction paths for the idler frequencies. Idler frequencies such as \( 4f_0 \), in the quintupler are not available as the output, but improve the efficiency of converting the fundamental, \( f_0 \), to the desired output frequency.
An example of the design of a tripler will indicate some of the important calculations and considerations required in designing multipliers in strip transmission line. For the tripler considered here, an output power of 1 watt was required at a frequency of about 5,500 Mc. The input frequency, therefore, had to be 1,833 Mc. The specified bandwidth at the output was less than 1%, which presented no problem for this design.

The basic design is a shunt-diode configuration with the varactor placed between the input filter and the bandpass filter, as is shown above. For both electrical and mechanical reasons the shunt-diode configuration is the best for strip transmission line work. In this configuration, one end of the varactor is physically grounded, with the ground plane acting as an excellent heat sink. Tuning and access to the diode are also easier with the shunt configuration.

### Positioning the diode

Location of the diode between filters depends both on the reflected impedance of the filters and the reactances of the diode. As in a doubler, the first approximation is to place the diode between the filters at a point which satisfies two conditions—namely, that the input low-pass filter present an open circuit to the diode junction at the third harmonic frequency and that the output bandpass filter present an open circuit to the diode junction at the fundamental frequency. These conditions prevent dissipation of the third harmonic and the fundamental at the input and output filters.

To idle the second harmonic, the tripler design also requires an additional circuit which presents a short circuit to the diode at 2f₀. In the diagram shown above, this circuit could be a series tuned circuit, connected in parallel with the diode and resonant at 2f₀. Here, the short at the diode was obtained by properly positioning the diode between the filters. The design of both the low-pass and bandpass filters is described later in this article.

The appropriate position of the open circuit which the input filter must present at the third harmonic, 5,550 Mc, can be calculated, but it is more precise to measure the position using a model of the filter. Measurements were made on a model fabricated in 1/16-inch Ralexene "P" dielectric. In these measurements the diode is not in the circuit. The output impedance of the low-pass filter at the second and third harmonic frequencies is measured with a coaxial slotted line, and plotted on a Smith chart. The Smith chart indicates the distances from the reference plane to the open and short circuits. The distance to the open circuit is represented on
Position of the varactor with respect to the output port of the low-pass filter is determined from voltage standing wave measurements made at a frequency of 3f1 (5,500 Mc). Distance X₁ indicates the position of an open circuit. Consideration of diode capacitance would require that the diode be placed at X₁, which is too close to the filter. Therefore, the diode is moved back a half-wavelength placing it a distance Y₁ from the filter.

Bandpass filter at the output of the tripler is realized by using parallel-coupled transmission lines. As in the low-pass filter, the position of the varactor diode with respect to the filter is determined from measurements and the capacitance of the diode. The VSWR measurement is made at a frequency of f₁ (1,833 Mc).

Because of the capacitance introduced by the diode, the measured distance X₁ to the open circuit would not be correct. When the diode capacitance is accounted for, a standard Smith chart analysis shows that the open circuit actually occurs at X₁'. This would place the mounting structure for the diode too close to the filter. Therefore, the diode position is moved back a half-wavelength from X₁'. At this position it is a distance Y₁ from the output of the low-pass filter.

The value of capacitance used to calculate the position X₁' is taken from the diode data sheet—in this case, a type D4852E diode was used in the tripler. It has been found that the capacitance of the diode at —6 volts is a good approximation for the average capacitance. For the type D4852E diode this capacitance is 1.5 picofarads.

For the bandpass filter, input impedance measurements were made at 1,833 Mc to determine the location of the open and short circuits, as in the lower diagram at the left. The diode relative to the input of the filter is determined by using the same procedure as the low-pass filter.

The prototype of the multiplier is then faced with the initial position of the diode at a distance Y₁ from the low-pass filter and distance Y₂ from the bandpass filter. Past experience has shown that this initial position is very close to the final position which gives maximum power output, indicating the procedure yields a rather good approximation for the design of the multiplier.

To determine the final position of the diode, measurements of the tripler's performance are made at various power levels, frequencies, and diode positions. A peak in the power output indicates the exact position for mounting the diode. In these tests, a special diode mount is used to reposition the diode relative to each filter. In addition, the strip transmission line is cut at the calculated diode position to allow the distance between the filters to be varied slightly by adding spacing blocks. Using this technique for trimming the position of the diode, only one breadboard is required before an engineering model is made.

Evaluation of the completed tripler showed that the spacing between the filters remained the same as in the breadboard but that the diode was located at the short-circuit point of the second harmonic. This point is shown in the diagram of the input filter at the top of the page. This provides the necessary idling of the second harmonic, yet positions the diode closely enough to an open circuit at the third harmonic to satisfy the original conditions.

Fine tuning is achieved by capacitive tuning screws placed on each side of the diode. The distances between the diode and the two filters are slightly foreshortened to accommodate the tuning screws.

A good way to bias the varactor diode is to connect a d-c blocking joint (a microwave analog of a blocking capacitor) followed by a physically small carbon resistor at the input of the low-pass filter. The resistor, which should be at least 10,000 ohms, is connected in shunt with the line. It provides the required r-f isolation for the d-c power supply and acts as a current limiter for the varactor. Another common biasing circuit is an L-C filter. This method often causes spurious response problems and ringing, in the case of pulse operation.

Performance results

Test results obtained for the broadband tripler were in good agreement with predicted performance. A conversion loss of 4 db was obtained for a power input of 2 watts, yielding an output of 0.8 watts at 5,500 Mc. The varactor was well saturated, indicating that the output power obtained was very close to the maximum obtainable. The frequency-output power curve was very flat over the required bandwidth of 1%. The dynamic range of the tripler was relatively small, as expected for a
multiplier with fixed external bias, and operated in saturation. Restricted dynamic range is not a problem in system integration if the variations of both the bias and the input drive power are made small.

Another engineering model of the tripler was built with right-angle, rather than in-line, connections to the circuit board. A circulator, integrated with the board, at the output of the bandpass filter, provided constant loading. This model yielded an output power of 1 watt for an input of about 3.3 watts—a conversion loss of 4.8 db. The higher conversion loss was attributed to right-angle connections and the addition of the circulator.

Test results on the engineering model with a large quantity of diodes proved very encouraging in terms of large-scale production. Ten diodes, type D4852E, were tested in the unit and each yielded approximately the same output power. In each case, only a change in the diode bias was required to optimize the output.

Spurious signals in the output were more than 50 db below the desired signal. Spurious signals are undesired frequencies generated in the low-frequency oscillator or are radiated signals that are picked up and amplified by stages preceding the tripler. Although not fully understood, it has been found from experience that spurious frequencies and noise within the bandwidth of the multiplier may be amplified as much as 5 to 10 db when passing through the multiplier circuit. The input signal, however, undergoes a conversion loss in the multiplication process. This means that the signal-to-noise ratio and spurious rejection—ratio of signal amplitude to spurious amplitude—at the input must be about 10 db greater than the values desired at the output.

In a chain of multipliers this effect is compounded, because each stage will amplify the undesired signals. As an example, a chain of four multipliers may reduce the spurious rejection and signal-to-noise ratio at the output by 20 to 40 db below its value at the input. To reduce the problem, the stages must be well shielded and spurious signals at the input must be held to a minimum.

An engineering model of the tripler that uses a circulator at its output is shown in the top photograph. The screws mounted on the unit are shorted to both ground planes and serve a dual purpose; one of them being to hold the strip transmission line sandwich together and the other to suppress spurious strip transmission line modes. The screws around the circumference also shield the unit preventing radiation from entering or leaving the board. Metalized tape around the edge of the unit also aids in shielding. Other screws on the face of the unit are mode suppressors which prevent the propagation of higher strip line modes that would be generated by the discontinuities at the filters, varactor diodes and connector.

The lower photograph, left, shows the center conductor configuration of the tripler, and more clearly indicates the relative positions of the diode mount, filters and suppression screws.

III. Filters in strip transmission line

Filters are important parameters in most strip transmission line designs. Impedance matching networks, frequency selecting circuits and broadbanding networks are all, in the most general sense, filter structures designed by similar techniques. The filters used in the varactor tripler offer a good example of some of the design considerations.

Low-pass filter

The low-pass filter in the varactor multiplier is illustrated in the figure on page 80 with its lumped-constant equivalent circuit and its frequency response. The characteristic impedance of
the filter is set at 50 ohms to match the input source. The 50-ohm impedance determines the width of the center conductor at the input and output of the filter. No attempt is made to match the filter impedance to the varactor diodes, because, in the overdriven condition, or at high power levels, the diode's impedance characteristics are difficult to predict accurately. The cutoff frequency \( f_c \) of the filter is established at 2,100 Mc. This is sufficiently above the fundamental frequency of 1,833 Mc so that the insertion loss at the fundamental frequency, \( f_0 \), is only about 0.2 db.

The design of the filter is based on an elementary lumped-constant filter consisting of three constant-K prototype L-C sections between m-derived end sections. As shown in the diagram, the various elements of the filter are directly related to various sections of the strip transmission line filter. The impedances of the various sections have been discussed in the section on equivalent circuits on page 75.

Making the width of the series-inductance line very narrow permits the characteristic impedance to be high and the filter length to be short. The length of these sections are set so that \( X_L = 2P \) at the cutoff frequency, \( f_0 \), where \( R \) is the 50-ohm load impedance that is to be matched by the filter. The shunt capacitive section lengths are \( \lambda_0/4 \), where the mean frequency \( f_m = \sqrt{f_0 f_2} \), and \( f_2 \) is defined as the upper limit of the stop band. The frequency \( f_2 \) is arbitrarily chosen to be \( 5f_0 \). The widths of the shunt capacitive sections are determined by the characteristic impedance required to make \( X_C = R/2 \) at the frequency \( f_0 \). The values of \( X_L \) and \( X_C \) satisfy the basic impedance relationship for a constant-K filter,

\[
X_L X_C = R^2
\]

Lengths of the m-derived end sections are chosen to be a quarter-wavelength at the frequency of infinite attenuation, \( f_m \), where,

\[
f_m = \frac{f_0}{\sqrt{1 - m^2}}
\]

The selection of \( m = 0.6 \) results in a very flat image impedance over the passband. The rate of cutoff outside the passband is determined by the number of constant K-sections and the resonant frequency of the end sections. Frequency response for the 3-section filter is down 3 db at 1.3\( f_0 \) and decreases to 60 db at 1.7\( f_0 \).

The frequency response in the stop band of the filter must be considered as carefully as in the passband's. When the filter elements are a half-wavelength long, a resonance occurs reducing the attenuation. In the low-pass filter, the first undesired resonant response occurs at 3.7\( f_0 \), when the inductive sections are \( \lambda/2 \) long. A second undesired resonant response occurs at 4.5\( f_0 \) when the shunt capacitive sections are \( \lambda/2 \) long. Spurious signals or harmonic frequencies appearing at these frequencies will not be sufficiently attenuated and must be reduced or eliminated before the filter.

**Bandpass filter**

The bandpass output filter in the varactor tripler is illustrated in the figure on page 81. Its frequency response is of the Chebyshev type also shown in the diagram.

A Chebyshev response is characterized by equal ripples in the passband. Maximally flat, or Butterworth, filters may also be constructed but the skirt selectivity is not as great as the Chebyshev response.

The filter is a parallel coupled resonator type
The Chebyshev frequency response filter is shown in the diagram. The equivalent circuit for the five-section, box-like resonators representing the parallel inductance and capacitance. The boxes between the resonators—representing the coupling between the resonant bars—are ideal impedance inverter circuits that have a $-90^\circ$ phase shift.

The bandpass filter was required to have low insertion loss in the passband and to attenuate the second and fourth harmonic by at least 50 db. A five-section filter is used because it gives 60 db rejection at the harmonic frequencies with less than 0.5-db insertion loss. Larger values of skirt attenuation are obtained by increasing the number of sections but this also results in an increase in the insertion and loss.

For a given number of filter sections, increasing the bandwidth reduces the insertion loss but requires increased coupling between sections and therefore closer spacing between the resonators. The bandwidth is made as large as possible to obtain low insertion loss but not so large that the spacing of the filter elements produces an etching problem. A 10% bandwidth is about the maximum that can be obtained with a five-section filter. For this bandwidth the spacing between elements must be as small as 0.005 inch. Closer etching tolerances can be maintained only with difficulty.

The dimensions of the filter are determined, using a suitable prototype filter for a model. For designing a five-section Chebyshev filter, the prototype is a low-pass filter consisting of shunt inductive and series capacitive elements. The prototype's frequency response is similar to the desired response, except that it is centered at zero frequency. Basically, a low-pass prototype circuit is used in filter design to take advantage of the symmetry of the response curve and because it may be easily transformed into various low-pass and bandpass configurations.

The ripple, $A_n$, determines the value of the inductive and capacitive elements in the prototype. These values and the characteristic impedance of the filter, $Z_m$, specify the even and odd impedances, $Z_{ev}$ and $Z_{od}$, respectively, of the coupled strip transmission line sections. Definitions of even and odd impedances appear on page 75 in the discussion of parallel coupled strip transmission lines. Once the even and odd impedances are known, the width and gap dimensions of the resonators can be obtained from nomograms.

In the bandpass filter, the line lengths must be corrected for fringing capacitance at the ends, by trimming each section by a small amount, $d$. The trimming is usually performed empirically, but is guided by approximate design equations for the capacitance derived by Cohn.

Strip transmission line filters designed at Sylvania have shown excellent correlation with the results predicted by the design procedure given above. However, the correlation is closely governed by the accuracy obtainable in the graphic and etching processes to be discussed in the next article of this series.

---

**Chebyshev frequency response** of the bandpass filter is characterized by equal amplitude ripples in the passband. The equivalent circuit of the filter consists of ideal inverters, represented by the boxes labelled $K_n$ to $K_{5n}$, and tuned resonant circuits, represented by the parallel inductance and capacitance.
IV. Multiple-pole diode switches

Strip transmission line is much less expensive than waveguide or coaxial line for the construction of multiple-pole diode switches. Such switches consist of many individual circuit elements which are costly to machine but are relatively economical to etch. Costly mounts are unnecessary in low-power strip transmission line switches, since the diodes can be inserted in cut-outs in the dielectric and attached simply to the center conductor.

A shunt-type switch is illustrated in the first schematic below. The diode is represented by its equivalent circuit consisting of the elements $L_o$, $C_J$ and $R_o$. If the spreading resistance, $R_o$, is neglected, the diode may be considered an ideal switch. When the diode is forward-biased it conducts, placing a near short circuit across the line so that no r-f energy reaches the output. Circuit is tuned to series resonance by an external capacitor, $X_{cs}$. The reactance across the line, therefore, is theoretically zero and the isolation of the switch is infinite. With reverse bias, the diode does not conduct; the parallel circuit is tuned to resonance by external inductance, $X_{LP}$, and the reactance across the line is theoretically infinite. In this condition, all available r-f power is transmitted to the output. For this switch, the external capacitive and inductive reactances must satisfy the following conditions:

\[
X_{cs} = \omega_0 L (1 - \omega_0^2 L D C_J)
\]
\[
X_{LP} = \frac{1 - \omega_0^2 L D C_J}{\omega_0 C_J}
\]

Diode in this schematic of the switch is represented by the elements $L_o$, $C_J$ and $R_o$. Parallel reactance $X_{LP}$ is added to increase the bandwidth by resonating the diode.

Multiport switch is formed by adding additional lines and shunt diodes (shown in color) to the basic switch circuit. In this configuration, the output at port 1 or 2 may be pulse modulated by the biasing waveform at diode $D_0$. For clarity, bias circuits are not shown in detail.
where $L_D = \text{diode series inductance}$  
$C_J = \text{diode junction capacitance}$  
$X_{LP} = \text{shunt resonant inductance (includes diode package capacitance)}$  
$X_{CS} = \text{series resonant capacitance}$  
$\omega_0 = 2\pi f_o$

The matching sections, which may be quarter-wave transformers or tapered sections, are designed to match the source and load to a characteristic impedance value of

$$Z_o = \frac{1}{2} \frac{V_D}{I_D} (1 - \omega_0^2 L_D C_J)^2$$

where $V_D$ and $I_D$ are the rated diode voltage and current, respectively. The maximum switching power is given by $P = \frac{1}{2} V_D I_D$ when diode and circuit ohmic losses are neglected.

The biasing circuit shown in the schematic of the switch comprises a d-c connection with a low-pass r-f biasing filter at one end of the diode and, at the other end, a d-c return that consists of an r-f short circuit at a distance $n\lambda_0/4$ from the diode, where $n$ is an odd number and $\lambda_0$ is the wavelength in the strip transmission line at mid-band. The low-pass filter for the bias circuit is composed of alternate capacitive and inductive, $C_T$ and $L_T$, strip transmission line sections. The circuit is similar to the low-pass filter discussed on page 80, except that the cutoff frequency is much lower.

The tuning reactance, $X_{CS}$ is normally considered a part of the biasing filter. If $X_{CS}$ is not needed, it may be replaced by an r-f bypass in the form of a large capacitor spaced a half wavelength from the diode.

With the addition of other shunt diodes spaced a quarter-wavelength from a point, A, as in the lower diagram on page 82, the circuit becomes a multiport switch with an additional feature—the output signals may be pulse modulated by diode $D_o$. The tuning inductance across the diodes and the biasing networks are not shown.

If diode $D_1$, is back-biased, energy at the input port will flow past $D_o$ towards point A. If, at the same time, diode $D_1$ is back-biased and $D_2$ is forward-biased, energy will flow out of port 1, and no energy will flow towards port 2. The reason for this is that the bias essentially removes $D_1$ from the circuit and makes line 1 appear as a properly terminated 50-ohm line; line 2, on the other hand, presents an open circuit at point A because of the reflected impedance of the shorted diode.

If, under the above conditions, diode $D_1$, is forward biased, it will prevent energy from reaching point A and both output ports will be isolated from the input. Therefore, a pulse modulated waveform that alternately forward- and reverse-biases $D_o$ will similarly modulate the output at port 1. If the d-c biases on diodes $D_1$ and $D_2$ are reversed, the modulated waveform will appear at port 2.

More than two outputs may be added. As an example, a five-port shunt diode switch that allows the outputs to be pulse modulated is shown in the photograph at the left. The BNC connector labeled “N” is not part of the switch circuit.

Series diode switches are also feasible, but while the series type has the advantage of greater potential bandwidth, it is not as convenient for design with strip transmission line. The bandwidth of a shunt diode switch is inversely proportional to the lead inductance and can be improved by the use of small pill-type diode packages.

Although the preceding designs are outlined in many instances, the reader can gain insight into the techniques of designing with strip transmission line together with an idea of some of the pragmatic but crucial hardware problems.

In the next article of this series, additional circuits such as tunnel-diode amplifiers and antenna arrays will be discussed. The article will also deal with methods of eliminating spurious responses, factors involved in etching, and maximum frequency and power limitations.

References
Circuit design

Designer's casebook

FET converts transducer for use in a-c bridge

By Alan R. Greenfield and William H. McCloskey

Oceanics division of Interstate Electronics Corp., Anaheim, Calif.

A field effect transistor (FET) operating as a voltage-controlled resistor converts d-c voltage output of a transducer to a-c so the transducer can be used in a bridge-controlled f-m oscillator, as in the circuit shown below. Transducers that are essentially variable resistors provide easy measurement of many parameters in a typical data acquisition system. Placed in an a-c bridge, the transducers control the output frequency of an f-m oscillator and provide extremely high sensitivity. But some transducers produce a variable d-c voltage rather than a varying resistance and must be converted.

Three matched precision resistors (R₁ in the schematic) form the arms of a bridge; the FET's drain and source terminals are connected to make the bridge's fourth arm. The bridge is excited by a reference a-c voltage $E_{in}$. The amplitude of the a-c output voltage $E_o$ varies proportionally with the d-c transducer output voltage, $V_{dc}$, $E_o$ is expressed

$$E_o = \frac{E_{in}}{2} \left( \frac{R_{ds} - R_1}{R_{ds} + R_1} \right)$$

(1)

where $R_{ds}$ is the effective resistance between the FET's drain and source terminals. If $R_{ds} \approx R_1$, then:

$$E_o \approx \frac{E_{in}}{4} \left( \frac{R_{ds}}{R_1} - 1 \right)$$

(2)

and the ratio, $R_{ds}/R_1$, will be either slightly greater or slightly less than unity. $E_o$ then becomes a small alternating voltage, which has either positive or negative phase with respect to $E_{in}$. In the oscillator, the phase of $E_o$ controls the direction of the output frequency's deviation.

With low drain-source voltages (less than 1 volt) near the origin of the $I_d$ versus $V_{ds}$ curves, the FET displays the characteristics of a variable resistor. Because the FET is unipolar, this property holds, regardless of the polarity of the drain-source voltage. The variable resistance effect is best observed in an FET having high pinchoff voltage and high gate-source voltage compared to $V_{ds}$. Expressed

Drain-source resistance of the Siliconix 2N2386 is controlled by the transducer d-c output. This unbalances the bridge and provides an a-c output whose frequency change is directly proportional to the d-c voltage change.
Charge feedback increases
pulse-rate meter accuracy

By R.J. Smith-Saville and S. Ness

University of Manchester, England

In many pulse-rate meters the input pulse triggers a monostable multivibrator to supply a current pulse to an output ammeter. The width of the current pulse determines the meter scale factor. For a given meter deflection, the ratio of time between pulses to the pulse interval is a constant, independent of the range. This makes it easier to calculate the true pulse rate of statistically distributed pulses from the apparent pulse rate. It also allows the ammeter to be calibrated directly in terms of true rate, if desired.

The circuit on page 86 also operates on this principle. However, for improved accuracy, the current pulse width is controlled by a feedback voltage proportional to the charge on the output capacitor. The feedback insures that the same charge is fed to the output circuit for each pulse. The unit measures pulse rates from 50 to 5 x 10^9 pulses/sec in five ranges. On each range, the dead time is 5% of the mean pulse interval at the maximum count rate.

For equally spaced pulses, the response can be extended linearly to beyond 5 megacycles per second by increasing the value of resistor R2. However, the ratio of dead time to pulse spacing increases, with the result that the extended range is not suitable for measuring statistically distributed pulses.

The description of the circuit operation assumes that the range switch is connected to C1. An input pulse, 50 nanoseconds wide and about 0.8 volts in amplitude, triggers a monolithic dual input NOR gate (Motorola type MC 359) cross-connected to operate as a flip-flop. This module's advantage over a standard MC 352 flip-flop is that the input switching threshold voltage is defined by an external bias voltage of 0.4 v and its temperature coefficient is only +0.2 mv/°C as opposed to +1.7 mv/°C for the MC 352.

When the flip-flop is triggered, switching transistors Q1 and Q2 are turned off, removing the short circuit across both the range capacitor, C1, and the output circuit consisting of R2, C6, and C7. As a result, charging current flows through R1 to C1 and through R2 to C6 and C7. Under these circumstances the charge per pulse delivered to the output capacitor is

\[ Q_o = \int_0^t v_i - V_r \, dt \]

and the voltage, v_o, across the range capacitor, C1, is

\[ v_o = \int_0^t v_i - V_{io} \, dt \]

where \( v_i \) is measured at the high-potential ends of R1 and R2 (neglecting the voltage drop across the diodes D1 and D2); \( V_r \) is the steady voltage, proportional to count rate r, developed across the output integrating capacitors due to the finite resistance of the ammeter; and \( V_{io} \) is the instantaneous value of \( v_o \). Since \( V_{io} \) is less than 0.05\( v_i \), the

justs the thermistor changes so that they are equal in amplitude but opposite in polarity to the FET's variations.

Resistors R4 and R5 are computed to produce a 350-ohm resistance for the entire FET bridge arm, and to adjust the effects of controlled changes of \( R_n \). Resistors R6 and R7 comprise an adjustable balance network required to compensate for slight differences in the values of the bridge resistors \( R_n \). The RC combination made up of potentiometer \( R_a \) and capacitor \( C_1 \) has a similar function: it balances any reactive components which can upset the bridge balance.

Transformer \( T_1 \) isolates the input to the bridge circuit, allowing the FET source terminal to be returned to common, and eliminating floating input to the oscillator.

The balanced bridge represents zero output for the transducer. The oscillator is adjusted to run at center frequency for the bridge's zero output.
second term in the integrand of equation 2 can be ignored with an error less than 0.2%.

When \( v_c \) exceeds the input switching threshold, \( V_T \), the flip-flop returns to its initial state, rapidly discharging \( C_1 \) and cutting off the current flow to the output. The time, \( t_r \), at which this occurs is

\[
t_r = \frac{V_T R_1 C_1}{V_i}
\]

(3)

Equation 3 assumes that \( v_i \) is a step voltage.

At this time, \( v_c \) and \( V_T \) are equal.

\[
v_c = V_T \quad \text{at } t = t_r
\]

(4)

Substituting equations 2, 3 and 4 into equation 1; multiplying by the rate \( r \); and using the fact that \( V_r \) is a constant, the d-c current in the meter is

\[
I_r = \frac{r}{R_2} C_1 \left( V_T - \frac{V_r}{V_i} \right)
\]

(5)

Except for the small error term, \( V_r/V_i \) the meter current, \( I_r \), is independent of the amplitude or waveform of \( v_i \), and is defined solely by \( r, R_1, R_2, C_1, \) and \( V_T \). Since the error term is proportional to \( r^2 \) it does introduce a nonlinearity. However, this term will not exceed 0.6% for the circuit values shown. If necessary, the error term could be eliminated by connecting \( R_2 \) into an operational amplifier which presents a virtual ground at its input. The amplifiers output could be arranged to drive either a linear or logarithmic display. The circuit is thus capable of linearity and accuracy well within 1%.

The +0.2 mV/°C temperature coefficient associated with \( V_T \) is compensated for by the temperature coefficient of the residual voltage across \( Q_1 \). As a result, the over-all temperature coefficient of the meter current, \( I_r \), is less than 0.02% /°C. In addition to its dependence on the +0.4 volt supply, \( V_T \) also partially depends on the values of the +1.6 and −3.6 volt supplies to the flip-flop. For maximum accuracy, these three voltages must be stabilized. The circuit is less sensitive to variations of the +12 volt supply and will accommodate deviations of ±10% with an error of less than ±0.5% on all but the highest pulse range. On the highest pulse range the turnoff time of the circuit becomes comparable to the current pulse width, resulting in less effective charge feedback.
Many commercial multimeters whose lowest voltage scales are either 1.5 or 3 volts cannot be used with semiconductor circuits because the $V_{BE}$ of germanium transistor is about 150 millivolts. The saturated $V_{BE}$ of both germanium and silicon transistors is even smaller. But a low-voltage d-c preamplifier that is inexpensive and stable with temperature and supply voltage variations, below right, extends the range of such instruments so they can be used effectively in semiconductor circuit measurements.

Transistors $Q_1$ and $Q_2$ in the diagram below left constitute an emitter-coupled amplifier; $Q_3$ is an emitter-follower connected so the circuit's entire output voltage is fed back to $Q_2$. With constant input voltage, the output voltage is essentially fixed, so a variation of $R_E = (R_2 + R_3)$ changes the collector current of $Q_1$. Therefore, $R_E$ may be adjusted to equalize the base-emitter drop of $Q_1$ and $Q_2$ and thus make the output voltage zero for zero input. The gain of this emitter-follower circuit is almost unity.

If a fraction, $f$, of the output voltage $V_2$ is fed back to $Q_2$, then the amplifier will have a gain approaching $1/f$. The circuit shown below can provide gains of 3 and 10 to extend the range of a 1.5-volt vacuum tube voltmeter, for example, down to 500 and 150 millivolts full scale. However, there are two disadvantages: the open circuit gain is not very large (typically 50) and it is sensitive to supply voltage variations. Since feedback helps stabilize the circuit and insure linearity, increased gain is obtained at their expense. Sensitivity to supply voltage variations is defined as $S = \Delta V_s/(A \cdot \Delta V_s)$ where $A = V_2/V_1$ is the over-all gain, and $V_s$ is the supply voltage. $S$ gives the effective input voltage change produced by supply voltage variations, typically $1$ to $4 \times 10^{-2}$.

Additional open circuit gain may be obtained by substituting a current source for the load resistor of $Q_2$. This reduces the battery supply effect on the zero setting. To reduce sensitivity to negative supply voltage excursions, a current source can also be substituted for the common emitter resistors $R_2$ and $R_3$. These changes are shown in the circuit below right. These modifications provide open circuit gains of greater than 300 and sensitivities to supply voltage changes of about $4 \times 10^{-3}$. The circuit now has gains of 3, 10, and 30, which extend the 1.5-volt meter scale to 500, 150, and 50 millivolts full-scale deflection.

In the circuit below, right, zero-adjust control is provided by variable resistor $R_1$. This resistor controls the collector current of $Q_2$. $R_7$ permits open-circuit zero adjustment.

**Emitter-follower** amplifier uses feedback for stability and linearity; these are requirements for application in multimeters at low ranges. For additional open circuit gain, the circuit is modified to include current sources for load resistor and common emitter resistors. $R_1$, in drawing at right provides circuit zero-set.
Phase-locked marker improves spectrum analyzer's accuracy

By measuring the frequency of the marker oscillator, the operator precisely determines the frequency of any spectral component; modified display makes readability easier

By Charles W. Wilson
Georgia Institute of Technology, Atlanta, Ga.

Rapid identification and accurate measurement of any frequency in the spectrum under analysis are now possible with an instrument called the frequency measuring spectrum analyzer (FMSA). Spectrum analyzers are versatile tools for analyzing complex waveforms and for finding out approximately what frequency components are in a given spectrum. But the conventional spectrum analyzer is inherently limited by the linearity of its sweep and the operator's ability to read its calibrated scale. The FMSA overcomes the limitations of the conventional analyzer by adding a phase-locked marker and a modified display.

Using the new display, the operator positions the marker on the screen to coincide with the frequency component to be measured. The marker, which appears as a negative-going pip, automatically locks phase with the unknown component when their frequencies are equal. Direct measurement of the marker frequency yields the component frequency.

The precise measurement of undesired frequencies, of course, is a prerequisite for their elimination. As a result, spectrum analyzers are widely used for radio-frequency interference (rfi) testing.

Oscilloscope display of spectrum analyzer output shows the negative-going pip produced by marker oscillator. The marker is phase locked to spectral line directly above it.

One basic rfi application involves the analysis of the various components that appear in the intermediate-frequency passband of a receiver. This cannot be done with conventional frequency counters because the individual components cannot be isolated from the composite spectrum.

Similar, but not the same

As in a conventional analyzer, the input signal to the FMSA is heterodyned with a local oscillator whose sweep rate and sweep width are functions of the sawtooth voltage's frequency and slope, respectively. The bandwidth of the intermediate-frequency amplifier is made variable so that any desired resolution between the individual frequency components is possible in the display. The output of the i-f amplifier is rectified and passed through a low-pass filter. The d-c voltage that results is proportional to the time-varying amplitude of the i-f signal. This d-c voltage is fed to the vertical-axis amplifier of the cathode ray oscilloscope; the sawtooth voltage is fed to the horizontal-axis amplifier.

The author

Charles S. Wilson has been a member since 1961 of the Georgia Tech Engineering Experimental Station staff, where he has worked on the problem of electromagnetic compatibility. He is responsible for the reduction of radio interference in equipment and the development of better techniques for measuring rfi.
For automatic gain control, transistor Q₁ is driven into conduction as the input signal increases. Diodes D₁ and D₂ conduct, lowering their impedance, and increasing the signal attenuation.

Marker oscillator and phase detector

The 455-kilocycle marker oscillator in the diagram on page 90 is a conventional Hartley circuit. A Hughes HC7005 varactor diode acts as a voltage-controlled element in the phase-lock loop. Automatic amplitude control restricts the voltage swing across the tuned circuit. The oscillator output is taken from the low-impedance emitter circuit of the oscillator to prevent any loading effects. To prevent the narrowing of this oscillator's frequency swing as the control voltage increases, part of the amplified signal is rectified by a conventional doubler, averaged in a low-pass filter, and compared with an internal d-c reference. The difference voltage then biases the oscillator transistor. This bias voltage controls the oscillator transistor gain to maintain the signal swing across the tuned circuit at a level that will not forward bias the varactor. The loop gain is sufficient to maintain the signal level across the resonant circuit at 1.5 volts peak-to-peak.

The oscillator has a tuning range of 93 kc and will maintain phase lock over a change in synchronizing signal frequency of approximately 40 kc.

A simple shunt switch, with a 2N706 transistor...
Marker oscillator is a conventional Hartley design. The varactor diode, HC7005, controls marker frequency and allows phase locking with any specific component in the spectrum.

serves as the phase detector for the marker oscillator as shown in diagram below. The marker oscillator signal $E_m$ drives the transistor into saturation, short-circuiting the input signal to the analyzer $E_s$ to a-c ground. The resulting sampled waveform is at left in the figure below. The d-c component of this waveform is zero since the two signals, $E_m$ and $E_s$, are 90° out of phase—a condition existing when the natural frequency of the oscillator is the same as the input signal.

Should the input frequency tend to increase, an error signal must be developed to control the marker oscillator and maintain lock. This condition is met as the phase of $E_s$ changes with respect to $E_m$, leading to the other waveform below. The d-c component is now positive. This error voltage applied to the varactor reduces its capacitance. The oscillator frequency increases and tracks the input signal.

To keep the oscillator stable, the total loop phase shift must not equal 180° at any frequency where the loop gain equals or exceeds unity. The phase-locked oscillator introduces an inherent 90° phase lag into the figure because this frequency is controlled by the phase error. So, the low-pass filter must add less than 90° phase lag at the frequencies where the loop gain either equals or exceeds unity. A simple RC filter, which can introduce a phase shift of almost 90°, requires a small phase shift in the remainder of the loop. This is a difficult criterion to meet. A filter of the type in the diagram atop page 91 insures a stable loop. The maximum phase shift through this filter is calculated from:

$$\theta_{\text{max}} = -\tan^{-1} \frac{R_1}{2\sqrt{R_2(R_1 + R_2)}}$$

The maximum attenuation is determined by the ratio of $R_2$ to $(R_1 + R_2)$. If greater attenuation is needed, two filters may be cascaded to give a maximum attenuation equal to the product of the two sections. However, the maximum phase shift through each of the filter sections must occur at a different frequency to maintain oscillator loop stability. Only a fixed amount of attenuation can be obtained for the high-frequency components, no matter how high in frequency these components may be, as in the diagram shown atop page 91. The fixed attenuation is directly related to the maximum phase shift and is the price for the necessary phase control.

Sweep rate and width are controlled

The sawtooth generator consists of a unijunction transistor oscillator with constant-current charging of the timing capacitor. This is a well-known, straightforward method of obtaining a linear sawtooth. The sawtooth generator, with a frequency variable in two ranges from 0.1 to 16 cycles per second, controls the sweep rate and the sweep width of the 555-kc local oscillator.

The design of the local oscillator is essentially the same as that of the marker oscillator except that three varactor diodes are used rather than one, and the local oscillator has a different biasing arrangement. This modified biasing circuit overcomes
the nonlinear variation in oscillator frequency produced by the linear sawtooth voltage.

I-f signals produced

The local oscillator is heterodyned with the input signal to produce a 100-ke i-f in the signal channel and with the marker oscillator to produce a 100-ke i-f in the marker channel. These signals are mixed in a shunt-transistor mixer. At the output of each mixer is a low-pass, two-section RC filter to attenuate the original input signals before the difference frequency is fed to the i-f amplifiers. A single control that selects the proper filters for both channels determines the bandwidths of the two i-f amplifiers. Any one of three bandpass filters in the signal channel can provide 3-db bandwidths of 25, 150 and 1,000 cycles. Two filters are in the marker channel. A 100-ke crystal filter is for the 25-cycle bandwidth, while the two broader filters are conventional L-C filters.

A linear/logarithmic gain control is provided for the signal channel i-f amplifier while the gain of the marker channel i-f amplifier is fixed. Because of the logarithmic feature, the gain can be increased sufficiently so low-level components can be seen while larger signals won't overdrive the amplifier. A conventional voltage-doubling rectifier is used in both channels to derive the d-c voltage proportional to the amplitude of the 100-ke signal component. The voltage is positive in the signal channel and negative for the marker channel. A low-pass filter averages the rectifier output.

The low-pass filter in the signal channel has a cutoff frequency of 15 cps or 125 cps. This cutoff is controlled from a front-panel switch and determines the basic sweep rate of the local oscillator. The 15-cps filter is for the low range, when the sweep rate varies from 0.1 cps to 1.6 cps. The 125-cps filter is for the 1.5-cps to 16-cps sweep rate. The narrow bandpass i-f amplifier filter, which requires a slower sweep rate to compensate for the response time of this high-Q filter, provides good resolution of closely spaced components. In this instance, it is then desirable to use the 15-cps filter of the rectifier circuit to attenuate any beat frequency that may arise from adjacent components. The broadband i-f filter makes it unnecessary to use a slow sweep speed. However, as the sweep frequency is increased, a shorter time constant is

Signal channel amplifier cutoff frequency can be selected at either 15 cps or 125 cps, depending on the sweep rate of the local oscillator and the desired resolution.

Astable multivibrator sets up chopper sampling rate in vertical output display. Sampled inputs from the marker oscillator and the input channel are fed to the vertical-axis amplifier of the cathode ray tube.
required in the low-pass filter; thus, the need for the 125-cps cutoff.

Since the marker channel contains only one frequency component, a simple low-pass filter is sufficient. A schematic of the signal channel amplifier and the low-pass filter is on page 91.

With each horizontal sweep, the vertical display system provides a simultaneous presentation of the input signal components and the marker. The marker is directly under the component to which it is locked, as shown in the photograph on page 88. The simultaneous display is accomplished by a sequential sampling of the signal channel and the marker channel at a much higher rate than the sweep speed. For example, at a 10-ke sampling rate, a minimum of 625 samples per centimeter are produced on a standard 10-centimeter sweep.

