Electronics

Which digital voltmeter? page 84

Sensors for celestial guidance: page 94

Transistors can multiply, divide: page 109

April 4, 1966
75 cents
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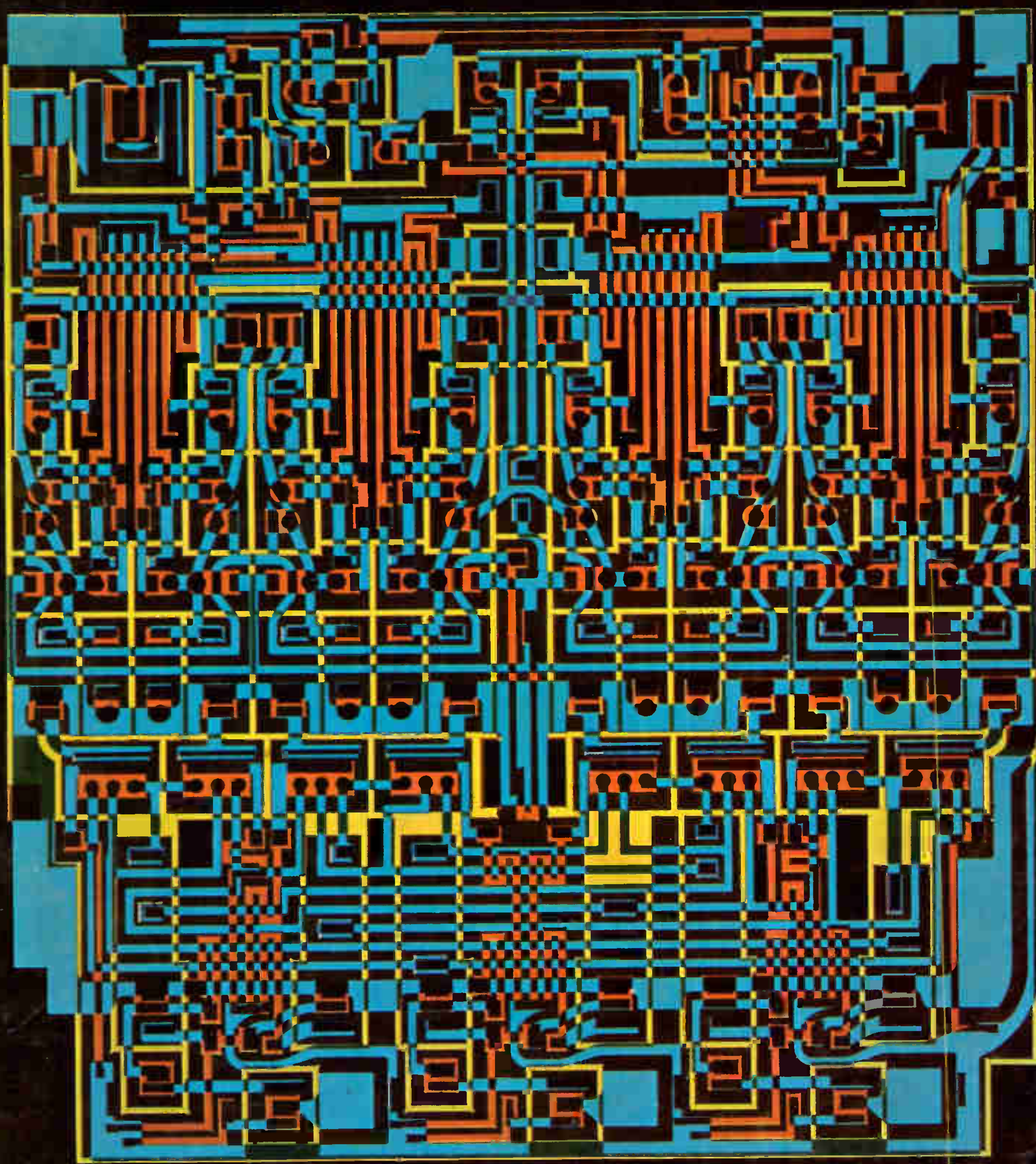
Below: Scratch-pad memory increases computer capability: page 118



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New Hewlett-Packard REVERSIBLE Counter

Here's an instrument offering all six counting modes necessary for today's laboratory and industrial measurement requirements, plus the high 2 MHz counting rate, 250 nsec reversing time, and standard features not found combined in other instruments, except, in some cases, as costly optional "extras."

With the new 5280A Reversible Counter and 5285A Universal Plug-in, you can count input channel A or B, or count A upwards or downwards, depending upon the polarity of B, at 2 MHz. Reversing time in the latter mode is 250 nsec. Or, you can count A+B, A—B, or count up or down, depending upon the phase relationship of A and B, up to 1 MHz. The latter mode is ideal for use with laser interferometers and other transducers for precision length and x-y positioning measurements.

An anti-coincidence circuit prevents loss of count if A and B arrive simultaneously in the A—B or A+B modes. Polarity switch permits reversing input signal directional sense. Trigger level controls provided (±100 volt range).

Measure such parameters as length, thickness, angular displacement, flow rate, liquid level, weight; use in such application areas as automatic process control, automatic machine tools, chemical, plastic or metal fabrication, readout of gyro test table position, intertial guidance element testing, readout of pulses in remote control or telemetering systems and comparison of frequencies.

The 5280A offers 100 mv input sensitivity, ac and dc coupling, 1 megohm input impedance, 6-digit in-line readout with ± sign, and with 7th and 8th digit available as options. Overflow of readout is indicated by a front-panel neon light. Versatile manual and remote controls are provided; four-line BCD outputs for recording and control also are standard.

Add to this the reliability and standard design features of Hewlett-Packard solid-state electronic counters, plus convenient and complete field applications assistance and service, and you have a new counter offering measuring capabilities previously unavailable in a single instrument. 5280A Reversible Counter, $1450 (plug-in required); 5285A Universal Input Plug-in, $450.

Ask your Hewlett-Packard field engineer for a demonstration or write for complete specifications to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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The design approach that made possible Sanborn true IRIG *instrumentation* performance at *lower cost* in low bandwidth tape recording is now available in intermediate band systems. Sanborn Models 3917B and 3924B 7- and 14-channel systems record and reproduce data up to 250 kc in direct mode, to 20 kc in FM mode. Pulse mode enables digital information as short as 2 μsec wide to be recorded and reproduced. *A complete 6-speed system ready for direct recording/reproducing costs $9966 for 7 channels, $15,977 for 14 channels.* (Same systems may be ordered with fewer tape speed plug-ins, at correspondingly lower costs.)

These new systems have the same improvements in performance, reliability and operating ease as the low bandwidth models, for instrumentation tape recording with complete IRIG compatibility. The tape transport, key to superior system performance, is of a rugged and simple Hewlett-Packard design which reduces costs without sacrificing uniform tape motion; six electrical speeds are pushbutton-selected (1⅞ to 60 ips) without idler or capstan change. Other standard features include provision for edge track for voice commentary, adjustable input/out levels, built-in 4-digit footage counter accurate to 99.95%, and easy snap-on reel loading. The transport needs no maintenance except occasional cleaning of the tape path.