To simultaneously display these two signals, an astable multivibrator is used to gate the sampling circuit. The output of this 20-ke multivibrator, in the diagram on page 91, is differentiated and amplified to provide a trigger for a flip-flop. The two outputs from the flip-flop, 180° out of phase, drive a pair of transistors, which alternately shunt the signal and marker to ground. The hopper outputs in the diagram on page 91, are summed and displayed on the cathode-ray tube.

The display signal is connected to the signal input jack on the front panel of the FMSA; the horizontal and vertical outputs are connected to the oscilloscope. The two horizontal outputs are internally paralleled so that either a coaxial cable or test lead may be used to connect the sawtooth sweep signal to the oscilloscope.

The input signal must be direct-coupled to the vertical input of the scope and the sensitivity of the input amplifier should be approximately 2 volts per centimeter.

For sweep widths of only several kilocycles, a visual indication of the marker locations with respect to the input signal components is sufficient to establish a phase-locked condition. For larger sweep widths, it is difficult to visualize when a particular component is within the capture range of the marker oscillator. For these cases, a portion of the phase detector output drives an audio amplifier with a loudspeaker output. This gives an audible indication of the beat frequency between the marker oscillator and the components of the input signal.

To lock the marker oscillator to a particular component, the phase-loop button is pressed, disabling the phase control loop. The oscillator is then tuned until the marker lies under the proper component, producing a zero beat from the audio oscillator. Releasing the button permits the marker oscillator to assume a phase-locked condition.

Another identification approach

An alternate method of spectrum component identification is to use an adapter and a conventional spectrum analyzer. Although this unit is not as versatile as the FMSA system, it is simpler. As before, the phase-locked oscillator determines the frequency of the individual components of a composite spectrum. The adapter’s functional block diagram is shown above.

The display is amplified and referenced with the marker oscillator in a phase detector. The marker and input signals are summed in a hybrid coupler to prevent marker oscillator feedback to the input amplifier and phase detector. This feedback would upset the locking action of the oscillator. The result is a positive marker pip superimposed on the analyzer display.

Besides measuring the components that appear in the i-f passband of a receiver, the FMSA may be used for analysis of a complex waveform or for measuring the frequency of a pulse-modulated carrier and its sidebands. Although it is less versatile than other methods, the spectrum analyzer adapter can provide the same frequency information when used with a conventional spectrum analyzer. The same principles may be incorporated in equipment capable of operating over a wide range of frequencies.

Acknowledgement

This work was sponsored by the Vulnerability Reduction Branch of the Rome Air Development Center under contract no. AF 30(602)-3282. The author is indebted to W.B. Warren Jr. and D.W. Robertson for the guidance and assistance.
Practical reasons why so many engineers choose EMC digital logic modules potted in TIMONIUM.

Complete families of digital logic modules operate over an ambient temperature range of $-55^\circ C$ to $+125^\circ C$. 
Soliton announces

325v
300v
250v
225v
200v

V_{CEO} (SUS)

in a 10 Amp. NPN Silicon Planar Power Transistor
Plus

50 mcs | 150 pfs

<table>
<thead>
<tr>
<th>Type Number</th>
<th>Pkg. Size</th>
<th>T_{a}</th>
<th>V_{CEO} (SUS)</th>
<th>P_{Fe}</th>
<th>V_{EE} (sat)</th>
<th>V_{CE} (sat)</th>
<th>I_{CEO}</th>
<th>f_{t}</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHT7801</td>
<td>TO-61</td>
<td>200</td>
<td>250</td>
<td>225</td>
<td>200</td>
<td>8</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>MHT7802</td>
<td>TO-61</td>
<td>200</td>
<td>50</td>
<td>250</td>
<td>225</td>
<td>8</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>MHT7803</td>
<td>TO-61</td>
<td>200</td>
<td>50</td>
<td>275</td>
<td>250</td>
<td>8</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>MHT7804</td>
<td>TO-61</td>
<td>200</td>
<td>50</td>
<td>325</td>
<td>300</td>
<td>8</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>MHT7805</td>
<td>TO-61</td>
<td>200</td>
<td>50</td>
<td>350</td>
<td>325</td>
<td>8</td>
<td>20</td>
<td>60</td>
</tr>
</tbody>
</table>

DESIGN LIMITS

<table>
<thead>
<tr>
<th>Type Number</th>
<th>Pkg. Size</th>
<th>T_{a}</th>
<th>h_{FE}</th>
<th>P_{Fe}</th>
<th>B_{Vcc}</th>
<th>B_{Vce}</th>
<th>B_{Vcc}</th>
<th>B_{Vce}</th>
<th>B_{Vcc}</th>
<th>B_{Vce}</th>
<th>B_{Vcc}</th>
<th>B_{Vce}</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHT7801</td>
<td>TO-61</td>
<td>200</td>
<td>2</td>
<td>50</td>
<td>225</td>
<td>200</td>
<td>8</td>
<td>1.2</td>
<td>0.50</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>MHT7802</td>
<td>TO-61</td>
<td>200</td>
<td>2</td>
<td>50</td>
<td>250</td>
<td>225</td>
<td>8</td>
<td>1.2</td>
<td>0.50</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>MHT7803</td>
<td>TO-61</td>
<td>200</td>
<td>2</td>
<td>50</td>
<td>275</td>
<td>250</td>
<td>8</td>
<td>1.2</td>
<td>0.50</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>MHT7804</td>
<td>TO-61</td>
<td>200</td>
<td>2</td>
<td>50</td>
<td>325</td>
<td>300</td>
<td>8</td>
<td>1.2</td>
<td>0.50</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>MHT7805</td>
<td>TO-61</td>
<td>200</td>
<td>2</td>
<td>50</td>
<td>350</td>
<td>325</td>
<td>8</td>
<td>1.2</td>
<td>0.50</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

TRANSISTOR DIVISION
DEVICES, INC.

1177 BLUE HERON BLVD. / RIVIERA BEACH, FLORIDA / (305) 848-4311

Leader in Germanium and Silicon Power Transistors, Cryogenic Thermometers, High Voltage Rectifiers, Temperature Compensated Zeners, Voltage Variable Capacitors, Random/White Noise Components and Microelectronic Components.
Six-foot diameter superconducting coil used to study radiation shielding. The black arrows are stamped steel pieces that are being supported by the magnetic field.

Components

**Putting superconductors to work**

Although superconducting materials are limited mainly to research applications, total sales should top $1 million this year with a dozen companies manufacturing magnets and magnet systems.

By Donald K. Fox


The bright future predicted for superconductors draws nearer as new superconducting materials are discovered—some of them able to operate at the relatively high temperature of 18°K. The manufacture of a variety of superconductor magnets and magnet systems is under way at more than a dozen commercial companies. Sales of superconductor equipment to universities, industrial laboratories and original equipment manufacturers are expected to top a million dollars this year. Superconductor applications are seen for computer elements, gyroscopes, frictionless motors, transformers, circuit breakers, rectifiers and transmission lines. Their ability to store large amounts of energy, as well as their small size, light weight and fast operation, give them potential advantages for military equip-
A 100-kilogauss superconducting magnet. Three concentric magnets were used to produce the field; the smallest one is shown next to the researcher's left hand.

Applications of superconductors

As an example of the potential of superconductors, the 100,000-gauss magnet at the National Magnet Laboratory at the Massachusetts Institute of Technology requires approximately 1.7 million watts to produce the field, and 1,000 gallons of water per minute to remove the heat generated in the copper windings. But for the same field strength, the superconducting magnet shown above requires only a six-volt battery—300 watts—power supply and a cryogenic environment maintained for a long time by a 10,000-watt refrigerator—the type used to cool helium. But at present, superconducting magnets have two limiting features: the cryogenic environment needed for such magnets; and, if improperly operated, the fact that they might go "normal"—reverting from the superconducting state to the resistive state. The heat produced boils off the coolant almost immediately and may damage the magnet. These two factors bar many industrial applications of superconductivity.

However, compact superconducting magnets, such as those on page 97, with field strengths up to 80,000 gauss and working volumes of 3 inches in diameter and 8 inches long, are being used to study superconducting properties of materials, nuclear magnetic resonance, magneto-optical phenomena, infrared absorption, neutron diffraction, adiabatic demagnetization and many other low-temperature effects. A complete superconducting magnet system includes a Dewar vessel, a superconducting coil, a transistorized power supply for energizing the coil, a gaussmeter for measuring the magnetic field intensity, a helium transfer tube, and a liquid-helium-level monitor.

Besides the relatively small magnets, several larger ones have been built for special applications that vividly illustrate the potential of superconductivity. One of these is a 6-foot-diameter superconducting magnet constructed for the U. S. Air Force to determine whether large superconducting coils could shield space vehicles against high-energy radiation. The test results indicate such a possibility because the magnet's liquid helium stayed at a cryogenic temperature long enough for a space mission.

The largest-volume, highest-field superconducting magnet is at the Argonne National Laboratory's accelerator division. This enormous magnet is a composite of three concentric coils with a 6-inch inside diameter and a field strength of 67 kilogauss. The stored field energy is greater than 600,000 joules. The magnet will be used with a 10-inch diameter superconducting helium-hydrogen bubble chamber, a device for showing the traces of ionized particles. Economical operation of such a bubble chamber could give rise to a new generation of superconducting magnets for high-energy physics applications.

Superconductors for masers

Superconducting materials can also be used in masers. If a superconducting electromagnet can replace the conventional permanent magnet, the maser's weight can be reduced by a factor of 50 to 70. Also, hard superconductors rolled into sheet resist magnetism and have made good magnetic insulators, preventing flux leakage from the region around the magnetizing coils. This means greater field stability and uniformity. Recent experiments with columbium-titanium alloy sheets indicate magnetic shielding capabilities of up to 4 kilogauss.

A 70-gigacycle traveling-wave maser with field coils wound of superconducting wire is in the photo on page 97. The columbium-zirconium superconducting magnet produces a 5-kilogauss field with a deviation less than one gauss perpendicular to the 1.5-inch length of the traveling-wave maser.
Traveling-wave maser has a superconducting field coil that is housed in the metal section attached to the left side of the maser.

World’s largest superconducting magnet—6-inch bore, 67,000 gauss. For ease of coil construction, a braided superconductor wire consisting of six wires was wrapped around a seventh wire.

Typical wire-wound superconducting solenoids. Although both magnets have the same rated field, there is a 10:1 ratio of working volume between the large and small solenoids.

Traveling-wave maser has a superconducting field coil that is housed in the metal section attached to the left side of the maser.

Element. The magnet weighs about three pounds and can operate in the persistent mode. In this mode, a superconducting switch is placed across the power leads. The columbium-zirconium wire has zero resistance, so the coil current theoretically should flow for infinite periods. This does not occur in practice because of losses at the wire junctions; however, 50-kilogauss coils have been operated in the persistent mode for several days without any detectable decrease in field strength.

Conventional electrical energy is stored in capacitor banks or batteries. The banks are limited by relatively low-energy densities, the batteries by relatively long discharge times. One superconducting coil, designed differently from the simple solenoids discussed previously, can be charged over a long period with a low-voltage power supply. The coil is made of braided wire to reduce inductance, thus reducing the high voltage that may be induced when discharging the coil. This method also avoids hazards to personnel. With a thermal switch, the coil’s current can be made persistent, thereby storing the energy for indefinite periods or until a rapid discharge is required. Several energy storage devices of this type, which deliver up to several hundred joules, have been built to pump lasers. But the high cost of materials makes energy storage by superconductors uneconomical at energies less than $10^7$ joules—compared with conventional methods—unless the lighter weight, smaller size, and faster operation are decidedly advantageous, as in certain military applications.

The persistent mode

Superconducting magnets are often equipped with a persistent mode switch for optimum field stability. The switch, a piece of superconductor placed across the magnet’s leads, allows the current...
Magnetohydrodynamic (MHD) generators use a 1-inch air-core superconducting coil for the field coil. The coil and its support are being lowered into the Dewar vessel.

**Circuit for a magnet with a persistent mode switch.**

When the heater raises the temperature of the switch to the transition point, resistance decreases the current flow through the magnet. Cooled, the switch becomes superconducting and allows current to flow.

of the energized solenoid to flow indefinitely without loss through the shorted circuit. Once the short circuit is established, the power supply can be disconnected with no effect on the magnetic field.

The persistent mode has two advantages—lower helium loss rate and a completely stable magnetic field. Operation is continuous as long as the coil remains immersed in liquid helium. The switch is controlled thermally by a resistance-type heater wound in close proximity to it. The heater raises the temperature of the switch causing it to go into the resistive state, and in effect, opening the switch.

Conversely, turning off the heater results in a closed switch. The circuit at the left is for a superconducting magnet with a persistent mode switch.

**MHD power generators**

The widest potential application for superconducting magnets is for magnetohydrodynamic (MHD) power generation. In MHD devices, a high-velocity jet of ionized gas—a plasma—is passed between the poles of a powerful magnet. An electromotive force is produced in the plasma conductor at right angles to both the magnetic field and the direction of the plasma's motion. Direct current can be extracted from the system by placing electrodes in the hot gas stream.

Superconducting magnets also reduce the weight of the field coil per unit of power output, thereby improving the competitive position of MHD generators over conventional power plants. The figure at the left shows a small, experimental MHD generator that has an air-core superconducting magnet with a 1-inch inside diameter as the field coil and a strength of 30 kilogauss.

So far, all of the superconductor devices described in this article are direct-current. But broad potential applications also exist in transformers, transmission lines, rectifiers, rotating equipment, and other alternating-current equipment. The practicality of these devices depends on producing superconductors that can carry high a-c currents with little or zero resistance. Evidence has shown that a-c losses in superconductors are substantial; however, some recent work on superconductor delay lines with ultrahigh-frequency pulses indicates that these losses can be reduced.

**Intermetallic compounds and alloys**

Superconductor materials with a combination of high current-carrying capacity (Jc), high critical magnetic field (Hc), and practical critical temperatures (Tc), fall into two classes—intermetallic compounds and alloys.

Intermetallic compounds such as columbium-tin, vanadium-gallium, and vanadium-silicon develop their useful superconducting properties from chemical composition. Although these materials exhibit higher levels of Hc and Tc than those of alloys, their brittleness results in serious fabrication problems. Only columbium-tin is now available commercially.

Because of inherent mechanical disadvantages or high cost, the available intermetallic compound
Theory of superconductivity

Some metals at or near absolute zero completely lose their resistance to the passage of current. A graph illustrating this relationship is shown below.

One explanation of this phenomenon: the electrons in an element or compound that is at a very low temperature give off part of their energy in the form of a phonon, or quantity of thermal energy arising from vibrations in the crystal lattice. A pair of de-energized electrons share each phonon, thus binding themselves together. These pairs are the superconducting electrons. Bound only to each other, their motion is no longer restricted by the confines of a crystal lattice and they move through the material without hindrance.

Critical temperature

The temperature at which a superconductor loses its "normal state" electrical resistivity, as shown below, is called the critical temperature, $T_c$, and is a characteristic of a given material. For example, the critical temperature of an alloy consisting of 75% columbium and 25% zirconium is 10.8°K. The highest known $T_c$ for a compound superconductor (columbium-tin) is 18°K.

Another characteristic important to the discussion of superconductivity is the critical field, $H_c$, the maximum magnetic field in which a superconductor material will continue to carry current. This field may be externally applied, or self-generated.

Until a few years ago, superconductor applications were severely limited because the superconducting state in all known superconducting materials could be destroyed by a magnetic field of modest strength—3 or 4 kilogauss. In 1961, however, it was discovered that certain alloys and compounds could sustain large current densities on the order of 10⁶ amperes per square centimeter in externally applied magnetic fields up to 90 kilogauss. Some of these materials even carry some current at 350 kilogauss.

Filamentary superconductors

These hard, or filamentary, superconductors owe

<table>
<thead>
<tr>
<th>Alloy</th>
<th>$H_c$ (gauss)</th>
<th>$T_c$ (°K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbium-25% zirconium</td>
<td>70,000</td>
<td>10.8</td>
</tr>
<tr>
<td>Columbium-50% zirconium</td>
<td>90,000</td>
<td>9.3</td>
</tr>
<tr>
<td>Columbium-48% titanium</td>
<td>120,000</td>
<td>10.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>$H_c$ (gauss)</th>
<th>$T_c$ (°K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbium-tin</td>
<td>183,000</td>
<td>18.0</td>
</tr>
<tr>
<td>Vanadium-silicon</td>
<td>156,000</td>
<td>17.0</td>
</tr>
<tr>
<td>Vanadium-gallium</td>
<td>350,000</td>
<td>17.0</td>
</tr>
</tbody>
</table>

superconductors have been limited to small-volume, research laboratory magnets. If superconducting magnets of field strengths more than 100,000 gauss are to be mass produced, improved fabrication methods are necessary.

To date, all commercial superconducting magnet systems have solenoid windings of columbium-zirconium or columbium-titanium alloys, or a combination of both. Although these ductile materials must be used with considerably lower maximum

Electronics | February 7, 1966
fields than the intermetallic compounds, they can be easily worked into wire or strip products, require no heat treatment in coil, and are available in long continuous lengths (e.g., 30,000 feet of 10-mil-diameter wire) at a reasonable cost.

One alloy, containing 25% zirconium, and 75% columbium, is the most widely used because of its good current-carrying capability and high critical magnetic field. The figure just below shows a typical current vs magnetic field curve for a 10-mil-diameter bare wire sample of Cb-25% Zr alloy. At zero applied magnetic field, the wire can carry about 180 amperes (a density of $3.6 \times 10^5$ amps/cm$^2$). At an applied field of 70 kilogauss, the current capacity falls to zero amperes. Because the current-carrying capacity of ductile superconductors depends on metallurgical variations, the shape and magnitude of the I versus H curve can be altered—depending how much the wire has been drawn, the hydrogen, nitrogen, and oxygen content, and the heat treatment. Most coil manufacturers use the I vs H curve of a short-length sample to assure that wire received from the supplier is comparable to past shipments, and is consistent with the manufacturer’s design parameters.

**Columbium-titanium series**

Offering higher critical magnetic field and a lower current density, a newer alloy is based on a columbium-titanium series. A typical I vs H curve for a 10-mil-diameter bare wire sample of this alloy is shown below, left. At zero applied magnetic field this alloy has a current-carrying capacity of over $2 \times 10^6$ amps/cm$^2$. Unlike the Cb-Zr alloys, it does not quench out (lose its current-carrying capability) at fields below 100 kilogauss. At 80 kilogauss, for example, the current density is approximately $4 \times 10^6$ amps/cm$^2$.

When either the critical current, critical temperature or the critical magnetic field is exceeded, a superconducting coil switches into normal conductivity. The circulating current meets a large resistance in the wire and the stored energy is rapidly dissipated as heat. This normalization is accompanied by the vaporization of liquid helium, which permeates the coil windings.

More important than the temperature rise, which can be on the order of $100^\circ K$, is the voltage induced by the rapid current decay according to the relationship $V = -L(\text{di}/\text{dt})$. In an inductive magnet, this voltage can be large enough to cause arcing between windings, to melt the wire, and to create a hazard. By coating the superconductor with copper, the coil current from the superconducting path can be shunted to the low-resistance normal path during normalization, thereby reducing the rate of current decay and induced voltage. The metallic coating also serves as additional insulation during the superconducting state, and diminishes the normalizing possibility from electrical and thermal transients at low currents or fields.

**Copper coating is standard**

Copper is chosen for shunting because of its low electrical resistivity, high thermal conductivity and high heat capacity at $4.2^\circ K$. Although other metals such as silver, cadmium, and lead might function as well, techniques for electrodepositing copper on columbium-zirconium substrates were developed during the early manufacturing stages, so copper has been accepted as the standard for the industry.

Because the ability to sustain maximum solenoid currents and coil stability depends on the quality of the deposited copper coating, many electrical tests to rate and grade wire have been developed. One of the most important grading parameters is the bond between the copper plating and the superconductor substrate. The lower the electrical resistance of the bond, the better the energy transfer during normalization, improving the absorption of local thermal transients that might cause the coil to go normal. Another significant parameter is the...
ratio of copper’s resistivity at room temperature to its resistivity at liquid-helium temperature (11°K). At temperatures close to absolute zero, electrical resistivity is primarily due to impurities. Thus the resistivity ratio is a way to determine the purity of the copper deposit: the higher the ratio, the higher the plating purity and energy transfer capability. Although there is some variation in different magnet manufacturers’ products, the standard copper plating thickness on 10-mil-base wire is 1 mil, measured along the radius.

Some preliminary work has been done on cladding superconductor wire by drawing a copper tube over the base wire. This configuration shows electrical characteristics that are better than electroplated coatings and provides more economical, thicker coatings. To date, however, the lengths required by the magnet industry have not been produced.

Besides copper plating, an organic compound to prevent shorting between turns and to minimize arcing insulates much superconductor wire. The three most common insulations are epoxies, nylon, and Formvar. Epoxies, which can be applied by conventional methods to yield a very thin, uniform coating—less than ¼ mil on the radius—are considered the best insulators. Nylon absorbs moisture and is often limited to a minimum 1-mil buildup on the radius because the nylon must be wrapped and fused. Although Formvar can be applied as a thin coating, its high curing temperature can cause annealing of the base material.

Superconductor coils

Significant decreases in current capacity of wire in coils, as compared to that observed in short-length tests, is characteristic of all superconductor materials, particularly at low magnetic field levels. Why this loss occurs is not completely understood, although it is generally accepted that the relationship between adjacent lines of magnetic force generated by the coil turns are manifested by flux-jumping. This causes the magnet to go normal at a lower field or current than anticipated from the short-length test. Flux jumping is the spontaneous and unpredictable movement of flux lines into the wires. Designers have attempted to achieve coil currents approaching short-length performance by increasing the spacing between wires and/or layers at the sacrifice of the packing factor. The packing factor is defined as the ratio of conductor wire area to the total winding area available. The increased performance has been achieved by increasing the amount of metallic coating or insulation on the wire. The performance of typical large coils (bore greater than 1-inch) of Cb-Zr and Cb-Ti is shown by the areas in color in the figures on the opposite page. The point within these areas at a specified magnetic field will vary depending on the wire composition, thickness of metal coating and insulation, coil configuration, and coil construction techniques. Generally, Cb-Ti coils operate closer to the short-length test sample curve than do Cb-Zr coils.

The cause of this difference in performance is not clear.

Great care must be taken during the construction of a superconducting coil. If joints between lengths of superconducting wire, or between the power leads and superconductor leads, are not properly assembled, they will become the source of thermal transients and premature normalization. The common method of making joints is by stripping the copper a short distance from the ends of the superconductor wires, mechanically abrading the stripped ends and rinsing them in acetone, tinning the ends with pure indium solder, and clamping the wires between indium-tined, high-conductivity copper joint blocks, which are subsequently placed on the flanges of the coil former. At a test current of 10 amperes, the voltage drop across such a joint at 4.2°K should not exceed 100 microvolts.

Thermal treatments affect characteristics

As mentioned previously, thermal treatments can markedly influence the shape of the I versus H characteristics of the superconductor wire and subsequently affect coil performance. Indium tinning must be done carefully and without excessive heating of the base wire. Poor coil performance has been traced to wire leads that were overheated during the tinning operation. The placement of the joint block on the coil former is also important because the joints may show current-directional behavior if the round wire is flattened. Optimum current capacity can be assured if the position of the wire joint is parallel to the magnetic field direction at the point of attachment to the coil former.

To maintain a solid, tightly wound solenoid at cryogenic temperatures, the thermal contraction characteristics of the wire must be matched to those of the coil former. Unless this is done, the coil former might shrink, resulting in a loose pack and erratic coil behavior. Winding tension may also influence coil performance and should be maintained at a back tension of about 6 to 8 pounds on a nominal 10-mil-diameter wire.

Progress in applying intense magnetic fields to ore benefaction, forming of metals, nuclear fusion containment, chemical processes, and power generation and distribution will depend on contributions from basic research. A better understanding of superconductor materials, the development of new and improved materials, and manufacturing innovations will determine superconductivity’s eventual role in industry.

The author

Donald K. Fox is senior metallurgical engineer at the Westinghouse Research and Development Center. He works on superconductor materials and on product-oriented metals research.

Electronics | February 7, 1966
to offer you harmonic distortion measurements
5 cps to 600 kc with 0.1% full-scale distortion
sensitivity...plus these features:

"AUTOMATIC NULLING" for simple,
fast measurements
0.3 v rms input sensitivity for
100% Set Level reference
300 µv rms voltmeter full-scale
sensitivity (residual noise <25 µv)

Solid-state design in four Hewlett-Packard distortion
analyzers offers you extended frequency range,
greater Set Level sensitivity, improved selectivity,
greater overall accuracy, unprecedented ease of use.
All four measure total distortion down to 0.1% full
scale, 5 cps to 600 kc, with harmonics indicated to
3 mc. They measure voltage 300 µv to 300 v full
scale, have flat frequency response 5 cps to 3 mc.
Distortion analyzer and voltmeter input terminals are
the same. One-megohm input impedance. Floating
input and floating, low-distortion output for scope or
true rms voltmeter monitoring.

Two models feature automatic fundamental nul­
ling (>80 db rejection): Manually null to less than
10% of the Set Level reference, flip a switch, and
nulling is completed automatically. No more tedious
tuning on the more sensitive ranges! Two other
models employ high reduction gear drive to aid man­
ual tuning.

Two of the analyzers provide a switchable high­
pass filter which attenuates frequencies below 400
cps on signals greater than 1 kc...removes hum
and gives you pure distortion measurements.

Two models incorporate an amplitude modulation
detector that covers 500 kc to greater than 65 mc,
measures distortion at carrier levels as low as 1 v.
Options include an indicating meter with VU ballistic
characteristics (01) and rear terminals in parallel with
front input terminals (02).

Ask your Hewlett-Packard field engineer for a dem­
onstration of the model incorporating features most
useful to your application. Or write for technical data
on all four models to Hewlett-Packard, Palo Alto, Calif.
94304, Tel. (415) 326-7000; Europe: 54 Route des
Acacias, Geneva; Canada: 8270 Mayrand St., Montreal.

<table>
<thead>
<tr>
<th>Model</th>
<th>Automatic Nulling</th>
<th>High-Pass Filter</th>
<th>AM Detector</th>
<th>Gear Reduction Tuning</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>331A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$590</td>
</tr>
<tr>
<td>332A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$620</td>
</tr>
<tr>
<td>333A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$760</td>
</tr>
<tr>
<td>334A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$790</td>
</tr>
</tbody>
</table>

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT PACKARD
An extra measure of quality
Automated ground station will check out Saturn

Computer-controlled telemetry at Marshall Space Flight Center will speed the testing of space vehicles and reduce the time required to change from one transmission mode to another.

By George D. Shollenberger
Defense Electronics, Inc., Rockville, Md.

An automated ground station may be NASA's solution to the problem of coping with the fast-growing volume of data transmitted by space vehicles. Construction of such a station, with its telemetry functions controlled by a general-purpose computer, will begin Feb. 25 at the Marshall Space Flight Center in Huntsville, Ala.

The National Aeronautics and Space Administration expects the automated station to speed the change from one operational mode to another—for example from pulse-amplitude modulation (pam) to pulse-code modulation (pcm)—and to reduce the testing time in each mode. The basic method of monitoring will remain the same because, although the volume of data received from space has increased enormously, the complexity has remained about the same.

Built by Defense Electronics, Inc., of Rockville, Md., the automated station will be controlled by a model 930 computer made by Scientific Data Systems, Inc.

The automated station's first major task will be to check out Saturn launch vehicles before their delivery to Cape Kennedy as part of the Apollo program to land men on the moon by 1970.

Catching up with the transmitters

Telemetry systems aboard most missiles are already automated. Sensors automatically determine the vehicle's rate of climb, its roll, pitch and yaw, and variations in its temperature and pressure. This information is converted from analog to digital form and transmitted automatically to ground stations. Because each vehicle has its own telemetry modes and frequencies, ground stations at the test sites must adapt quickly to a variety of techniques.

In the automated station, the speed of this change is limited only by the response time of the electronic equipment. The computer will be preprogramed with information about the operating mode of each piece of equipment in the ground complex. When it receives a command to change state, such as from pam to pcm, it changes the operational mode of all the receiving equipment.

Automated telemetry does not require special receivers, transmitters or other components. However, it does require control circuitry that accepts and executes the digital addresses and instructions received in “words” meaningful to a computer.

Each computer word controls equipment that sets up an operational sequence for the telemetry system or for the fault-detection equipment, it also provides a means of system testing. Each computer-control word contains 25 bits—one strobe bit and 24 instruction or address bits. Digital control information is transferred to individual subsystems during a strobe pulse, the 750 nanoseconds that it takes for a digital word to travel from the computer's digital control bus and be stored or routed.

The telemetry receivers at Huntsville have the same basic design as do receivers in manually op-
Sacrificing selectivity

Receivers in an automated ground station must be tuned rapidly to any standard IRIG (interrange instrumentation group for the Department of Defense) frequency. A computer-tuned receiver with the selectivity of a manually tuned receiver would be impractical. Instead, a receiver with a nonselective front end was designed; selectivity is achieved by controlling the i-f bandwidth.

Difficulties arise when strong extraneous signals are received at frequencies near that of the desired signal; the receiver cannot reject these, and it may become overloaded, causing spurious responses and suppressing the desired signal.

The telemetry standard IRIG 106-60 permits error of only 0.005% in the transmitter frequency at ultrahigh frequency. Thus a transmitter operating at 2,300 megacycles per second may be off frequency by 115 kilocycles. This error is intolerable in receivers that have narrow bandwidths required in the i-f, down-converter and predetection stages. At present, the IRIG does not specify an allowable receiver error at very high frequencies because all uhf receivers are assumed to be manually tunable.

To eliminate manual operations, two approaches...
are being tried. One is a semiautomatic feature that requires the receiver's second local oscillator frequency to be variable in discrete steps. A central operator, using pushbuttons and go-no-go tuning indicators, makes the necessary adjustments.

The second approach adds a demodulator circuit, which examines the signal band and automatically adjusts the second local oscillator in discrete steps, or continuously (afc) until the received signal is centered within the preselected passband.

The other principal subsystems in the automated station have the same basic design as in manually controlled stations. These subsystems are a digitizer for pulse-amplitude modulation, pulse-duration modulation (pdm); a single-sideband (ssb) demultiplexer and digitizer, and an IRIG f-m demultiplexer.

In the pam/pdm digitizer, the three synchronizers can be fed simultaneously from three noncoherent pam or pdm wavetrains that have the same recurrence rate. The computer-controlled inputs are conditioned, sampled, converted to 8-, 9-, 10-bit binary code and multiplexed into a parallel output with the necessary frame and master-frame synchronization information. An analog-to-digital converter codes the pam and pdm samples.

The pcm demodulator accepts a pcm pulse train, locks on to the pulse synchronization pattern and pulse rates, then converts the serial digital words to a parallel output. Words containing discrete data are demultiplexed to ten event registers. These registers drive event recorders, lights and other displays in other parts of the ground system.

One word from the computer. . . .

The ssb subsystem accepts as its input a composite ssb signal consisting of 15 multiplexed data channels and one special service channel; the subsystem also receives a calibrate signal. On command from the digital control unit, the subsystem's analog multiplexer connects the digitizer to the calibrate signal, the special service channel or to one of the demultiplexed data channels.
Pulse-code modulation subsystem (top) and single-side band subsystem (bottom) receive inputs from a signal-distribution panel. After processing and buffering, their outputs are sent to the formatter, where they are selected by the computer for display and control. Pcm systems are one of the easiest types to automate, because their outputs are already in a digital format. In this system, the serial pcm wavetrains are converted to parallel outputs. The single-sideband subsystem is more complex. There are numerous channel and logic selectors as well as analog-to-digital converters. Every time a signal is operated upon in an analog subsystem, the incidence of error increases.
A single word from the computer is enough to make the ssb demultiplexer adjust to any of the 15 channels; to prepare the analog multiplexer to accept either the ssb demultiplexer output, a special service channel or the calibrate signal; and to set up the digitizer's mode.

The digitizer looks at the analog multiplexer's output for one second. During this time the signal amplitude is converted to a "n" bit binary word while the signal is gated to a counter where the incoming frequency is measured. Then the signal's digitized amplitude is gated to output buffers, which use the digitized amplitude and frequency count to determine the frequency response of all channels in the airborne multiplexer.

Another drawback: degraded performance

The switching of analog channels in an automated system can introduce data errors that are avoided in digital channels. An error is possible each time the system automatically switches any part of the f-m demultiplexer: 34 data discriminators, a timing discriminator, five reference-frequency discriminators, three delay lines (each tapped for a choice of five delays), and a band-switching discriminator.

The data discriminators conform to IRIG channels 1 through 21 and A through H. For IRIG channel 18, a 70-kc channel, a special ±30% deviation of the center frequency discriminates the data. Each discriminator is connected to one of three input buses, from three receivers or three tracks of a tape recorder, through a three-position analog multiplexer. The multiplexer has a 50,000-ohm impedance at 200 kc and a linear dynamic range of 0 to 10 volts peak-to-peak. Minimum detectable signal level in the discriminator is 10 mv root-mean-square; however, losses through the analog multiplexer increase the minimum detectable signal of the system to approximately 25 mv rms. This deterioration is tolerable because the rms level of the multiplexed signals at the receiver or tape-recorder output is approximately 1 volt rms.

The complex f-m calibration subsystem is set up by the computer with only two words. The first 15 instruction bits of the first control word determine the calibrate mode, the calibration deviation from center frequency, automatic sequencing and the sequencing dwell times.

The final five instruction bits of the first control word and the first 16 instruction bits of the second control word define the channels in each of four possible modes. Mode 1 encompasses IRIG channels 1 through 21; mode 2 has IRIG channels A through H; mode 3 contains channels 18 through 21; and mode 4 is triple f-m.

For Saturn telemetry, triple modulation results when IRIG channels 14 and 17 are multiplexed after each has been modulated by multiplexed channels 2 through 6 and 2 through 8 respectively.

The computer automatically calibrates the f-m multiplexers and discriminators at five equally spaced and discrete frequencies in the four individual modes. When commanded by the computer to strobe (change calibration channels), each channel in the multiplexed group sequences automatically through the frequencies at selectable dwell times of 1/4, 1/2, 1, 2, or 4 seconds.

How much automation?

If automation passes its test in Huntsville, the next question will be, "How much of each station should be automated?" The prototype station at Huntsville will be only about 85% automated.

For best efficiency, advances in automating ground stations should be matched by improvements in sensing and telemetry equipment aboard the space vehicles. Wholesale conversion to computer controls also will require more standardization of equipment both in the air and on the ground.
Nothing new . . . nothing "state of the art" in low-cost digital voltmeters? Don't you believe it! Right now, all but one low-cost DVM is "old hat" because only one—El's brand new Model 620—has AUTOJECT.

With AUTOJECT, noise is automatically rejected by synchronizing the sample period with the noise component. The result? Noise integrates to zero—irrespective of its phase or frequency.

And that's not all. Even by the traditional yardsticks, the Model 620 is quite a package. Look at the year's best buy in low-cost DVM's . . . point by point . . .

<table>
<thead>
<tr>
<th>Circuitry: All-solid-state?</th>
<th>HP 3440A</th>
<th>NLS 5005</th>
<th>Cubic DV-271</th>
<th>Kintel 511</th>
<th>El 620</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Common-mode noise rejection (@ 60cps, no filters)</td>
<td>70db</td>
<td>106db</td>
<td>20db</td>
<td>100db</td>
<td>140db</td>
</tr>
<tr>
<td>Normal-mode noise rejection (superimposed noise)</td>
<td>30db</td>
<td>30db</td>
<td>40db</td>
<td>50db</td>
<td>60db</td>
</tr>
<tr>
<td>Accuracy (as % of reading)</td>
<td>± 0.05%</td>
<td>± 0.01%</td>
<td>± 0.01%</td>
<td>± 0.01%</td>
<td>± 0.01%</td>
</tr>
<tr>
<td>Encoding speed (readout to meter's full accuracy and max. noise rejection at any noise frequency) in milliseconds</td>
<td>450 (to .1%)</td>
<td>600 (avg)</td>
<td>500 (avg)</td>
<td>700 (to 2 sec.)</td>
<td>250 (fixed to full accuracy)</td>
</tr>
<tr>
<td>Over-range (5th digit to extend meter resolution)</td>
<td>5%</td>
<td>none</td>
<td>10%</td>
<td>none</td>
<td>20%</td>
</tr>
<tr>
<td>4-Wire ratio capability (ratio between 2 unknown voltages with no common lines)</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

Model 620

AS OF NOVEMBER, 1965

IF YOU DON'T KNOW
autoject,
YOU NO LONGER KNOW DVM'S

FROM $995.00

- automatic ranging and polarity
- electrical outputs • remote control
- high input impedance to signal and external reference (1000 meg-ohms on 10 volt range)—zener reference • plug-in module available for AC, resistance and preamplifier

Electro Instruments, Inc.
8611 Balboa Avenue, San Diego, California 92112
The packaging revolution, part V: simpler designs for complex systems

Integrated circuits can be assembled economically in large digital systems if the design procedure demands simplicity in the wiring structure; multilayer circuit boards aren't needed—two-sided boards will do.

By Rex Rice
Fairchild Semiconductor, a division of Fairchild Camera & Instrument Corp., Mountain View, Calif.

The engineering practices that worked for digital systems built with discrete components fail when digital systems are built with integrated circuits. The engineers will waste time and money designing complex interconnection structures.

Digital systems can be made economical to design and produce with off-the-shelf IC's, if the right design procedures are used. Even large, high-speed systems can be built with a few two-sided circuit boards.

It is important to adopt procedures that force the system’s functional organization to be regular and the interconnections simple. This demands orderly arrangement of the components of a function and rejects the old concept of standard subassemblies with as few components as possible.

The advantages of systematic design were recently demonstrated at Fairchild Semiconductor division of Fairchild Camera & Instrument Corp. by a digital-systems research model. The model, an equivalent to the arithmetic portion of a large, commercial computer's central processor, contains approximately 5,000 logic gates, in 1,550 IC packages. All the packages are soldered into nine double-sided printed-circuit boards, and the nine boards are interconnected with one single-sided motherboard. The completed model, shown on the next page, has a clock rate of 5 megacycles—a high speed by commercial-computer standards. The performance characteristics are given in the table on the following page.

To have designed this system with discrete components and conventional, commercial design practices would have taken an estimated 200 man-months of professional engineering time, or longer. The IC version required less than 20 man-months to design.

The engineering crew enjoyed the work. The headaches of circuit and interconnection design were eliminated by design procedures which virtually wiped out the need for routine decisions. The design was so simple, in fact, that no computers were needed to devise circuit and wiring layouts. Technicians did most of the layouts in a total of eight man months.

The project was not an idle exercise. It generated data that has aided in development and application of a new family of logic circuits. It also shows that digital system engineers who persist in trying to apply discrete-component design practices to the organization and interconnection of IC systems are borrowing trouble.

Although the research model can compute, it was not designed for production or use as a computer. However, if it had been a prototype, it could have been converted readily into a model that could be produced by low-cost, conventional assembly techniques. The packages of the control and logic...
circuits are inserted directly into the circuit boards and the joints are made by a conventional flow-soldering machine. There are no complicated, difficult-to-fabricate interconnection structures such as multilayer circuit boards or transmission lines.

**System costs are different now**

Digital-system design practices should be re-evaluated to capitalize on the very low cost of mass-produced monolithic IC's. It is now economical to "waste" circuits, when extra circuits make the system organization and interconnection simpler. It is now expensive, in most cases, to custom-design circuits to satisfy an arbitrary system design.

The goals of discrete-component design practices are obsolete when IC's are used. Trying to retain a modular construction based on a few types of standardized subassemblies forces complex and costly interconnection structures. Attempting to make the circuits with a minimum number of components and a system with a minimum number of circuits raises design and fabrication costs.

Packaged IC's now cost less than the connectors and wires needed to make plug-in subassemblies. Soldering the IC packages to large circuit boards, to assemble large functional units, is less expensive than assembling functions the old way, with a large number of small plug-in cards. It is also more reliable because joints are fewer.

The traditional design emphasis—make the function with as few circuits as possible—can also be expensive because it results in a rat's nest of plugs and wiring. Traditionally, parts placement follows logical design and the circuit interconnections are developed last.

When IC's are used, the primary design emphasis should be on coordinating interconnection and functional design with parts placement. Reducing the cost, in numbers of circuits, per function, is a second goal. The result will be a more regular system.

It pays to use a few extra IC's to make interconnection and packaging simpler. For example, a package may contain three circuits. If it is difficult to get the interconnections to one of the circuits, it may be cheaper not to use that circuit. Trying to use every circuit in every package may prevent interconnection with a simple two-sided board and require a more expensive multilayer board. It may be less costly to provide additional circuits elsewhere on the board.

Here's a more specific example. A control signal can be left in a coded form on the system interconnection bus wire and then be decoded locally at each functional element. Local decoding requires a few more circuits but can greatly reduce wiring complexity.

Another way to save money is to design the system to use inexpensive, mass-produced IC's. It is a waste of engineering time to propose special circuits, with minor variations that optimize circuit parameters, merely to satisfy the whims of digital-circuit designers. The initial development expenses of IC's are high—making low-production, custom

---

**System specifications and organization**

**Speed**

A 5-megacycle clock rate with 12 AND gates, 3 logical level setters and 16 wired-OR locations provided in one clock cycle.

Add or subtract 11 decimal digits (floating decimal point) in 4 microseconds in a serial-by-character mode.

**System characteristics**

- Decimal input and output from typewriter
- Field length of numbers is variable from 1 to 15
- Automatic (hardware) conversion to and from floating operations with exponent range of ±99
- Serial-by-character operation
- Add, subtract, multiply, divide and transfer previous result (note: the system is not intended to be a complete stored-program calculator)

**Packaging and functional design**

Interconnection structure is 10 printed circuit boards. The first nine boards listed below are two-sided printed circuit boards measuring 14 by 12 inches and the tenth is a single-sided board. Numbers refer to those in the block diagram and table on the facing page.

1. Input-output control and 8-bit code translator
2. Decimal formatting and instruction controls
3. Two 72-bit registers, gating and controls (A-input and B-input)
4. Two 72-bit registers, gating and controls (multiply-divide-input and multiply-divide-temporary)
5. Two 72-bit registers, gating and controls (C-output and multiply-divide-output)
6. Arithmetic processing unit (register and adder, phase control, register and delay, and flip-flop control)
7. Printed-circuit base which interconnects the other cards

Digital system research model, on the table, contains approximately 5,000 logic gates. Nine two-sided printed circuit assemblies are plugged into a connector card, left foreground, facing the reader.

Electronics | February 7, 1966
 circuits costly. The circuit manufacturer has already freely used devices in his circuits to optimize their processing, performance and cost. He has this freedom because it matters little in mass-production costs whether a circuit has six transistors or twenty.

First steps in system design

The objectives of the research-model project were to establish simple procedures for building a large system and to aid in the development of Fairchild's new Complementary Transistor Micrologic circuits (CTµL). At the time the project began, in September, 1964, these circuits were in pilot production and their packages, the dual-inline package, were also new and untried.

As a first step, the economic valuations were stated as three rules intended to make the design work easy:

- Keep the logical, functional and packaging designs—and design records and documents—simple.
- Organize the specifications, design and construction so that the hardware is reduced to orderly elements. This eliminates many routine and unnecessary design decisions.
- Relax all tolerances. No attempt was made, for instance, to squeeze the last nanosecond of speed out of the circuits or to obtain a minimum-sized system, since extremely high parts density is costly.

Defining the system, which took four man-months of engineering, was completed in November, 1964. The system organization and functional units are given in the illustration and tables at the left and on this page.

The system contains 1,550 CTµL packages, equivalent to 5,040 NOR gates, exclusive of the power supplies for the processor and the typewriter.

Detailed design work, done by April, 1965, required 11 man-months of engineering time, plus 8 man-months of technician's time. Most of the technicians' time was spent in layout and preparation of the printed-circuit artwork.

Design procedures are detailed in another publication. Their applications to the research model and the design flow of the project are summarized on the next page. After the logic flow chart is prepared, the engineers begin writing a logic glossary and continue to add to it as package locations and wire routings are developed in later design stages.

Fast circuitry, simple wiring

The upper graph of the figure on page 114 illustrates the effect of circuit speed on system packaging. Circuits that operate at speeds of 1 to 5 nanoseconds require terminated strip-transmission-
Ordinarily, these speeds require complex circuits and interconnection media such as multilayer printed circuit boards or coaxial cable.

When the speeds range from 5 to 10 nanoseconds, stripline can be avoided. Then two-sided printed circuit boards may be used to reduce total system costs. The dot on the curve labeled "simple package" on the graph shows an ideal cost-oriented design point.

To maintain simple packaging, the pulse rise time should be no faster than about 7 nanoseconds. However, as shown by the lower graph of the figure on page 114 logic-stage delays of about 3 nanoseconds can be achieved with emitter-follower circuits. Net speeds of about 5 nanoseconds, or less, can be obtained by providing at least three stages of logic between level setters.

Also, more logic can be provided in the average stage and fewer interconnection lines will be needed with the logic-circuit configuration known as the "dot" or "wired" OR, in which the OR function is performed by the connecting wiring rather than by separate circuits.

Packaging is further simplified by reducing circuit sensitivity to the noise generated in the interconnections. Large signal swings provide good noise margins; for the CTµL family, a swing of 3 volts was chosen. The circuits are designed to eliminate unwanted oscillations.

The research model reflects these cost-oriented design decisions. Its pulse rise time is 7 nanoseconds, its gates are 3-nanosecond emitter-follower circuits, signal swings are 3 volts and the wired-OR configuration is used.

**Logic-string considerations**

Once the basic logical-design ground rules were established, the next step was to set up the logic implementation and wiring rules governing the functioning and location of the circuits in the logic chains. The result is illustrated on page 114.

It is unnecessary to conduct extensive preliminary analyses of system operation to predict all worst-case system conditions when the design procedures are systematic and the circuits are IC’s. It is cheaper and faster to set reasonable rules, design and build the system and then fix the few inadequate parts of the system. Experience with the research model verified this.

The project engineers reviewed the CTµL specifications then being prepared for publication and, as in any design project, conducted several simple tests with a few circuits working in the proposed packaging environment. It is difficult, if not impossible, for a manufacturer to prepare circuit specifications that apply to all possible applications and system environments.

**System engineering procedures**

Logic flow chart is prepared for the input-output function. Then a glossary of the logic is begun.

Referring to the logic flow chart, an engineer prepares the logic diagram. Next step is at the right.

Signal-wiring layout is prepared on vellum over the logic design master pattern.

Wiring layouts on board-artwork masters are checked against the logic diagram.
An estimate of system overhead was then made. Overhead refers to such design factors as delays due to timing problems (clock skew) and wiring delays. This estimate, the logic design rules and the CTµL circuit performance, as published in preliminary data sheets, were combined and restated as logic-implementation rules as follows:

- The normalized loading rules were those in the CTµL specifications.
- Three gates were allowed before level setting. In the illustration on page 114, the levels are restored after each set of three gates G by the following circuits: CTµL type 952 inverter, type 956 buffer and type 957 flip-flop.
- Four sets of gate and level-setter combinations were allowed in one clock cycle. This provides up to 15 AND logic decisions and 16 wired-OR logic decisions within one clock cycle. At a clock rate of 5 megacycles per second, the clock cycle is 200 nanoseconds long.
- The lengths of the printed circuit conductors between circuits could average 12 inches.

The following additional rules govern the clock timing, as shown in the figure on page 114:

- As the clock goes negative, the data transfers from the first rank to the second rank of the 957 flip-flops. Transfer is completed in 25 nanoseconds.
- The clock is left negative long enough to allow for data propagation (estimated worst case) and system overhead delays. Propagation time is 100 nanoseconds and overhead is 51 nanoseconds.
- The clock is driven positive long enough to allow data to be entered into the first rank of the 957 flip-flops. This requires 24 nanoseconds.
- The clock pulses are generated on the input-output control and translator board (see diagram on page 111) and sent to all other boards through the base interconnection board. The clock pulse is repowered locally on each board with buffer circuits.

Master plan for interconnections

Studies by Fairchild engineers and another study recently published by another source show that an economical interconnection structure is obtained by soldering the IC package leads into large, two-sided printed circuit boards.

Fairchild placed its design emphasis upon obtaining maximum interconnection density, not maximum circuit density, so that the boards could carry a relatively large number of IC packages without additional wiring layers. This was accomplished by having all the printed wiring on the board conform in general to an X-Y wiring matrix. That is, all the wiring runs in a horizontal direction on one side of the board and in a vertical direction on the other. The positions of the IC packages on the boards were worked out to accommodate this arrangement.

The boards measure 14 by 12 inches and can carry 242 dual-inline packages in 11 rows of 22 packages each. However, there are blank locations on the research model's boards; the omissions allowed the use of only two layers of wiring. The package count per board is given on page 111.

The package and wiring layouts were prepared...
Logic implementation and wiring rules. Block diagram indicates allowable numbers of gates between level restorers, shown in color. The curve below indicates clock timing.

with a coordinated set of layout masters, one for component layout and one for logic design. These and the associated board-artwork masters are shown at the right and can also be seen in the photographs on the preceding pages.

At first, package positions are tentatively assigned on the component layout master, which is the same size as a board. The positions are firmed up as the interconnection patterns take shape. Packages are relocated and extra circuits occasionally used to make wiring layout easier. A few positions are purposely left vacant to further ease wiring layout problems and in anticipation of logic modifications during system debugging. This master, plus a logic diagram, provides a point-to-point wiring schedule (not the actual wire routing).

The logic design master is twice the length and width of the board. The line grid consists of dark lines at 200-mil increments (0.2 inch) and light lines (invisible in the photo) at 100-mil increments. The light-line spacing reduces to 50 mils on the actual board; these lines govern the spacing between wiring runs. The spacing of the dark lines corresponds to the 100-mil spacing of the plug-in pins of the dual-inline packages.

At each package-pin position is a disk 50 mils in diameter. On the finished board, these are 40-mil soldering pads with a plated-through hole that is 22 to 25 mils in diameter at the center of each pad. All connector positions are also shown on the master.

The master is preprinted with all plus and minus voltage lines, ground lines and the return paths for these lines. The ground lines are the lower zigzag lines of each group of three horizontal lines; the top lines of each group are the plus-voltage lines, and the minus-voltage lines are in the center of each group.

The horizontal lines are fabricated on the top, or component-mounting side, of the board. Since the dual-inline package pins have stand-offs which raise the package above the boards, these lines can be run through the package positions. The vertical lines run between the pin rows on the bottom,
Master patterns for circuit layouts

Component layout master assigns package positions.

Master layout for base card, the interconnection board.

Logic design master for drafting printed wiring routes.

Artwork taping master for top side of printed circuit.

Standard artwork for bottom side of printed circuit.

Superimposed artwork for top and bottom of one board.
or soldering side, of the printed-circuit board.

The designers draw in the signal wiring needed to interconnect the IC packages. The drawing is done on vellum placed over the logic-design master. The signal wiring can run along any of the grid lines not already occupied by the standardized voltage and ground lines. Blue pencil is used for the horizontal, top-of-the-board wiring and red pencil for the vertical runs. Through-hole positions are marked where the runs change direction.

The completed wiring pattern is transferred to artwork taping masters. There is one master for the top and one for the bottom of the board. These masters, also double scale, contain all the hole locations and interconnections common to all functional boards. Red adhesive tape is applied to duplicate the signal wiring. After the patterns are double-checked with the original logic diagram, they are photographically reduced to provide the photoetching tool films for board fabrication.

The base-card layout is a unique and striking example of the simplicity that can be achieved in IC systems. The other nine boards will be interconnected with the board produced by this pattern, a single layer of copper with only 162 straight, parallel wiring runs. To remove unwanted interconnections between the boards, the standard pattern shown is modified by merely deleting segments of the lines between connector-pin positions.

**Pin count drops**

One measure of layout efficiency is the ratio of circuit leads to board-interconnection pins. The layout of the model is efficient, as shown by the table on page 111.

Although 162 connector pins are available on each board, most boards use less than half the pins. The large number of pins was retained to keep the base-card wiring orderly.

The register boards are exceptionally efficient in pin usage because their component and interconnection densities are high and the wiring is very orderly. The other boards require control logic or tree logic, which makes the wiring runs random and restricts the number of IC's that can be mounted on the boards. Nevertheless, the ratios compare favorably with those of multilayer boards [See, for example, Electronics, Nov. 29, 1965, page 90].

**Packaging and assembly**

The nine logic and control modules were assembled by plugging the IC packages into the lead-insertion holes. Seven boards were soldered on a flow-soldering machine and two were hand soldered. A few discrete wires were added to the boards to correct errors.

The power supplies were built of conventional components. The only other conventional wiring in the system are the cables between the power supplies and the base card and typewriter.

The contact springs of the connectors on the base card are soldered directly into that printed circuit. The other boards slide into guides in the rectangular system frame and plug into the base-card connectors, as shown in the photographs on pages 110 and 113.

During board insertion or removal, the connector contact springs are open. They are locked onto the contact fingers of the boards by cams; the cams are long, round rods with a flat spot. When the cams are rotated to the closed position, with a key, they apply more than 750 grams of pressure to each contact.

The circuits are cooled by air, blown by fans at a minimum of velocity of 50 feet per minute over the boards and out through the card guides.

**System debugging**

The detailed design was completed by April, 1965. Fabrication began in February and ended in August. During August and September, the system was debugged; that took 1½ man-months of engineering time.

To test the operation of each module board while the system was operated, an extender card was connected between the board being tested and the base-board connector. Strip transmission lines were not used on the extender; the increase in lead length did not present any difficulty because the extender was a two-sided board with ground runs between adjacent signal wires.

Two engineers cooperated in tracing the logic step by step with a normal oscilloscope test probe and test lights plugged into terminals provided along the top edge of the board as part of the printed wiring pattern. The test documents were a reduced-scale copy of the logic diagrams, the flow charts and a set of artwork prints.

The usual design errors, logic oversights, tapping errors and other mistakes were encountered and fixed. A few circuits proved to be faulty (the CT_L circuits in the model were from a preproduction run). Components were replaced by desoldering and resoldering, a few IC's were added at vacant positions on the boards and wiring was changed by adding discrete wires.

No wiring changes were needed on the three register boards nor on the base board. Each of the other boards had a few changes. No faulty solder or connector joints were found.

The system is now operating according to specifications. It is presently being used to accumulate data on CT_L circuits and as a test bed for improved IC configurations.

**References**


Ultra-fast, high conductance FDR-600: guaranteed forward voltage of one volt or less, at 200mA forward current, after radiation exposure.

Picosecond switching FDR-700: guaranteed forward voltage of one volt or less, at 30mA forward current, after radiation exposure.

High voltage rectifiers FRR-300: the only Planar passivated rectifiers in the 350-450V range with guaranteed forward voltage of one volt or less, at 100mA forward current, after radiation exposure.

For evidence see chart below. For proof see our data sheets. See your Fairchild Distributor or write us.

<table>
<thead>
<tr>
<th>SERIES</th>
<th>GUARANTEED PERFORMANCE AFTER EXPOSURE</th>
<th>EXPOSURE TO FAST NEUTRON RADIATION (@100keV)</th>
<th>BREAKDOWN VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra fast, high conductance FDR-600</td>
<td>$I_r = 200\text{mA} @ 1.0V$</td>
<td>$1 \times 10^{14}\text{nvt}$</td>
<td>FDR-600: $B, 75\text{V} @ I_r = 5\mu\text{A}, t_r = 4.0\text{nsec.}$</td>
</tr>
<tr>
<td>Picosecond switching FDR-700</td>
<td>$I_r = 30\text{mA} @ 1.0V$</td>
<td>$1 \times 10^{14}\text{nvt}$</td>
<td>FDR-700: $B, 30\text{V} @ I_r = 5\mu\text{A}, t_r = 750\text{psec.}$</td>
</tr>
<tr>
<td>High voltage high conductance FRR-300</td>
<td>$I_r = 100\text{mA} @ 1.0V$</td>
<td>$5 \times 10^{14}\text{nvt}$</td>
<td>FRR-300: $B, 300\text{V} @ I_r = 100\mu\text{A}$</td>
</tr>
</tbody>
</table>
New total protection...
against all hostile environments

Most switch manufacturers seal just the switching area. But Only CDI Seals both The Switching Area and The Panel, Pat. Pending.

Exclusive CDI total switch sealing benefits you by protecting all other components in your system against dust, dirt, salt spray and other foreign elements which reduce performance. Switching area and panel are independently sealed for full protection and reliability.

Clean room assembled. Decimal or coded models. For R.F.I. applications, Series PS tab type Thumbwheel Switch mounts on 5/8" centers and retrofits Series TTS. Switch life exceeds 100,000 operations. Send for data sheet.

NO SCREWS VISIBLE. NEW ALUMINUM BEZEL permits rear mounting of miniature and standard type switches with no screws visible. Accommodates to 20 switch modules. Miniature model fits CDI Series TTD and TTB standard type switches. Available in colors to match any instrument panel. Send for data sheet.
Microwave heating has recently emerged from the laboratory and is now finding its place in the food processing and other industries. Because it is fast, efficient, and highly controllable, microwave heating is particularly suitable for on-stream operations.

For example: Revolutionary new potato chip processing machinery manufactured by the Cryodry Corporation, a subsidiary of the Armour Company, uses the EIMAC EM15LS magnetron in a conveyorized microwave oven to finish-dry to optimum color potato chips which have been pre-cooked in oil.

M. R. Jeppson, President of Cryodry, says: "We chose Eimac's new magnetron to power our machinery because the tube has an unusually high dc-to-rf conversion ratio—80%—and promises a very competitive life cost per kilowatt hour of only 2¢."

Moisture removal is only one of the tasks which industry can assign to microwave heating. Others include chemical catalysis, distillation, puffing, fermentation, and sterilization. Eimac has built pioneering tubes to supply microwave power for this new technique. As fast as new applications for microwave heating arise, Eimac is developing appropriate power supplies. If you'd like to find out more about what you might do with microwave heating, write on your letterhead to Microwave Marketing, Eimac.
Achieve optimum strike potential with Ferranti F1600

The family of computers that permits initiation of real-time retaliation within two radar sweeps.

Before the antenna has completed its second sweep the F1600 carries out a thorough threat evaluation and presents Central Command with an overall picture of the national defence situation. Subject to human decision, retaliation can proceed instantly.

This is how member nations of NATO can achieve strategic superiority with a defence system based on the F1600 — organised in a radically new mode pioneered by Ferranti to make it the world’s fastest and most powerful computer for advanced military applications.

The F1600 compiles ‘track files’ on attacking aircraft and missiles, evaluates the state of readiness, performance and location of individual units in the defence network, and selects the most likely weapon for effective combat from the nation’s armoury. Performs all these functions in micro-seconds.

Based upon information gathered from surveillance radar the F1600 then calculates and transmits vital ‘kill point’ data to a fighter aircraft before it leaves the ground, to a fighter already in the air, or to a surface-to-air missile complex.

This very high speed stored program computer has been chosen to form the heart of the British Royal Navy’s Action Data Automation System (ADA) for the new generation of aircraft carriers and guided missile destroyers.

Within a few hours flight of every European capital, Ferranti have unequalled experience in the creation of real-time computer-based systems to meet specific Service requirements. Having worked closely and successfully with members of NATO, Ferranti are uniquely qualified to provide an individual solution to problems of national defence.

Ferranti Ltd., Digital Systems Department, Moston, Manchester 10, England.

DSD Research and Development Laboratories, Bracknell, Berkshire, England.
WANT TO SAVE MONEY BY USING GUDEBROD LACING TAPE? . . .

YOU DO IT HERE!

Harness tying may be a relatively minor operation. But it also can be a major cost drain. Lacing tape is one of the smallest costs in the harnessing operation but with Gudebrod Tape you can save dollars in making harnesses. Knots tie easier, workers say they almost tie themselves, knots stay tied, the harness workers can go right on with the harnessing without having to go back for re-tightening. Workers like to use Gudebrod Tape. You cut harnessing time—you have fewer rejects. All of this works for you in saving money on cable harnesses—that's why it pays to specify Gudebrod Lacing Tape, the original flat braided tape. Prove these statements in your own harnessing department—give Gudebrod Tape a comparative test.

CABLE LACING INFORMATION:

When you need help on knots, on spacing, on the type of tape to use—Gudebrod is your one best source for information. We have over 200 different lacing tapes in stock, for temperatures up to 1500°F, or down to -100°F, burn proof tapes, tapes that do not outgas in vacuum, color coded tapes, cut lengths, tapes of nylon, Dacron®, Teflon®, spun glass, silica fiber. Ask for a copy of our Product Data Book.

GUDEBROD CABLE LACER

—ANOTHER MONEY SAVER

The first hand tool specifically engineered for continuous wire harnessing. Handle holds bobbin, feeds tape as needed, grips tape for knotting. Speeds, eases harnessing. Has paid for itself in a day in many plants.

GUDEBROD BROS. SILK CO., INC.

FOUNDED IN 1870

Electronics Division

12 SOUTH 12TH STREET, PHILADELPHIA, PENNSYLVANIA 19107

Area Code 215, WA 2-1122

© Du Pont Registered Trade Mark
The newest, finest Bendix Autosyn Synchros won’t carry much weight.

Unless you consider the 1.3 ounces typical of the new Size 08 Autosyn® Synchros “much”. Which most engineers don’t. And which, when coupled with the fact that the 16 new Size 08 Synchros boast a maximum diameter of just 0.750 inch, is enough to influence almost every weight- and size-critical design on the drawing boards.

But subminiaturization is only one of the talents Bendix Autosyn Synchros offer you. All sizes (08, 10, 11, 15 and 22) are available in stainless steel or aluminum housings, for instance. Some are accurate and stable at operating temperatures as high as 800° F, which makes them ideal for use in supersonic aircraft. Others are built for increased radiation resistance. And hundreds more are specifically designed for aircraft instrument applications.

There’s certain to be an Autosyn Synchro that’s right for your needs. To find out which one, call us at 717, 278-1161, in Montrose, Pennsylvania. Or write for our new 42-page catalog.

Montrose Division

THE BENDIX CORPORATION

Circle 122 on reader service card 122
**Only ONE dvm**

**offers you the advantages of integrating AND potentiometric operation:**

Measure 1 v to 1000 v with ±10 µv resolution, to 1200 v with overranging, and get the noise rejection performance of an integrating DVM, plus the accuracy of a potentiometric DVM. Range selection by front-panel pushbuttons, automatically or remotely. Function symbol is displayed, and decimal point is positioned automatically.

You need to read all the specifications to learn the uniqueness of this remarkable instrument which is the heart of a series of systems available from the Dymec Division. Or see it perform on your bench or in your system. Call your Hewlett-Packard field engineer for a demonstration or write for complete data to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal,

**Unique design offers you this:**

**Accuracy:** ±0.005% of reading ±2 counts, +10°C to +40°C!

**Stability:** Calibrate only once every 2 months!

**Speed:** Up to 15 readings per second!

**Ranges:** Four 5-digit ranges, 1 v to 1000 v (10 µV sensitivity)!

**Input impedance:** 10 megohms (±0.03%) on all ranges!

**Price:** Only $3600!

**Plus all these features, yours on the STANDARD instrument, at no increase in cost!**

- **Autoranging**
- 20% overrange on all ranges, 6th overrange digit
- **CMR** of 160 db at dc
- Remote programming
- BCD printer output
- Selectable front and rear inputs
- Manual trigger
- Overload indication
- Operation to 50°C
- **Optional ac/ohms measurements**

Data subject to change without notice. Price f.o.b. factory.

**HEWLETT PACKARD**

An extra measure of quality

---

Electronics | February 7, 1966

Circle 123 on reader service card 123
The Hughes Aircraft Company
is proud to announce the establishment of

THE HUGHES PROFESSIONAL CAREER DEVELOPMENT PROGRAM

This new Program emphasizes individual career growth through a sequence of selected work assignments for graduate engineers who have acquired between two and eight years of professional experience. It is designed primarily for two types of development:

1. Specialized, in-depth assignments to develop unusual proficiency in a specific area of interest.

2. Broad, systems-types of assignments to prepare for system and project engineering responsibilities.

There will be a maximum of three assignments which will be determined jointly by the participant and the Professional Development Section. The assignments, which are flexible in length would normally extend for one year each. They may be selected from a broad spectrum of aerospace electronics hardware and systems-oriented programs and will be designed to provide optimum backgrounds in specialized areas of interest.

The Program will be limited to 50 participants in 1966. These will be selected from candidates who are graduates in E.E., M.E. or Physics from fully-accredit-
what ceramic capacitor manufacturer can meet or exceed all these MIL specs?

Hi-Q can!

...and does. Right in step with the increasingly stringent demands of aero/space technology, Hi-Q today provides "one-stop shopping" for all types of Military ceramic capacitors. State-of-the-art temperature compensating, high K, and high reliability ceramic formulations are always available from the company that leads the pack in product advancement. Styles? Whether you need a ceramic high voltage disc, a subminiature radial lead part, a feed thru, a temperature compensating tubular, or a molded high capacitance tubular...you can be sure of getting it from Hi-Q.

And now Hi-Q has developed CERALAM to dramatically increase capacity-to-volume ratios—typified by the CKR12, the CKR13, and the extended range CKR06.

To meet MIL Specs like NPC-200-3, MIL-STD-790, and MIL-Q-9858, Hi-Q has created in-house Reliability and Quality assurance programs that cover everything from design and raw material to the carefully controlled process and inspection that produce the world's finest capacitors. And all this is carried out in outstanding clean room facilities at Myrtle Beach, S. C. and Olean, N. Y.—clean rooms that make it possible to meet the unique demands of HI REL specifications such as MIL-C-38101 and MIL-C-39014.

So if you're looking for a manufacturer that can meet any or all of your requirements for Military ceramic capacitors, call us. We're it.

Circle 125 on reader service card
Revolutionary new temperature transducers fit both bridge circuitry and sensing elements in the measuring stem.

CEC's Type 4-550 Integral Bridge Temperature Transducers introduce a consistent degree of accuracy never before achieved in the temperature measurement of liquids and gases. Also, being engineered to withstand extreme vibration and shock environments, these new transducers are the logical choice for missile applications.

The secret is in the stem.

A new design concept has made it possible to locate both the bridge completion circuitry and the sensing elements within the measuring stem of the transducer. Result: since all critical resistors remain at the same temperature, effects of temperature changes on the bridge are included in the calibration and standardization of the transducers. No longer need you be concerned about possible errors due to variations in external ambient air temperature.

Three models are available.

The 4-550 family includes the 0001, 0002 and 0003. The distinction between them is in range only, which is, respectively: 0 to 200°F, 0 to 100°F and 0 to 500°F. All employ special strain-free, vibration-resistant sensing elements of high purity nickel. The completion bridge is designed to provide a linear output with temperature, 40 mv full scale. No need to call for computer help to unscramble non-linear functions.

The six advantages of the 4-550s:

1. Elimination of external bridge circuitry.
2. Operational simplicity.
3. Interchangeability of calibrations.
4. Improved overall system accuracy.
5. Linearized output.
6. Less weight and space.

Significant specifications:

- **Range**: Zero to full scale within the limits of -100 and +500°F.
- **Output**: 4.0 mv/V full scale.
- **Overall Accuracy**: ±0.25% of full scale (including calibration interchangeability).
- **Nominal Excitation Voltage**: 10.0 volts d-c.
- **Rated Load Impedance**: 100,000 ohms.
- **Output Impedance**: 500 ±25 ohms.
- **Time Response**: 250 milliseconds for 63% response in water at 3 ft/second.
- **Working Pressure**: 1500 psig.
- **Calibration**: Five point calibration certificate supplied with 0, 25, 50, 75 and 100% of full scale temperature vs. output values.

For complete information, call or write CEC for Bulletin 4550-X1.
now coast-to-coast

General Electric can meet your permanent magnet, thermistor and Thyrite® Varistor needs.

We’ve redrawn our sales map. General Electric now has magnetic material and specialty resistor sales assistance in 18 offices from coast-to-coast... one is near you.

G-E Alnico and Lodex® permanent magnet materials, thermistors, and Thyrite® Varistor materials are already at work in dozens of industries helping to solve sticky and critical design problems. They can help you, too.

Just give us a call today and we’ll send a man with technical assistance your way fast. Let us show you why General Electric is the industry leader in magnetic materials and specialty resistors. MAGNETIC MATERIALS SECTION, (Telephone 517-427-5151), Edmore, Michigan 48829.

G-E MAGNETIC MATERIALS SALES AND SERVICE OFFICES

1. Seattle, Washington
   220 S. Dawson Street
   206-729-6804

2. Redwood City, California
   555 Veterans Blvd.
   415-369-7151

3. Los Angeles, California
   11840 W. Olympic Blvd.
   213-479-7763

4. Phoenix, Arizona
   Suite 712, Guaranty Bank Bldg.
   602-264-1751

5. Denver, Colorado
   201 University Avenue
   303-388-5771

6. Dallas, Texas
   4447 N. Central Expressway
   214-521-1931

7. Cedar Rapids, Iowa
   210 Second Street SE
   319-364-9149

8. Kansas City, Missouri
   106 W. 14th Street, Room 2500
   816-221-4033

9. Chicago, Illinois
   3800 N. Milwaukee Avenue
   312-777-1600

10. Rochester, New York
    39 Jefferson Road
    716-436-2800

11. Clifton, New Jersey
    200 Main Avenue
    201-757-3673

12. Wellesley, Massachusetts
    468 Washington Street
    617-235-5521

13. Philadelphia, Pennsylvania
    3 Penn Center Plaza
    215-568-1800

14. Baltimore, Maryland
    1 N. Charles Street
    301-685-6500

15. Washington, D.C.
    777—14th Street NW
    202-393-3600

16. Lynchburg, Virginia
    Carroll Avenue
    703-846-7311

17. Charlotte, North Carolina
    129 W. Trade Street
    704-375-5571

18. Tampa, Florida
    2106 South Lois Avenue
    813-877-8311

Progress Is Our Most Important Product

GENERAL ELECTRIC
Quality Need Not Be Expensive

Some people would have you believe that to buy the best, you must pay the most. This is not necessarily true. Price is only a measure of value—never a substitute for it.

At Stackpole, the real value of any resistor is determined by a combination of its performance record and its price. Perhaps this is why so many of our customers continue to specify Stackpole resistors year after year to maintain top performance for established products and for their new ones, too. Such confidence and loyalty cannot be based on price alone.

Uniformity has become the accepted characteristic of Stackpole resistors. Unique production methods, coupled with in-depth experience in manufacturing and testing are your assurance that Stackpole resistors will give you absolute performance. The resistors you order today will be identical in every way to your last order.

Most leading manufacturers of electronic equipment have long recognized Stackpole resistors for reliability. Whether it be the rugged demands of portable television or the critical tolerances of space age communication and tracking equipment, Stackpole resistors deliver the performance you expect—the kind of dependability that builds a reputation for your products.

Why continue to pay a premium for quality? Let us prove that you get value from Stackpole. Quality resistors, economically priced, are delivered promptly and backed up by our complete corporate facility. Next time, specify Stackpole. There’s a family of fine resistors available in sizes of 2, 1, 1/2 and 1/4 watts. For samples and additional information, write: Stackpole Carbon Company, Electronic Components Division, Kane, Pa. Phone: 814-837-7000 — TWX: 510-695-8404.
At last—a production laser welder that really works:

the Linde LWM-1

This is the first practical laser welder that makes precise, reproducible welds on a production basis—the Linde LWM-1.

Another important thing: it's easy to use. Almost anyone can learn to operate it in about five minutes. The 25:1 ratio micro-manipulator makes positioning a snap. And the operator has a continuous right-side-up image in the binocular viewer, even during welding.

The LWM-1 Laser Micro-Welder is manufactured by Korad Corporation to Linde specifications. Want complete details? Contact the nearest Linde Division office, or send the coupon.

"Linde" is a registered trade mark of Union Carbide Corporation, Korad Corporation is a subsidiary of Union Carbide Corporation.
Here are growth opportunities in Communications with TRW Systems in Los Angeles and Houston

There is "room at the top" for your special talents on America's major missile and space programs with TRW Systems' Communication Laboratory in either Los Angeles or Houston. From the beginning of communications via space, this group has played a pre-eminent role in developing communications systems for the nation's major missile and space programs. Major achievements include the first unified carrier tracking, telemetry and command system and the first PCM telemetry system for space. Now is the time for you to investigate these opportunities with this outstanding professional organization.

MAJOR PROGRAMS . . .

Apollo spacecraft systems
Advanced Minuteman systems
Mars mission and spacecraft studies
Nuclear Detection (Vela) Satellites
Pioneer interplanetary spacecraft
Weather satellite systems
Standardized tracking, telemetry and command system (SGLS)
Advanced space probes
Lunar telemetry systems
Communication satellite systems

Senior Communication Engineers
For design, analysis and management of communication systems and evaluation of scientific and military applications of communication techniques for aircraft, spacecraft and underwater craft use. BSEE, MSEE or PhD.

Communication Equipment Design Engineers
Several years' experience in design and analysis in the following fields: RF filters, diplexers, antennas, phased arrays, feeds, solid-state transmitters, receivers, phase-lock loop techniques, cavity techniques, strip line, very wide and very narrow band circuits, circuit engineering, and modulation techniques. BSEE or MSEE.

Communication System Analysis Engineers
Conceptual design, analysis and synthesis of wide variety of digital and analog communication systems, employing coding, modulation, and statistical communication theory. Systems include integrated coherent-carrier systems, phase lock demodulation (restrictive/ non-restrictive), communication satellites and deep space probes. MSEE or PhD.

Signal Processing Engineers
Design and development of sophisticated communication systems and components. Signal conditioners, analog and digital encoding and decoding, modulation tracking and carrier tracking phase lock loops, and multiphase modulation are involved in tracking, telemetry and command equipment which includes but is not limited to space applications. BSEE or MSEE.

Telemetry Circuit Design Engineers
To design a wide variety of analog and digital signal processing circuits for spacecraft digital telemetry equipment. Experience should relate to the design of analog-to-digital converters, analog and digital multiplexers, logic and data storage. Familiarity with microelectronics desirable. BSEE or MSEE.

Telemetry System Engineers
Experienced in the functional and logical design of analog and digital telemetry systems. Familiarity with design, development, application and evaluation of spacecraft instrumentation systems. Experienced in the design of data systems to interface with a wide variety of data sources including scientific experiments, and engineering measurements.

Please submit resume and salary history in confidence to R. J. Brown, TRW Professional Placement, Dept. L-21. One Space Park, Redondo Beach, California 90278. TRW is an equal opportunity employer, male and female.
Gentlemen:
Consider yourselves challenged. Send me your short form specification sheet for custom-welded modules. I'll fill it out. Then you quote a price and give me whatever suggestions you may have for improving the module.

Name ____________________________
Title ______________________________
Company ____________________________
Address ____________________________
City ____________ State ____________ Zip ____________

If you would like your system to have the reliability and size reduction advantages of custom welded modules but think you can't afford it, challenge us! Whether you need to design an all-new circuit, to adapt an existing design to welded packaging or to locate a qualified vendor for production quantities of your circuits, Space Craft will perform for you at surprisingly low cost. To call our hand, just use the coupon above.
Opens fresh design horizons...

microminiature
solid cermet
discrete resistor

Explore new design areas with these Ceradot® pellet resistor characteristics available only from CTS:

- To ± 1% tolerance.
- 15 watts/cm³ power to size ratio.
- Won't short out under any operating conditions.
- Extreme stability under extreme environments.
- 15 ohms to 200K ohms resistance range.
- Not affected by radiation.
- Operates at 175°C hot spot without leads.
- Available with leads or terminating surfaces for soldering or welding.