Check the system specifications here and call the H-P Field Engineer in your locality for complete technical data and application engineering assistance. Offices in 48 U.S. and Canadian cities, and major areas overseas. Sanborn Division, Hewlett-Packard Company, Waltham, Massachusetts 02154. Europe: Hewlett-Packard S.A., 54 Route des Acacias, Geneva, Switzerland.

representative specifications

DIRECT MODE

Tape Speed	Bandwidth	Frequency Response	S/N Ratio Filtered	Minimum RMS Unfiltered
60 ips	300-250 KC	±3 db	35 db	29 db
15 ips	100-62.5 KC 300-44 KC	±3 db	32 db 38 db	27 db
1⅞ ips	50-7 KC 300-5 KC	±3 db	30 db 39 db	26 db

*Measured with bandpass filter at output with an 18 db/octave rolloff

FM MODE

Tape Speed	Bandwidth	Frequency Response	FM Center Carrier Frequency (Nominal)	S/N Ratio* Without Flutter Comp.	Total Harmonic Distortion
60 ips	0-20 KC	+0, −1db	108 KC	45 db	1.5%
15 ips	0-5 KC	+0, −1db	27.0 KC	45 db	1.5%
1⅞ ips	0-625 cps	+0, −1db	3.38 KC	40 db	1.8%

*Noise measured over full bandwidth, min. rms at zero freq. dev., with lowpass filter placed at output. Filter has 18 db/octave rolloffs.

TAPE TRANSPORT

Maximum Interchannel Time Displacement Error: ±1 microsecond at 60 IPS, between two adjacent tracks on same head.

Tape Speeds: 60, 30, 15, 7½, 3¾, 1⅞ ips standard; 0.3 to 120 ips optionally available.

Tape: 3600 feet, 1.0 mil, ½" (7 channel), 1" (14 channel).

Controls: Line (Power), Stop, Play, Reverse, Forward (fast) and Record are pushbutton relays. A receptacle at the rear of the transport is provided for remote control operation.

Drive Speed Accuracy: ±.25%.

FLUTTER

Speed	Bandwidth	Flutter (p-p)
60 ips	0-200 cps 0-10 KC	0.2 % 0.6 %
30 ips	0-200 cps 0-5 KC	0.2 % 0.8 %
15 ips	0-200 cps 0-2.5 KC	0.25% 0.6 %
7½ ips	0-200 cps 0-1.25 KC	0.5 % 0.65%
3¾ ips	0-200 cps 0-625 cps	0.5 % 0.8 %
1⅞ ips	0-200 cps 0-312 cps	0.8 % 1.2 %

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Circle 2 on reader service card

Electronics

April 4, 1966
Volume 39, Number 7

Electronics Review

Probing the News

Electronics Abroad

Technical articles

I. Design

II. Application

Electronics

Editor: Lewis H. Young

Electronics: April 4, 1966, Vol. 39, No. 7

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Readers Comment

Strip line discussion

To the Editor:

In my opinion the article, "Using strip transmission line to design microwave circuits" [Feb. 7, p. 72] contains a number of misleading ideas.

The authors state that the strip transmission line is formed by etching one side of a doubly-clad board and using pressure plates for rigidity. The Electronized Chemical Corp. of Burlington, Mass., manufactures a low-loss material, Polyguide, which can be purchased with aluminum backing adhered to the dielectric.

The authors also imply that the coupling arrangement shown on page 74 of the article is the only acceptable form. On the contrary, coplanar coupling as described is useful only for loose to moderate coupling.

The lumped-element equivalents are almost completely erroneous. The equation shown by Dangl and Steele for the characteristic impendance of strip line is useful only for $w/b < 0.35$. With center conductors etched from one- or two-ounce copper and $w/b < 0.35$, only characteristic impedances greater than 100 ohms are possible.

The authors also show a means for creating a series inductance in strip line and describe how series capacitances can be formed. An abrupt change in the width of the center conductor actually behaves as a transformer, while a transverse slit acts as a Pi-network having a series capacitance and two shunt inductances. The equation as given for the series inductance, if this simplification is to be used, should read:

$$\frac{X_L}{Z_{o2}} = \left[\frac{2W_2 + (4b/\pi)\ln 2}{\lambda}\right] \ln \csc\left(\frac{\pi}{2}\,\frac{Z_{o2}}{Z_{o1}}\right).$$

Steven March
HRB-Singer, Inc.
State College, Pa.

■ **The authors reply:**

The authors are indebted to Mr.

New Bridge Design For Safe, Accurate, Easy Measurement of 'Lytic Capacitors

The Sprague Model 1W2A Capacitance Bridge introduces new, improved technical refinements as well as restyling for added attractiveness and ease of operation. Built *by* capacitor engineers *for* capacitor users, it incorporates the best features of bridges used for many years in Sprague laboratories and production facilities.

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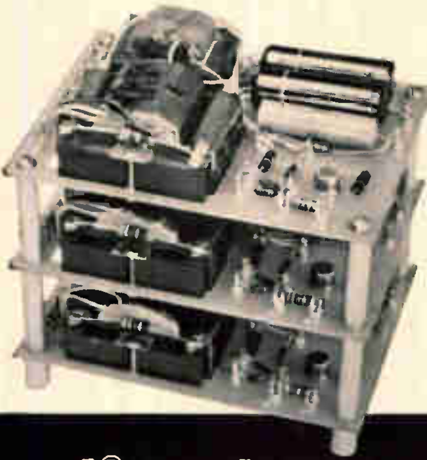
The model 1W2A Capacitance Bridge will not cause degradation or failure in electrolytic or low-voltage ceramic capacitors during test, as is the case in many conventional bridges and test circuits. The 120 cycle A-C voltage, applied to capacitors under test from a built-in source, never exceeds *0.5 volt!* It is usually unnecessary to apply d-c polarizing voltage to electrolytic capacitors because of this safe, low voltage.

Complete Specifications Available

For complete technical data on this precision instrument, write for Engineering Bulletin 90,010A to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

4SSP-128-83

New from Sprague!



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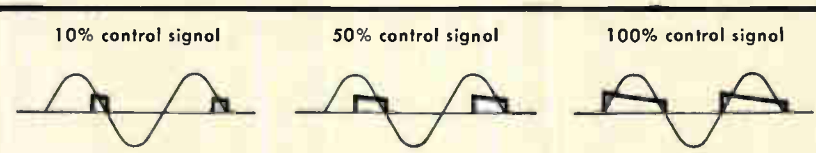
- Available in half-wave or full-wave designs—Series VS6532 produces one gate pulse per cycle per phase, while Series VS6732 provides two isolated gate pulses per card for a total of six gate pulses per cycle.



Gate Pulse Phase Shifting as Control Signal is Applied

For complete technical data, write for Engineering Bulletin 85525 to the Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01248.