Current CTS Ceradot applications include numerous aerospace, military and industrial microcircuits, such as discrete components inside transistor cans and flat packs, microwave loads, temperature compensated transistor circuits, load resistors, etc. How can Ceradot's unique characteristics help solve your design problem?

EXPERIMENT WITH CTS CERADOTS

Designers' Kit contains an assortment of pellet resistors in these sizes: .050" dia. x .030"; .050" dia. x .062"; .100" dia. x .030" and .100" dia. x .062" in random resistance values. Uses: in prototypes, development programs, testing and experimental microcircuits. Kit price $10.00. Immediate delivery.

Principal Products

Variable Resistors
Selector Switches
Loudspeakers
Trimming Potentiometers
Fixed Resistor Micromodules & Microelectronic Circuity
Crystals, Filters, Oscillators & Ovens

Subsidiaries

CTS of Asheville, Inc., Skyland, N.C.
CTS of Berne, Inc., Berne, Indiana
CTS of Paducah, Inc., Paducah, Ky.
Chicago Telephone of California, Inc., South Pasadena, Calif.
CTS of Canada, Ltd., Streetsville, Ontario
CTS Microelectronics, Inc., Lafayette, Ind.
CTS Research, Inc., Lafayette, Ind.
CTS Knights, Inc., Sandwich, Ill.

Founded 1896

CTS CORPORATION
Elkhart, Indiana

Sales Offices and Representatives conveniently located throughout the world.

Circle 132 on reader service card
Through 1965, the United States budget had never exceeded $100 billion. Now the Johnson Administration has presented an 18-month spending plan that would propel two budgets beyond that imaginary barrier—the $106.4-billion plan for fiscal 1966 and the $112.8-billion budget for 1967, both boosted by supplemental spending requests totaling $14.7 billion.

Defense spending, which constitutes 57% of next year's $112.8-billion budget, offers rich rewards to military electronics companies. There are also a few consolation prizes to the industry's participants in the Great Society and other civilian programs.

The military buildup hastens the trend away from strategic weapons and toward equipment for close-range fighting of the kind encountered in Vietnam. Intercontinental missiles such as the land-based Minuteman and the submarine-launched Polaris will continue to be built, and development of both types will be accelerated. But high on next year's military preferred list are helicopters (3,678 ordered), radars, and portable radios that can transmit through the jungle.

Civilian programs also are relying more heavily on electronics, although many projects—particularly in aviation and astronautics—are being postponed, curtailed and slowed down. Budget Director Charles Schultze says his bureau chopped about $20 billion off agencies' requests for funds. He doesn't enumerate them, but some of the casualties are known:

- The Voyager program to land instruments on Mars by 1971 has been set back at least two years.
- The Federal Aviation Agency is requesting $22 million less for air-traffic control facilities than it received last year.

- The National Institutes of Health, which supports 40% of the nation's medical research, will receive only a $59-million increase—the smallest in a decade.

Beyond Project Apollo, NASA has had little success in speeding work on advanced programs such as the Apollo Applications Project to put scientists into orbit for months at a time. But if it's any consolation to the space agency, the budget-cutters have also been stern with the military. The Air Force's plan for a manned orbiting laboratory has received only token authorizations.

Other programs that have been touted by Administration officials will have to achieve their goals with little or no research money. There will be some impetus for electronics in the control of air and water pollution and in instrumentation for nuclear reactors. But plans for research into better high-speed ground transportation have been slashed almost in half, and work on the highly publicized supersonic transport plane will move along no faster than it did this year.

The new highway-safety program will have to rely on the automobile industry for any sophisticated testing and research it may require. That's like asking the steel industry to help establish wage-price guidelines.

Military electronics

Lion's share to defense

The war in Vietnam, long called the "unbudgeted war" by many members of Congress, has suddenly become the most conspicuous item in the federal budget. Because of it, President Johnson, within five days—from Jan. 19 to Jan. 24—revised the fiscal 1966 defense budget upward by $12.3 billion to make a total authorization of $66.46 billion. He then asked for a huge 1967 budget—$61.42 billion. If this is not enough, the President told Congress, "I will not hesitate to request the necessary sums."

Most of the extra money in both budgets will go for Vietnam; it will help replenish stockpiles in the United States and Europe that were dipped into before the Vietnam war was budgeted fully; it will help pay for the present fighting in Southeast Asia; and it will help finance further escalation if it takes place. If the war does expand, supplemental requests are inevitable in 1967.

The money on hand, and that requested, should hold the Defense Department for a while. The 1967 budget calls for $59.85 billion in new obligatory authority (NOA)—new funds that the Defense Department can spend, or can prom-
ise to spend in 1967 or later. Added to this amount are unused funds brought forward from 1966; these will bring the total contractual authority next year to an estimated $61.42 billion.

Still more money may end up in the 1967 kitty if some is left over from 1966. Beginning as a modest $51.74 billion when the 1966 budget was first drawn up, the total obligational authority for 1966 was expanded with a $700-million supplemental authorization in May, 1965; $1.7 billion more in August, 1965; and the $12.3 billion on Jan. 19, 1966, five days before the 1967 budget was introduced. The Pentagon’s total obligational authority for 1966 comes to a hefty $66.46 billion; $63.681 billion of this will be committed to contractors, and $54.2 billion will actually be spent. The $9.5-billion difference between commitments and expenditures represents long-lead-time items that won’t be delivered or paid for until 1967—such items as aircraft, ammunition, and missiles including Bullpup, the air-to-surface missile used by all three armed services.

In 1967, contracts totaling $62.8 billion are expected to be awarded, with $55.3 billion being spent. Only $4.5 billion is earmarked for long-lead-time items in the 1967 budget.

The impact of Vietnam is seen in the sharp contrast between the 1965 budget and those for 1966 and 1967. Contract awards in 1966 are expected to exceed 1965’s by $13.5 billion, and 1967 contracts will total $12.6 billion more than in 1965. Expenditures in 1966 are $8.5 billion more than in 1965; and in 1967 they will be $10.9 billion more than in 1965.

I. Vietnam supplementals

The war in Vietnam is not being funded completely from supplemental appropriations—the Defense Department says it doesn’t know how much the war is costing. The supplementals, however, are paying for part of the war, and the Defense Department knows what this money is buying. A total of $4.635 billion of the supplementals is scheduled for spending for Vietnam during the rest of fiscal 1966, and $10.335 billion in 1967.

Aircraft. With the supplementary funds for Vietnam, the Army will spend $826 million for aircraft and related equipment, $168 million of this will be used to equip new aviation units. The Navy will spend $738 million for aircraft, and the Air Force $1.568 million.

The services will buy 2,005 helicopters—1,813 of them for the Army—and more than 900 fixed-wing planes—only 64 for the Army. Aircraft to replace those lost in Vietnam will cost $1.8 billion.

Missiles. The three services will buy a total of 4,530 tactical missiles, including the Army’s Hawk for use against low-flying planes and the Navy’s Bullpup for use against ground targets. The Air Force will spend $64 million for missiles; the Navy $26.2 million; the Army $64 million and the Marine Corps $27.5 million.

Replenishing stockpiles. Some

Not all budgetary discrepancies are on the credit side. In his budget message last year, Johnson requested $106.4 billion of new obligational authority for the current year, fiscal 1966. Now, for military expansion alone, he has asked Congress for about $11 billion more for this year, including the $12.3 billion for Vietnam that he requested on Jan. 19.

For most government programs—research and development, or the activities of the Federal Aviation Agency or of the Federal Communications Commission—the appropriations by Congress are apt to be closer to the spending totals. Thus, the Defense Department expects to have a newly obligated authority of $6.9 billion next year for research, development, test and evaluation, and it expects to obligate exactly the same amount. Spending is expected to be $6.4 billion, the $500-million difference being for such things as research facilities that can’t be delivered until after fiscal 1967.

A review and a forecast

The federal budget is a many-splendored thing: a financial accounting of the past year, a midstream adjustment of the $99.7-billion spending plan for the current year, and a forecast of plans and expenditures for the fiscal year ending June 30, 1967.

It is also a snapshot of each agency’s programs, from studying ferroelectricity to buying missiles or transistors: perhaps most important, the budget is a political document designed to put the President and his administration in the most favorable light possible.

The document that President Johnson has sent to Congress for approval indicates that he expects the Treasury to write checks totaling $112.8 billion during fiscal 1967. He is also asking for $106.3 billion of new spending authority, to be added to $15.6 billion of previous appropriations which can be carried over into the new year. These two amounts would authorize him to spend $121.9 billion in 1967.

When Congress authorizes spending, it ties it to specific programs. For example, the Pentagon is seeking $6 billion in new obligatory authority for the purchase of aircraft. If Congress approves, as it undoubtedly will, the purchasing officials of the Army, Navy, and Air Force will be free to sign firm contracts with airplane manufacturers, electronics companies and other suppliers. These contracts will become “direct obligations”; they will call for deliveries over varying periods—some for three or four months from now, others 18 to 24 months from the time the contract is signed.

Direct obligations for aircraft purchases actually will total $7.2 billion in 1967—well over the $6 billion in new obligational authority. This discrepancy is possible because of the carry-over of obligatory authority from previous years, including the aircraft-procurement authority granted in the request, now before Congress, for a $12.3-billion supplement to the fiscal 1966 budget.

As this equipment is delivered, the Treasury writes checks to the suppliers. The total of these checks constitutes the “expenditures” section of the budget—the most widely used measure of the government’s activities.

For aircraft, for instance, “spending” in fiscal 1967 is expected to be $6.7 billion. But Defense Secretary Robert S. McNamara and his procurement chiefs have considerable leeway within the congres-
of the supplemental money for Vietnam—but only a small portion of the amount needed—will be spent to replenish stockpiles at Army depots in the United States and Europe; these supplies kept the war in Vietnam going. Although Secretary of Defense Robert S. McNamara has not released, in any form, a report prepared by the Senate Armed Services Preparedness Investigating subcommittee on the condition of these stockpiles, many kinds of equipment are known to be in short supply and must be replaced—radar, helicopters, portable radio transmitters and receivers, generators, electronic test equipment, rockets and other gear.

Particularly important are survival radios such as the AN/URC-10, which is used by lost troops or pilots; the radio transmits a signal that can be used for homing, and also has voice capability.

II. General-purpose forces

Although it is customary in discussing the defense budget to take up strategic forces first, general-purpose forces such as those used in Vietnam are far bigger in this budget. While emphasis on strategic offensive forces is holding its own—with $5.1 billion in 1967, the same as in 1966—general-purpose forces in 1967 will cost five times this amount: $25.7 billion. With all the supplementals, much of which will spill over into 1967, the total obligatory authority for general-purpose forces in 1966 is even higher—$30 billion.

Communications and electronics.
The Army has requested $292.3 million for communications—80% for tactical gear, such as the AN/VRC-12 and the AN/PRC-25 radios for Vietnam—and other electronic equipment. Avionics will cost an additional $60 million, and ground-support for Army aircraft will cost $11.6 million.

Helicopters.
Both the Army and the Marine Corps will organize additional helicopter units; the Army will buy 1,400 and the Marines 273. Most of the choppers will be UH-1D Iroquis built by the Bell Helicopter Co. and the CH-47A Chinook produced by the Vertol division of the Boeing Aircraft Co. The Army spent $75.2 million for Chinooks in 1966. Another item is the CH-54 heavy-lift chopper produced by the Sikorsky division of the United Aircraft Corp.

The first of 714 Light-Observation Helicopters (LOH), being produced by the Hughes Tool Co., will be delivered in June. The avionics package, mainly for communications, will be built by Sylvania Electric Products, Inc., a subsidiary of the General Telephone and Electronics Co. (see p. 52).

Development of the advanced airborne fire-support system (AAFSS) will begin in fiscal 1967. This fight ing helicopter will be designed for its combat mission and will replace the HU-1B which, in spite of its success in Vietnam, was not built specifically for its fighting role. The Lockheed California Co., a division of the Lockheed Aircraft Corp., has the project-definition phase for AAFSS.

Fixed-wing.
The Pentagon plans to order 565 tactical fixed-wing aircraft in 1967. These will include additional carrier-based attack aircraft and land-based antisubmarine planes for the Navy. The Air Force will get the A-7A, the new attack aircraft already in production for the Navy. Produced by Ling-Temco-Vought, Inc., the A-7A is equipped with the AN/APN-153 doppler radar for navigation, built by the GPL division of General Precision, Inc. The A-7A also will use Texas Instruments Incorporated's AN/APQ-99 search radar.

Also for Vietnam will be more production of the F-4B and 4J Phantom II fighter-bomber built by the McDonnell Aircraft Corp. The plane has an infrared seeker, four computers, two data-link systems and two bombing systems.

Large-scale purchases of the F-111A for the Air Force will begin. And for all three services a new, lightweight, multipurpose aircraft will be developed for counterinsurgency (COIN) warfare.

Missiles.
The three services will buy a total of 52,297 strategic and tactical missiles next year, 11,286 more than in 1966. The programmed cost is $1.98 billion.

The Army will continue to buy Redeye, the hand-held, heat-seeking missile that knocks down aircraft. Redeye cost $35.3 million in 1966. Chaparral, the air-to-air Sidewinder converted to a surface-to-air missile, will be another big buy; this year about $20.4 million is being spent for these missiles. The surface-to-surface Shillelagh missile that is mounted on the M-60 tank will continue to be a big production item; sales totaled $80 million in 1966.

Procurement of the surface-to-surface Lance missile will begin in 1967. With a 45-statute-mile range, Lance will replace the Honest John and Little John missiles. If tests at the Naval Ordnance Test Station, China Lake, Calif., turn out well, Lance may also be used by the Navy as an off-shore weapon to support ground troops.

Funding will be substantially increased for the development of a surface-to-air missile known now as SAM-D and formerly as AADS-70; the missile will be used in the battlefield and for continental defense. It is effective against aircraft and tactical missiles.

Research and development will continue on two wire-guided missiles: TOW, and a new medium-assault weapon called MAW.

The Navy will begin full pro-
Got a Problem of DIMENSIONS?

TEMPERATURE?

UNUSUAL CYCLING?

SHOCK RESISTANCE?

turn the job over to SYNCHRON® MOTORS!

What's the motor problem you face in the design you're working on? One of tricky performance requirements? Difficult environment? Total accuracy? Before you do anything else, see how SYNCHRON Motors can be applied. (Do the same thing even when you have a simple, straightforward application in mind!)

Just write us at Hansen Manufacturing Company and tell us what you want a motor to accomplish. You'll get an immediate answer and any help you need for specific problems.

HANSEN MANUFACTURING COMPANY, INC.

PRINCETON, INDIANA


Electronics | February 7, 1966

136 Circle 136 on reader service card

Defense budget by mission

<table>
<thead>
<tr>
<th>Defense budget by mission</th>
<th>Total obligational authority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fiscal 1965</td>
</tr>
<tr>
<td>Strategic offensive forces</td>
<td>5.3</td>
</tr>
<tr>
<td>General-purpose forces</td>
<td>19.0</td>
</tr>
<tr>
<td>Air and missile defense of North America</td>
<td>1.6</td>
</tr>
<tr>
<td>Research and development</td>
<td>4.9</td>
</tr>
<tr>
<td>Airlift and sealift forces</td>
<td>1.5</td>
</tr>
<tr>
<td>General support</td>
<td>14.5</td>
</tr>
<tr>
<td>Other (military assistance, retired pay, reserve and guard forces)</td>
<td>4.8</td>
</tr>
<tr>
<td>Total authority to contract</td>
<td>51.6</td>
</tr>
<tr>
<td>Total estimated expenditures</td>
<td>47.4</td>
</tr>
</tbody>
</table>

duction of the Standard ship-to-air missiles in 1967. It will also continue to buy Talos missiles and support items for the Tartar and Terrier missiles. Tartar D, the result of the Navy's "get-well" program for this bug-ridden missile, will go into production in 1967; the modification consists of a new computer to increase the missile's accuracy and reaction time.

The Navy and the Air Force will buy Shrike, the antiradiation bird that can be launched from an aircraft to home on and destroy ground-based radar. An improved version of Shrike, called Arm-I, is also being developed.

Besides Shrike, the Air Force will buy the air-to-ground Bullpup B missile, the air-to-air Sparrow, the air-to-air trainer called Falcon, and the Firebee target drone.

Ships. The big news in the 1967 ship construction and conversion program is the request for authorization to build a nuclear-powered aircraft carrier—the second in the fleet. The new one will use a four-reactor propulsion system; its sister ship, the Enterprise uses a four-reactor system.

Besides the carrier, 20 ships will be constructed or converted for antisubmarine warfare (ASW). New construction consists of five nuclear-powered attack submarines and 10 destroyer escorts; five destroyers will be converted.

Two new guided-missile destroyers will be built—the new Tartar D missiles will be tried out on these—and five frigates; one cruiser will be modernized.

Twelve amphibious ships will be built—11 tank-landing ships and one dock-landing ship. Five logistics ships will be built for the sealift program, and five ocean mine-sweepers.

III. Continental defenses

"The relative decline of the threat from bomber attack permits further downward adjustments in active-force interceptor aircraft, surface-to-air missiles and radar sites," the President said in his budget message.

Increased funds are proposed, however, for continued development of the Nike X antimissile defense system; more than $400 million was spent in 1966. Development will continue on satellite interception and detection, and on over-the-horizon radar. Another continuing program is modification of radars along the seacoasts to enable them to detect missiles as well as bombers.

IV. Strategic offensive forces

More Minuteman II and Polaris A-3 missiles will be bought. Development of the Minuteman III and the Navy's advanced Poseidon submarine-launched ballistic missile will be accelerated. Poseidon's $33 million appropriation for 1966 will be exceeded next year. Total development of Poseidon will cost close to $900 million. Modifying the submarine to accommodate the larger missiles will cost $1.1 billion.

Penetration aids for ICBM's, which cost $138 million in 1966, will remain at about the same level in 1967.

Bombers. In answer to requests by Congress and the Air Force for a bomber to replace the aging B-52 and B-58, the Pentagon plans to modify the ever-changing F-111, adding a capability to drop bombs and to fire the short-range air-to-surface Sram missile. The 1966 budget calls for modifying the aircraft, and the 1967 budget provides for buying the first of the
planned 210 planes. The Martin-Marietta Corp. and the Boeing Co. are both competing in the project-definition phase for Sram.

The advanced strategic manned aircraft (ASMA) concept is being kept alive; the Pentagon is asking for funds to continue work on its avionics.

V. Airlift and sealift

Procurement of the gigantic C-5A cargo/transport plane will begin this year. The cost of development and procurement will exceed $2.2 billion. Meanwhile, procurement of the C-141 jet cargo plane will be completed in 1967. The Air Force plans to spend $400 million in fiscal 1966 for C-141's. The Lockheed Marietta Co., a division of the Lockheed Aircraft Corp., is building both the C-5A and the C-141.

Contracts for competitive design will be awarded later this year for the first of a new class of fast-deployment logistic ships. These vessels will provide larger capacity, greater speed and more efficiency than do present transport ships.

ASW. The antisubmarine-warfare (ASW) effort seems to be permanent and stable; for the past two years it has represented one-quarter of the Navy's budget for research, development, test and evaluation. Last year this amounted to $386 million. For all search and surveillance programs, the Navy is spending $188 million this year.

Procurement will continue of such ASW weapons as Subroc, the torpedo-missile-torpedo; Asroc, the rocket-torpedo; Dash, the drone helicopter; and for various torpedoes.

VI. Research and development

The $5.1-billion research-and-development category includes all R&D efforts not directly identified with other programs.

The manned orbiting laboratory (MOL) will continue at its 1966 pace—about $150 million. Work also will continue on the military communications satellite, with some effort beginning on the small tactical terminals for each service's use. Other space programs will be the navigation satellite, nuclear test detectors and early warning of missile launches.

Other continuing R&D projects will continue at their present rate.

You probably think of Victoreen Corotron diodes as high-performance thoroughbreds for exotic uses. And they are. But this is only part of the Corotron pedigree. They're also real workhorse diodes for everyday uses. As regulators and H-V references... H-V pulse couplers... high-impedance voltage dividers. And still we haven't run out of Corotron applications. So put your imagination to work. Savings in cost, complexity and weight can put you on velvet. Right away, write away for latest dope on Corotron diodes — high-voltage workhorse. Address Applications Engineering Department.

Write for free copy of illustrated 40-page catalog of Victoreen diodes.
Space electronics

Slowdown for NASA

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely." That objective, enunciated by John F. Kennedy on May 25, 1961, is so clearly in sight that Lyndon B. Johnson can cut the space budget for next year and still express confidence that Kennedy's goal will be attained.

Requests for space funds have been pared down to $6.7 billion, after this year's peak of $6.97 billion. The figures include money for five federal agencies that are active in space; the National Aeronautics and Space Administration, the Defense Department, the Atomic Energy Commission, the Commerce Department's new weather-satellite organization, and the National Science Foundation.

The reductions may not be felt until next year. The government figures that spending will decline by $320 million next year to $7.1 billion, but NASA, whose budget has been reduced for the first time in the agency's eight-year history, expects its expenditures to climb nearly $300 million above the Budget Bureau's official estimates, nearly balancing the cuts elsewhere. On July 1, at the start of fiscal 1967, NASA will have $2.9 billion in unspent money that was previously appropriated; about $100 million of this will not have been contracted for, according to officials of the space agency.

Either way, the space effort will continue to be a valuable market for the electronics industry. Frank J. Sullivan, director of NASA's electronics and control division, says 40% to 50% of the space agency's funds go for electronics.

I. Eye on the moon

The dominant space program continues to be Project Apollo,

II. General support

The Defense Communications System is getting bigger and costing more to operate. In 1966 it cost $387 million. Other communications systems will also cost more than the $700 million of fiscal 1966. These include the Army's Starcom, Navy's Navcom and Air Force's Aircom.

The National Military Command System, the major part of the worldwide military command-and-control system, will cost about $120 million next year, about the same as in 1966. The system was established to provide the national command authorities—the President, the Secretary of Defense and the Joint Chiefs of Staff—with the means to provide strategic direction to the armed forces.
whose mission is to land men on the moon. It accounts for $2.97 billion in next year's budget, about the same as this year's and more than half of NASA's $5.01-billion request for fiscal 1967. The Gemini program of orbiting two-man spacecraft, nearing an end, drops sharply to $40.6 million from $226.6 million this year.

After Apollo peaks out next year, NASA hopes to spur its lagging Apollo Applications Project to orbit scientists for several months at a time. The agency wanted to spend $200 million on this program next year, double the present year's amount, but the Budget Bureau said no.

**Ups and downs.** The austerity atmosphere has already claimed a casualty. The Voyager program to land instruments on Mars by 1971. The new timetable calls for a landing in 1973 at the earliest.

Although research and technology will be cut nearly $10 million next year, to $278.3 million, electronics systems research will be increased $4.5 million to $36.8 million. Ten million dollars of this is earmarked for the Electronics Research Center in Cambridge, Mass., up from $6 million this year.

About $2 million of the center's funds will go into studies of reliability of electronic components; NASA would like to reduce its 10 or more reliability standards to 2 or 3. Another $1.5 million to $2 million will go for studies of guidance systems developed at other NASA centers to see whether a system designed for one program can serve in other space ventures.

Purchases of equipment for tracking and data acquisition will increase $48.2 million to $279.3 million this year, largely for a manned space-tracking network for Apollo.

**Looking at lasers.** Lasers will receive close attention in instrumentation and data processing—which will take about $2 million of the center's money—and for possible applications in gyroscopes and in holography. Lasers also figure prominently in the center's plan to spend about $3 million studying communications and tracking. NASA also plans to explore the use of the submillimeter waveband, near the infrared, for deep space communications.

At NASA's Langley Research Center, the agency's laboratory for research and development, the site for the new Electronics Research Center, the center's plan to spend $200 million will increase $48.2 million to $279.3 million this year.

---

**Why Hyvac puts a high voltage relay in a vacuum—**

one word... **RELIABILITY!**

**VACUUM RELAY RELIABILITY** means short contact travel, low contact mass, contacts free of oxides and pitting and minimum contact bounce. These long-life reliability features are made possible because of operation in a high vacuum dielectric. Vacuum technology has made high reliability, long life high voltage switching practical, with considerable savings in space and weight. Developed for high voltage, high peak current applications, Hyvac relays are well suited and widely used in radar, communications, pulse forming networks, ECM, sonar, medical electronics, antenna switching and antenna couplers, microwave systems and switching in explosive atmospheres.

Hyvac's broad line and "Quick Reaction Time" is geared to your most critical delivery schedule. We have the high vacuum experience, design and production capability to provide special modifications of our standard off-the-shelf designs in unbelievably short order. Hyvac, a company small enough to be responsive, large enough to be responsible. Check the brief specifications of our "H" series:

<table>
<thead>
<tr>
<th>HYVAC TYPE</th>
<th>H-8</th>
<th>H-9</th>
<th>H-11</th>
<th>H-12</th>
<th>H-14</th>
<th>H-16</th>
<th>H-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Arrangement</td>
<td>SPDT</td>
<td>SPST</td>
<td>SPST</td>
<td>SPDT</td>
<td>DPDT</td>
<td>DPDT</td>
<td>SPDT</td>
</tr>
<tr>
<td>Rated operating voltage (kv dc)</td>
<td>20</td>
<td>20</td>
<td>12-air</td>
<td>18-air</td>
<td>8-air</td>
<td>12-air</td>
<td>18-air</td>
</tr>
<tr>
<td>Continuous current, *max. (amps-rms)</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Operating time, max (ms)</td>
<td>15</td>
<td>15</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Coil voltage, nominal (vdc)</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
</tr>
<tr>
<td>Approx. price (1-9 pcs)</td>
<td>$98</td>
<td>$98</td>
<td>$105</td>
<td>$110</td>
<td>Factory quote</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Carry only

---

For complete technical information, contact your nearest sales engineering representative, or write directly to us.
Center in Virginia, the big search next year will be for better guidance and control in space rendezvous and later for landings on the moon. Besides this $7-million study, Langley engineers will work on radiation conditioning of semiconductor strain gauges, which show promise for force measurements but are very sensitive to temperature changes. By radiating the silicon strain gauges, NASA thinks it can improve their performance.

The Ames Research Center in California will spend about $3.7 million on electronics research, concentrating mainly on guidance and control.

### II. Military and nuclear programs

The armed services will receive $1.62 billion for space projects, down $72.8 million from this year. Spending, however, will rise $10 million to $1.65 billion. Most of the military space program is classified.

One cutback is in the Air Force's Manned Orbiting Laboratory.

### Space research and development

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA</td>
<td>5,035.0</td>
<td>5,521.0</td>
<td>5,211.0</td>
</tr>
<tr>
<td>Defense Dept.</td>
<td>1,591.8</td>
<td>1,640.0</td>
<td>1,650.0</td>
</tr>
<tr>
<td>Atomic Energy Commission</td>
<td>232.2</td>
<td>201.0</td>
<td>173.7</td>
</tr>
<tr>
<td>Commerce Dept. (Environment Science Service Administration)</td>
<td>24.1</td>
<td>19.2</td>
<td>27.0</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>3.0</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,886.1</strong></td>
<td><strong>7,384.7</strong></td>
<td><strong>7,063.5</strong></td>
</tr>
</tbody>
</table>

---

**NASA research and development**

(Millions of dollars)

<table>
<thead>
<tr>
<th>Agency</th>
<th>Fiscal 1965</th>
<th>1966</th>
<th>1967</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manned space flight:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gemini</td>
<td>308.40</td>
<td>226.61</td>
<td>40.60</td>
</tr>
<tr>
<td>Apollo</td>
<td>2,614.61</td>
<td>2,967.38</td>
<td>2,974.20</td>
</tr>
<tr>
<td>Advanced mission studies</td>
<td>26.00</td>
<td>10.00</td>
<td>8.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,949.02</strong></td>
<td><strong>3,204.00</strong></td>
<td><strong>3,022.80</strong></td>
</tr>
</tbody>
</table>

| Space science and applications:       |             |      |      |
| Physics and astronomy                 | 139.08      | 143.50 | 131.40 |
| Lunar and planetary exploration       | 206.03      | 251.34 | 197.90 |
| Sustaining university program         | 46.00       | 46.00  | 41.00  |
| Launch vehicle development            | 96.50       | 55.30  | 33.70  |
| Launch vehicle procurement            | 154.49      | 178.70 | 152.00 |
| Bioscience                            | 28.50       | 36.70  | 35.40  |
| Meteorological satellites             | 30.99       | 38.90  | 43.60  |
| Communication and applications        |             |      |      |
| technology satellites                 | 30.77       | 32.80  | 26.40  |
| **Total**                             | **732.36**  | **783.23** | **661.40** |

| Advanced research and technology      |             |      |      |
| Basic research                        | 21.23       | 22.00 | 23.00 |
| Space vehicle systems                 | 44.19       | 35.00 | 36.00 |
| Electronics systems                   | 25.62       | 32.30 | 36.80 |
| Human factor systems                  | 13.32       | 14.90 | 17.00 |
| Space power and electric propulsion systems | 58.22 | 45.20 | 42.50 |
| Nuclear rockets                        | 57.00       | 58.00  | 53.00  |
| Chemical propulsion                    | 76.50       | 39.70  | 37.00  |
| Aeronautics                           | 35.24       | 41.50  | 33.00  |
| **Total**                             | **331.33**  | **288.60** | **278.30** |

| Tracking and data acquisition         |             |      |      |
| **Total**                             | **253.24**  | **231.06** | **279.30** |

| Technology utilization                |             |      |      |
| **Total**                             | **4,270.69** | **4,511.64** | **4,246.60** |

---

Of critical importance to present day telemetry systems is the reliable performance of high frequency patching components. COAX components assure the most dependable communication links available today. A unique cable strain relief feature in the single plug illustrated here is just one of several features which make COAX components superior. Write for complete data on all COAX components.
(MOL), which is scheduled to orbit in 1968 with two astronauts aboard. Despite a $150-million appropriation for this year, the Air Force is being allowed to spend only $100 million; next year's spending will be held to the same level.

While keeping its spending plans secret, the Pentagon says its intermediate satellite communications program is on schedule, with the first launches due this spring. By 1968 the advanced military-satellite communications system is expected to be in operation.

**Joint ventures.** Together with the Atomic Energy Commission, NASA will continue to work on the largest auxiliary power plant being developed for space—a 30- to 50-kilowatt system. The program is called SNAP-8, for systems for nuclear auxiliary power.

Another joint project of NASA and the AEC is Project Rover, whose goal is to develop a nuclear rocket engine with 250,000-pound thrust, for flight in the mid-1970's. NASA will spend $53 million on nuclear rocketry next year and the AEC has budgeted $78 million.

### Civilian aviation

**Brakes applied**

President Johnson's budget is almost certain to put the skids under many long-sought advances in avionics. The leading candidates for stretch-out or interruption are development programs aimed at avoiding collisions, detecting clear-air turbulence, introducing digital communications into commercial aircraft, and speeding the collection of weather information.

The Federal Aviation Agency's authorization is slashed to $757.99 million from $868.36 million in the year ending June 30. While accounting departments worry about the cutbacks this year, engineers and stockholders are not likely to notice their effect until 1967. To fulfill its long-term commitments, the FAA will actually spend more next year than this—$840 million compared with $799.9 million.

Unlike most governmental departments, the FAA is allowed to
Why sacrifice high speed for low power in aerospace systems? You can get both in Signetics SE 400 series integrated circuits.

Signetics SE 400 series provides:
- 40% to 70% less power consumption than comparable devices while maintaining equal or greater speed and noise immunity,
- 50% reduction in flip-flop can-count with a new dual binary, off-the-shelf delivery.

This family of four full MIL range integrated circuits features a dual 5 Mc Binary element operating on less than 9 mW per flip-flop. Like the other members of the family, it was designed for maximum speed consistent with low power operation. The family is intended for use in applications where high density packaging and the ability to drive high capacitances associated with multilayer printed circuit boards are important considerations. For complete data and specifications, write today.

SPEED-POWER CHARACTERISTICS OF SE400 FAMILY

This family of four full MIL range integrated circuits features a dual 5 Mc Binary element operating on less than 9 mW per flip-flop. Like the other members of the family, it was designed for maximum speed consistent with low power operation. The family is intended for use in applications where high density packaging and the ability to drive high capacitances associated with multilayer printed circuit boards are important considerations. For complete data and specifications, write today.

SPEED-POWER CHARACTERISTICS OF SE400 FAMILY
Federal Aviation Agency

<table>
<thead>
<tr>
<th>New obligatory authority</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td></td>
</tr>
<tr>
<td>Operation and maintenance of air-traffic control (ATC) system, including installation, materials and administration</td>
<td>551.99</td>
</tr>
<tr>
<td>Facilities and equipment</td>
<td></td>
</tr>
<tr>
<td>Purchase of ATC, navigation and related equipment</td>
<td>50.00</td>
</tr>
<tr>
<td>Research and development</td>
<td>40.00</td>
</tr>
<tr>
<td>Grants in aid for airports</td>
<td>75.00</td>
</tr>
<tr>
<td>Supersonic transport development</td>
<td>140.00</td>
</tr>
<tr>
<td>Totals</td>
<td>726.85</td>
</tr>
</tbody>
</table>

carry its spending authority over from one year to the next. Many carry-overs to fiscal 1968 are going to be skimpier than usual. An example is in the classification for facilities and equipment. The new budget provides for a $67.65 million balance at the end of fiscal 1967; that’s little more than half the $123.32-million balance anticipated at the end of this year and barely one-third of the $181.39 million on hand at the end of fiscal 1965. This means that expenditures in 1968 and 1969 are going to be very lean unless liberal new authorizations are voted for those years.

The FAA hopes an aggressive cost-cutting program will soften the effects of some budget cuts. The agency’s engineers already have reduced the average cost of an instrument-landing system to about $100,000 from $300,000; this has been accomplished by housing the equipment in trailers instead of in permanent buildings. Automated equipment also may allow fewer employees to do as much work for the FAA; 441 people who are expected to retire or resign this year will not be replaced—a 1% cut in the work force.

1. In R&D, nothing new

“The 1967 budget is for the continuation of past programs,” says one FAA official. “There are no new programs.” That’s why the agency will receive only $30 million for research and development next year, down from $37.5 million in fiscal 1966. The only program that is not expected to be curtailed is aviation medicine—the attempt to identify and eliminate human factors that can affect safety. Cuts are expected as well in these major R&D programs:
- Air-traffic control (ATC).
- Navigation, both short and long range, including landing systems and in-flight inspection.
- Weather-reporting programs, including transmission and display of information.
- Improved airport design.
- Aircraft safety devices.

**Airway modernization.** Now that the FAA has completed construction of its air-traffic control centers, the next step is the installation of the more-sophisticated solid state electronic systems for the National Airspace Stage A and for Metroplex air-traffic control complexes.

Installation of NAS Stage A—automation of the en-route air-traffic control centers with digitized, computer-controlled equipment and alphanumeric displays—is expected to proceed on schedule. Tests of the engineering model of the system will begin early next year at Nafec, the National Airways Facilities Experimental Center in Atlantic City, N. J. The first operation site at Jacksonville, Fla., will be ready in April, 1968. About one year behind is the Stage A Metroplex—automation of airport terminal areas. Metroplex will consist mostly of NAS components fitted to terminals’ needs. Last year $5.3 million was spent on NAS Stage A; the estimate for fiscal 1966 is $12.2 million. In 1965 the FAA also spent $200,000 on Metroplex development; this figure will rise to $5.4 million this year and remain at that level in 1967.

**Instrument landings.** In 1965 the FAA received $2.8 million in appropriations for research on instrument landing systems (ILS). This jumped to $4.8 million in 1966; next year the agency would have liked to allot even more to the development of ILS localizers, glide-slope markers, visual lighting systems, distance-measuring equipment, flare computers, and other gear, especially those that apply to category-2 (100-foot decision level, 1/4-mile runway visual range) and category-3 (zero-altitude decision level) criteria and to development of a supersonic transport (SST). This year there will only be about $3.5 million for ILS research.

In 1959, the FAA bought a complete single-channel automatic-landing system as a test bed. The system was first installed on a DC-3; later it was modified with a Sperry autopilot, made by the Sperry Gyroscope division of the Sperry Rand Corp., and fitted aboard a DC-7. More than 1,000 automatic landings were made with this system. The FAA now has a DC-7 equipped with a manual system for studying blind landings. Lear-Siegler Inc., makes the attitude indicator, Collins Radio Co. the peripheral vision indicator, Bendix Corp.’s Radio division the altimeter, and Sperry Gyroscope Co. the gyrocompass. This system, which is being evaluated at Nafec, is directed toward determining the landing-system requirements of the SST.

**In any weather.** Other landing studies, aimed at determining what is needed for a true category-3 all-weather landing system, are being conducted by the Lockheed-Georgia Co., a division of the Lockheed Aircraft Corp. This joint program
of the FAA and the Air Force will determine the operating requirements of autopilots, throttle controls and other instruments and displays.

The FAA has given the Bunkerk-Ramo Corp. a contract to build a simulated airplane cockpit that would contain all the displays and controls needed for an all-weather landing system. The simulated cockpit will help the FAA determine how the pilot can best participate in a programmed all-weather landing.

Lockheed will outfit its C-141's with category-2 equipment; one plane will carry category-3 equipment. The C-141's, which are getting category-2 equipment, will begin their tests next fall. These aircraft will have automatic touchdown capability, but there will be no de-crapping (compensation for wind shear) equipment and other redundant equipment required for category-2 landing. The category-3 tests by the FAA are scheduled for June, 1967.

The FAA is also investigating new guidance and distance-measuring equipment (DME) for airport runways. In the category-3C situation, where there is no runway-visual-range (RVR) precision, DME equipment on the runway and precise displays in the cockpit are needed to indicate to the pilot the proper turns for maneuvering on and off the ramp.

**Pinpointing the storm.** Heavy rain and snow can be a hazard both to pilots and to air-traffic controllers. The pilots can fly around or over storms but the controller sometimes loses the plane in the radar weather return.

Several research programs are being conducted to detect, report and display weather on the ATC controller's scope. Most of the detection programs are directed to the detection of clear-air turbulence. This kind of storm is most hazardous to high-speed jets. Others are concerned with weather analysis and the most efficient way to outline the weather on the controller's scope. One technique is to measure the radar signal (line of equal intensities), then use a digitizer to draw weather contours on the scope.

**More R&D.** Other programs—such as the advanced radar tracking system (ARTS), the stored-program alphanumerics (SPAN) and Common IFR (Instrument Flight Rules) Room will proceed almost on schedule.

The first SPAN system will be operating in July at the Lake Ronkonkoma, N. Y., air-route traffic control center. This system, which is designed to provide area positive control above 24,000 feet, will give traffic controllers three-dimensional position information as well as aircraft identification. ARTS is being tested at the FAA's Atlanta facility. The agency has already started construction of a Common IFR Room at Kennedy International Airport in New York. The consolidated airport radar room will control all traffic at Kennedy, La Guardia, Newark and Teterboro, N. J., and 12 other metropolitan airports. An entire ARTS facility, including the Common IFR Room, will be in operation at Kennedy Airport in about two years.

**II. Operation and maintenance**

A total of $561.5 million has been requested for the operation and maintenance of the air-traffic control system next year. The FAA expects to spend $550 million, up from $543 million in fiscal 1966. Another $28 million was requested for the purchase of long-range radars, terminal radars, instrument landing systems, automation equipment, navigational equipment and other facilities that will be installed in the FAA's traffic-control centers and airports; this is down sharply from $49.8 million authorized for 1966. The agency operates and maintains 28 air-route traffic-control centers and 300 airport control towers, in addition to numerous flight-service stations and remote communications sites across the country.

About $75.2 million will be spent on electronic equipment next year, down from $91.1 million this year. This category includes installation of 152 Vortacs (Vertical Omnidirectional-Tactical Air Navigation System) and 118 direction finders of the uhf-vhf type. The International Telephone and Telegraph Corp., makes the Vortac antenna and transmitter, and the Raytheon Co. produces the test and monitoring subsystem.

Two hundred of the 280 control towers in existence at low-density airports differ from each other; the FAA is replacing them with standardized modern towers. Next year the agency will only obligate $7.4 million for improvements of tower facilities; that's less than half the amount obligated for fiscal 1966.

**III. No push for SST**

Despite Johnson's announcement that he will offer a joint government-industry program this year to build a prototype of a supersonic transport, there will be no speed-up of the SST program. The $80 million in new funds requested in the budget will complete the $220 million originally programmed for the SST's development phase. This phase is now scheduled to be completed in December. The President must request more money later this year for the prototype phase.

The development costs are being shared, 75% by the government and 25% by the manufacturers. The 1966 budget earmarks $140 million for this work and for supporting studies. Congress previously had appropriated $91 million for SST research and design. This year's total obligations are about $128 million, of which the FAA expects to spend about $115 million. Some FAA officials peg the total cost of a flying prototype at about $1.5 billion. The FAA's budget for SST development requires a separate appropriation.

Other than for basic system studies, avionics has played only a small role in SST development so far. Most of the avionics work has been sponsored by the two competing airframe manufacturers—the Boeing Co. and the Lockheed-California Co., a division of the Lockheed Aircraft Corp. The SST will benefit from the design experience gained in military avionics programs such as those for the F-111, C-5A and C-141 aircraft.

The FAA insists that new systems must be phased into existing systems both functionally and geographically. The terminal area at Kennedy and the en-route air-traffic center at Lake Ronkonkoma are being studied on computer-driven simulators at Nafe. In this way the system's operational advantages will be available as quickly as possible.
Civilian electronics

Gains on the home front

From weather eyes to water monitoring, from surgical suites to particle accelerators, electronics is playing an increasing role in the Great Society. Unlike military development, which is leveling off at about $5 billion a year, these civilian programs are likely to continue expanding.

In health and medical research, for instance, where estimates of electronics’ share range from 15% to 30% of the expenditures, federal spending in fiscal 1967 will increase $1.6 billion from this year’s level, to $7.8 billion.

I. Medical electronics

At the National Institutes of Health which supports 40% of the biomedical research in the nation, the $39-million increase to $1.3 billion is one of the smallest in a decade. But some identifiable electronics projects have been singled out for growth:

- A shared-time computer center for NIH scientists will receive $3.3 million, up from $2.7 million this year.
- A major effort to develop artificial kidneys, including instruments small enough for chronic sufferers to carry with them, is up $1 million to $3.5 million.
- Artificial-heart research is holding steady at $3.8 million, while a group of aerospace corporations—including the Convair division of the General Dynamics Corp., the Avco-Everett Research Laboratory and Westinghouse Electric Corp.—complete feasibility studies on a more massive push.
- Automation of the pathology department of the NIH clinical center will double this year’s authorization to $240,000.
- Efforts to perfect a computerized monitoring program, which will ultimately cost $1 million, in the clinical center’s new surgical suite will continue.

Similarly, while the Veterans Administration is asking only $15.3 million, down from this year’s $16.3 million, the VA is poised for a probable investment of $100 million between fiscal 1968 and 1970 on a hospital-automation project being checked out in Washington.

II. Revolution in science

Under pressure of the President’s pollution-control program, the Water Pollution Central Administration will increase its spending for automatic monitoring equipment to $194,000 from this year’s $128,000. Air-pollution control grants to states for monitoring and other technical equipment will rise to $1.96 million from $1.40 million, equipment will rise to $1.96 million from $1.40 million and purchases of electronic equipment for measuring air pollution will be increased to $625,000 from $495,000. "Electronics," says a White House science adviser, "is revolutionizing several scientific disciplines."

The National Science Foundation, which estimates that 7% to 10% of its budget goes for electronics, comes up roses in the President’s tight proposals for 1967. The NSF will get a $45-million increase, to $525 million. Geared largely to university support, NSF is increasing its matching-grants $3 million to $12 million; the program is aimed at helping universities obtain computer facilities for scientific and general purposes.

Inner and outer space. The NSF will also finance the operation of a nuclear particle accelerator, which will generate 10 billion electron volts, at Cornell University. Later, it expects to share with the Atomic Energy Commission and the Department of Defense bigger shares of the “big science” roles in high-energy physics and radio astronomy.

And despite a holdback on the $375 million, 200-bev accelerator, the Atomic Energy Commission is moving ahead with two other accelerator programs that are highly electronic: the $55-million, 300-mev “meson factory” at Los Alamos Scientific Laboratory in New Mexico and a $45.5-million modifi-

cation of the 33-bev machine at Brookhaven National Laboratory, New York.

Here are some other programs:

- The Coast Guard’s spending for electronics will jump 25% to $11.6 million for operations and maintenance, with a $500,000 chunk to start a long-range program to install single-sideband equipment on vessels as well as in aircraft and ground stations.
- Expanding research efforts at the National Bureau of Standards, where about $2 million a year is spent on electronic instrumentation, will concentrate on the semiautomated Standard Reference Data System’s effort to keep engineering data up to date.
- The new Environmental Science Services Administration, incorporating the Weather Bureau, Coast and Geodetic Survey and the Radio Propagation Laboratory in Boulder, Colo., will receive a $20.5-million increase to $165.1 million, with continued emphasis on earthquake prediction, meteorological satellites and electromagnetic wave propagation. Replacement of an ocean survey vessel and weather-surveillance radars down the Midwest’s “tornado alley” increase the agency’s facilities budget $2.5 million to $7 million; satellite operations will rise $8.5 million to $33.6 million.

Slight gains. Over-all, the government’s interagency research budget for the atmospheric sciences will rise $10 million to $234.6 million.

Similarly, the interagency budgets for oceanography and ocean technology will rise only $41.7 million to $219.9 million.

- The Post Office Department will spend $100 million on post-office modernization, including procurement of alphanumeric scanners and an electronic data-processing complex to serve 75 major installations.
- High-speed ground transportation will be funded at $24-million—a good start even though it’s less than the $35 million the planners had hoped for. Research on such exotic devices as the linear induction motor may be stretched out. Highway-safety projects, however, are being left to industry—or postponed until more federal money is available.
How to cut the high cost of electronic measuring:

Use the Below Coupon To Order Editorial Reprints From Electronics!

Fill in, cut out the coupon, insert in envelope and mail to:
Electronics Reprint Department
330 West 42nd Street, New York, N.Y. 10036

Reprints Available:
(Price: 50¢ each unless otherwise noted.)
Key no. R-84 European Electronics Markets 1966, 16 pages with 4 page foldout chart.
Key no. R-83 A Look at Japanese Electronics Technology, 36 pages.
Key no. R-82 Computer Time Sharing, 20 pages
Key no. R-80 The Packaging Revolution In Microelectronics (2 part series, 32 pages.) $1.00.
Key no. R-79 MOS Integrated Circuits Save Space and Money, 16 pages.
Key no. R-78 The Overlay Transistor, 4 color special feature, 15 pages.
Key no. R-77 Cold Cathode Tubes (3 part series, 28 pages).

Reprint order form
(See the above list, please order by key number.)
To help expedite mailing of your reprints, please send cash, check, or money order when you order.
Send me . . . reprint(s) of key no(s) . . . . at . . . . ₤ each.
Name..............................................................................................................
Number & Street .........................................................................................
City, State, Zip Code ..................................................................................
Get the extra capability, greater reliability, and longer useful life of Rohde & Schwarz!

Since 1933, Rohde & Schwarz' group of unusually creative engineers have been designing electronic instruments that are truly unique. These instruments are constantly ahead of what is considered to be the state-of-the-art. They are more precise, they are easier to use and read. Many perform extra functions. Some do jobs never done before. All are constructed with uncompromising quality—drastically reducing maintenance requirements. As a result, they do not become obsolete as fast as ordinary instruments—thus provide more years of useful life. As you might expect, you pay a little more initially for some of these—but an investment in Rohde & Schwarz saves you plenty in the long run!

Now! One Diagraph measures and plots

- Impedance and admittance
- Transmission characteristics
- Phase differences
- Perfect for measuring transistor characteristics!

Plot important characteristics rapidly and directly on a Smith Chart—Carter Chart—or polar-coordinate diagram—eliminating the need for calculations. Plot impedance of antennas, cables, transistors, varactors, terminations, four-terminal networks, etc., with the accuracy of a slotted line! And since a Rohde & Schwarz Diagraph incorporates the circuitry of a superhet receiver, it can also be used as a linear measuring receiver!

FEATURES:
- Two frequency ranges available: 30 to 420 MHz or 300 to 2400 MHz.
- Characteristic impedances of 50 and 75 ohms available.
- With transistor adapter, it measures transistor parameters in the VHF and UHF ranges.
- Use of precision connectors results in exact definition of electrical lengths and excellent repeatability.
- Many accessories make it a versatile instrument!

For 6-page Data Sheet with complete specifications, CIRCLE 80 ON READER SERVICE CARD.

Measure video noise in presence of sync and blanking pulses!

The new R&S UPSF Video Noise Meter is an extremely versatile instrument, suitable for noise voltage measurements on TV cameras, film scanners and video tape recorders, radio links, coaxial lines, and TV transmitters, receivers, and transposers. Measurements of both weighted and unweighted noise voltages can be made, and in the presence of sync and blanking pulses, thanks to a new idea in circuit design. The UPSF can also be used as a conventional VTVM, extending the value of your investment.

FEATURES:
- Meets requirements of all U.S. black-and-white and NTS color systems.
- 40 Hz to 5 MHz frequency range.
- 7 measurement ranges: 1/3/10/30/100/300/1000 mVpp.
- Either RMS or peak-to-peak indication.
- Input imped. 1MΩ shunted by 30 pF, or 75 Ω bridging.
- Output for oscilloscope.

For complete 4-page Data Sheet, CIRCLE 81 ON READER SERVICE CARD.

Measure the overall efficiency of your receiving system!

Covers 47 to 225 MHz!

This proved-in-operation Rohde & Schwarz portable Field Strength Meter is perfect for use both in the field and in the laboratory. It covers FM, TV, aircraft, police and mobile radio bands, and is ideal for determining propagation conditions, polarization and radiation patterns. The HUZ is especially useful to help select the best location for receiving antennas. Since the HUZ is also a selective voltmeter, it can be used to measure antenna gain and antenna cable attenuation, under various weather conditions. It locates and measures interference and can measure automotive noise. All in all, as you would expect from Rohde & Schwarz, a very versatile instrument!

FEATURES:
- 47 to 225 MHz.
- 1 µV-100 mV.
- AM/FM detection.
- Battery or AC operation.
- Self calibrating.

For complete Data Sheet, CIRCLE 82 ON READER SERVICE CARD.
Manufacturing

Factories of the future

Beams of light automatically trace unique wiring patterns on large monolithic circuits

Researchers peering into a monolithic array of integrated circuits can see factories of the future in its curious wiring pattern. They envisage computer-controlled production of other computers, at a fraction of the cost per circuit of today's computers.

The pattern shown below was traced on the slice of silicon by an improved version of the beam-of-light technique that the International Business Machines Corp. now uses to produce custom-designed printed circuit boards [Electronics, Nov. 1, 1965, p. 90]. The thin-film wiring of the slice is unique because it was designed by a computer to thread its way around the unusable circuits on the slice. On another slice, the beam would follow a different path.

Eventually, the scientists at the IBM Watson Research Center in Yorktown Heights, N. Y., hope to produce computer subsystems with up to 1,000 gates in an array. Other researchers are also striving toward the same goal. At Texas Instruments Incorporated, for example, a computer runs a drafting machine that makes photographic etching masks [Electronics, April 19, 1965, p. 36 and Jan. 24, 1966, p. 26]. Westinghouse Electric Corp. has been developing ways of tracing interconnections on silicon with electron beams [Electronics, Nov. 16, 1964, p. 82].

In each case, the aim is an economical way of forming a different pattern for each array. Standard patterns can't be used because each slice has a different arrangement of good and bad circuits. Standard patterns would re-
Delco Radio's new 400V silicon power transistors will change your thinking about high voltage circuitry. You can reduce current, operate directly from rectified line voltage, and use fewer components. Our standard TO-3 package stays cool (junction to heat sink 1.0°C per watt). And price is low—less than 3c a volt even in sample quantities—for wide ranging applications. Vertical and horizontal wide-screen TV outputs, high voltage, high efficiency regulators and converters. Your Delco Radio Semiconductor distributor keeps them on ice. Call him today for data sheets, prices and delivery.

The heat's off high energy circuits

<table>
<thead>
<tr>
<th>RATINGS</th>
<th>DTS 413</th>
<th>DTS 423</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLTAGE</td>
<td>400 V</td>
<td>400 V</td>
</tr>
<tr>
<td>VCEO</td>
<td>325 V (Min)</td>
<td>325 V (Min)</td>
</tr>
<tr>
<td>VCEO (Sus)</td>
<td>0.8 (Max)</td>
<td>0.8 (Max)</td>
</tr>
<tr>
<td>Ic (Cont)</td>
<td>0.3 (Typ)</td>
<td>0.3 (Typ)</td>
</tr>
<tr>
<td>Ic (Peak)</td>
<td>1.0 A (Max)</td>
<td>2.0 A (Max)</td>
</tr>
<tr>
<td>lsb (Cont)</td>
<td>1.0 A (Max)</td>
<td>10.0 A (Max)</td>
</tr>
<tr>
<td>POWER</td>
<td>75 W (Max)</td>
<td>100 W (Max)</td>
</tr>
<tr>
<td>FREQUENCY RESPONSE</td>
<td>0.8 (Max)</td>
<td>0.8 (Max)</td>
</tr>
<tr>
<td>t&lt;sub&gt;f&lt;/sub&gt;</td>
<td>0.3 (Typ)</td>
<td>0.3 (Typ)</td>
</tr>
</tbody>
</table>

FIELD SALES OFFICES

UNION, NEW JERSEY*  
Box 1018 Chestnut Station  
(201) 637-3770

SYRACUSE, NEW YORK  
1004 James Street  
(315) 472-2668

DETROIT, MICHIGAN  
57 Harper Avenue  
(313) 873-6560

CHICAGO, ILLINOIS*  
5151 N. Harlem Avenue  
(312) 775-5411

SANTA MONICA, CALIF.*  
770 Santa Monica Blvd.  
(213) 470-8807

DETROIT, MICHIGAN  
57 Harper Avenue  
(313) 873-6560  
General Sales Office:  
700 E. Firmin, Kokomo, Ind.  
(317) 457-8461—Ext. 500

*Office includes field lab and resident engineer for application assistance.

DELCO RADIO  
Division of General Motors, Kokomo, Indiana
Logic cells are tested by probing the test pattern seen in the top photo, before thin-film interconnections (bottom photo) are designed.

strict array production to those slices with large enough clusters of good circuits and would make custom-design of the logic functions, another important research aim, impractical.

Direct masking. Photographic-film masks are customarily used to develop IC interconnections. "It takes two months to prepare a set of masks," explains Sol Triebwasser, IBM program manager. "Our process generates the masks directly on the array in half a day."

IBM tests the gates automatically by a system that probes the test pattern seen in the photo at the top of this page. Test information goes into an IBM 7094 computer, which decides in 30 seconds what gates are usable and how to connect them. The slice is recoated with aluminum and negative photoresist and placed on a table that moves the slice under a 0.002-inch-square beam of light which is turned on and off by shutters. This operation, controlled by a tape prepared by the computer, generates
Low Cost Test Signals
10 MHz to 1000 MHz

with the 3200B VHF OSCILLATOR

The VHF Oscillator Model 3200B is designed for general purpose laboratory use including receiver and amplifier testing, driving bridges, slotted lines, antenna and filter networks, and as a local oscillator for heterodyne detector systems in the frequency range from 10 to 500 mc.

The push-pull oscillator is housed in a rugged aluminum casting for maximum stability and extremely low leakage; six frequency ranges are provided for adequate bandspread on the slide-rule dial. Internal CW operation is provided; AM and pulse modulation may be obtained through the use of a suitable external source. The RF output is coupled through a waveguide-below-cutoff variable attenuator; in addition, an electrical RF level vernier is included as a front panel control.

An optional accessory Frequency Doubler Probe, Model 13515A incorporates a solid-state doubler circuit and provides additional frequency coverage from 500 to 1000 mc.

The push-pull oscillator is housed in a rugged aluminum casting for maximum stability and extremely low leakage; six frequency ranges are provided for adequate bandspread on the slide-rule dial. Internal CW operation is provided; AM and pulse modulation may be obtained through the use of a suitable external source. The RF output is coupled through a waveguide-below-cutoff variable attenuator; in addition, an electrical RF level vernier is included as a front panel control.

An optional accessory Frequency Doubler Probe, Model 13515A incorporates a solid-state doubler circuit and provides additional frequency coverage from 500 to 1000 mc.

Features:
- ±0.002% Frequency Stability
- External AM and Pulse Modulation
- Waveguide-Below-Cutoff Output Attenuator
- Solid-State Power Supply

Data subject to change without notice.

SPECIFICATIONS 3200B
- Frequency range: 10 to 500 Mc (MHz)
- in six bands: 10 to 18.8 Mc; 18.5 to 35 Mc; 35 to 68 Mc; 68 to 130 Mc; 130 to 260 Mc; 260 to 500 Mc.
- Frequency accuracy: within ±2% after 0.2 hour warmup (under 0.2 mw load).
- Frequency calibration: increments of less than 4%.
- Frequency stability (after 4-hour warmup under 0.2 mw load): ±0.002%; long term (1 hour) ±0.02%; line voltage (5-volt change) ±0.001%.
- RF output: Maximum power (across 50-ohm external load): >200 mw (10 to 130 Mc); >150 mw (130 to 260 Mc); >25 mw (260 to 500 Mc).
- Range: 0 to >120 db attenuation from maximum output.
- Load impedance: 50 ohms nominal.
- RF leakage: sufficiently low to permit measurements at 1 V.

13515A FREQUENCY DOUBLER PROBE
- Frequency range: 500 to 1000 Mc (MHz) with the 3200A/B operating at 250 to 500 Mc.
- Harmonic suppression: (at 4 mw output): fundamental: >16 db down; higher order: >16 db down (500 to 800 Mc); >14 db down (800 to 1000 Mc).

For more information contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.
**Regulated D.C. Power Supplies**

If design experience and performance reliability are factors to be considered in your buying, Acme Electric should be your first-choice source for D.C. Power Supplies. Converting alternating current to direct current is an old Acme Electric specialty. In over 35 years we have produced millions of low-voltage power supplies for battery charging and thousands of high-voltage power supplies for electrostatic precipitators. We've had our hand in the "state-of-the-art" for a long time and know the limits of each component for each application.

The standard stock model "off-the-shelf" D.C. Power Supplies listed below were designed to provide reliable performance at an economical price.

### PARTIAL LISTING OF STOCK MODELS AVAILABLE

**SINGLE PHASE, 100-130 Volts; Input 50 or 60 Cycles**

<table>
<thead>
<tr>
<th>Catalog Number</th>
<th>D.C. OUTPUT Volts</th>
<th>Current Amps</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-47509</td>
<td>10</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>PS-47623</td>
<td>12</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>PS-47508</td>
<td>15</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>PS-57352</td>
<td>22</td>
<td>25</td>
<td>550</td>
</tr>
<tr>
<td>PS-57353</td>
<td>24</td>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>PS-47123</td>
<td>24</td>
<td>6</td>
<td>144</td>
</tr>
<tr>
<td>PS-57353</td>
<td>24</td>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>PS-57355</td>
<td>24</td>
<td>15</td>
<td>360</td>
</tr>
<tr>
<td>PS-57354</td>
<td>24</td>
<td>20</td>
<td>480</td>
</tr>
<tr>
<td>PS-47125</td>
<td>24</td>
<td>50</td>
<td>1200</td>
</tr>
</tbody>
</table>

**Multi-Phase, 100-130 Volts; Input 50 or 60 Cycles**

<table>
<thead>
<tr>
<th>Catalog Number</th>
<th>D.C. OUTPUT Volts</th>
<th>Current Amps</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS-1-47461</td>
<td>24</td>
<td>75</td>
<td>1800</td>
</tr>
<tr>
<td>PS-1-47200</td>
<td>24</td>
<td>100</td>
<td>2400</td>
</tr>
<tr>
<td>PS-47202</td>
<td>26</td>
<td>4</td>
<td>104</td>
</tr>
<tr>
<td>PS-47638</td>
<td>28</td>
<td>8</td>
<td>224</td>
</tr>
<tr>
<td>PS-47712</td>
<td>28</td>
<td>25</td>
<td>700</td>
</tr>
<tr>
<td>PS-57355</td>
<td>28</td>
<td>30</td>
<td>840</td>
</tr>
<tr>
<td>PS-57356</td>
<td>44</td>
<td>25</td>
<td>1100</td>
</tr>
<tr>
<td>PS-47124</td>
<td>38</td>
<td>4</td>
<td>192</td>
</tr>
<tr>
<td>PS-57357</td>
<td>48</td>
<td>6</td>
<td>288</td>
</tr>
<tr>
<td>PS-47519</td>
<td>48</td>
<td>10</td>
<td>480</td>
</tr>
<tr>
<td>PS-57358</td>
<td>48</td>
<td>15</td>
<td>720</td>
</tr>
</tbody>
</table>

+ 24 volt output units of same current rating can be paralleled to multiply current capacity.

Write for catalog 175 and full list of "off-the-shelf" D.C. Power Supplies.
DESIGN ENGINEERS:
NOW... Capacitance-to-volume ratio to 20 mf/cu. in.
in Subminiature, Highly Reliable Ceramic Capacitors

SUBMINIATURE
MONOBLOC
CAPACITORS

Featuring HIGH CAPACITANCE ... HIGH RELIABILITY

Erie's new Monobloc ceramic film Capacitors represent the most significant design advance in more than a decade. Now, Erie's exclusive Monobloc Process, in which very thin films of ceramic can be bonded into solid structures, permits virtually unlimited range of capacitance values, characteristics and sizes to suit exacting design requirements. Monobloc Capacitors provide volumetric efficiencies from 10 to 100 times the capacitance (to 20 mf/cu. in.) attainable in conventional components of the same size... and still meet Established Reliability specifications for Aerospace, Military and Commercial applications.

These proven subminiature Monobloc Capacitors are encapsulated to suit the design engineers' need: hermetically sealed, glass encased... precision molded... and phenolic coated as illustrated at right. No other manufacturer produces a true hermetically sealed, glass encased capacitor... and in capacitance values to 10,000 pf.

Write TODAY, for literature and samples to: Monobloc Dept., Erie Technological Products, Inc., Erie, Pa.

Design Advantages...
- Volumetric efficiency to 20 mf/cu. in.
- Capacitance values 5 pf to .5 mfd... higher values upon request.
- IR at room temperature...100 K megohms.
- Working Voltage... 50 V, 100 V and 200 V.

- Inherent stability due to monolithic construction.
- Conservatively rated for long, trouble-free life.
- Available to Established Reliability or to your custom specification.

Another series of components in Erie's Project "ACTIVE"... Advanced Components Through Increased Volumetric Efficiency.

ERIE MONOBLOC
CAPACITORS...
- Hermetically Sealed
  Glass Encased Types
- Precision molded
  Types
- Phenolic Coated
  Types Weecons

644 West 12th Street
Erie, Pennsylvania
The Airpax MAS50 Signal Conditioning Amplifier is a dc-to-dc amplifier. It converts a transducer signal (current or voltage) to a standard output range of 0 to +5 vdc. Input is differential and floating. • Voltage gain, 0 to 100 with a stability of ±0.01% per degree C. • Linearity is within 0.1% of full scale. • Zero null stability of 0.5 microvolts per degree C. • Common mode rejection at 60 CPS is 120 db minimum.

Strain-Gage Amplifier: Extremely high rejection of common mode interference by the MAS50 enables it to operate with a floating input circuit, as in strain gage applications. The signal, after conditioning by the amplifier, can be multiplexed with other conditioned signals because any number of MAS50's can share a common ground at their outputs.

Thermocouple Amplifier: In applications such as amplification of a thermocouple output, the MAS50 combines inherently stable high gain with negligible drift in zero offset. Because input and output are electrically isolated from each other, the input can be either grounded or ungrounded while the output has one side grounded. Calibration of thermocouple lead length is unnecessary in normal-length runs because amplifier input resistance is much higher than thermocouple resistance.

Isolation Amplifier. Basically the MAS50 is an active 4-terminal device that produces 0 to +5 vdc output from a 0 to 50 microampere input. The amplifier provides a change of scale and of zero in several ways: by using a resistance in series with the input, by choice of a voltage gain of 1 or of 100 within the amplifier and by a bias current through the auxiliary winding. A screwdriver adjustment on the amplifier changes the gain by about 20% to calibrate the scale change and to compensate for tolerance in metering circuits.

Delivery from stock

$157 EACH

(1 to 6 pieces)
New Products

FET voltmeter called accurate up to 1,200 Mc

Only vacuum tube circuitry could previously provide equivalent frequency range and accuracy, according to Data Instruments.

A broadband voltmeter, designed with field effect transistors, is said to provide a frequency range and accuracy that were previously attainable only with vacuum-tube circuitry. The manufacturer, Data Instruments Division, subsidiary of IEH, says its model SSVM-1 is accurate to 2% at up to 100 megacycles per second and 1 decibel at up to 700 megacycles. The company explains that accuracy is expressed in decibels at frequencies above 100 megacycles because at these higher frequencies the instrument is more likely to be used as an indicator than for measuring voltage. Data Instruments says this is the first broadband voltmeter designed with FET's and that it is effective at as high as 1,200 Mc.

Peter Reynolds, chief engineer at Data Instruments, attributes the broadband response to the packaging of the coaxial probe. The high-frequency diode is mounted in the probe to rectify the input signal. The input capacitance presented by the probe is approximately 2 picofarads, including the diode and the probe housing. At low frequencies, the a-c input impedance is 15 megohms in parallel with 2 picofarads; the d-c resistance is greater than 100 megohms.

The unit requires no warm-up time and is free from any significant drift, a characteristic inherent in conventional vacuum tube designs. Reynolds says this drift-free performance is due to the use of two balanced FET's operating as a differential amplifier. Symmetrical arrangement tends to make the two n-channel FET's self-compensating for temperature effects. Also, because the circuit operates at very low currents, there is practically no heating, resulting in stable performance.

The circuit is isolated from the case, allowing measurements to be made remote from ground. Isolation and portability are possible through the use of a self-contained power supply consisting of three mercury cells. In normal use the minimum life of the cells is at least six months. However, this depends on how often the ohms scales are used, with maximum drain on the lowest ohms scale.

For measurements above 100 megacycles, the manufacturer recommends use of a coaxial tee adaptor for inserting the probe into a coaxial system.

Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D-c voltmeter</td>
<td>0 to 1,000 volts in 7 ranges</td>
</tr>
<tr>
<td>A-c voltmeter</td>
<td>0 to 300 volts in 6 ranges</td>
</tr>
<tr>
<td>Ohmmeter</td>
<td>0 to infinity (midscale values to 10 megohms)</td>
</tr>
<tr>
<td>Frequency response</td>
<td>±1 db from 20 cps to 700 Mc</td>
</tr>
<tr>
<td></td>
<td>±2% from 50 cps to 100 Mc</td>
</tr>
<tr>
<td>Input impedance</td>
<td>D-c, greater than 100 megohms</td>
</tr>
<tr>
<td></td>
<td>A-c, low frequency—approximately 15 megohms shunted by 2 picofarads</td>
</tr>
<tr>
<td></td>
<td>50 megacycles—greater than 100,000 ohms shunted by 2 picofarads</td>
</tr>
<tr>
<td>Size</td>
<td>6 by 3½ by 8 in.</td>
</tr>
<tr>
<td>Weight</td>
<td>5 lb.</td>
</tr>
<tr>
<td>Price</td>
<td>$215</td>
</tr>
</tbody>
</table>

Data Instruments Division, 3700 Crescent Boulevard, Pennsauken, N.J. Circle 350 on Reader Service Card.
**New Components and Hardware**

**Crt produces uniform size spot**

A high-resolution cathode ray tube (crt), which produces a uniform size spot independent of its position on the face of the tube, has been developed by DuMont Electron Tubes, a division of the Fairchild Camera & Instrument Corp. Maximum spot sizes of 0.0015 mil at the center—and 0.002 mil at the edge—of the flat-faced tube are claimed by DuMont. This is a reduction in spot-size variation of about 30% when compared to similar tubes.

High resolution and small spot-size variations permit a uniform, high-density presentation of numbers and letters on the face of the tube, as might be required in digital readout applications. It also permits fine-lined traces for accurate measurements in laboratory.

These characteristics are achieved in the KC2515 crt by using a precision electron gun, fine-grain phosphor screen and specially designed electrostatic focusing and magnetic deflection elements. To minimize deflection defocusing, the deflection angle has been reduced to 26°. In addition, high-quality glass—optically finished to 0.005 mil—ensures that defects or blemishes in the glass are smaller than the resolvable spot size.

An aluminumized screen backing increases light output and prevents the buildup of spurious charge effects. Three phosphors of varying persistence are available for high resolution displays. These include a type P-1 medium-persistence yellow-green phosphor with a spectral range of 4,900 to 5,800 angstroms; a type P-11 medium-to-short persistence blue phosphor with a spectral range of 4,000 to 5,500 angstroms; and a type P-16 short-persistence bluish-purple phosphor with a spectral range of 3,500 to 4,500 angstroms.

A fiber-optic face plate that covers the entire viewing area is optional. It allows light generated by the phosphor screen to be used for direct photographic recording of full scope traces.

The tube has a maximum diam-
New low-cost Daystrom Model 333 commercial trimmer has knurled finger-tip adjustment knob. It also has an Allenhead for fine adjustment . . . 4 to 1 ratio, nominal. Designed for PC board use, it requires approximately ½ cubic inch of space. Price is another unusual feature—only $1.45 in 100 lot quantities!

Model 333’s unique resistance element is the same as used in MIL-type Squaretrim® pots for high resolution, linearity, and low noise. Also, it is vibration and shock resistant.

This is just one of the special-purpose Daystrom units—from industry’s broadest line of subminiature square-trimming potentiometers. Chances are that we can fill your most exacting requirements with a standard, off-the-shelf model.

See your Weston distributor for catalog, prices and evaluation units. Weston Instruments, Inc., Archbald Division, Archbald, Pennsylvania 18403. Phone: (717) 876-1500.

Only Weston’s exclusive wire-in-the-groove offers LOCKED-IN LINEARITY

From Weston’s broad trimmer line

<table>
<thead>
<tr>
<th>Model 333 — ⅛” by ⅛” by ⅛”. Dual adjustment: knurled finger-tip knob and Allenhead. For PC board mounting. Resistance: 50Ω to 10k, up to 50k on special order. Rating: 0.2w @ 40°C in still air.</th>
</tr>
</thead>
</table>

| Series 200 — ⅜” Square-trim, 0.150” thick, slotted or Allenhead adjustment screws. This is only one of a full line of ⅜” pots. Operation: from -55 to 150°C. Resistance: 10Ω to 150Ω. Rating: 1w @ 50°C in still air. |

let your fingers do the trimming

WESTON® prime source for precision…since 1888
The above photograph shows Circuit Breakers at Wood Electric being tested for temperature and humidity requirements of MIL Standard 202B. Units undergo temperature changes from 14 to 160°F during a 10 day cycle while relative humidity is held constant at 50%. Test chamber is controlled within ±2°F and ±2% humidity.

There are other specs and other tests, lots of them, but they all have one purpose in common—to assure the most reliable performance in the industry. If it's by Wood Electric—you can depend on it!

Choose from a wide variety of proven commercial and military Circuit Breakers to meet the specific needs of your application—Thermal types with time delays from 0.5 to 90 seconds and Magnetic types with temperature-stable trip points from instantaneous to 10 seconds. Models are available with ratings from ½ to 50 amps...AC or DC...single pole, two pole and three pole.

Write for Circuit Breaker Catalog CB-10-65

**New Components**

Model 14 servo/differential relay is an all a-c operated device requiring a primary power source and a phase-sensing signal source derived from the same primary power source. It can be used as a servo relay, differential relay or phase detector.

The relay is an epoxy-encapsulated, all-silicon solid state device incorporating two dry reed switches. The signal source is normally derived from a four-arm bridge excited by a low voltage a-c source. When the bridge is balanced, both reeds are open. When the bridge is unbalanced in one direction, one reed will close. When the bridge is unbalanced in the other direction, the other reed will close. Signal power requirements to cause switch closure are less than 10 µw, allowing high positional or other sensing accuracy. Primary source requirements are 1 w, 120 v ±15%, 60 to 400 cps. The relay is unaffected by temperature or voltage variations in its operating range of −40° to +85°C.

For operation as a servo relay the four-arm bridge may consist of two...
CONSIDER COLORADO

...where research and education are industry's partner...

Directly. Indirectly. From government, university and private sources...

Consider 103 research organizations located in the state...headed by a total of 3500 graduate scientists who guide the efforts of 23,000 employees to discover the unknown. Everything from economics and marketing to cryogenics and advanced nuclear research and neutron generator performance.

In close support of science, research and industry are Colorado's educational institutions: 12 colleges and universities; 7 junior colleges. Plus an increasing number of vocational and trade schools whose primary mission is to serve the needs of Colorado and the nation's industry.

If research and education are important to your business, consider industrial Colorado for your expansion or relocation. Complete information is available from Dwight E. Neill, Director, Division of Commerce and Development, 14 State Services Building, Denver, Colorado.

INDUSTRIAL COLORADO
Stumped? Don’t be. We made up the word to emphatically set forth the ability of Phelps Dodge coaxial cable assemblies to solve very difficult transmission and installation problems.

A coaxial cable assembly, designed to specific requirements, is often the ingenious solution to cable connections in close physical confines or under difficult environmental conditions. Very tight specs can be met: delay time, ±0.02 NS — phase length, 0.4° relative — VSWR, 1.01; insertion loss, 0 to 40 db ± 0.5 db and 40 to 60 db ± 1.0 db — impedance, absolute value of average, 0.2Ω.

Phelps Dodge Electronics coaxial cable assemblies have been designed and built as tracking antenna harnesses, special oscillator and receiver lines, transitions to waveguide, airborne vibration isolators, matching sections, and for equalizing and balancing networks. We have a new catalog that describes many more. Please write for it. Bulletin CC, Issue 1.

New Components

potentiometers, one used to provide a set point and the other coupled to an actuator driven by a reversible motor. The resulting positional accuracy depends on the potentiometer quality and the exciting voltage. Use of standard available potentiometers can produce 1% accuracy.

Another application of the relay is as a temperature indicator or controller. In this application the signal is derived from a four-resistor bridge. One resistor is a thermistor. The bridge is balanced at a required temperature. When the thermistor senses temperature below the preset point, one reed will remain closed. When the bridge is balanced, both reeds are open. When the thermistor senses temperature above the balance point, the other reed will close. The high/low differential can be as small as one degree. Price of model 14 is $21.75.

Sensitak Instrument Corp., 531 Front St., Manchester, N.Y. [352]

Dual trimming pot

in miniature size

Series 190 dual trimming potentiometer measures only 0.405 x 0.775 x 0.185 in. Designed for precision applications, it features two in-phase resistance elements controlled by a single adjustment screw. With matched resistance elements, an electrical phasing of ±5% is standard.

Standard p-c board pin spacing of 0.1 in. center-to-center is used with a choice of terminations—printed circuit pins or 2-in. weldable leads, both gold plated. Series 190 is designed to meet the require-
Terminal junctions
with modular design

The TJ series of terminal junctions provides convenient, reliable replacements for bulky terminal strips, even in areas exposed to extreme environments, and at the same time reduces wiring steps and weight. The lightweight devices, which are also available in nonenvironmental styles, feature a modular design which, together with associated hardware, allows junctions of varying lengths. The modules are available in a wide variety of bussing configurations. The terminal junctions use crimp-type contacts in sizes 20, 16, 12, and 8, designed to geometry similar to NAS1600. The contacts are inserted and removed from the rear by the use of a single insertion-removal tool; they are crimped by the use of a standard MS3191 tool. The socket assembly is an integral part of the bus bar, and features a chamfer lead-in to accept the pin contact. Each module features high-temperature silicone inserts with triple-web rear seals, and meets electrical requirements of applicable Mil-Spec paragraphs.