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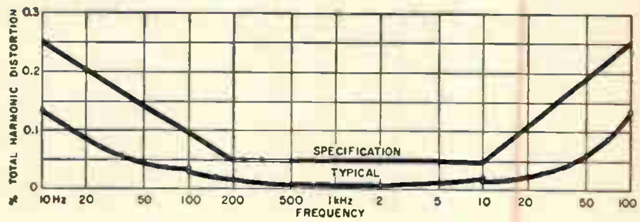

Type 1309-A Oscillator, 10 Hz to 100 kHz, $325 in U.S.A.

Excellent Output Characteristics: Waveform purity is unmatched by that of any other oscillator in this price class. Hum is only 0.001% of full output. Open-circuit output is 5 V and is typically constant to 0.5%; guaranteed to be constant within ±2% over the entire frequency range. Amplitude stability is ±0.2% per hour, typically.

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Square Waves as well as Sine Waves: Symmetrical positive-going square waves with typical rise times of 40 ns into 50 Ω are also available. Output is greater than 5 V, p-to-p, and is dc coupled, so the waveform is flat-topped, even down to 10 Hz.

Synchronization, a unique feature: This oscillator can be synchronized to an external signal, or it can furnish a sync signal to other equipment. The sync output is greater than 1.5 V, open-circuit, behind 12 kΩ and is in phase with the primary output. A small sync-input voltage will effectively phase-lock the instrument; one volt, for example, provides a ± 3% locking range (2 volts provide 6% locking range, etc).

Other Oscillators in this New Series:

Type 1310-A
with 2-Hz to 2-MHz range and 20-volt, open-circuit output . . . **$295** in U.S.A.

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March for pointing out the obvious omission in the equation for series inductance.

But we disagree with his comments about material with adhering aluminum backing. It is the experience of the authors that final production designs often incorporate such items as mounting bosses, line stretchers, and isolators in the backing plate structure. In these cases, the separately fabricated pressure plates serve a dual purpose and are therefore advantageous.

His comments on coupling and simplified lumped circuit equivalents indicate possible misunderstanding of the purpose of these sections in the article. The sections are purposely limited in scope to the minimum felt necessary to understand the circuits presented in later paragraphs. The references designated in the article also provide additional information, including graphs, for the design engineer requiring detailed data.

J. R. Dangl
K. Steele
Sylvania Electronic Systems
Williamsville, N. Y.

Applauds stand

To the Editor:

As an IEEE member and active participant at the section and group levels since 1946, please accept my heartfelt thanks for penetrating the shroud of silence covering internal IEEE policies through your perceptive editorial entitled "IEEE settles for second rate sessions" and for publishing the letter headed "Raising the standards" [March 21, 1966]. It takes raw courage and dedication to shout that the Emperor is naked!

The IEEE establishment, in addition to ineptly handling the quality of the 1966 convention's technical sessions, appears to lack the sense of command responsibility that can cope with mundane problems such as a tricky computer that switched my address from Doylestown, PENNSYLVANIA, to Doylestown, OHIO, with the subsequent loss and diversion of IEEE publications and notices. During the past 10 months, I contacted the former and present IEEE presidents, the headquarters staff including the general manager, the Philadelphia section chairman and officers while trying to soften an ossified structure. Only the regional director had the administrative maturity to inquire, question and call for remedial action.

Maybe it is the time to re-examine the power structure of the IEEE and recognize that the presidency should not be a sort of super fellowship, an accolade that is automatically bestowed yearly, but is indeed a hot seat for attempting to get an unwieldy monster on its feet.

Your editorial highlights a potentially lethal IEEE deficiency: there are no IEEE channels at conventions, section and group meetings, nor in the correspondence columns of IEEE publications for the rank-and-file to discuss vital internal questions relating to technical-programs substance, quality and atmosphere; criteria for selecting fellows; fiscal solvency; office procedures and practices. It does you at Electronics great credit that a feedback path to the IEEE leadership has been completed.

Sam Levine
Senior member, IEEE
Doylestown, Pa.

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People

The field of education is opening new vistas to electronics engineers, says **Richard L. Bright**, 40, the recently appointed director of research at the United States Office of Education. But before engineers can apply their design talents to the development of electronic teaching equipment, they will have to know what's needed. "Our job is to find out and to tell them," Bright points out.

Bright, who holds a doctorate in electrical engineering, is the first science-oriented person to head the Office of Education's research department. At the Westinghouse Electric Co. he directed a study on computerized classrooms and earlier was engaged in semiconductor and computer research.

Computerized classrooms. His appointment comes on the eve of a revolution in the field of education. "Within the next 10 or 15 years," Bright says, "classrooms around the country will probably be completely computerized."

To provide the foundation for this revolution, Congress in 1965 allocated $100 million over the next five years to develop new educational techniques and the electronic equipment to go with them. In addition, Congress gave the Office of Education the authority to contract with industry to develop the educational technology. The techniques will be programed instruction and the hardware will include computers and closed-circuit television networks. Within a month, Bright says, the first requests for proposals for electronic teaching equipment will probably be issued to industry.

Selling the idea. Developing equipment and techniques is only part of the problem of developing computerized classrooms, Bright explains. Equally important is the task of selling the idea to the customers: 26,000 separate school boards around the country and 2

million teachers and 100,000 school administrators.

Unfortunately, the director says, many educators fear automation in education. "Our responsibility, then, is to convince them that the machine will never replace the teacher."

The machine, he adds, will change the teacher's role from one of presenting information to the student to one of fostering "creative communications" between the teacher and the student. "A machine can teach a kid a fact, but it takes a teacher to teach him to apply knowledge to a new situation."

Never angry. Bright explains that computers free the teacher from routine teaching chores; the student gets constant individual attention; good students will never be bored and poor students will never be lost.

And he adds: "The computer will never get angry with the frustratingly slow student."

Electronics also will play a major role in teaching the teachers, Bright points out. For example, in the past few months the Office of Education has been opening technical centers throughout the country that store copies of research studies on education. The material is stored on microfilm—called microfiche—and is available to all educators. Although the storage system isn't electronic yet, the Office of Education expects eventually to support an information-retrieval system modeled after one which is operating at the University of Michigan. In that system, an educator searching for special material, puts a code into a push-button telephone. The code represents the key words of the subject. A computer then sifts through the available material and automatically provides the user with summaries of the studies. The educator can then get photo copies of any study.

A new field. Industry is moving quickly to enter the new market. Within the past year many large electronics companies have formed either their own educational subsidiary or have acquired an established publishing concern.

RESOLVER/SYNCHRO INSTRUMENTATION

A very short course for engineers engaged in testing and evaluation of resolvers and synchros as components or as system transducers.

Selecting a resolver/synchro test instrument for any engineering, production or system requirement is remarkably simple from North Atlantic's family of resolver and synchro instrumentation. Because this group has been developed to cover every area of need in both manual and automatic testing, obtaining the desired combination of performance and package configuration usually demands no more than 1) determining what you need and 2) asking for it.

Remote Readout of Angular Position

For remote indication of resolver or synchro transmitters in system testing, North Atlantic's Angle Position Indicators (Figure 1) provide the advantages of low cost and continuous counter or pointer readout. These high-performance instrument servos are accurate to 4 minutes of arc, with 30 arc seconds repeatability and 25°/second slew speed. Dual-mode capability, multi-speed inputs, integral retransmit components and other optional features are available to match application needs. Priced from $895.

Figure 1. Angle Position Indicators are available in half-rack, quarter-rack and 3-inch round servo packages.

High-Accuracy Testing Of Receivers And Transmitters

Measuring receiver and transmitter performance to state-of-art accuracy is readily accomplished with North Atlantic's Resolver/Synchro Simulators and Bridges (Figure 2). Each of these dual-mode instruments tests both resolvers and synchros, and provides direct in-line readout of shaft angle, accurate to 2 arc seconds. Simulators supply switch-selected line-line voltages from 11.8 to 115 volts from either 26 or 115 volts excitation, and so can be used to test any standard receivers. Bridges have constant null voltage gradients, making them ideally suited for rapid deviation measurements. Simulators and Bridges each occupy only 3½ inches of panel height and are available in a choice of resolutions. They are priced in the $1500 to $3000 range.

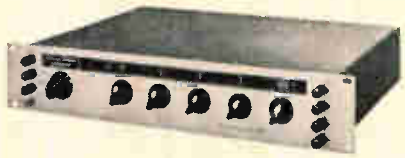

Figure 2. Resolver/Synchro Simulator provides ideal source for receiver testing.

Automatic Measurement And Conversion

Where systems require continuous or on-command conversion of resolver or synchro angles to digits, North Atlantic's Automatic Angle Position Indicators (Figure 3) handle the job without motors, gears or relays. These solid-state automatic bridges accommodate all standard line-to-line voltages and provide both Nixie display and printer output, accurate to 0.01° and with less than 1 second update time. Many variations, including 10 arc second accuracy; binary, BCD or decimal outputs; multiplexed channels and multispeed operation, are available for specific requirements. Ballpark price: $5900.

Figure 3. Model 5450 Automatic Angle Position Indicator. It measures shaft angles, converts them to digital data.

Measuring Electrical Characteristics

Combine a Resolver/Synchro Bridge and a Simulator with a North Atlantic Ratio Box, a Phase Angle Voltmeter and a test selection panel and you have an integrated test facility for determining all electrical characteristics of resolvers and synchros in component production or Quality Control. An example is the North Atlantic Resolver/Synchro Test Console shown in Figure 4. It measures phasing, electrical zero, total and fundamental nulls, phase shift and input current, as well as angular accuracy. Standard North Atlantic instruments are used as modules, making it a simple matter to fill the exact need. The unit shown sells for about $7500.

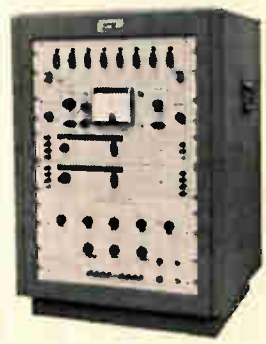

Figure 4. Model RTS-573 Test Console is a complete facility for the production line or in quality control.

If you require performance, reliability and convenience in resolver and synchro testing, we want to send you detailed technical information on these instruments (also on related instruments for computer system interface). Or, if you prefer, we will arrange a comprehensive technical seminar at your plant. Simply write to: North Atlantic Industries, Inc., 200 Terminal Drive, Plainview, N.Y. 11803 • TWX 516-433-9271 • Phone (516) 861-8600.

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Triple 3	205	8	305	5	505	8
Quad 2	206	8	306	5	506	8
RS Flip Flop	208	7	308	4	508	7
Line Driver	209	12	309	8	509	12
Expander	111	—	111	—	711	—

*New high-speed JK Flip Flop soon to be introduced.
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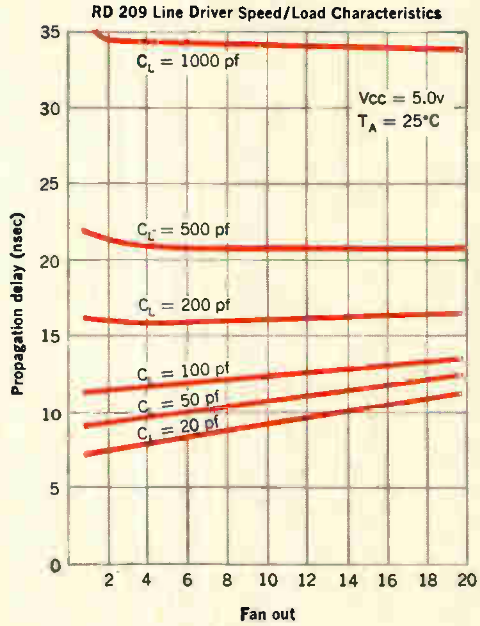
RD 209 Line Driver Speed/Load Characteristics



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Meetings

Conference on Ground-Based Aeronomic Studies of the Lower Ionosphere, AFCRL, DRTE; Defense Research Telecommunications Establishment, Ottawa, Canada, **April 11-15.**

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

Cleveland Electronics Conference, Cleveland section of IEEE; Engineering and Scientific Center, Cleveland, **April 12-14.**

Symposium on Electronics Measurement and Controls in Ships and Shipbuilding, IEE, IERE; University of Strathclyde, Scotland, **April 12-15.**

Symposium on Remote Sensing of Environment, Office of Naval Research; University of Michigan, Ann Arbor, **April 12-14.**

Quantum Electronics Conference, IEEE Groups on Electron Devices and Microwave Techniques; Towne House, Phoenix, **April 12-14.**

International Symposium on Generalized Networks, Polytechnic Institute of Brooklyn, AFOSR; Hotel Commodore, New York, **April 12-14.**

Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; El Cortez Hotel, San Diego, **April 13-15.**

Jurema International Seminar and Exhibition, Federal Council of Automation for Yugoslavia; Zagreb, Yugoslavia, **Apr. 16-24.**

International Conference on Electron and Ion Beam Science and Technology, Institute of Metals, Metallurgical Society of AIME, Electrochemical Society; Park Sheraton Hotel, N. Y., **Apr. 17-20.**

Symposium on Process Automation, Beckman Instruments, Inc., Consolidated Electrodynamics Corp., Control Data Corp., et al: Newporter Inn, Newport Beach, Calif., **April 18-20.**

International Scientific Radio Union Meeting (URSI), National Academy of Sciences, National Research Council; Washington, D.C., **April 18-21.**

International Seminar on Automatic Control in Production and Distribution of Electrical Power, Institut Belge de Regulation et D'Automatisme; Brussels, Belgium, **April 18-22.**

Frequency Control Symposium, U.S. Army Electronics Command; Shelburne Hotel, Atlantic City, **April 19-21.**

Colloquium on Microwave Communication, Dept. of Technical Science of the Hungarian Academy of Sciences, Scientific Society of Telecommunication; Budapest, Hungary, **April 19-22.**

International Conference on Magnetics (INTERMAG), Magnetics Group of the IEEE, Stuttgart, Germany, **April 20-22.**

Conference on Interservice Data Exchange, Grumman Aircraft Engineering Corp.; Waldorf Astoria Hotel, N.Y.C., **April 20-22.**

Naval Material Support Establishment System Performance Effectiveness Conference (NMSE SPECON 2), Navy; State Department Auditorium, Washington, **April 21-22.**

Spring Joint Computer Conference, American Federation of Information Processing; Boston, Mass., **April 26-28.***

Call for papers

Electronics Materials Conference, Metallurgical Society of the AIME; Sheraton-Boston Hotel, Boston, Aug. 29-31. **May 1** is deadline for submission of 300-word abstracts on the preparation and properties of electronic materials for the control of radiative processes, light-emission detection, modulation and microwave generation (including Gunn effect and Reade diode), to E. P. Warekois, Lincoln Laboratory of the Massachusetts Institute of Technology, Lexington, Mass. 02173.