Adjustment ratio is 25:1; resistance range per section, 10 to 50,000 ohms; resistance tolerance, ±5%; power rating per section, 1 w at 50°C; operating temperature range, −65°C to 175°C; temperature coefficient, 50 ppm/°C maximum. Techno-Components Corp., 7803 Lemon Ave., Van Nuys, Calif. [353]

STATHAM MODELS SD6 AND SD3
ARE 700 CU. IN. CAPACITY CHAMBERS FEATURING ±¼°F CONTROL ACCURACY

Designed for precise temperature testing of electronic components, Statham Models SD6 and SD3 chambers feature true proportional control of heater power by all solid-state circuitry.

This new generation of test chambers eliminates the conventional heater power relay, prevents cycling about the control point, and substantially reduces RFI noise.

The controller maintains a set-point temperature within .01°F per °F ambient. An improved controller design provides excellent temperature uniformity with gradients of ±1.3°F at 300°F.

SUPERIOR TEMPERATURE CONTROL

24 Inch Dial Control
Models SD6 and SD3 feature 24 lineal inches of calibrated set-point scale. Temperature readout is obtained by a deviation meter calibrated in one-degree increments. This expanded scale approach provides a level of accuracy and readability not attainable in conventional chambers.

Optional Push-Button Control
Frequently repeated temperature settings can be made faster and more accurately with Statham’s push-button temperature selection control. The buttons, which may be set at any desired temperature, provide precise repeatability.

Cycle Time Controller
Statham cycle time controllers permit programming the chambers in any required sequence of hot-ambient-cold-ambient, etc.

Statham Instruments, Inc.
Environmental Products Division
2221 Statham Blvd., Oxnard, Calif.
HUnter 6-8386 (Area Code 805)

Write for Statham’s new 12-page Temperature Test Chamber Brochure.

Circle 161 on reader service card 161
IMPORTANTLY NEW!!
SOLID STATE STANDARD OSCILLATORS

THE ONLY

WIDE-RANGE • FLAT-RESPONSE • LOW-DISTORTION
STABLE-AMPLITUDE • CALIBRATED-OUTPUT • OSCILLATORS MADE!!!

If you think your present signal source fits that description, we suggest that you question its performance again from a slightly different viewpoint. For instance:

<table>
<thead>
<tr>
<th>Question</th>
<th>K-H Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is your tuning range from 1 Hz to 100 kHz?</td>
<td>Flat ±0.2 db in this range?</td>
</tr>
<tr>
<td>K-H gives you three extra decades, covers</td>
<td>K-H response is flat ±0.05 db over seven decades.</td>
</tr>
<tr>
<td>from 0.001 Hz to 100 kHz.</td>
<td>0.1% distortion here?</td>
</tr>
<tr>
<td></td>
<td>K-H gives you 0.1% over eight decades — 0.01% over five of them.</td>
</tr>
<tr>
<td></td>
<td>±1%/hr amplitude drift?</td>
</tr>
<tr>
<td></td>
<td>K-H gives you ±0.05%/hr over this range.</td>
</tr>
<tr>
<td></td>
<td>±1% voltage accuracy here?</td>
</tr>
<tr>
<td></td>
<td>K-H gives you ±0.5% to 1 Hz, without a meter.</td>
</tr>
</tbody>
</table>

The Krohn-Hite point of view is simple: a precision oscillator must deliver state-of-the-art performance in the basics of frequency range, frequency response, sine wave purity, amplitude stability, and amplitude calibration. That’s what saves time and trouble on the really critical jobs. K-H oscillators deliver this kind of performance first . . . then add the useful extras like quadrature output, square wave, variable-width pulse, transient-free tuning, and external synchronization. If your viewpoint is at all like ours, you should lose no time in meeting these remarkable new instruments. Write NOW!

ADVANCE NOTICE!
SEE THESE NEW OSCILLATORS AT THE IEEE SHOW ... BOOTHS 3F12-14

KROHN-HITE CORPORATION
580 Massachusetts Ave., Cambridge, Mass. 02139
Telephone: 617/491-3211
Pioneering in Quality Electronic Instruments

New Components

cal and mechanical requirements of MIL-C-26482.
The Deutsch Co., Electronic Components division, Municipal Airport, Banning, Calif. [354]

Miniature, high-speed sensitive relays

Two miniature, mercury-wetted contact relays have been announced. Type HGSL is designed for wired assemblies; type HGSM, for printed circuit board applications. The high-speed relays provide two sensitivity ratings: 40 mw single-side stable, and 20 mw bistable.

Either Form D (bridging) or Form C (nonbridging) contacts are available. The contacts can handle power switching requirements up to 100 v-a, a-c or d-c, over billions of operations. Low-level contact ratings are 0 to 300 mv, 0 to 100 ma.

The HGSL has a contact circuit resistance of 35 milliohms max: the HGSM, 20 milliohms max. Both types have a nominal operate time of 1.0 msec at maximum coil power. Compact, space-saving packages meet a wide range of design requirements for both p-c boards and wired assemblies.

The relays are said to be applicable in both commercial and military electronic systems. For example, their complete freedom from contact bounce, isolation between coil and contacts, and high speed qualify them as excellent input buffers to solid state circuitry; or, as output buffers, they can be driven by low-power circuitry with...
an input-to-output power gain of up to 5,000.

As scanner contacts in checkout systems, the relays can stand off a high-potential voltage of 1,000 v a-c and, at the same time, offer a contact resistance variation of less than 2 milliohms over life for critical resistance-measuring circuits.

C. P. Clare & Co., 3101 Pratt Blvd., Chicago, Ill., 60645. [355]

Snap-slide
wedge-action switch

The 84000 series of snap-sliding wedge-action switches is said to be the first of its size and rating to offer: a-c and d-c ratings; quick make, quick break with wiping contact action; two- or three-lever positions; maintained or momentary action — on one or both sides of center; choice of three contact materials; and compact physical dimensions.

The switches are rated for a-c at 5 amps 125 v, and 2 amps 250 v; and for d-c at 4 amps 125 v and 1 amp 250 v. The 84000 series is offered in all circuits spst through dpdt.

Three types of contact materials are offered — silver plated bronze, supplied as standard and best for power circuits; silver alloy, best adapted to low-voltage circuits; and gold plated, providing long shelf life and used on low-energy circuits.

The new switch line is supplied with either a nickel-plated, brass bat lever handle or a paddle-shaped nylon lever. Wiring terminals are the combination solder-lug and quick-connect type.

Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford, Conn. [356]
New Semiconductors

Scr handles 550 amperes

A silicon controlled rectifier capable of handling root-mean-square forward currents to 550 amperes can simplify the design of adjustable motor controls that are operated directly from 3-phase 480-volt power lines. With the new scr water cooling is not required.

The rectifier, which is being manufactured by the International Rectifier Corp., does not as yet have a type number assigned. Because it can be operated directly from high-voltage a-c distribution lines, it should also find application in battery-charging equipment in central telephone offices, and in electric-vehicle controls, welding and oven controls, high-power plating power supplies and machine-tool drives.

Forced-air cooling is recommended by the manufacturer in most applications of the scr. The copper-base device has an over-all length of approximately 10 inches. It measures 1.69 inches from flat to flat and has a 3/4 in.-16 mounting stud.

Other variations of the new scr are being made available, including one with a turn-off time of 40 microseconds.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum peak forward voltage drop</td>
<td>1.48 volts</td>
</tr>
<tr>
<td>Maximum rms forward current</td>
<td>550 amperes</td>
</tr>
<tr>
<td>Maximum average forward current</td>
<td>350 amperes</td>
</tr>
<tr>
<td>Maximum peak 1-cycle surge current</td>
<td>6,250 amperes</td>
</tr>
<tr>
<td>Maximum allowable peak reverse voltage</td>
<td>1,200 volts</td>
</tr>
<tr>
<td>Maximum transient peak reverse voltage</td>
<td>1,800 volts</td>
</tr>
<tr>
<td>Minimum peak forward breakover voltage</td>
<td>1,200 volts</td>
</tr>
<tr>
<td>Availability</td>
<td>6-8 weeks</td>
</tr>
<tr>
<td>Price: 1-9</td>
<td>$629</td>
</tr>
<tr>
<td>Price: 10-99</td>
<td>$561</td>
</tr>
</tbody>
</table>

International Rectifier Corp., El Segundo, Calif. [361]

Plastic-encapsulated dual switching diodes

Users of silicon switching diodes, particularly computer and test-equipment manufacturers, can improve product performance and reduce total system costs by using the new MSD6100 dual switching diodes, according to Motorola Semiconductor Products Inc. Ideal for high-speed switching and other critical applications, the dual switching diodes are fabricated simultaneously on the same chip of silicon; therefore, their characteristics are closely matched. A common cathode configuration simplifies subsequent assembly operation.

The MSD6100 is encapsulated in a single-piece, transfer-molded plastic form that provides a uniform package free of voids and leaks. Because it is a pressure-molded solid, the package offers extra physical strength to the internal leads and connections while insuring excellent heat-transfer characteristics. The "D" shaped package lies flat for easy printed-circuit mounting.

Each diode in the device has a high breakdown voltage of 100 v minimum and a low capacitance of 1.48 v.

Zero Manufacturing Co.

Choose from more than 25,000 sizes and shapes. Rectangular, square, round. Sizes from 7/8" x 1 1/8" to 28" x 54-3/16". Draft-free deep drawn aluminum. No Welds. Satiny, wrinkle-free surface requires no preparation for painting. Shipment made from $1,000,000 inventory, normally within one week, from the nearest factory. Complete facilities available for economical secondary operations and finishing if required.

Send for New 38-Page Catalog

Zero Manufacturing Co.
1121 Chestnut Street
Burbank, California 91503
Telephone Victoria 9-5521
area code 213
TWX 213-646-8094
Factories in Burbank, Calif. and Monson, Mass.

164 Circle 164 on reader service card

Electronics | February 7, 1966
1.5 pf maximum at a reverse voltage of zero. The reverse recovery time for each diode is 4 nanoseconds maximum at 10 ma.

Because of the plastic encapsulation, the common cathode configuration and improved process techniques, the dual diode device is priced as 75 cents in quantities from 100 to 999.

Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz. [362]

**Integrated-circuit video amplifier**

A low-cost integrated-circuit video amplifier, type E13-511, features high stability from −55° to +125°C. It amplifies from d-c to over 50 Mc (−3 db) with an essentially flat gain characteristic to 40 Mc.

Key specifications include voltage gain of 24 db, bandwidth (−3 db) of 50 Mc, gain variation (−55° to +125°C) of ±0.3 db, limits of gain variation (d-c to 10 Mc) of ±0.5 db, and dynamic range of 7.0 v.

Silicon planar production techniques using high resolution photomasking and epitaxial material are said to achieve exceptional isolation between circuit parts and uniformity of characteristics. Delivery of the new device is from stock; price is $12 each from 1 to 99 with lower prices available on higher quantities.

Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. [363]

**Uhf transistor for microcircuits**

Designed for thin-film and other microcircuit packaging techniques, the K2857C double-diffused npn silicon transistor is intended for uhf and vhf amplifier applications. Exceptional performance is noted in converter and oscillator circuitry, according to the manufacturer.

Typical performance at 450 Mc is 14-db gain with a noise figure of less than 4 db. Selected versions of the transistor are available with noise figures down to 2.5 db maximum at 450 Mc.

Price is $24.75 with delivery currently at 10 days.

Kmc Semiconductor Corp., Parker Road, RD 2, Long Valley, N.J. [364]

---

**PRINT ELECTRONIC COMPONENTS ...EFFECTIVELY**

That word efficient means a high ratio of output to input. In a MATTHEWS OFFSET PRINTER marking transistors, modules, capacitors and other electronic wonders, it means trouble-free operation, legible printing, it means a spoonful of ink goes a long way—installing a MATTHEWS printer means at least one of your problems is solved.

Write for illustrations of our electronic component printers or send a sample of your product. We'll be glad to see if we can be efficient for you too.

---

**JAS. H. MATTHEWS & CO.**

Industrial Marking Products Division

6788 PENN AVE., PITTSBURGH, PA. 15206

MARKING METHODS SINCE 1850

Circle 165 on reader service card 165
Design Brochure
Cable Assemblies & Coaxial Delay Lines

This 4-page brochure details specifications and multiple design possibilities of cable assemblies and coaxial delay lines. It also follows through with evaluation, production and test procedure info.

For your copy write or phone:
Times Wire & Cable, Wallingford, Conn. (203) CO 9-3381

Seamless Metal Tube Sheathed Coaxial Cable

1. Time's new semiflexible coaxial cable with seamless aluminum tube sheath conductor is available in two standard versions:
   1. ALUMIFOAM® — Foam polyethylene dielectric where pressurizing isn’t practical.
   2. ALUMISPLINE® — Air dielectric where pressurizing is practical. These cables offer more isolation—at 80 db more than ordinary coax. Uniformity average — VSWR 1.1 or less. Stability — 10 times better. Lower loss — 20% less. Pulse reflection — less than 1%. Less distortion. Also avail. in solid dielectric and high temp. constructions.

   For prices & data write or phone: Times Wire & Cable, Wallingford, Conn. (203) CO 9-3381

Connectors for Solid Sheathed Cable

Only one step required to use the new one-piece TIMATCH® Connector with its own pat. CoilGrip® clamp—just unpack it, Its reusable and repeated assembly and disassembly does not impair either the RF or physical characteristics of the connector or the cable. Available in all popular sizes and fits all metal tube sheathed coaxial cables.

For prices & data write or phone: Times Wire & Cable, Wallingford, Conn. (203) CO 9-3381

New Instruments

Coupler makes dvm printer of calculator

A digital coupler, developed by Cahu Electronics, Inc., turns an ordinary desk calculator into a digital printer. By combining the series 490 coupler with Cahu's series 510 digital voltmeter and a desk calculator, it is possible to have a digital-voltmeter printout system that is less expensive than presently available dvm printers. Including the cost of the calculator, says a company spokesman, the Cahu system is at least $100 less than comparable digital printers.

The desk calculator fits between the coupler's electronics module and a set of 11 solenoids. Ten solenoids drive plungers which activate the calculator's number keys; the 11th operates the tabulating key. The printer is activated only when the voltage changes and the dvm seeks a new null. The plunger-assembly arms are slotted for calculators of different heights.

The coupler is fitted to the dvm through a 42-pin connector—the only modification necessary to enable the series 510 voltmeter to work with the coupler. The coupler operates from the same biquinary-code system as the series 510 dvm. Dvm's that use other codes can be connected if a suitable converter is provided.

The calculator can be used for routine office tasks when not installed in the coupler. Even installed, it can be used for quick computations by operating the calculator's keys with the solenoid shafts that extend through the coupler. Standard office calculators need no modifications to work with the series 490 coupler. This is an attractive feature, according to Kenneth Walker, engineering supervisor at Cahu, since warranties on the calculators would be affected if alterations were made.

Specifications

- Input power: 105 to 125 volts, 50/60 cps
- Size: 19¾ in. long, 12½ in. wide, 11½ in. high
- Price: $795.00

Cahu Electronics, Inc., Box 623, San Diego, Calif. 92112 [371]

Highly accurate lab potentiometer

A three-dial, four-range potentiometer, known as model 2784, is designed to measure voltages from 0
to 11.110 v. Its stated calibrated accuracy on the 1-v range is ± (0.002% + 10 µv).

The instrument uses a nonconvoluted, single-turn slidewire to achieve infinite resolution on the third dial. The ability of the user to read between scale divisions is the only factor limiting resolution, the company says.

The extremely low temperature coefficient of the model 2784 permits its use as a high-accuracy production calibration instrument as well as for measurements in temperature-controlled standards laboratories. Thermal emf's are held to less than 0.1 µv. The instrument has guarding provisions to intercept both internal and external leakage currents.

Other features include a single window readout of all digits, automatic decimal-point positioning, complete electrostatic shielding, and self-checking capability. Price is $860; delivery, stock to 30 days. Honeywell, Inc., Denver Division, 4800 E. Dry Creek Road, Denver, Colo., 80217. [372]

Swr meter features high usable range

A standing-wave-ratio meter now available has a noise-figure specification of less than 4 db, giving it greater usable range than any previously offered swr meter, according to the manufacturer.

Model 415E is used in r-f and microwave measurement systems, not only to measure standing wave ratio, but also to measure attenuation, gain, or any other parameter determined by the difference between two signal levels. It is a tuned amplifier-voltmeter calibrated in db and swr for use with square-law detectors. Its low noise

An Operational AUTOMATIC MICROWAVE SPECTRUM SURVEILLANCE SYSTEM

And The Management/Engineering Team That Made It Work

The new Watkins-Johnson microwave collection system combines the most sophisticated techniques and proven materials to receive, detect and analyze electromagnetic emissions in the frequency range of 1 to 18 GHz. Whether airborne, aboard ship, in a mobile van or at a fixed location, the WJ-1007 performs automatically and continuously for ferret, ELINT and reconnaissance applications.

- The WJ-1007 requires no mechanical tuning — it is fitted with electrically-tracked preselectors and oscillators. It provides continuous coverage through automatic switching of full octave and waveguide frequency bands.
- Digital tuning and direct digital readout delivers automatic data for transmission and teletype reproduction.
- The ability of the system to measure frequency to an accuracy of .01 percent is the result of a solid-state local oscillator development unique at W-J.
- The system is of solid-state design throughout, except for TWT’s and CRT’s.
- A core memory unit provides a “lock out” and recall capability.
- The modular design provides for ease of system expansion to cover the 18 to 40 GHz range as well as frequency bands lower than 1 GHz.
- Each module is fully self-contained with its own power supply (diplexers, local oscillator synthesizer, spectrum display, DF display, demodulator, digital tuner, receiver control, frequency memory, IF pan display, analysis indicator and so forth), resulting in a perfectly synchronized system.
- Supplementary equipment is available to suit any application.

The team that delivered the WJ-1007 as promised can be engaged to any similar systems program calling for refined skills and engineering ingenuity.

Electronics | February 7, 1966
NEON or INCANDESCENT SUB-MINIATURE INDICATOR LIGHTS
MEET OR EXCEED ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS OF MIL-L-6723 AND MIL-L-3661

Miniaturization is made possible by the wide selection of Dialco Sub-Miniature Indicator Lights for mounting in 15/32" or 17/32" clearance hole. Among the features offered are: Watertight construction; resistance to vibration and corrosion; high-heat plastic or glass lenses; anti-rotation (locked) construction; phenolic insulation of military specification grade.

Neon assemblies accommodate T-2 lamps in two types: NE-2D (MS25252) for 105-125V AC-DC; and High Brightness NE-2J for 110-125V AC only. In DIALCO units, the current limiting resistor is built-in (U.S. Pat. No. 2,421,321).

Incandescent assemblies accommodate T-1 1/4 lamps in voltages from 1.35 to 28V—with life ratings to 50,000 hours.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE.

WRITE FOR CURRENT CATALOG

New Instruments

figure permits accurate measurement at lower levels than formerly were practical. A result is the ability to exploit fully the newest state-of-the-art detectors, around whose source impedance the 415E noise figure was optimized. Usability of low signal levels reduces the necessary drive to the measured array and reduces the necessary modulation index for the detected signal, easing the problems of such measurements in all respects.

Additional accuracy improvement arises from a new high in specified attenuator precision. An expand-offset feature allows any 2-db portion of the instrument’s 70-db range to be expanded to full scale for maximum resolution, at a specified linearity of ±0.02 db.

Model 415E operates with either crystal or bolometer detectors, with capability to operate from both low (100 ohms) and high (5,000 ohms) source impedance crystals. It provides precise bias currents of 4.5 or 8.7 ma as selected on the front panel to activate all standard bolometers. Bias is peak-limited for bolometer protection.

The instrument has both recorder and amplifier outputs, which are isolated. The fully transistorized unit weighs 8 lb and consumes only about 2 watts. Price is $350; delivery, an estimated 4 weeks.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., 94304. [373]
A novel technique of modulation and demodulation enables the resistance comparison to be made at 5 cps, thus taking advantage of the accuracy of the highly permeable toroidally wound transformers, while eliminating the reactive effects of a-c.

Balancing the bridge with the six decades produces a digital readout of the resistance ratio to seven figures accurate within 20 ppm. This accuracy is available for measurements from 0.1 to 500 ohms. Measurements with reduced accuracy may be made from $10^{-5}$ to $10^4$ ohms. The rapid measurements possible with the VLF51 greatly facilitate calibration work. While the bridge is specifically designed for resistance thermometry, it is applicable to any resistance comparison within its range.

Rosemount Engineering Co., 4900 W. 78th St., Minneapolis, Minn. [374]

Signal selector for vibration testing

An automatic signal selector for vibration testing, model N668 automatically compares up to six accelerometer input signals, and can be set to select either the largest or smallest for presentation to the automatic exciter control, rejecting the remaining five.

Previously, in operating to test specifications that require control to a specified level, selection of the control point had been by approximation. The model N668, a solid state unit, in addition to automatically selecting and controlling to the maximum or minimum, includes provision for weighing the input signals, permitting comparison and selection between signals at different levels.

A wide range of inputs can be handled satisfactorily. The extremely fast switching time of less than 1 microsecond insures that there are no transients during switching.

MB Electronics, division of Textron Electronics Inc., 781 Whalley Ave., New Haven, Conn. 06508. [375]

MOL Resistors

PROMPT DELIVERY

...is one reason why all major TV manufacturers use Mallory MOL film resistors.

Other reasons? Temperature coefficient only 250 PPM/°C; proved flame resistance; high stability in humidity; less than 5% resistance change after 10,000-hour load-life test. Write for data and quotation. Mallory Controls Company, a division of P. R. Mallory & Co. Inc., Frankfort, Indiana 46041.
New Subassemblies and Systems

Core plane production tester

Designers testing the ferrite core planes from which computer memories are built must measure a number of parameters to learn in great detail how the memory will perform under all kinds of conditions. On the production line many of these parameters need not be measured in testing core planes, since the question in production is simply whether a particular plane comes up to specification. Therefore, a laboratory-model core plane tester usually has capabilities that are never used in a production testing; and a manufacturer that buys a laboratory tester for production pays for equipment that is scarcely ever used.

The model 1527 ferrite tester, according to Digital Equipment Corp., is a fast, inexpensive unit for production testing of core planes. It is mounted in two standard 19-inch racks. The operator can reach all the knobs and buttons, calibrate all measurements, even open the panels for maintenance—without getting out of his chair. And it sells for less than half the price of most testers of comparable capability, according to DEC.

The new tester has a diode-transistor matrix adapted from DEC's line of Programmed Data Processor (PDP) computers; the matrix generates test patterns for the memory connected to it. In effect, the tester is a computer without a memory; when a memory from the production line is plugged into the tester, it puts the memory through its paces by writing and reading one or more test patterns in the memory and verifying the results. The matrix required a special packaging technique to overcome inductance and capacitance in the long leads between the tester and the core plane. The performance of even a perfectly functioning core plane could be affected if the lead length were not compensated for.

Test patterns that the unit can use with a core plane include all 1's, all 0's, alternate 1's and 0's, (single checkerboard) and something called a double checkerboard with variations. A double checkerboard has this pattern repeated along the full length of every row of ferrite cores in the plane:

```
0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1
0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
```

Four variations of the double checkerboard start with one of the four bits shown in the upper left corner (first two bits, first two rows). The various patterns are designed to present worst-case noise and signal waveforms to the sense windings and amplifiers. External pattern generators may also be connected to the unit.

The tester is of modular construction. There is a timing and control section, a switching system that can cycle from address to address of a 128 by 128 core array in less than two microseconds, a difference amplifier, and a four-channel discriminator. The input to the difference amplifier is a response signal from the core plane and generates four positive and four negative signals that can be

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing and control</td>
<td>340 cps to 2 Mc</td>
</tr>
<tr>
<td>Stepping frequency</td>
<td>3.5 µsec to 3 µsec</td>
</tr>
<tr>
<td>Test patterns</td>
<td>All 1's, all 0's, checkerboard, complement, external complement</td>
</tr>
<tr>
<td>Bandpass</td>
<td>5 kHz to 50 Mc</td>
</tr>
<tr>
<td>Common mode rejection</td>
<td>1 Mc &gt; 1,000, 30 Mc &gt; 200</td>
</tr>
<tr>
<td>Output rise time</td>
<td>≤ 8 nsec (input rise ≤ 2 nsec)</td>
</tr>
<tr>
<td>Signal delay</td>
<td>6.5 nsec</td>
</tr>
<tr>
<td>Gain nonlinearity</td>
<td>≤ 0.5%</td>
</tr>
<tr>
<td>Differential Input impedance</td>
<td>300 ohms, ±0.1%</td>
</tr>
<tr>
<td>Four-channel discriminator Offset voltage</td>
<td>≤ ±2 µV per mv common-mode voltage</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>≤ ±150 µV per degree C</td>
</tr>
<tr>
<td>Input voltage range</td>
<td>0 to -1 volt</td>
</tr>
<tr>
<td>Input current</td>
<td>4 µA/microamperes</td>
</tr>
<tr>
<td>Strobes—number width</td>
<td>10 to 600 nsec</td>
</tr>
<tr>
<td>position</td>
<td>50 to 600 nsec from reference time</td>
</tr>
</tbody>
</table>

Electronics | February 7, 1966
connected in any combination to the discriminator. An optional oscilloscope display and two external pattern generators for the equipment are available.

Digital Equipment Corp., Maynard, Mass. [381]

Plug-in power supply has wide voltage range

A plug-in power supply now available furnishes a regulated d-c output from 8 to 21 volts at 200 ma. Input voltage is 105 to 125 v a-c. Load regulation is ±0.1%; line, ±0.05; ripple, 1 mv. The voltage may be adjusted either by a built-in accessible internal potentiometer or by a remote potentiometer.

Case size is 3 3/8 x 3 1/4 x 4 1/2 in. Price is $70. Shipment is 3 days after receipt of order.

Acopian Corp., P.O. Box 585, Easton, Pa., 18043. [382]

Optical encoder has half-bit accuracy

Model 219 is an 8-bit, cyclic binary (Gray) code photoelectric shaft position encoder with 1/2-bit accuracy. It measures 3 in. high by 2.625 in.

Signaflo...aci systems employing advanced interconnection expertise...

Signals flow through "wiring that moves" in this retractable rack and panel aci Signaflo system of round wire to flat cable connections and memory coiled flat conductor cables.

Bac : Signaflo Systems

Send for literature

aci DIVISION OF KENT CORPORATION
206 INDUSTRIAL CENTER, PRINCETON, N.J. 08540

Let the aci engineering staff and its unique problem solving capability design aci Signaflo systems into your circuitry cabling...whether you require shielded or unshielded, fixed impedance, minimum cross talk, etc.

Signals flow by the millions through this multiple layered aci Signaflo system for computers. Narrow cable uses exclusive aci "spread pitch" development for connector compatibility.
Great editorial is something he takes to lunch

(What a climate for selling!)

New Subassemblies

in diameter, and weighs 14 oz. It has long-life, low-torque bearings with life expectancy in excess of $125 \times 10^6$ revolutions. Maximum slew rate is 5,000 rpm; moment of inertia, 30 gm-cm$^2$; and maximum acceleration, 30,000 rad/sec$^2$.

A replaceable 5,000-hour nominal life lamp requiring 6.3 $\pm$ 5% d-c volts is used. Output for a logical "1" is 40 $\pm$ 10% millivolts, and logical "0" 8.0 millivolts maximum. Working temperature is from $-40^\circ$F to $+131^\circ$F; storage temperature from $-72^\circ$F to $+185^\circ$F. Rotation for increasing count is counter-clockwise as viewed from shaft end.

Price is $8279. Quantity discounts are available on request. Baldwin Electronics, Inc., 1101 McAlmont St., Little Rock, Ark. [383]

Delay line memory module

Model 06 delay line memory module is one of a complete new line of 1-Mc system logic modules now available in both germanium and silicon versions. It can be used to store up to 2,000 bits of information for 2 milliseconds. The information can be recirculated to increase the storage period, or, in the case of shorter records, can be recorded repetitively to decrease the access time. Delay lines of other lengths are also available on special order.

A flexible array of input gating is incorporated on the module, and readout is via standard flip-flop
Six-inch crt display with silicon IC logic

An inexpensive, general purpose six-inch crt display has all logic designed of silicon monolithic integrated circuits. Model 80-806 is a compact electrostatic display having many state-of-the-art advantages found only in more expensive units. Bright and easy to read, the crt is ideally suited for industrial and scientific uses that require alphanumeric display, small-screen monitoring for direct computer readout, data display for plotting, bar graph display, vector or dot display, remote monitoring and photo-recording display.

The unit is capable of an alphanumeric display of up to 512 characters. More than 3,800 dots or vectors can be displayed.

Features include P-31 phosphor tube, 0° to 55°C temperature operating range, accuracy of ±1% of full scale and a 60-cycle refresh rate for prevention of flicker. Crt shielding permits asynchronous operation with 60-cycle a-c line. The unit can be operated remotely up to 1,000 ft. from a refresh memory.

Designed to fit in a 24 by 19 by 7-in. rack mounting or the manufacturer’s standard multiplexer case, the display includes all power supplies needed for complete operation.

Systems Engineering Laboratories, Inc., Box 9148, Fort Lauderdale, Fla., 33310.

Electronics | February 7, 1966
New Microwaves

Customer can assemble flexible waveguide

Designers of waveguide assemblies for microwave systems can now purchase lengths of flexible waveguide that can easily and quickly be cut and assembled to meet configuration needs.

Flexible waveguide sections in a microwave assembly are used where vibration or movement is expected, or to compensate for the fixed mechanical tolerances of rigid waveguide sections. Previously, engineers estimated the required length of the flexible section, ordered it from a manufacturer, and waited four or five weeks for delivery.

But now, Airtron, a division of Litton Industries, offers immediate delivery of flexible tubing and flanges that the customer can assemble. Called Airflex and designated type AFF by the company, the tubing is cut to the length required and the ends are flared. Each flange consists of two sections. The flared ends are inserted between the flange sections, which are fastened by two screws. No brazing or soldering is necessary.

Although the waveguide can be cut and assembled with ordinary tools, Airtron offers a tool kit that makes assembly neat and efficient. The kit includes a heavy serrated blade and tools to flare the tubing.

An extruded neoprene rubber jacket is provided for applications where the flexible section must be pressurized. The jacket is slipped over a waveguide tubing and clamped. The waveguide can be pressurized up to 60 psig.

Although lengths of two or three feet are commonly needed, Airtron can provide tubing in any length from six inches to 10 feet. Each foot of Airflex can be stretched or compressed one-half inch.

Flexible waveguide for X band, which is designated size WR-90, is available. It can be bent to a radius of 1 3/8 in. in the E-plane and 2 1/4 in. in the H plane. Airtron expects to expand the line to include sizes for S, C and K bands within the next few months. Either military or EIA (Electronic Industries Association) types of flanges are available.

Airtron also provides twistable waveguide tubing, designated AFT, which is made of convolutely wound brass strips 5 mils thick—
like the flexible section—but with the seams of the convolution left unsoldered. AFT waveguide can be twisted 180° for each foot of length.

The company also offers the new flexible waveguide sections completely assembled. Cost of AFF and AFT, according to the company, is less than that for conventional flexible waveguide with molded jacketing and brazed flanges. Cost upon request. Delivery immediate.

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>8.2 to 12.4 gigacycles</td>
</tr>
<tr>
<td>Attenuation</td>
<td>0.08 decibel per foot</td>
</tr>
<tr>
<td>Vswr</td>
<td>1.10 maximum across full frequency range</td>
</tr>
<tr>
<td></td>
<td>1.08 maximum across a 10% bandwidth</td>
</tr>
<tr>
<td>Peak power at 60 psig</td>
<td>1.2 megawatts</td>
</tr>
<tr>
<td>Temperature</td>
<td>-55°C to 125°C</td>
</tr>
<tr>
<td>Military specification</td>
<td>Mil-W-287C</td>
</tr>
</tbody>
</table>

Airtron, 200 East Hanover Ave., Morris Plains, N.J. [391]

X-band oscillator delivers 1-mw average

An X-band oscillator, model X920, features 1-mw (0 dbm) output at a center frequency tunable over a 100-Mc band in the 8.2-Gc to 9.6-Gc range. A silicon planar epitaxial transistor is operated in the oscillator-varactor-multiplier mode to drive a step-recovery diode multiplier with output in WR-90 waveguide.

The oscillator is ideal for production-line and bench-test equipment, system breadboards, antenna ranges, classroom demonstrations, portable X-band traffic beacons and similar applications where lightweight low-voltage power supply requirements, and low cost are prime factors. A novel application, as a calibrations laboratory trans-

What is small? Merely 1/3 to 1/2 the size and weight of tubes built just a year ago.

Available? Yes, we’re delivering miniature low-noise, low- and medium-power TWTs in quantity for military systems.

Why small? To anticipate urgent requirements for reduced size and weight in military, airborne and other applications where component density is critical.

But not small in performance. Noise figure, gain, power output and other performance characteristics are equal to or better than their bigger and heavier ancestors. And all MEC miniature tubes have PPM focusing, full magnetic shielding, military environmentalization and rugged metal-ceramic construction.

What’s next? Contact MEC’s representative in your area for details, or drop us a line in Palo Alto.

Exceptional opportunities on our technical staff for qualified scientists and engineers. An equal opportunity employer.
SOLID STATE LASER SYSTEM Model SSCW
- Frequency: 1.06 microns
- Power output: 500 milliwatts
- Power input: 1000 watts
- Total weight of head: less than two pounds

SEMI-ELEMENTS SPECIALS OF THE MONTH...
GOOD UNTIL MARCH 15, 1966

COHERENT LASER DIODE SLD-2 .................... $250.00
LASER DIODE SYSTEM LDS-2 .......................... $975.00
    Complete with coherent laser diode, cryogenic dewar and heat sink
RUBY LASER CRYSTAL ................................. $125.00
    1/4" diameter by 2" long
    Finished and coated ends

LARGE VARIETY SINGLE CRYSTALS AVAILABLE

LATEST IN SINGLE CRYSTALS...
- Lithium Niobate
- Potassium Tantalum Niobate
- Tantalum Pentoxide
- Barium Titanate
- Beryllium Oxide
- Spinel (MgO • AL2O3)
- Tantalum Pentoxide (also MgO • 3AL2O3)

For literature write Dept. EL-1

semi-elements, inc.
Saxonburg Blvd., Saxonburg, Pa. 16056
Phone: 412-352-1548

Circle 212 on reader service card

PACKAGE INSURANCE
SKYDYNE sandwich construction
TRANSPORTATION/OPERATING CASES

Simple insurance to make sure that your expensive equipment gets where it’s going in operable condition. It’s a good policy to use Skydyne sandwich cases for 100% protection of your equipment against shock...vibration...dust...water...and virtually every other environmental hazard that it might encounter.

Transit and combination cases to meet MIL-T-945, MIL-T-21200, MIL-T-4734 and MIL-T-4150 can be readily assembled to meet just about every equipment configuration from the hundreds of standard components available...and without special tooling charges.


Circle 176 on reader service card

New Microwave

Two high-power, differential phase shift circulators have been introduced for L-band operation. Model CLH13 operates over the frequency range of 1.28 to 1.35 Ge. Peak power is 10 Mw. The average power, based on a 2:1 load mismatch, is 16 kw. Maximum vswr is 1.10.

The CLH14 operates between 1.29 and 1.31 Ge. With dummy loads connected to ports 3 and 4, a short circuit at port 2—the antenna port—will safely reflect 5-Mw peak and 9 kw average transmitter power into port 3. Maximum vswr is 1.10.

Both circulators have an isolation of 20 db minimum and a maximum insertion loss of 0.6 db. The 76-in. long CLH13 weighs 150 pounds. The CLH14 weighs 170 pounds and is 75 inches long.

Each of the units is fitted with WR-650 waveguides and mates with UC-418/U flanges.

Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass., 02154. [393]

Fixed attenuator pads operate to 1.2 Ge

The model FP-75 line of precision 75-ohm fixed attenuator pads is designed for operation from d-c to 1.2 Ge. The company says they provide accurate attenuation never before
COMMERCIAL PLANETARY GEARMOTOR
to 200 lb./in. continuous duty to 600 lb./in. intermittent duty

Now you can get 200 lb. in. of torque from a gearmotor only 3\(\frac{1}{2}\)" dia. x 9" long. Globe’s new Type CLC commercial planetary gearmotors are ideal for your most demanding high-torque applications. Designed for long reliable service, Type CLC gearmotors give you highest torque at lowest dollar cost. Call 513 222-3741 for application assistance.

VOLTAGE: 115 or 230 v.a.c.

FREQUENCY: 50 or 60 cps.
PHASE: 1 or 3.
OUTPUT SPEED: 17 standard speeds from 1 to 300 rpm.
Custom units also available. For information, request Bulletin CLC.
Globe Industries, Inc.
2275 Stanley Ave., Dayton, Ohio 45404, U.S.A. Tel.: 513 222-3741.

DRAMATIC REDUCTION
formerly 77"h. x 33"w. x 33"d.
now only
29\(\frac{1}{4}\)"X17\(\frac{1}{2}\)"X17\(\frac{1}{2}\"
(5 KW Audio
(Power Amplifier)

All other models similarly reduced... (but in size only)
For instance, 10 KW Model,
formerly 78"h. x 78"w. x 36"d., now only 48"h. x 34"w. x 24"d. CML Audio Power Amplifiers produce tremendous power in the smallest packages. Wide frequency range. Low distortion. Ideal for CW and pulsed operation, acoustic testing, vibration testing, plasma tubes, ion propulsion engines. Perfect for marine installations. All units with wide range of output impedance taps. Air-cooled and vapor-cooled units. Full power available into low power factor loads. Call or write today for details.