Symposium on Reliability, ASQC, IEEE, IES, SNT; Sheraton Park Hotel, Washington, Jan. 10-12, 1967. **May 6** is deadline for submission of five copies of 800-word abstracts, on recent technical developments in reliability analysis of space projects, system analysis, and component parts to H. D. Hulme, program chairman, Westinghouse Electric Corp., R&D Center, Bldg. 601-1B46, Pittsburgh, Pa. 15235.

* **Meeting preview on page 16**

How do you unscramble signals from a moon-bug?

At top speed and accuracy, using the most advanced data reduction system ever designed. Months before the first Americans blast off toward the moon, an Astrodata system is already at work digesting and displaying messages from the bug-like Lunar Excursion Module. No other data reduction system in operation today has been able to handle data with as much speed and flexibility . . . *automatically!*

Astrodata systems superiority comes from mating proven components with functionally-oriented software. For example, all telemetry conversion units are directly under computer program control. Stored commands therefore automatically calibrate all subsystems: selecting bandwidths, frequencies, rates, formats and outputs; control speeds, tracks; provide tape search, and other data traffic functions conventionally requiring extraneous controls and adjustments.

In effect, this means significantly less error, greater speed, optimum performance and economy in your data reduction system.

Perhaps you're not headed for the moon, but you do have other problems in data acquisition and processing, telemetry, or range instrumentation. Then Astrodata's expert know-how should be of interest to you. Write for your free copy of our 20-page brochure "Astrodata's Systems Experience."

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Circle 15 on reader service card

Meeting preview

SJCC in Boston

Time-sharing techniques and the use of computers in simulation will be major subjects at the Spring Joint Computer Conference in Boston, April 26 to 28, sponsored by the American Federation of Information Processing Societies.

An opening-day session on time sharing will be followed, on Wednesday, by a panel discussion with six experts examining time sharing in "a realistic content" says the program chairman, Jack L. Mitchell of the Lincoln Laboratory, Massachusetts Institute of Technology. The panelists are James D. Babcock, Allen-Babcock Computing, Inc.; L. R. Hague, the Westinghouse Electric Corp.; Thomas E. Kurtz, Dartmouth College; K. F. Powell, International Business Machines Education Center; Ivan E. Sutherland, Advanced Research Projects Agency of the Department of Defense; and James R. Ziegler, The National Cash Register Co.

Hybrid techniques. Two sessions are scheduled on simulation: one on simulation and model-building, the other on the successful use of hybrid techniques in simulation and data processing. In addition, there will be a panel discussion on hybrid computation.

R. Belluardo, R. Gocht and G. Paquette, all of the United Aircraft Corp. Research Laboratories, will report on a time-shared hybrid simulation facility in the session on hybrid techniques; they will also serve on the panel.

A session on coherent optical information processing will include a paper on requirements for hologram construction by Emmett N. Leith and Juris Upatnieks, both of the University of Michigan's Institute of Science and Technology.

Waveform processing and current developments in peripheral hardware will be discussed at other sessions.

After four papers are delivered on results achieved using computer techniques in pattern recognition, Marvin L. Minsky, professor of electrical engineering at MIT, plans to give a critique of the presentations. He is being billed as the devil's advocate.

Circle 17 on reader service card

New Tektronix *Automatic* Oscilloscope System SEEKS and presents a measurable display

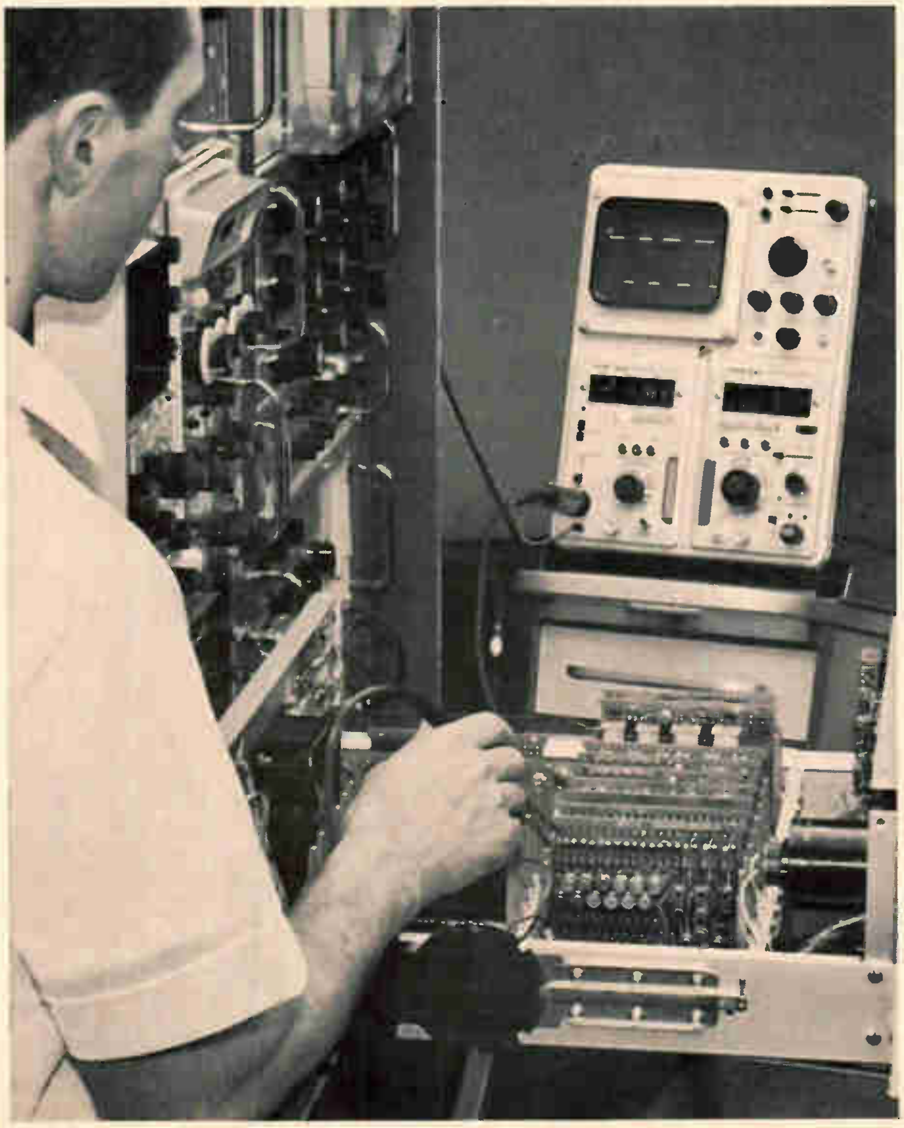
New Type 3B5 Time Base Unit Makes Automatic Operation Possible

The Tektronix Automatic Oscilloscope System, with the new Type 3B5 Automatic/Programmable Time Base Unit, now makes DC-to-15 MHz measurements faster and simpler than ever before.

The automatic system package includes the Type 3B5, the companion Type 3A5 Automatic/Programmable Amplifier Plug-in Unit, a P6030 Probe and a Type 561A, RM561A, 564 or RM564 oscilloscope.

Upon SEEK command, the oscilloscope automatically presents an optimum display. The SEEK command to the plug-in units automatically controls the time and amplitude settings, eliminating the need for continuous front-panel adjustments. Indicators on the plug-ins light automatically to show these settings. Measurements can then be made quickly and accurately from the CRT display.

Using the P6030 Probe and Automatic/Programmable Plug-In Units simplifies trouble-shooting, other applications where measurements on electrical equipment can be made without remaining within arm's length of the oscilloscope.



- **AUTOMATIC SEEKING**
  - . . . will operate upon SEEK command from the probe or from the Automatic/Programmable Plug-Ins.
- **MANUAL OPERATION**
  - . . . overrides the SEEK command
  - . . . extends sweep range and deflection factors beyond capability of Automatic Seeking Mode. Indicators light to show SWP MAG'D and UNCAL warnings, set manually.
- **REMOTE PROGRAMMING**
  - . . . overrides the SEEK command and Manual Operation.
  - . . . uses the Type 263 Programmer for remote control of the Automatic/Programmable Plug-In Units.

WHEN PLUG-INS RECEIVE SEEK COMMAND

TYPE 3A5
automatically establishes the optimum deflection factor. Indicators light to show readout with input coupling, such as .5 V/DIV, DC (coupled) WITH PROBE.

TYPE 3B5
automatically establishes optimum trigger settings and automatically selects time per division setting. Indicators light to show readout, such as .2 µs/DIV, and to show NOT TRIG'D condition.

Add a Type 263 Programmer and Speed Up Sequential Measurements

TYPE 3A5

Operating Modes: SEEK, Manual, and External.

Deflection Factor: 10 mV/div to 50 V/div in SEEK and External Modes. 1 mV/div to 50 V/div in Manual Mode.

Bandwidth: DC-to-≥15 MHz, from 10 mV/div to 50 V/div. 5 MHz at 1, 2, or 5 mV/div, in Manual Mode only.

Risetime: ≤23 ns at a deflection factor of 10 mV/div to 50 V/div.

Input RC: 1 megohm by ≈ 24 pF.

Programmable Functions: V/div, 10X probe attenuation, and AC, DC or AC stabilized coupling, by contact closure to ground. Vertical positioning by analog current.

P6030 Probe supplied with Type 3A5—has SEEK COMMAND button and 6 ft. cable.

Type 3A5 Automatic Programmable Amplifier Unit $760

TYPE 3B5

Operating Modes: SEEK, Manual, and External.

Sweep Range: 5 s/div to 0.1 μs/div in SEEK Mode.

5 s/div to 10 ns/div in Manual and External Modes.

Delayed Sweep Magnifier: X10 or X100. A calibrated delay control selects starting point of the magnified sweep, allows viewing of both the normal sweep (before start of the magnified sweep) and the delayed magnified sweep. With the magnifier operative, readout is automatically corrected to indicate the setting and SWP MAG'D condition.

Trigger Modes: Internal, either AC-coupled or AUTO (combined level-seeking and bright-line Automatic); External, either AC-coupled or DC-coupled.

Programmable Functions: Time/div, magnifier range, trigger mode with coupling, and trigger slope, by contact closure to ground. Horizontal positioning, trigger level, and magnifier delay, by analog current.

Type 3B5 Automatic/Programmable Time-Base Unit $890

- **Remote Program Feature** in the Automatic Oscilloscope System permits the instrument to be externally preset for a given measurement. With selection of eleven different programmable functions from Automatic/Programmable Plug-Ins, the combination offers new convenience for applications involving many measurements, as in production-line testing and systems checkouts, and also simplifies "away-from-the-oscilloscope" tests, where manual manipulation of the front-panel controls would be inconvenient.

- **Plug-In Type Program Card Feature**
  The Type 263 accepts up to six plug-in type program cards, each of which can be programmed for a specific measurement. Each program card, after initial set-up, establishes the plug-in control functions required for a particular test or measurement. Programming each card can be done simply by changing jumper wires and potentiometer settings. Any number of programmers can be cascaded for applications requiring pushbutton control of more than six measurement set-ups.

Once set up, the programs on the Automatic Oscilloscope System can be carried out by non-technical personnel with little or no training, since the instrument settings are all pre-selected. Actual measurements can be made conveniently from the CRT display, as usual.

Type 263 Programmer $325
(complete with 6 program cards)
(Size: 5½" by 8⅝" by 9";
Weight: ≈ 5 lbs.)

U.S. Sales Prices, f.o.b. Beaverton, Oregon

Using the Type 263 Programmer and Automatic/Programmable Plug-In Units facilitates such applications as production testing on limited production items not justifying full automation, where most or all of the controls can be preset for each test.

For complete information, call your nearby Tektronix field engineer, or write Tektronix Inc., P. O. Box 500, Beaverton, Oregon 97005.

Tektronix, Inc.

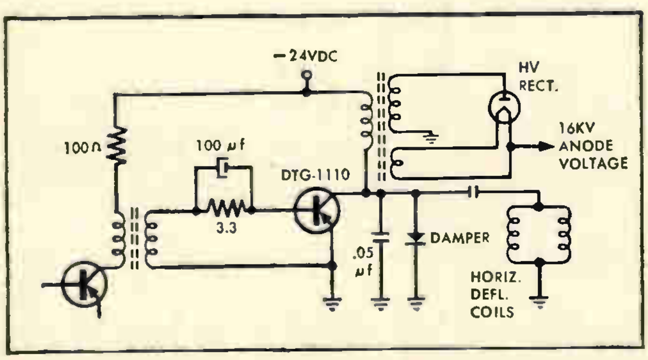
FOUR SPECIALISTS
(and what they can do for you)

These four high power Nu-Base germanium transistors were created to relieve some special problems where reliable peak power handling is a requirement. Each is in a class by itself with special benefits for ignition, TV horizontal sweep circuits and high power audio output (tentative specifications are provided).

These are rugged, durable transistors with built-in protection against secondary breakdown (thanks to Delco's Hydrokinetic Alloy process). Extreme parameter stability is a result of our Surface Passivation and Ambient Control (SPAC).