CML, Inc.
A subsidiary of Tenney Engineering, Inc.
359 Leland Avenue • Plainfield, New Jersey
(201) 754-5502 • TWX: 201-756-2064

FORK CONTACTS


IMMEDIATE DELIVERY

Write For Technical Bulletin

Methode Electronics, Inc.
7447 W. Wilson Ave. • Chicago, Illinois 60656
UNderhill 7-9600
Licensed under Elco patents.
MAGNETICALLY SHIELD YOUR COMPONENT IN SECONDS

Versatile Netic and Co-Netic Foils cut to any size or outline with ordinary scissors—wrap easily

High attenuation to weight ratio possibilities; can dramatically enhance component performance. The shields stop degradation from unpredictable magnetic fields. When grounded, they also shield electrostatically. Co-Netic and Netic shielding foils are not significantly affected by dropping, vibration or shock, and do not require periodic annealing. Foils are available in thicknesses from .002" in rolls 4", 15", and 19-3/8" wide. Extensively used in experimental evaluation and production line operations for military, commercial and industrial applications.

New Microwave

available at a 75-ohm impedance level.

The higher frequency performance is not only an asset for operating above 300 Mc, but a result is superior accuracy specifications at lower frequencies.

The FP-75 fixed pads are available at standard attenuation values of 1 db, 2 db, 3 db, 6 db, 10 db, and 20 db with attenuation accuracies of better than ±0.3 db to 500 Mc and ±0.5 db to 1 Ge. Each pad is calibrated at two frequencies, 30 Mc and 1 Ge, with the calibration recorded on the body of the attenuator. This provides convenient, easily read calibration data. The vswr of these units is held to less than 1.2:1 to 500 Mc and 1.3:1 to 1 Ge.

The fixed pads are available with BNC or TNC, male or female connectors. They are tubular in construction, measure approximately 2 in., by 1/2 in. in diameter, and weigh about 1 oz. They are priced at $12.50 each in small quantities with delivery from stock.

Texscan Corp., 51 South Koweba Lane, Indianapolis, Ind.[394]

Stripline-type triode oscillator

Model GSJ-1001 stripline triode oscillator is a new concept in oscillator design which offers conventional triode-oscillator electrical characteristics with the added advantage of a simple, small-size, lightweight, rugged package. Grid pulsed power is in excess of 0.8 kw at a frequency of 2.25 Ge. Volume is 1.5 cu in. excluding projections, and weight is 3 oz.

Terra Corp., 505 Wyoming Blvd. N.E., Albuquerque, N.M., 87112. [395]
CRAMER LIFT-LOK Stools
adjust to every worker like fine tools!

Because Cramer Lift-Lok is infinitely adjustable! Just lift the seat and stop at the most comfortable height. It takes less time than to read this sentence. Since fatigue is a critical factor in efficiency of seated workers, it makes good sense to provide tools that minimize fatigue. With Lift-Lok every worker can seek exactly his own efficient level. Available in four base types, steel, wood or plastic seats, contoured or flat, adjustable or flexible backs. To find out about the stools that qualify as production tools, write: V.P. Sales, Cramer, 625 Adams, Kansas City, Kan. 66105.

CRAMER INDUSTRIES INC. • KANSAS CITY, KANSAS
Fine seating—safety ladders—stands and related products for office, industry and institutions.

Circle 217 on reader service card

Right. Here's the world's only gas laser under $300. Another important first for Optics Technology. We've been able to design a precision laser which we can produce for only $295. It's our Model 170 AC Continuous Gas Laser.

Rounding out our complete line of quality lasers and laser products, the Model 170 offers:

- Adjustment-free, reliable operation
- A plasma tube with built-in reflectors
- No Brewster windows, or optics, to collect dust or get damaged
- Operation directly from the AC line by means of a built-in transformer, no other power supply involved
- Power over .3 milliwatts in TEM$_{00}$ mode, guaranteed
- Beam divergence less than .4 milliradians

We see great potential for the Model 170 as a basic tool in optics; for example, as an aid in aligning your apparatus. We'll be glad to send complete data. Just write $295 Laser on a postcard (with your name and address) and mail it to:

OPTICS TECHNOLOGY INC
901 California Avenue, Palo Alto, Calif. 327-8600 (Area Code 415)
In Europe, contact Optics Technology Instruments, Ghent, Belgium

Circle 179 on reader service card
The controller of a new printed-circuit-board driller is made of monolithic integrated circuits—probably the first use of IC’s in commercially available electronics production equipment.

The Model 105, numerically controlled, will automatically drill 50 or more holes per minute when programmed with punched tape, which it can prepare with an optical programer.

According to the Machine Control Corp., the monolithic circuits makes the controller small, highly reliable and easy to maintain. All the circuitry is on eight plug-in cards, two of which are interchangeable. The controller measures 7 by 14 by 24 inches and weighs 50 pounds—about half that of previous controllers. The controls are mounted at eye level and interlocked to prevent operator error.

As in most numerically controlled drillers, the boards are placed on a table that moves in the X and Y directions to bring the hole locations under drill heads that move up and down in the Z direction. These motions can be commanded by tape or manually. The depth and drilling rate are also controllable. Depth precision is 0.01 inch.

The operator prepares tapes with the optical programer. The drills follow the hole pattern in a photographic transparency of the hole pattern. At each hole location, the coordinates of the location are punched into the tape.

Four boards can be drilled simultaneously, with hole location repeatable to 0.0002 inch. This means that the drilled hole in the fourth board will be within 0.0006 inch of the position in the first board, Each of the four drilling stations has two drill heads, so that drills can be changed while the machine operates.

Specifications

| Drill motors | ½ horsepower, 35,000 rpm |
| Runout       | 0.0002 inch maximum |
| Resolution   | 0.001 inch |
| Price        | $45,000 |
| Delivery     | 60 days |

Machine Control Corp., 4112 Del Rey Avenue, Venice, Calif. 90292 [401]

Ultrasonic degreaser for bench mounting

The Gibson Girl MSVR-1 ultrasonic degreaser is designed to operate either with chlorinated or fluorinated solvents, changing from one to the other with the flick of a
VERSATILE WORK HORSE
Ultrasonic Spectrum Analyzer

The LCA-1 ultrasonic spectrum analyzer monitors signals and presents a spectral display of the 50 cps to 600 Kc range. Excessive harmonic content, intermodulation distortion, Loran C checkout, vibration analysis, medical research studies, multiplex voice and teletype monitoring are some of its many uses.

EXCLUSIVE FEATURES INCLUDE:
Input Zo — balanced input 55K or unbalanced
Amplitude Scale — Linear, 40 dB, 60 dB, 2.5 dB on screen calibration.
Power In — 105-125 VAC, 47 to 430 cps, no line volt. regulator required.

OTHER FEATURES:
Freq. Markers — 10 Kc and 100 Kc plus harmonic Xtal marks every 10 Kc.
Scanning Rate — 30 sec — 60 cps
Sweep Width — 1 Kc to 200 Kc.
Resolution — 50 cps to 4 Kc.
Full Scale Volt. Range — 200 uv to 200 V.

WORLD'S LARGEST ELECTRONIC KIT CATALOG...FREE!

- Laboratory & Test Instruments
- Malmstadt-Enke Laboratory Educational & Research Instrumentation
- Radio-TV Repair Instruments
- World's Largest Selection Of Amateur Radio Equipment
- Citizens Band Radio Equipment
- Color And Black & White TV
- Stereo Hi-Fi Equipment
- Electronic Organs
- Marine Electronics
- Instrumentation For Biology & Physiology

Heath Company, Dept. 67-2
Benton Harbor, Michigan 49022
Please send FREE 1966 Heathkit Catalog.

Name ___________________ 
(Please Print)
Address ___________________ 
City ___________ State _____ Zip ___________

It's new from IMC

How fast do you need a step servo motor?

1 millisecond fast; day after tomorrow fast? That's what's new from IMC—The first factory stocked broad line of step-servo motors. 18 models including a unit capable of one thousand pulse per second operation—bi-directionally. And all for day after tomorrow delivery. Sizes from 5 to 20. Running torque up to 6 oz. in. Step angles of 15 and 90 degrees. And proven capability on programs such as Polaris, Surveyor, Mariner and LEM. Included in the stock program are units designed for business machine and commercial applications.

Call your nearest IMC Engineering Representative or use the coupon for IMC's latest literature which will include our line of stock step-servo motor electronic controllers. Better still, test us with a fast order!

Check IMC also for: Precision Solenoids—factory stocked!

ENGINEERING REPRESENTATIVES FOR IMC STEP SERVO MOTORS

(Not to mention solenoids, synchros and resolvers, DC synchro indicators)

Albuquerque: J. F. Quirk & Assoc., 256-0864
Dallas: Hillman Enterprises, Inc., LA 1-2070
Georgetown, Tex.: Hillman Enterprises, Inc., UN 3-7390
Los Allos, Calif.: Richard Strassner Co., 949-334
Portland: Shaffer & Nelson, Inc., 234-7437
Salt Lake City: Oscar Saline & Assoc., Inc., AM 2-2349
Seattle: Shaffer & Nelson, Inc., MU 2-6189
Chicago: Berndt & Klein Assoc., SP 3-3468
Dayton: Bek Assoc., Inc., CR 8-1343
Kansas City: Design & Sales Eng. Co., PA 1-6403
Minneapolis: D. A. Schultz Co., FE 9-7011
St. Louis: Design & Sales Eng. Co., PA 1-6403
Atlanta: Bill Henry Assoc., 259-6290
Charlotte, N. C.: Bill Henry Assoc., 375-9658
Sarasota: Bill Henry Assoc., 955-4637
Binghamton, N. Y.: Engineering Components, RA 3-4197
New Haven: Edcom, Inc., MA 4-7919
Newtonville, Mass.: Edcom, Inc., WO 9-9710
Ottawa, Ontario: M. J. Howard Co., Ltd., PA 8-2991
Philadelphia: Burgin-Kreh Assoc., Inc., OR 7-1646
Syracuse, N. Y.: Engineering Components, HE 7-6181
Towson, Md.: Burgin-Kreh Assoc., Inc., VA 5-3212
Westwood, N. J.: Clarfield-Stollmack Assoc., 965-8989

Manufactured by IMC Western Div., 6058 Walker Ave., Maywood, Calif. 90270. Tel. (213) LU 3-8785, TWX 213-773-5307.

Send my Step Servo Motor Catalog, fast
Send a Rep., faster
And/or tell me about ___________________

Name ___________________ 
Title or dept. ___________________
Company ___________________
Address ___________________
City ___________ State _____ Zip Code _____

Circle 220 on reader service card
“One cannot continually disappoint a Continent.”

We have designed, constructed, and installed antenna and tower systems in North America, South America, Europe, Asia, Africa, Antarctica. We wish someone from Australia would call us.

ENGRAVE EVERYTHING FROM 6 FT. PANELS TO TINY NAMEPLATES

Tracer-guided arm guides the worker — makes everyone a skilled engraver.

Convenient — It’s right in the plant when and where you need it.

Accurate — Positive depth of cut with automatic depth regulator. 15 accurate ratios.

Speedy — Self-centering work holder cuts set-up time in half.

Ask for complete, illustrated catalog EE-14

new hermes engraving machine corp.

154 WEST 14th ST., NEW YORK 11, N. Y. Chicago, Atlanta, Dallas, Los Angeles, Montreal

Production Equipment

selector switch. Ful-Wall cooling is provided to minimize the loss of solvent. The dual heating system changes the heat density as well as the temperature setting necessary for each type of solvent.

The Gibson Girl degreaser is designed for bench mounting, and the generator and the control station are remotely located. A model is available for easy transporting, and the generator fits snugly into the Ful-Wall cooling jacket for packing and carrying.

The MSG 90 generator operates at 40 kc, the most effective cleaning frequency for small precision components and assemblies, and has automatic sonic control providing the most even cavitation pattern, and high cleaning efficiency.

Units are available from stock to one week.

Multisonic Corp., 1100 Shames Drive, Westbury, L.I., N. Y. [402]

Crimping press cuts wiring cost

An air-operated crimping press now on the market lowers installing wiring cost by automatically feeding up to 1,500 tape-mounted solderless terminals an hour. Tape automatically positions and loads the terminal barrel in crimping dies, and holds each terminal securely for hazardless, fool-proof wire insertion.

Changed in seconds, dies crimp any of 5 terminal tongue types and
Spray etchers feature rotating work rack

Rotational spray etchers produce a fast, uniform, precise etch without patterning for chemical machining of metal parts and printed-circuit production.

A rotating work rack insures a 360° movement of each small area being etched through the spray of several nozzles. Fixed spray heads spray straight down on the work piece at a 90° angle, reducing undercutting. There is no puddling of the etchant because of the constant movement of the work rack.

The resulting etch is faster and more precise than conventional etches, with better resolution and no patterning, says the manufacturer. Speed of the rotary motion is controlled by a variable speed motor.

The new etchers have heavy wall polyvinyl chloride etching chambers of dovetailed, cemented and welded construction. The etchers also have metal parts of titanium or stainless steel, corrosion-free pumps, an electric timer with automatic reset for repeat runs, and a built-in loading and rinse station.

Seelye Plastic-Fab, Inc., 9812 James Circle So., Minneapolis, Minn. [404]

...shortest distance between problem & solution

LOCI-2 (Wang Laboratories'LOGarithmic Computing Instrument) is the most powerful desktop computer you can obtain. At its keyboard you can expand your horizons, multiply your problem-solving capabilities and penetrate straight to the answer.

Because of its revolutionary logarithmic approach to data manipulation, LOCI-2 provides an inherent, absolutely unique flexibility and simplicity of operation. For example, it can compute Ln (x) or e^x in only two keystrokes.

LOCI-2 can be readily programmed for a broad variety of complex routines, by means of pre-scored, easily-punched cards. Thus, with the appropriate card inserted in the reader, you can instantly compute and display sin (x) or cos (x) with a single keystroke. An extensive library of programs (statistical, general mathematical, etc.) is furnished free of charge to LOCI-2 purchasers.

And, best of all, LOCI-2 is always at your command. No standing in line for computer time, no complicated operating procedures, simply drop in your program card, enter variables, press RUN key and see your results immediately.

LOCI-2 prices range from $2750 to $8450. If you would like to learn more about this remarkable instrument, write for complete descriptive literature.
PRODUCE CUSTOM CABLES
WITH STANDARD PRODUCTION TECHNIQUES

No T's, Y's, forks or fingers, no special boots, no special techniques are required when you use Multiple Channel Tear- SEAL Zippertubing®. Two, three and four-channel construction is standard — additional channels are available on special order as is a cross-over feature. Unique Z-Trac closure permits easy access for modifications or repairs. If desirable, track can be permanently sealed.

Like to know more about Multiple Channel Tear-Seal Zippertubing®? Write or call:

THE Zippertubing® CO.
Main Office and Plant:
13000 S. Broadway, Los Angeles 61, Cal. • FA 1-3901
Eastern Office and Warehouse:
480 U. S. Hwy. 46, S. Hackensack, N. J. • HU 7-6261

New Materials

Fine-grain alumina casting ceramic

Ceramcast 505 is a 96% fine-grain alumina casting ceramic with use temperatures as high as 1,600°C. It is a hydraulic setting material requiring no heat to set. The material combines good dielectric strength with high thermal conductivity and low thermal expansion rate (1.4 x 10⁻⁶ in./in./°F), thus offering excellent thermal shock resistance. Since the material shrinks only 0.2% volumetrically after curing, it offers many applications as an encapsulant, coating or cement. Furthermore, Ceramcast resists oils, solvents, and all acids except hydrofluoric.

Applications for Ceramcast 505 include encapsulation of electronic components such as resistors, end-seal material for thermocouples, high-temperature furnace coatings, and potting material for r-f heating coils.

The material is available in powder form. Research quantities are offered at $25 per quart container, with delivery from stock. Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y., 10510 [406]

Thermoplastic cures without heat, pressure

A crystal-clear, thermoplastic, methyl methacrylate, called Klearmount, requires no heat or pressure for curing. Its applications include embedments, encapsulations, preparation of models, potting, coating, specimen mounting, casting, sealing and duplicating. It bonds to plexiglass with no visible parting lines. Klearmount is crystal-clear in its cured state and is rigid and tough, with high impact strength. It is said to have unusual resistance to effects of exposure, sunlight, heat and weathering.

Vernon-Benshoff Co., Inc., P.O. Box 350, Albany, N.Y., 12201. [407]

Fluorescent coating for p-c boards

Eccocoat T264F is a two-part, thixotropic epoxy coating designed particularly for printed circuit boards. In daylight it is transparent and water white; under ultraviolet light it fluoresces a bright yellow green. Inspection under UV highlights surfaces that have not been coated, thus providing a simple and rapid means for quality control.

The coating is a solventless system, so that any porosity in the laid-down film is eliminated. Its adhesion to plastics, ceramics, glass, metals and wood is excellent. Because it is thixotropic, it holds well on sharp corners to give a rounded edge. At room temperature, its useful pot life is 5 to 6 hours. It can be applied by brush, dip or spray.

Typical properties of cured film (10 mils thick) are: Shore D hardness, 80; flexibility, unaffected by ½-in. bend; dielectric strength, above 300 volts/mil; volume resistivity, 10¹² ohm-cm; dielectric constant (60 to 10¹⁰ cps), approximately 3.0; dissipation factor (60 to 10¹⁰ cps), less than 0.02.

Eccocoat T264F is available in 2-lb kits, 1-gallon cans, and 5-gallon pails. Price is $2 to $2.25 per lb.

Emerson & Cuming, Inc., Canton, Mass. [408]
LEADING TEXTILE COMPANY ANNOTCES DEVELOPMENT OF
Disposable Dust Cloths*
*NON-WOVEN FABRIC
UNIFORMLY TREATED-HIGH CAPACITY
PLUS A HIGHLY EFFICIENT BACTERIOSTATIC AGENT

FOR SAMPLES AND INFORMATION
Chicopee Mills, Inc.
1450 BROADWAY, N.Y. 10018

YOUR SHORTEST ROUTE
to what's new in
Semiconductor Coolers
WAKEFIELD DISTRIBUTOR
PRODUCTS CATALOG

The latest designs in Heat Sinks are as near as your nearby authorized WAKEFIELD Electronic Distributor. His name is in our catalog along with the full line he stocks: milliwatt to high power coolers, circuit board coolers, extrusions, thermal joint compound, DELTA BOND 152 Thermally Conductive Adhesive.

FOR YOUR COPY, WRITE

WAKEFIELD ENGINEERING, INC.
139 FOUNDRY ST. / WAKEFIELD, MASS. (617) 245-5900 • TWX 617-245-9213

We now offer 40 different micro manipulators for single or multiple test stations—in various designs and with various sensitivities.
NEW ZELTEX AMPLIFIER WITH FETS!
- New, Smaller Package
- Lower Cost
- Improved Performance

More FET amplifier news from Zeltex—true economy with the industry's most outstanding performance! Featuring exceptionally high differential and common mode input impedance with low current, this new Zeltex amplifier utilizes silicon transistors throughout for utmost reliability. Where performance, cost and size are important, the Model 132 offers the industry's best from the industry's leader!

Check these key specifications:
- Input Current: 100 picoamp
- Voltage Gain: 100,000
- Voltage Drift: 20 µvolt/°C
- Input Impedance: 10,000 meg
- Slew Rate: 10 v/µsec

Also available in a 0.4 in. high enclosure, this remarkable new Zeltex FET Amplifier is available virtually from stock. For complete information, write or phone today.

ZELTEX, INC.
1000 Chalomar Road, Concord, California
Phone: (415) 686-6660

The broadest spectrum of Amplifiers and Computer Elements

DELAYS
FROM 10 TO 10,000 μS

DELTIME MAGNETOSTRICTIVE DELAY LINES
Deltime, with over a decade of experience in precision magnetostRICTIVE delay line technology, offers models to fill virtually every delay requirement. Complete input-output circuit modules for carrier and RZ or NRZ digital systems... torsional, longitudinal, tapped and adjustable models as well as high vibration and shock withstandinG delay lines for airborne applications are included in the standard line.

If your application requires a signal delay or extremely economical delay line memory element, contact us, our application engineers are at your service... or write for our complete technical catalog.
New Books

Tube design
Power Travelling-Wave Tubes
J.F. Gittins
American Elsevier Publishing Co.
276 pp., $10

Not since J. R. Pierce's classic work "Traveling Wave Tubes," published in 1950, has a book dealt exclusively with these high-power devices. Nearly all aspects of traveling-wave tubes are discussed, including slow-wave circuits, electron beams and guns, collectors, windows, severs (intentional breaks in the circuit) and attenuators, construction techniques and measurements. However, klystron-twt hybrid tubes, which are certainly power traveling-wave tubes, are not discussed. This is a major omission.

The book addresses itself to the engineer designing traveling-wave tubes. Although there is much of interest to power-tube users as well, major topics related to application such as phase characteristics, amplitude-to-phase conversion and intermodulation are not covered.

The theoretical treatment begins with an analysis of an artificial model of the traveling-wave, based on interaction at successive klystron-like gaps. The a-c beam currents and circuit voltages at the successive gaps are calculated; with these calculations the author shows through vector diagrams the relationships between current and voltage in a variety of circumstances. This analysis, although not well suited for practical calculations, illustrates many fundamental concepts of traveling-wave interaction.

The rest of the theoretical material is based upon Pierce's small-signal theory. The notation essentially conforms to that of Pierce—a major convenience, since the majority of twt literature uses this notation.

Throughout the book the emphasis is on concept and principle, not on details. Neither sample design calculations nor analysis of any specific tube design is given. However, this approach is acceptable since such calculations often make tedious reading and rarely applies to a new design problem. With its numerous references, the book is a good guide to significant technical literature on traveling-wave tubes since the early 1950's.

The organization is quite logical and reading is easy. There is a fair amount of mathematics, but the demands on the reader are modest.

A problem the author faced was in deciding what knowledge to assume on the reader's part. He decided, he says in the preface, to assume the reader is familiar with other types of vacuum tubes, but had no knowledge of traveling-wave tubes. Yet, the concept of space-charge wavelength is introduced without a word of explanation, and it is highly unlikely that anyone who is familiar with this concept is not familiar with twt's.

The author says the magnetic field required to confine a hollow beam to a specific radius is the same as that required to confine a solid beam of the same current. This is true only if potential depression due to space charge is negligible. In high-perveance hollow beams, the required magnetic field increases as the beam is made thinner.

The author also says that there is no condition in a hollow beam which corresponds to Brillouin flow, that is, uniform axial velocity. Such a condition, which reduces to Brillouin flow as the inner beam radius is reduced to zero is described by Sammel in the Proceedings of the Institute of Radio Engineers, November, 1949, p. 1252.

In discussing slow-wave structures, it is also implied that gains of about 40 decibels are the maximum attainable without multiple severs. However helix circuit tubes with stable gains of 60 db or more have been built with single severs.

In the discussion of window electron discharges, the author suggests that an r-f electric field applied normal to the window is necessary to draw electrons back to the window surface. D-c charging of window surfaces can also provide the restoring force, and vigorous multipactor discharges can take place on windows where the electric field is purely tangential to the window and does not vary along the waveguide, as is the case with a half-wave window. In the United States, at least, windows have been coated primarily to reduce secondary emission rather than to provide charge drainage.

In the section on tube techniques, no mention is made of the precautions required in handling metal stock to avoid problems due to defects in the metal known as "pipes." Also, the text implies that sprayed colloidal carbon is the usual way of making film attenuators on ceramic rods. Pyrolytic deposition of carbon films is commonly used today.

The discussion of demountable techniques displays a preference for O-ring seals. However bakeable metal gasket seals are far more satisfactory.

These criticisms are not major. The book is a worthwhile addition to the literature.

Philip M. Lally
Sperry Rand Corp.
Gainesville, Fla.

Recently published

Space Charge Conduction in Solids,

Basic Tables in Electrical Engineering,


Introduction to Semiconductor Phenomena and Devices, Lloyd P. Hunter, Addison-Wesley Publishing Co., 218 pp., $8.95

Space Communications Techniques, R.F. Filipowsky, E.I. Muchdorf, Prentice-Hall, Inc., 333 pp., $11.95


Technical Abstracts

Physics of failure
Minuteman 2, physics of failure program
Capt. J.F. Wiesner
Air Force Ballistic Systems Division
Failure mechanisms associated with thermocompression bonds in integrated circuits
G.V. Browning, L.E. Colteryahn and D.G. Cummings
Failure mechanisms associated with thermally induced mechanical stress in Minuteman devices
C.G. Jennings
Properties of plastic materials and how they relate to device failure mechanisms
S.M. Lee, J.J. Licari and A. Valles
Investigation of surface failure mechanisms in semiconductor devices by envelope ambient studies
G.V. Brandewie, P.H. Eisenberg and R.A. Meyer
Improperities and impurities in silicon associated with device surface failure mechanisms
J.E. Forrester, R.E. Harris, J.E. Meinhard and R.D. Nolder
Failure mechanisms associated with die-to-header bonds of planar transistors
J.D. Guttenplan and F.H. Stuckenberg
Design and progress contribution to inherent failure mechanisms of microminiature electronic components for Minuteman 2
A.J. Borofsky and D.C. Fleming
All authors, with the exception of Wiesner, are with the Autonetics division of North American Aviation, Inc., Anaheim, Calif.

The Air Force’s Minuteman missile programs have been prime movers in the improvement of design and reliability of electronic components. Many of the improvements in discrete components resulting from the original Minuteman program have already been applied to components used in other types of equipment.

Now, the Air Force is sponsoring a more advanced program—called the Component Quality Assurance Program—to upgrade the integrated circuits and other devices for the new Minuteman 2 system.

In this program, a physics of failure approach to reliability improvement is being added to the life testing, process controls and failure analysis techniques employed in the previous program. The objective of the physics of failure approach is to uncover and define the physical mechanisms which cause component degradation or failure so that corrective action can be taken in component design and processing.

The series of papers listed above are a preliminary report on the program, explaining its organization, goals, procedures and results to date. Among the highlights of the reports:

- Discovery of a new failure mode in semiconductor lead bonds, the interdiffusion of gold and aluminum. This subject was also reported at the Western Electronics Show and Convention [Electronics, Aug. 23, 1965, p. 46].
- Development of techniques to measure and identify stresses caused in semiconductor devices by manufacturing and test procedures. Although thermally induced stress may not cause device failure, that stress coupled with other stresses will cause device failure.
- Analysis of the plastics used to encapsulate components. For example, ammonia was found in a phenolic encapsulant for diodes; the ammonia made the diode’s reverse current erratic. In another case, resistor values rose above specification limits because of moisture passing through the plastic, setting up an electrolytic cell that corroded the resistor wire.
- Methods of analyzing gases within the sealed cases of semiconductor devices. Chemicals that corroded aluminum interconnections, such as chlorine, were found in the supposedly inert atmosphere.

Sciences of proven or suspected failure causes are identified in the papers, along with many corrective processes. Equally important, since many solutions have not yet been found, are the ways in which the failure detectives are employing electron microscopy, infrared spectroscopy and other highly precise investigative methods to seek failure mechanisms and contaminants.

Presented at the Fourth Annual Symposium on the Physics of Failures in Electronics, Rome Air Development Center and IIT Research Institute, Chicago, Nov. 16-18.

Guiding star
Sensor problems in space and interplanetary navigation
Hans D. Heyck
Aircraft Armaments Inc.
Cockeysville, Md.

Space missions near earth are controlled by networks of ground radar and radio command stations, But
Just Out!
Compact Ladder Filter from Clevite

Good Selectivity at a Practical Price

Take a close look at the newest member of Clevite's family of i-f filters. This 9-disc ceramic miniature is a rugged, lightweight device (MIL 2028) that offers excellent selectivity and stability in less than .07 cu. in. It's perfect for transistorized i-f amplifier circuitry plus many other applications requiring a fixed-tuned filter element. Stop band rejection is 50 db, center frequency tolerance is ± 3 kc. Stability: within + 0.2% for 5 years; within 0.2% from -40°C to + 85°C. Impedance (in and out) @ 27°C: 10 kc B/W 2000 ohms, 16 kc B/W and above 1000 ohms.

Following models standard (custom models on special order):  

<table>
<thead>
<tr>
<th>Model Number</th>
<th>min. @ 6db</th>
<th>max. @ 60db</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL1009-20A</td>
<td>10 kc</td>
<td>20 kc</td>
</tr>
<tr>
<td>TL1609-32A</td>
<td>16 kc</td>
<td>32 kc</td>
</tr>
<tr>
<td>TL2009-38A</td>
<td>20 kc</td>
<td>38 kc</td>
</tr>
<tr>
<td>TL3009-57A</td>
<td>30 kc</td>
<td>57 kc</td>
</tr>
<tr>
<td>TL4009-72A</td>
<td>40 kc</td>
<td>72 kc</td>
</tr>
</tbody>
</table>

*PRICES: 1 to 24—$25 ea; 25 to 99—$20 ea; 100 to 499—$17.50 ea; 500 to 1999—$15 ea; 2000 to 4999—$12.50 ea.

Send order or request for Bulletin 94021 to: Clevite Corporation, Piezoelectric Div., 232 Forbes Rd., Bedford, Ohio 44014.

*Prices subject to change without notice.

Circle 226 on reader service card

---

What happens when you insulate with HYGRADE SLEEVING?

No cracking, no corrosion, no wicking, no dielectric breakdown . . . nothing! It just sits there . . . preventing trouble the way it's supposed to. In fact, you can forget it! Isn't that what you want in insulating sleeving? Just tell us where you plan to use it, under what conditions. We'll recommend the right material. You can take our word for it . . . because we've been insulation specialists for 44 years.

HYGRADE® INSULATING SLEEVINGS

Markel HYGRADE Sleevings are constructed of carefully braided fiberglass yarn, impregnated and coated with specially formulated varnishes, vinyls, resins, or silicone rubber compounds. A wide range of types, grades and sizes meet virtually every conceivable requirement for dielectric and mechanical strength under all kinds of operating conditions . . . at continuous temperatures from -70°F to 1200°F. We'll be glad to send you specifications and Sample File on the entire HYGRADE Sleevings line. Just write. No charge or obligation.

L. FRANK MARKEL & SONS  
Since 1922  
Norristown, Pa.  
215-272-8960  
INSULATING TUBINGS & SLEEVINGS • HIGH TEMPERATURE WIRE & CABLE

*Prices subject to change without notice.

Circle 189 on reader service card
Technical Abstracts

deep-space probes do their own navigating, and like the ancient mariners, must look to the stars to guide them.

Successful space travel requires extremely precise information on a vehicle's trajectory. Six degrees of freedom must be known and controlled:
- Angular acceleration, velocity and position (or altitude) must be found in three axes: pitch, roll and yaw.
- Linear acceleration, velocity, and position also must be known in three axes: fore and aft, up and down, and left and right.

The Mariner spacecrafts, in the Venus and Mars fly-by missions, used the sun and one of the brightest stars, Canopus, as direction references. The difficulties Mariner 4 had in finding Canopus, and staying locked on, indicated the need for improved sensors.

Typical accuracies of sensors today are: direction 0.001° to 0.01°; attitude 0.1° to 0.5°; acceleration 0.001 G to 0.01 G; velocity 10 feet per second to 100 feet per second; position 1.0 to 10 miles.

The shortcoming of today's sensors and proposed equipment which may help are described.

Voltage-tapered twt's

Efficiency improvement of traveling wave tubes by step velocity and voltage tapering
O. Sauseng and W. Hant
Microwave Tube Division
Hughes Aircraft Co., Los Angeles, Calif.

The efficiency of traveling-wave tubes can be improved 50% by using velocity or voltage tapering. These corrective measures maintain synchronism between the slow space-charge-wave velocity of the beam and the phase velocity of the radio frequency wave in the tube. Velocity tapering has been used previously, but voltage tapering is a new technique. Efficiencies ranging from 37% to 56% have been measured on a tube that under standard conditions has a corresponding efficiency of only 26% to 40%. A one-dimensional, large-

signal model of the twt was used for a computer analysis of the velocity and voltage schemes.

In a conventional twt, the kinetic energy of the electron beam is converted to radio-frequency power by the interaction between the electrons and the r-f field that occurs in resonant cavities located along the tube. Under large-signal conditions, the loss in kinetic energy slows down the beam velocity. This results in a loss of synchronism, which causes the tube to saturate. To maintain synchronism, either the beam must be reaccelerated or the phase velocity of the r-f wave must be decreased.

In velocity tapering, the phase velocity of the r-f wave is reduced at the output end of the tube by decreasing the period of the coupled cavity circuit. Two abrupt changes in the period reduced the phase velocity to nearly 50% of its original value. The efficiency was 37%, as compared with an efficiency of 26% for the untapered tube.

In voltage tapering, the electrode beam is reaccelerated at the output section of the tube by providing an abrupt change in voltage level. A 50% increase in the voltage produced a velocity change that was 20% of the original beam velocity.

In depressed collector operation, in which the collector voltage is reduced below the beam acceleration voltage to produce enhanced beam bunching, the efficiency with the velocity taper was 50%; with the voltage taper, 56%. This compares with 40% efficiency obtained with an untapered circuit.

The computer predicted and experiments verified that efficiency was improved when the circuit voltage was lowered considerably below the voltage for maximum small-signal gain. This had been unexpected, because the efficiency of conventional twt's reaches an optimum when the circuit voltage is increased above the voltage for maximum small-signal gain. In small-signal theory, this unusual result corresponds to a very strong coupling of the circuit wave to the fast space-charge wave of the beam, rather than the slow space-charge wave.

EMPLOYMENT

QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information. The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL. Your Qualification Form will be handled as "Strictly Confidential" by Electronics. Our processing system is such that your form will be forwarded within 24 hours to the proper executive in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO. (1.) Review the positions in the advertisements. (2.) Select those for which you qualify. (3.) Notice the key numbers. (4.) Circle the corresponding key number below the Qualification Form. (5.) Fill out the form completely. Please print clearly. (6.) Mail to: Classified Advertisement Department, Electronics, Box 12, N. Y. 10036.

COMPANY PAGE # KEY #

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>PAGE #</th>
<th>KEY #</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOMIC ENERGY OF CANADA LTD.</td>
<td>192</td>
<td>1</td>
</tr>
<tr>
<td>ATOMIC PERSONNEL INC.</td>
<td>192</td>
<td>2</td>
</tr>
<tr>
<td>BAUSCH &amp; LOMB</td>
<td>191</td>
<td>3</td>
</tr>
<tr>
<td>BOOZ-ALLEN APPLIED RESEARCH IN</td>
<td>184</td>
<td>4</td>
</tr>
<tr>
<td>ELDORADO ELECTRONICS</td>
<td>192</td>
<td>5</td>
</tr>
<tr>
<td>ELECTRONIC COMMUNICATIONS INC.</td>
<td>192</td>
<td>6</td>
</tr>
<tr>
<td>GENERAL TELEPHONE &amp; ELECTRONICS LAB</td>
<td>183</td>
<td>7</td>
</tr>
<tr>
<td>LOCKHEED-CALIFORNIA CO.</td>
<td>161</td>
<td>8</td>
</tr>
<tr>
<td>SPACE GENERAL CORP.</td>
<td>191</td>
<td>9</td>
</tr>
<tr>
<td>TRW SYSTEMS</td>
<td>130</td>
<td>10</td>
</tr>
<tr>
<td>ATOMIC ENERGY OF CANADA LTD.</td>
<td>192</td>
<td>1</td>
</tr>
<tr>
<td>ATOMIC PERSONNEL INC.</td>
<td>192</td>
<td>2</td>
</tr>
<tr>
<td>BAUSCH &amp; LOMB</td>
<td>191</td>
<td>3</td>
</tr>
<tr>
<td>BOOZ-ALLEN APPLIED RESEARCH IN</td>
<td>184</td>
<td>4</td>
</tr>
<tr>
<td>ELDORADO ELECTRONICS</td>
<td>192</td>
<td>5</td>
</tr>
<tr>
<td>ELECTRONIC COMMUNICATIONS INC.</td>
<td>192</td>
<td>6</td>
</tr>
<tr>
<td>GENERAL TELEPHONE &amp; ELECTRONICS LAB</td>
<td>183</td>
<td>7</td>
</tr>
<tr>
<td>LOCKHEED-CALIFORNIA CO.</td>
<td>161</td>
<td>8</td>
</tr>
<tr>
<td>SPACE GENERAL CORP.</td>
<td>191</td>
<td>9</td>
</tr>
<tr>
<td>TRW SYSTEMS</td>
<td>130</td>
<td>10</td>
</tr>
</tbody>
</table>

Bausch & Lomb has openings for ELECTRONIC ENGINEERS

B.S. or M.S. with one to five years experience in the design of analog and digital circuits and systems. Good theoretical background in math, physics and network analyses desirable. Experience in control systems and low signal level circuit techniques helpful. Projects involve development of sophisticated instruments in biomedical, chemical, optical and electronic fields at the applied research stage.

Please send resume in confidence, including salary requirements to: E. J. Walter, Employment Specialist, Bausch & Lomb, 620 St. Paul St., Rochester, N. Y. 14602.

An Equal Opportunity Employer
2 REASONS WHY THERE'S MORE ENGINEERING OPPORTUNITY AT ECI

Where there's engineering excitement there's engineering opportunity. Two key indicators — prime contracts in progress and R&D work in progress — prove that exciting things are happening at Electronic Communications, Inc. ECI has generated these remarkable activity increases by building a solid, successful reputation in airborne systems, multiplexing, space instrumentation and other areas of military and aerospace communication. You can get aboard this upward trend immediately if you are qualified in:

RF ENGINEERING — aggressive new programs are now under way in the design and development of microcircuit transmitters and receivers. Positions require at least a BS degree, with a minimum of three years experience, and sound knowledge of transmitter and receiver design theory.

SPACE INSTRUMENTATION PROJECT ENGINEERING — you'll need in-depth technical ability, plus six years experience in data handling, control or analog instrumentation.