THE DTG-1110

This is a 200-volt 15-amp transistor with high power dissipation characteristics, low thermal resistance and a rugged performance record.



TV horizontal deflection incorporating the DTG-1110.

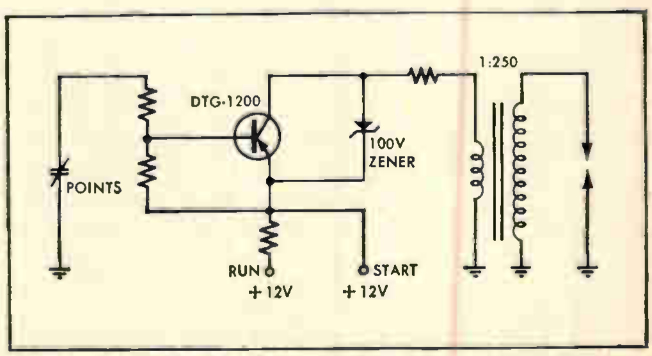
The drive requirements for your circuits are substantially reduced because of the high saturated current gain of this special application transistor.

THE DTG-1010

A 325-volt 15-amp transistor, this device's higher voltage offers many advantages. It's ideal for switching high inductive loads as found in many CRT deflection circuits.

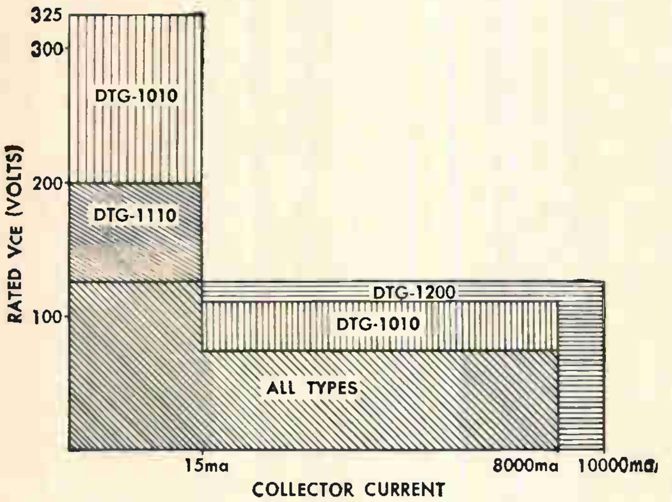
THE DTG-1200

With a (V_{CE} Sus) rating of −120 volts, it offers excellent gain, high speed and high sustaining voltage characteristics.



Automobile ignition circuit with the DTG-1200.

It's the ideal transistor for an ignition circuit. Also can be used in fluorescent light power inverter circuits. Mobile or portable operation is possible and fluorescent tube efficiency is improved due to higher oscillation frequency.



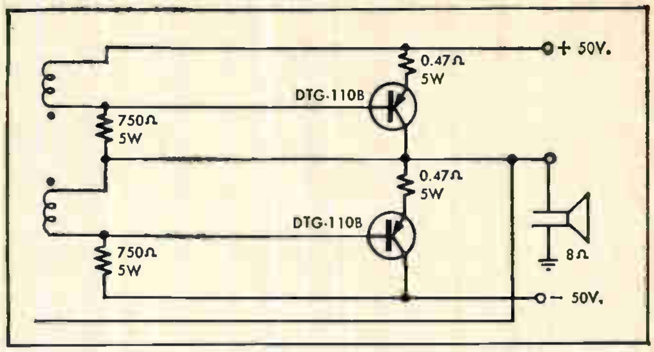
Tested sustaining voltage areas of the DTG-1110, DTG-1010 and DTG-1200.

THE DTG-110B

The DTG-110B is a high power transistor which will substantially reduce component costs and improve the reliability of quality home entertainment audio output circuits. It's designed especially for use in high fidelity amplifiers.

The linear gain and the specific gain band-width product of the DTG-110B offer low distortion and improved amplifier gain-phase characteristics.

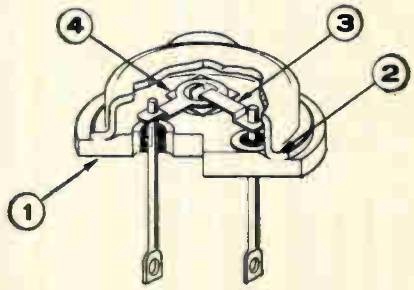
Exceptional efficiency in the driver stages is possible because of the DTG-110B's superb transconductance properties.



This two-stage output circuit produces well in excess of 50 watts RMS audio power with a simple drive requirement.

THE TO-3 PACKAGE

Delco Radio's TO-3 package wraps up this group of transistors.



With its solid copper base (1), maximum thermal resistance is just 0.8° per watt, and freedom from conventional weld contamination is assured with Delco cold weld construction (2). The TO-3 heavy-duty connectors (3) offer high current ruggedness, and the large germanium wafer (4) delivers high continuous and peak power handling ability.

Totally, four Nu-Base specialists in Delco TO-3 packages. For data, prices and delivery, call one of our sales offices or your Delco Radio Semiconductor Distributor.

	DTG-1110	DTG-1010	DTG-1200	DTG-110B
Collector Emitter Voltage (V_{CE} SUS)			−120V	−40V
Collector to Emitter Voltage (V_{CEX})	−200V	−325V		−90V
Collector Emitter Voltage (V_{CEO})				−40V
*Emitter Diode Voltage (V_{EBO})	−1.0V	−1.0V	−1.0V	−2V
Collector Current (I_C)	−15A	−15A	−15A	−25A
Base Current (I_B)	−3A	−3A	−3A	−5A
Maximum Junction Temperature	110°C	110°C	110°C	110°C
Minimum Junction Temperature	−65°C	−65°C	−65°C	−65°C
Lead Temperature 1/16" ± 1/32" from case for 2 seconds	245°C	245°C	245°C	245°C

*This voltage can be exceeded provided the maximum I_B and device dissipation limits are not exceeded.

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Division of General Motors, Kokomo, Indiana