THIN-FILM CIRCUIT DESIGN — involving theory and application of thermodynamics, mechanics of materials and electronic component design in the development of microelectronic circuitry. BS or MS in EE or physics required.

SYSTEMS INTEGRATION — you must be thoroughly grounded in airborne electrical systems and be familiar with interface problems involved in installation of airborne communications equipment. Prior systems integration or field installation experience is most desirable.

If you are qualified, send your resume, in confidence, to Duane Meyer, ECI, Box 12248E, St. Petersburg, Fla., or call him collect at (813) 347-1121. (An equal opportunity employer.)

ELECTRONIC COMMUNICATIONS, INC.
ST. PETERSBURG, FLORIDA
SCR 584 AUTOMATIC TRACKING RADARS

360 degree azimuth, 210 degree elevation sweep with better than 1 null accuracy. Missile velocity acceleration and steering data with better than 0.01% accuracy and 0.05% false nulls. Will handle up to 20 ft. dishes. Supplied complete with control center, missile tracking, tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

E-4 FIRE CONTROL SYSTEM

Higher Quality—Lower Cost

WE BUY COMPLETE INVENTORIES

to 250 kw RF package. 25 kw to 400 mc. Includes 5944 hydrogen thruster. Input 120/240 vac 60 cycle. Complete with high voltage power supply.

MIT MODEL 3 PULSER

Output: 57 kw (12 kw at 12 amp.) Duty ratio: .90. Pulse duration: 1.2 to 2 microsec. Input: 115 v to 2080 vac 24 volt. $375 each. Full description in 5 MIT Ind. Lab. series, pp. 140. 250kw HARD TUBE PULSER

Output: 15 kw at 30 amp. Pulse: Can be used. Output: 120/240 vac 60 cycle. $1200 each. 5949 THYRATRON AGING RACK

Our 584 s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, analog tracking, digital tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

MICROWAVE SYSTEMS

EQUIPMENT FOR SALE?

We buy complete inventories of electronic equipment—systems, parts, and accessories. We pay cash. Ask us about our complete system and parts purchase program.

COLUMBIA ELECTRONICS—Dept E

1236 Market St., San Francisco, Calif.

Phone: Underhill 3-1215

CIRCLE 959 ON READER SERVICE CARD

ACQUIRING NEW ITEMS

We build, buy, and sell. Complete system and parts purchase program.

COLUMBIA ELECTRONICS—Dept E

1236 Market St., San Francisco, Calif.

Phone: Underhill 3-1215

CIRCLE 959 ON READER SERVICE CARD

AUTOTRACK ANTENNA MOUNT

SCR 584 AUTOMATIC TRACKING RADARS

360 degree azimuth, 210 degree elevation sweep with better than 1 null accuracy. Missile velocity acceleration and steering data with better than 0.01% accuracy and 0.05% false nulls. Will handle up to 20 ft. dishes. Supplied complete with control center, missile tracking, tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

AN/GPG-1

SKYSWEP TRACKER

2 kw automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

PULSE MODULATORS

MIT MODEL 9 PULSER

1 MEGAWATT—HARD TUBE


MIT MODEL 3 PULSER

Output: 57 kw (12 kw at 12 amp.) Duty ratio: .90. Pulse duration: 1.2 to 2 microsec. Input: 115 v to 2080 vac 24 volt. $375 each. Full description in 5 MIT Ind. Lab. series, pp. 140. 250kw HARD TUBE PULSER

Output: 15 kw at 30 amp. Pulse: Can be used. Output: 120/240 vac 60 cycle. $1200 each. 5949 THYRATRON AGING RACK

Our 584 s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, analog tracking, digital tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

MICROWAVE SYSTEMS

E-4 FIRE CONTROL SYSTEM

Higher Quality—Lower Cost

WE BUY COMPLETE INVENTORIES

to 250 kw RF package. 25 kw to 400 mc. Includes 5944 hydrogen thruster. Input 120/240 vac 60 cycle. Complete with high voltage power supply.

MIT MODEL 3 PULSER

Output: 57 kw (12 kw at 12 amp.) Duty ratio: .90. Pulse duration: 1.2 to 2 microsec. Input: 115 v to 2080 vac 24 volt. $375 each. Full description in 5 MIT Ind. Lab. series, pp. 140. 250kw HARD TUBE PULSER

Output: 15 kw at 30 amp. Pulse: Can be used. Output: 120/240 vac 60 cycle. $1200 each. 5949 THYRATRON AGING RACK

Our 584 s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, analog tracking, digital tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

MICROWAVE SYSTEMS

E-4 FIRE CONTROL SYSTEM

Higher Quality—Lower Cost

WE BUY COMPLETE INVENTORIES

to 250 kw RF package. 25 kw to 400 mc. Includes 5944 hydrogen thruster. Input 120/240 vac 60 cycle. Complete with high voltage power supply.

MIT MODEL 3 PULSER

Output: 57 kw (12 kw at 12 amp.) Duty ratio: .90. Pulse duration: 1.2 to 2 microsec. Input: 115 v to 2080 vac 24 volt. $375 each. Full description in 5 MIT Ind. Lab. series, pp. 140. 250kw HARD TUBE PULSER

Output: 15 kw at 30 amp. Pulse: Can be used. Output: 120/240 vac 60 cycle. $1200 each. 5949 THYRATRON AGING RACK

Our 584 s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, analog tracking, digital tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

MICROWAVE SYSTEMS

E-4 FIRE CONTROL SYSTEM

Higher Quality—Lower Cost

WE BUY COMPLETE INVENTORIES

to 250 kw RF package. 25 kw to 400 mc. Includes 5944 hydrogen thruster. Input 120/240 vac 60 cycle. Complete with high voltage power supply.

MIT MODEL 3 PULSER

Output: 57 kw (12 kw at 12 amp.) Duty ratio: .90. Pulse duration: 1.2 to 2 microsec. Input: 115 v to 2080 vac 24 volt. $375 each. Full description in 5 MIT Ind. Lab. series, pp. 140. 250kw HARD TUBE PULSER

Output: 15 kw at 30 amp. Pulse: Can be used. Output: 120/240 vac 60 cycle. $1200 each. 5949 THYRATRON AGING RACK

Our 584 s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, analog tracking, digital tracking, and all associated electronics. Immediate delivery. For more information, call MINERVA MIL-17. SCR-284. NIKE Ajax mounts also in stock. Contact 584 automatic tracking radar system. Complete package with indicator system. Full target acquisition and automatic tracking. In stock for immediate delivery. Complete with high voltage power supply.

MICROWAVE SYSTEMS

E-4 FIRE CONTROL SYSTEM

Higher Quality—Lower Cost

WE BUY COMPLETE INVENTORIES

to 250 kw RF package. 25 kw to 400 mc. Includes 5944 hydrogen thruster. Input 120/240 vac 60 cycle. Complete with high voltage power supply.
Great editorial is something he takes to a meeting

(What a climate for selling!)
New Literature


Vswr detector. Telonic Engineering Co., 480 Mermaid St., Laguna Beach, Calif., has prepared an eight-page application bulletin containing vswr measurement techniques for broadband sweep radio frequencies. [423]

Interferometric surface testers. Carl Zeiss, Inc., 444 Fifth Ave., New York, N.Y., 10018, offers a catalog explaining the use of interferometric surface testers and illustrating practical examples of application with 15 micrographs of interference images. [424]


Vaneaxial blowers. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. Type VAX-1.5 DC vaneaxial blowers with outputs to 15 cfm at 1.3 in. H.O. 27 or 50 v d-c are described in bulletin C-5120. [425]

Fiber optics. Chicago Aerial Industries, Inc., 550 West Northwest Highway, Barrington, Ill., 60010. An illustrated two-color brochure gives a comprehensive list of fiber optics applications, and graphically explains the basic principle of fiber optics. [426]

Digital voltmeter. Trymetrix Corp., 204 Babylon Turnpike, Roosevelt, N.Y., 11575, has published a four-page, two-color folder on its series 4000 solid-state digital voltmeter. [427]

Aerospace indicators. The Bendix Corp., Montrose Division, South Montrose, Pa. Synchro, servoed and tachometer aircraft indicators are covered in catalog No. 15. [428]

Power twt amplifiers. Alto Scientific Co., Inc., 4083 Transport St., Palo Alto, Calif., has released a data sheet describing the 20-watt twt amplifiers that operate from 1.0 Gc to 12.4 Gc. [429]

Component testing. Teradyne, Inc., 87 Summer St., Boston, Mass., 02110, has available a 32-page, illustrated booklet entitled “Automatic Test Instruments For Electronic Components.” [430]

Aircraft batteries. Sonotone Corp., Elmsford, N.Y., 10523. A four-page brochure lists the firm’s nickel-cadmium batteries used in aircraft as original equipment or retrofit to aircraft. Replacement batteries are also listed. [431]

Octave filter nomograph. TT Electronics, Inc., Box 180, Culver City, Calif., 90231. A nomograph for octave filter arrays gives center frequencies for 2 to 20 channels spaced with equal frequency ratios within the octave. A method for determining frequencies in the octave below the reference frequency is included. [432]

Communications amplifiers. Sierra Electronic Operation of C&E division, philco Corp., 3885 Bohannon Drive, Menlo Park, Calif., 94025, has available brochure PM-109 describing a line of amplifiers designed for wideband data transmission and scatter communications. [433]

Infrared ovens. Infra-Red Systems, Inc., Route 23, Riverdale, N.J., has released a bulletin on a line of infrared ovens that give fast heat and close control in the curing of protective coatings for p-c boards. [434]

Continuous-wave generator. James Electronics, Inc., 4050 N. Rockwell St., Chicago, Ill., 60618, announces data sheet F-3851 on a new continuous-wave generator for ultrasonic testing systems. [435]

Varactor diodes. Amperex Electronic Corp., Hicksville, N.Y., 11802, has published an application report outlining a course in varactor diode theory and applications for communications design engineers. Copies may be obtained by writing on company letterhead.

Instrument rectifiers. Eddal Industries, Inc., 4 Short Beach Road, East Haven, Conn., 06512. Bulletin 102 describes a full line of copper oxide instrument rectifiers. [436]

When a capacitor failure means the failure of an entire system, you can't afford to take chances!

**Why the first thing you learned about capacitors is still the most important thing you can know about them.**

You remember the Leyden jar, the classic capacitor. Made of glass.
The Leyden jar is two centuries old. So is man's recognition of glass as the ideal dielectric.
You can boil glass, freeze glass, bury glass, drown glass, irradiate glass—and its dielectric properties won't change measurably.
You know how a glass capacitor will behave. Classically. According to the book.
In 1965, CORNING® glass capacitors give you this classically predictable performance, backed up by stability and reliability data that is unequalled.
Why settle for less than the predictable performance that's your with CORNING glass capacitors. Millions have performed without failure on Titan, Surveyor, Syncom, Apollo, Mariner, Gemini, and Minuteman.
Specify CORNING glass capacitors and tuned circuits stay tuned, RC time constants stay constant, coupled circuits stay coupled, decoupled circuits stay decoupled, phase shifters stay fixed. There's none better for high-frequency applications.

Send to Corning Glass Works, 3913 Electronics Dr., Raleigh, N.C., for complete technical data on CORNING glass capacitors, or ask your Corning distributor.

CORNING ELECTRONICS
Soviet Union

Scuttling Secam?
Are the Russians losing their enthusiasm for Secam? Their proposed improvement for the French sequence-and-memory approach to color television stirred that speculation last month. The Soviet version, called NIR, is closer to PAL (phase-alternation line)—the rival system developed in West Germany—than to Secam.

France has rejected NIR. But the suggestion from Moscow prompted international observers to wonder whether Secam’s principal ally outside France might be considering defecting. Without Soviet support, Secam probably would lose even its underdog chance of adoption as Europe’s color-tv standard. The Russians have not said whether they will continue to support Secam or insist on NIR.

Secam’s rivals are PAL and the United States system, called NTSC for National Television Standards Committee.

Strange ally. Coming from an ally, the Soviet proposals are strange indeed. They would:

- Scuttle Secam’s biggest difference with its rivals: its form of modulation. Secam frequency-modulates the subcarrier with color information, but NIR transmits its color information as amplitude- and phase-modulated signals—the same quadrature modulation used by PAL and NTSC.
- Appear to offer no improvement over PAL. NIR would have the same control over differential phase distortion as is inherent in PAL, but apparently the Russian approach requires somewhat more complicated circuitry at both the transmitting and receiving ends. Furthermore, an expensive delay line is mandatory in NIR receivers but optional in PAL [Electronics, Jan. 10, p. 239].
- Offer no evidence that the system really works. The Russians have shown only diagrams; they have not said whether they have been able to design the coding and decoding circuits needed for NIR. Nor does NIR seem to have been field-tested, a time-consuming procedure that might well prevent fulfillment of Moscow’s pledge to introduce color tv in 1967, in time for the 50th anniversary of the Russian Revolution.

PALward shift. Why have the Russians proposed this shift toward PAL and NTSC? Their changes would eliminate two potential faults in Secam, both caused by frequency-modulating the subcarrier with color information. The faults, which may have shown up in field tests, are:

- A loss of color from the picture in weak signal areas, resulting in white streaks called silverfish.
- Lack of compatibility with black-and-white receivers, causing an objectionable dot pattern on monochromatic screens.

Comparison. In NTSC and PAL, red and blue color information quadrature-modulates the color subcarrier so that the final color signal, added to the black-and-white luminance information, is in the form \( C \sin(\omega t + \theta) \), where the amplitude \( C \) contains the color-saturation information and the phase \( \theta \) contains hue information, and \( \omega \) is the frequency of the color subcarrier. (Pink and red are the same hue, but red has a higher saturation.)

This signal is recovered in the receiver by impressing it with a locally generated subcarrier, which must be kept in perfect phase synchronization with the color signal to recover the correct hue. In NTSC and PAL, a reference subcarrier burst is transmitted between the lines of picture information to synchronize the local oscillator.

However, because of nonlinearities in recording, transmission and receiving equipment, instantaneous differences in phase between the color signal and the local subcarrier cause differential phase distortion.

PAL eliminates this distortion by
reversing the phase of the signal every line, so that phase errors cancel out every two lines. NIR prevents the introduction of phase errors during demodulation by making up its signal in such a way that there is no need for a demodulator or local oscillator in the receiver. NIR, like PAL, does this by alternating the form of the color information from line to line. On one line, the color signal transmitted is in the form $\sqrt{C} \sin (\omega t + \theta)$—the same as in NTSC and PAL except that the amplitude is the square root of the saturation. On the next line, the NIR signal leaves off the phase information and takes the form $\sqrt{C} \sin \omega t$.

The receiver. In the receiver, a multiplier combines the signal being transmitted with the signal transmitted during the last line—stored in a delay. The result of the multiplication is $\frac{1}{2} C \cos \theta$ plus a high-frequency component, which is filtered out. This corresponds—with some gain correction—to the blue information component $B - Y$, which can be used directly by the color picture tube.

Another multiplier, in conjunction with a 90° phase shift, results in $\frac{1}{2} C \sin \theta$, which is equal to the red information, $R - Y$. To maintain the correct polarity for the $R - Y$ component, the 90° phase shift must be positive when shifting $\sqrt{C} \sin \omega t$ and negative when shifting $\sqrt{C} \sin (\omega t + \theta)$. So NIR, like PAL, requires a switch in the receiver, synchronized to the incoming signal.

A spokesman for the Radio Corp. of America says the Russians might have trouble building circuits to code the complicated signal at the transmitting end and to shift the phase of the signal in the receiver. He points out that the phase shifter must be wideband to accept the sidebands of the color signal. Phase-shifters in NTSC and PAL receivers, in contrast, are narrowband because they shift only the single frequency of the subcarrier from the local oscillator.

---

**Japan**

**Color on demand**

A frustrating experience for a color-television set retailer is to see a couple musing over his wares—with only a black-and-white picture on the screen. One impractical solution is for the retailer to invest $100,000 in color studio equipment. But now the Sony Corp. of Japan says it has come up with a practical solution: these retailers will soon be able to keep their sets aglow not only with pretty pictures, but with full-color spot announcements advertising wares in other parts of the store—all for about $2,600.

Sony recently demonstrated its Colormat, a color-television recorder that stores as many as 40 full-color still pictures on a magnetic disk the size of a long-playing record. Pictures are recorded on three tracks as red, blue and green information signals by three heads in contact with the disk. The disk rotates at 30 revolutions per second so that the picture information needed for a complete frame—which takes 1/30 second to scan—is available in each revolution.

During playback, the red, blue and green signals are available simultaneously to produce a full-color picture on each frame. However, the three colors are recorded separately in sequence so that a simple black-and-white vidicon camera can be the source. To record pictures from color film slides, one at a time, red, blue and green filters are placed between the camera lens and the slide projector and that information is recorded in the appropriate track.

**Tentative prices.** Although Sony has not yet completed its production and marketing plans, it has carried development far enough to determine tentative prices for most of the various units making up the Colormat system. The basic recording-playback unit, with one disk and a separate f-m modulator needed for recording, will cost about $1,500. A color injector, one of which is needed for each color set in the system, will sell for about $100. Additional recording disks will cost about $40 each.

A slide projector and monochrome camera will sell for about $300. A shading amplifier, required with both cameras to correct their brightness characteristics for color use, will cost about $100. Also necessary is a color controller to adjust color balance; its price is about $600.

Pictures can also be recorded live—without using color film—with a monochrome camera and rotating color wheel controlled by a switching unit, but no price has been set for this combination.

Disk wear is negligible since very little pressure is needed to maintain good contact between the heads and the flat disk. Sony engineers say the signal-to-noise ratio is better than 50 decibels, compared with 35 db for a broadcasted NTSC color signal.

**The recording disk.** The magnetic disk—the same material used for high-quality video tape—is cemented to an aluminum ring for support. The ring has an outside diameter of 12 inches and an inside diameter of 11 inches. The
Sony's video demonstrator, shown with some of its components, records 40 full-color still pictures on a magnetic disk the size of a long-playing record and replays it through any color-television set.

Recording area is a 20-millimeter band between four and five inches from the center. At this distance from the center, the head-to-tape speed is high enough—about 900 inches per second—to produce a horizontal resolution equal to 350 vertical lines.

The radial motion of the head assembly from the first to the fortieth set of three tracks is only six millimeters—less than the 7-mm spacing between adjacent heads so that the 40 tracks of one color do not overlap the 40 tracks of another. The record-playback head assembly is indexed from one set of three tracks to the next set by a lead-screw mechanism similar to that used for positioning in machine tools. Each half turn of the 0.3-mm-pitch lead-screw places the head assembly over another set of tracks to reproduce another picture. Individual tracks are 0.1 mm wide and have a 0.15-mm center-to-center spacing.

The Colormat can be easily connected to any standard television set—either shadow mask or Chromatron. The signal from the recorder, amplified in the color injector, is connected directly to the picture tube's three grids through an adapter inserted between the picture-tube base and the tube socket. A synchronization signal from the injector is also applied to the television terminals.

Tubes are used in the color injector because of the high voltage required for picture-tube grid drive. Other units, however, are transistorized. The Colormat recorder can be used with an audio recorder to provide background music and announcements. Pictures can be changed automatically by a control signal on one track of the audio tape so that audio and video remain synchronized.

Sony hopes to market the video demonstrator in 1966, but only for professional use because it considers the system too complex and expensive for consumer use.

Sweden

Controlling nuclear power

The 140-megawatt nuclear power plant rising at Marviken, 100 miles south of Stockholm, may be the first one to be started and shut down automatically by a process computer. Full plant operation, with on-line control by a closed-loop computer made in Britain, is scheduled late in 1968.

Complete digital control of a swimming-pool reactor was claimed last year by the Tokyo Shibaura Electric Co. (Toshiba). Various degrees of computer control also have been achieved over nuclear reactors in the United States, Canada and France [Electronics, Sept. 6, 1965, p. 180].

The Swedish plant's normal operations will be controlled by the CON/PAC 4060 computer, manufactured by Associated Electrical Industries, Ltd. (AEI) under license with the General Electric Co. of England.

Alternatives. Computer programs will permit automatic operation whether the heavy water is saturated or superheated. Superheating will permit increase of the plant's capacity to 200 Mw, according to AEI. The computer can also be programmed to permit certain manual operations while the computer's output relays continue to run other operations in an open-loop mode.

The $330,000 computer system
is scheduled to be delivered May 1, 1967; software costs will be extra. Training of plant operators will begin soon with another computer, a CON/PAC 4040. The 4040 will be installed at the headquarters of ASEA, the Swedish electrical company that is building the nuclear facility. In addition to its training function, the 4040 will be used with an analog-computer simulation of the reactor process to check out systems for controlling the power plant.

Three displays. A unique feature of the Marviken installation will be three alphanumerical data displays on a cathode-ray screen. These will replace conventional indicators, alarms and annunciating equipment.

Two screens will display process variables: one will continuously monitor key variables while the other, on demand, displays other variables requested by the operator. Each display will show 30 lines of text, with the latest incoming information being shown at the bottom of the screen. The third CRT will be for alarm annunciation, data logging and for information display about research tests on the station.

The station will have one control panel for manual operation and a second for computer control.

Great Britain

Composition

Although more people are reading newspapers than ever before, the number of daily publications has been dwindling on both sides of the Atlantic because of high costs. This trend may soon be reversed in Britain, with the help of a new kind of computer system and a publisher's confidence in it.

Lord Thomson, publisher of Britain's newest daily, is so hopeful of success with computerized typesetting that he is planning similar ventures. Thompson already owns 128 newspapers—14 in Britain—and 150 trade publications.

On line. Typesetting under computer control is not new. Such systems are operating at about 90 newspapers in the United States, including the Los Angeles Times, Kansas City Star, Miami Herald and Washington Post; they are also helping to produce six papers in Britain, six in West Germany, three in the Netherlands and one in France, according to Composition Information Services of Los Angeles. In most of these systems, edited articles are translated onto punched tape to be fed into a computer. The computer justifies each line.

What is new at the four-month-old Reading Evening Post, 40 miles west of London, is its on-line time-shared computer. Each of 12 operators feeds edited articles directly into the computer by means of a keyboard, instead of punching tape, and immediately sees each line of type printed out.

The 803B computer, made by Elliott-Automation, Ltd., automatically justifies each line—adjusts the spaces between words so that the lines of type are flush left and right. If spacing alone won't do the job, because the spaces would be too narrow or too wide, the last word on the line must be hyphenated; in that case the computer alerts the operator and prints out the two extremes between which the last word can be split—with the maximum and minimum allowable spacing between words. The operator then keys in a hyphen at the appropriate place in the word. The final tape feeds a Photon 713 photo-composition machine, which sets the type.

Backtalk. Conventional computerized typesetting doesn't have this dialogue between operator and computer.

The off-line approach presents several problems, all of which are said to be overcome by the in-line method. Processing the tapes through the computer, instead of electronic signals, creates the possibility of a bottleneck or of failure in case a punch should breakdown. Also, if hyphenation is to be directed by the computer instead of by the operator, a large memory is required with a massive backup to store all the hyphen-
Economy and reliability do come in one package

AMP's full line of COAXICON* connectors give you both the low cost and the high reliability you need for your coaxial cable circuits.

Reliability comes from AMP's formidable engineering and manufacturing know-how combined with finest quality materials.

Economy comes from AMP's simplified tooling and assembly procedures.

This is one of the most comprehensive coaxial connector lines on the market and still growing. You can find just the connector you want in the Standard, Twin Standard, Miniature and Subminiature lines—including the new T and Y configuration connectors.

And no matter which size you choose, you'll get all the benefits of AMP's unusual COAXICON contact. Both the inner conductor and the outer shield of your cable are simultaneously terminated with just one precise, controlled crimp. Contacts then snap quickly and securely into housing through AMP's special retention spring.

So get the reliability you need, the economy you want for all your coaxial cable requirements . . . from AMP. Get the full story today.
Bugged by dirty power-line noises?

Keep power clean with Hopkins filters!

As a pioneer in power-line filtration Hopkins has designed and built more than 2,000 different types of filters. Used in thousands of varied applications under all operating conditions in ground installations, in secure rooms, aircraft, on board ships, HOPKINS POWER-LINE FILTERS HAVE PROVED UNSURPASSED.

Designed for easy economical space-saving installation, Hopkins power-line filters are available individually or in groups (preassembled in cabinets) for multiple-circuit applications. They are available in a choice of three basic series—each with top performance—in the frequency range needed for your circuit.

Send for complete information on Hopkins power-line filters

 Hopkins filters clean dirty lines—remove radiated and conducted interference from your power circuits. Meeting MIL-STD-220A, Hopkins Series 1960 power-line filters suppress interference more than 100 db in frequencies from 14 kc to 10 kmc.

HOPKINS Engineering Company

12900 Foothill Blvd., P. O. Box 191, San Fernando, Calif. 91341
Telephone: (213) 361-8691 • TWX 213-764-5998 • Cable: HOP

A Subsidiary of Maxson Electronics Corporation

Electronics Abroad

Savings. How effective is the Reading system? Margerison says 12 operators can set the 24-page paper in one eight-hour shift; with conventional line-casting machines, he says 24 operators would be needed. Speed is also increased by the ability of a compositor to set any of eight styles of type in four sizes without moving from his keyboard. Conventional typesetting machines require a separate operation for each change in type style or size.

The computerized installation costs about $100,000, Margerison says. The computer accounts for $34,000 of this; the rest goes for the keyboard and the printout for each operator.

Do the savings justify the expense? It’s still too early to know with certainty, Margerison says, because of other associated expenses. But he adds: “A paper using these techniques of computer-controlled tape production, phototypesetting and offset production, as does the Reading Evening Post, should be able to break even at a daily circulation of 25,000.”

Keep power clean with Hopkins filters!

Electronics Abroad
Electronics advertisers

February 7, 1966

ACI Division of Kent Corporation 171
Richard L. Renner
ADC Products Inc. 140
John Gomper & Associates

AMP Incorporated 201
Garceau, Hargrave & McCullough Inc.

API Instrument Company 14
George Z. Griswald

Acme Electric Corporation 152
Scheel Adv. Agency
Acoplan Corporation 170
Mort Barish Associates Inc.
Aerovox Corporation, Hi-Q Division 125
Jencornbaugh Advertising Inc.
Airpax Electronics Inc. 154
Welch Mibrable & Co. Inc.
Amphenol Borg Electronics Corp., Connector Division 62, 63
Marsteller Inc.

Astrodata Inc. 15
Bonfield Associates Inc.

Bausch & Lomb Inc. 47
Wolff Associates Inc.
Beckman Instrument Inc. Berkeley Division 45
Hickson & Jorgensen

Bendix Corporation, Monterey Division 122
MacNamus, John & Adams Inc.
Bendix Corporation, Semiconductor Products MacNamus, John & Adams Inc. 9

Boonton Electronics 188
Kniep Associates

Bohme Inc. 49
Allen, Dorsay & Hatfield Inc.

Brinkmann Instruments 185
The Shalter-Rubin Co. Inc.

Brush Instrument Div. of Cleve Corp. 3rd Cover
Carr Liggett Adv. Inc.
Bulova Electronics Div. of Bulova Watch Co. 156
Ted Gravenson Inc.
Burroughs Corporation 70
Continental Advertising Inc.

CML Inc. 177
Keyes, Martin & Company Inc.

CTS Corporation 132
Burton Browne Advertising

Chicago Dynmics Industries Inc. 118
Burton Browne Advertising

Chicopee Mills Inc. 185
Bert Paul Kun Advertising Agency

Chrono-Log Corporation 178
The Hill Associates Inc.

Clevite Corporation, Piezoelectric Div.
Carr Liggett Advertising Inc.
Cleveland Institute of Electronics 200
Rapp & Collins
Colorado Dept. of Development 159
Buchen Advertising Inc.

Computer Control Company 58, 59
Franklin P. Fords Inc.

Consolidated Electrodyonamics Corp. 126
Hixson & Jorgensen Inc.
Corning Electronic Company 196
Rumilly-Hoyt Company
Cramer Industries 179
Potts & Woodward Inc.

Deico Radio Company 148, 149
Campbell-Ewald Company

Dialight Corporation 168
H.J. Gold Company

DuPont de Nemours & Co. Inc. E'I. 53, 69
Botten, Barton, Durstine & Osborn Inc.

ELMAD Div. of Varian Associates 119
Hoefer, Dieterich & Brown Inc.

Electro Instruments Inc. 108
Van Der Boom McCarron Inc.

Electronic Modules Corporation 93
Ray Thompson & Associates

Erie Technological Products Inc. 153
Altmann Half Associates

Fairchild Semiconductor Corporation 12, 13, 117
Faust/Day Inc. Advertising

Ferranti Ltd. 120
Rowlinson-Broughton Ltd.

General Electric Company, Magnetic Materials 127
George R. Nelson Inc.

General Radio Company 6
K.E. Morang Company

Globe Industries Inc. 177
Odiaine Industrial Adv. Inc.

Gudebrod Bros. Silk Co. Inc. 121
Ramsdell, Buckley Company

Hansen Mfg. Co. Inc. 136
Keller-Crescent Company

Heath Company 181
Advance Advertising Services Inc.

Hewlett Packard Company 1, 36, 37, 54, 55, 102, 123
Lennen & Newell Inc.

Hewlett Packard Company, Boonton Division 151
George Homer Martin Associates

Hopkins Engineering Company 202
Philip J. Meany Company

Hughes Aircraft Company 124
Foote, Cone & Belding Inc.

High Vacuum Electronics Inc. 139
Bonfield Associates Inc.

IEEE 168
Alpahga Advertising

IMC Magnetics Corporation 181
Monad Advertising Design

IRC Inc. 20, 21
Gray & Rogers Inc.

International Rectifier Corp. 50
Willard G. Gregory & Co.

Interstate Electronics Corporation 163
Hixson & Jorgensen Inc.

Kahle Engineering Company 16
George Homer Martin Associates

Kay Electric Company 17
Josephson Cufffair Company

Kepco Inc. 22
Weiss Advertising

Krohn-Hite Corporation 162
Stern/Frank Adv. Inc.

Lambda Electronics Corporation 64, 65
Machiel Cather Inc.

Leach Corporation 18, 19
Jay Chiat & Associates

Machlett Laboratories 11
Fuller & Smith & Ross Inc.

Magnetc Shield Div. of Perfection Mica Co. 178
Burton Browne Advertising

Mallory Company, P.R. 169
Aitkin Kynott Co. Inc.

Markel & Sons L. Frank 189
George Moll Advertising Inc.

Matthews & Co. Jas. H. 165
W.S. Hill Company

McDonnell 68
John Patrick Starks Inc.

Memorex Corporation 35
Hal Lawrence Inc.

Methode Electronics Inc. 177
Burton Browne Advertising

Microvac Electronics Corporation 175
Bonfield Associates Inc.

Motorola Semiconductor Products Inc. 56, 57
Lane & Bird Adv.

New Hermes Engraving Machine Corp. 182
Doner Harrison Inc. Advertising

North Atlantic Industries Inc. 8
Murray Heyert Advertising

Optics Technology Inc. 179
Hoefer, Dieterich & Brown Inc.

Pamotor Inc. 174
The Harry P. Bridge Company

Pheps Dodge Electronic Products Corp. 160
Smith, Dorian & Burman Inc.

For more information on complete product line see advertisement in the latest Electronics Buyer's Guide.

Electronics | February 7, 1966

203
### Electronics advertisers

**February 7, 1966**

  - Grant, Schwenck & Baker Inc.
- Princeton Applied Research Corp.
  - Mort Barish Associates
- Probescope Inc.
  - Connolly Associates Inc.
- Radio Corporation of America
  - Al Paul Letton Company
  - Ted Gravenos Adv.
- Sage Electronics Corporation
- Scrivener & Company Inc.
- Sanborn Company Div. of Hewlett Packard
  - Colver Advertising Inc.
- Selectro Corporation
  - Lescourrs Adv. Inc.
- Semi-Elements
  - Cavanagh Morris Adv.
- Signetics Corporation
  - Cunningham & Walsh Inc.
- Skydine Inc.
  - Lescourrs Advertising Inc.
- Sola Electric Company
  - Klau-Yan Petersen Dunlap Inc.
- Soliton Devices Inc.
  - Haselmire Pearson Adv.
- Space Craft Inc.
  - Neals & Hickok Inc.
- Sprague Electric Company
  - The Harry P. Bridge Company
- Stackpole Carbon Company
  - Meek and Thomas Inc.
- Stanpat Products Inc.
  - Morton Advertising Inc.
- Statham Instruments Inc.
  - David Johnson Adv.
- Struthers-Dunn Inc.
  - Harry P. Bridge Co.
- Superior Tube Company
  - Gray & Rogers Inc.
- Sylvanian Electric Products Inc.
  - Tatham, Laird & Kudner Inc.
- TRW Systems
  - Fuller & Smith & Ross Inc.
- TRW Capacitors
  - Fuller & Smith & Ross Inc.
- Tektronix Inc.
  - Hugh Dwight Advertising Inc.
- Telrex Laboratories Inc.
  - George P. Martin Associates
- Texas Instrument Incorporated
  - Semiconductor Division
  - Don L. Baxter Inc.
- Thermal American Fused Quartz Company
  - Knoll Associates
- Time Wire & Cable Company
  - Mohr & Company Inc.
- Tobe Deutschmann Laboratories
  - Engineered Advertising
- Trygon Electronics
  - Conner Company Inc. The
- Trylon Inc.
  - George Molloy Adv. Inc.
- Union Carbide Linde Division
  - J.M. Mathies Inc.
- United Transformer Corporation
  - 2nd Cover
  - Philip Stiegel Company Inc.
- Victoreen Instrument Company, The
  - Palm & Patterson Inc.
- Wakefield Engineering Inc.
  - Sales Promotion Services
- Wang Laboratories Inc.
  - Larcom Randall Adv. Inc.
- Watkins-Johnson Company
  - William C. Estee Co.
- Weston Instruments
  - Arndt, Preston, Chapin Lamb & Keen Inc.
- Wood Electric Corporation
  - L.K. Frank Co. Inc.
- Zero Manufacturing Company
  - Guerin, Johnstone, Gage Inc.
- Zeltex Inc.
  - Sturges Associates
- Zigpurring Company Inc.
  - Edward S. Kellogg Company

### Classified advertising

- **Employment Opportunities**
  - Use or Surplus New
  - For Sale

### Classified advertisers index

- A & A Electronics Corp.
- Atomic Energy of Canada Ltd.
- Atomic Personnel Inc.
- Bausch & Lomb
- Columbia Electronics
- El dorado Electronics
- Electronic Communications Inc.
- Emmons Electronic Supply Co.
- Fishman Co., P.
- Mart's Mart
- Norman Electronic Sales
- Radio Research Instrument Co.
- Space General Corp.
- W.D. Contracting Engineers

- For more information on complete product line see advertisement in the latest Electronics Buyer's Guide

### Advertising sales staff

**Gordon Jones [212] 971-2210**
- Advertising sales manager

**Atlantic, Ga. 30309:**
- Gus H. Krimsier, Michael H. Miller, 1375 Peachtree St. N.E., (404) TR 6533

**Boston, Mass. 02116:**
- William S. Hodgkinson, McGraw-Hill Building, Copley Square (617) CO 2-1160

**Chicago, Ill. 60611:**
- Robert M. Denmead, J. Bradley MacKimm, 645 North Michigan Avenue, (312) MD 4-5800

**Cleveland, Ohio 44113:**
- Paul T. Fegley, 55 Public Square, (216) SU 1-7000

**Dallas, Texas 75201:**
- Richard P. Poole, The Vaughn Building, 1712 Commerce Street, (214) RI 7-9721

**Denver, Colo. 80202:**
- Joseph C. Page, David M. Watson, Tower Bldg., 1700 Broadway, (303) AL 5-2994

**Detroit, Michigan 48226:**
- Paul T. Fegley, 856 Penobscot Building (313) 962-1793

**Houston, Texas 77002:**
- Kenneth George, 2270 Humble Bldg., (713) CA 4-8381

**Los Angeles, Calif. 90017:**
- Ian C. Hill, John G. Zisch, 1125 W. 6th St., (213) HU 2-5450

**Minneapolis, Minn. 55402:**
- J. Bradley MacKimm, 1104 Northstar Center (612) 332-7425

**New York, N. Y. 10036:**
- Donald R. Firth [212] 971-3615
  - Frank LeBeau [212] 971-3615
  - George F. Werner [212] 971-3615
  - 500 Fifth Avenue

**Philadelphia, Pa. 19103:**
- William J. Boyle, Warren H. Gardner, 6 Penn Plaza Center Plaza, (215) LO 8-6161

**Pittsburgh, Pa. 15223:**
- Paul T. Fegley, 4 Gateway Center, (412) 391-1314

**Portland, Ore. 97204:**
- James T. Haught, Pacific Building, Yamhill Street, (503) CA 5-1118

**San Francisco, Calif. 94111:**
- James T. Haught, 255 California Street, (415) DO 2-4600

**London W1:**
- John W. Patten, Edwin S. Murphy Jr., 34 Dover Street, Hyde Park 1451

**Milan:**
- 1 via Baracchini
  - Phone: 86-90-617
  - 86-90-656

**Frankfurt/Main:**
- Gerd Hinske, 85 Westendstrasse Phone: 77 26 65 and 77 30 59

**Geneva:**
- Michael R. Zeynel
  - Joseph Wuenisch
  - 1, rue du Temple
  - Phone: 31 95 60

**Paris VIII: Denis Jacob, 17 Avenue Matignon ALMA-0452

**Tokyo:**
- Nobuyuki Sato, 1, Kotohira
  - Shiba, Minato Ku (502) 0656

**Osaka:**
- Ryoski Kobayashi, 163, Umeegcho-cho, Kita-ku [362] 8771

**Hugh J. Quinn:**
- [212] 971-2335

**Milton Drake:**
- [212] 971-3485

**Wallace C. Carmichael [212] 971-3191**
- Business manager

**Theodore R. Geipel:**
- [212] 971-2044
- Production manager