Circle 21 on reader service card

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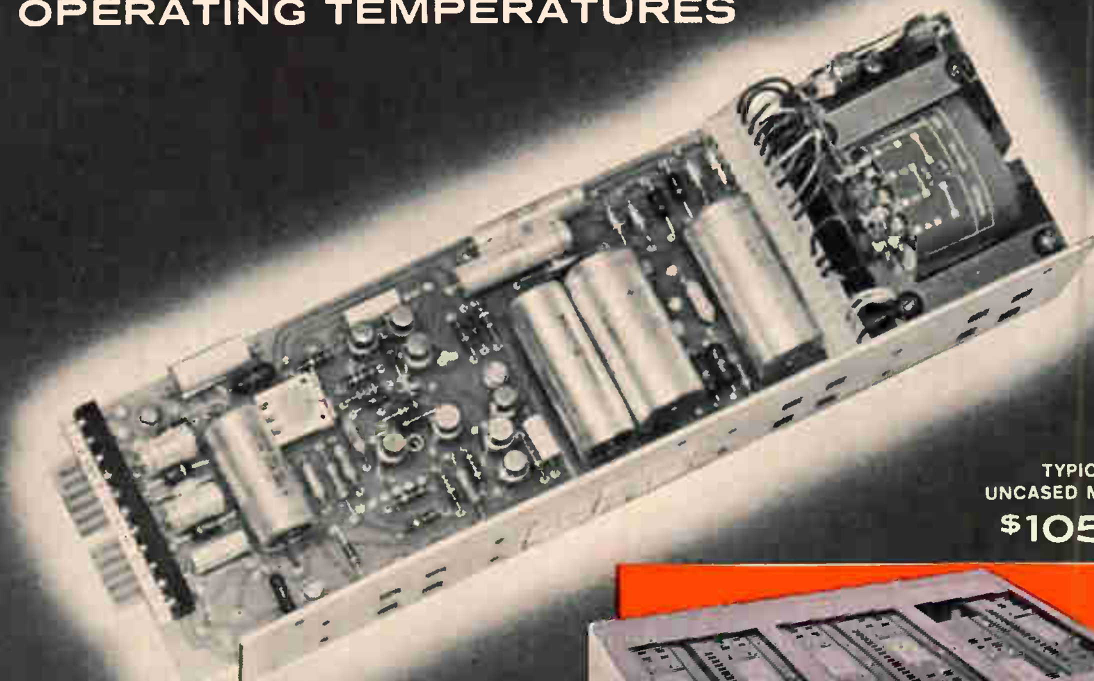
6 BRAND NEW PROGRAMMABLE SUPPLIES OFFER MORE PRECISE REGULATION GREATER POWER AND HIGHER OPERATING TEMPERATURES



TYPICAL UNCASED MODULE
$105.00

6 cased modules with Panel Adapters in Rack Cabinet RA 6-6

In introducing the all silicon PBX Group, Kepco has packed *more power and more features* into a low cost power supply module than ever before. Designed to complement the popular PAX Group, the new PBX modules share the same hardware, rack enclosures and mounting flexibility.

- **PACKAGE:** Identical to the popular PAX plug-in modules
- **POWER:** Twice the PAX rating
- **REGULATION and STABILITY:** 0.01%
- **RIPPLE:** Less than 0.1 mv rms
- **HIGH TEMPERATURES:** Up to 71°C
- **CURRENT LIMITING:** Now so sharp, it's practically automatic crossover current regulation
- **PROGRAMMING:** By resistance, voltage or current.

0.01% REGULATION and STABILITY

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS	RIPPLE (MAX) RMS MV	MAX.* INPUT AMPS
PBX 7–2	0–7	0–2	0.1	0.6
PBX 15–1.5	0–15	0–1.5	0.1	0.7
PBX 21–1	0–21	0–1	0.1	0.5
PBX 40–0.5	0–40	0–0.5	0.1	0.5
PBX 72–0.3	0–72	0–0.3	0.1	0.5
PBX 100–0.2	0–100	0–0.2	0.1	0.5

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Editorial

Playing both sides of the street

Now that it's clear that integrated circuits are moving into industrial, commercial and consumer equipment far faster than anybody expected a couple of years ago, makers of instruments, subassemblies and systems are seriously pondering whether they should make their own integrated circuits or buy them—a question that has been nagging equipment people almost since the IC was born. The way they answer this question will affect almost everybody in the electronics industry. It will determine where a lot of the engineering will be done—at the equipment maker's or semiconductor producer's plants—and what technical direction many companies will take.

Makers of integrated circuits are quick to point out that there are large-scale economies to be reaped if equipment makers buy off-the-shelf IC's from a semiconductor specialist. The customers also receive, the argument continues, the advantage of the best and latest technology, because a specialist in semiconductors is the man who has to keep pace with fast-moving technology, who must keep abreast of the technology or drop out of the business.

David Packard, president of the Hewlett-Packard Co., the large instrument, microwave and medical equipment producer, concedes there is an economic advantage to buying off-the-shelf integrated circuits, but he feels that is only one part of the picture. He says, "If you design around available circuits, you get some cost advantages, but the equipment is limited. To improve the equipment design, we have to design our own circuits."

That's why Hewlett-Packard is setting up integrated-circuit production facilities at three separate divisions, and why Packard says that soon every H-P division will have its own integrated-circuit manufacturing facility. The IC facility at H-P's Frequency and Time division in Palo Alto, Calif., is already in operation and one at the company's Dymec division nearby is almost ready. Space has been cleared for an IC facility at the company's Loveland (Colorado) division and development work should start there next month.

Packard has concluded that the technology of designing with IC's differs so radically from that of designing with discrete components that the IC shop has to be near the engineers. "Maybe you can design computers whose circuits are repetitious and whose logic design is often more important than the hardware without a microcircuit capability," he says. "But you can't design sophisticated instruments without your own integrated facilities."

He adds, "If you go to a store and buy a lot of parts which we then assemble, anybody else can go to the same store, buy the same parts and produce the same thing. If we have depth, do our own design and engineering, then we can make products that other people cannot make."

With its many IC facilities, H-P expects to develop both monolithic and hybrid circuits as well as digital and linear circuits. In his business Packard believes that monolithic techniques lend themselves better to digital circuitry, and many of the applications in instrument and microwave fields are better done with linear circuits. For example, hybrid techniques will be applied to one of the first projects that the Loveland facility will tackle: an integrated-circuit sampling probe, which is a diode gate—and some linear circuitry—that's turned on and off at a rapid rate by a pulse generator.

Though Hewlett-Packard's chief reason for setting up its own facilities is to retain design initiative, there is another important consideration. The company has contracts for design projects with three separate integrated-circuit suppliers, and every single project has been delayed, falling way behind schedule. Packard says sadly, "We've had difficulty getting what we want from outside suppliers. They are so busy filling orders from the computer makers they don't have time for us. Our volume could never match that needed by a computer maker so we take a back seat."

At least a handful of other equipment suppliers feel as David Packard does about integrated-circuit facilities. In Boston, both the Digital Equipment Corp. and the Computer Control Corp. have set up their own IC facilities. The latter has a policy that might well become the pattern for the electronics industry. It has set up a model shop that builds pilot quantities of newly designed circuits, then turns over the designs to an outside contractor for production runs. "That kind of capability," comments Packard, "lets you play both sides of the street."

Will this new General Purpose P&B relay make our best seller obsolete?

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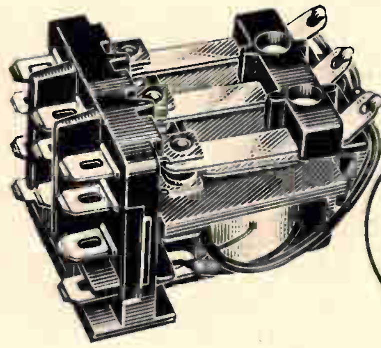


Never?

Well, maybe!

Our new KU relay is quite exceptional. For many relay users, it will be more convenient, more versatile, easier to install and replace . . . and cost substantially less money. Here's why.

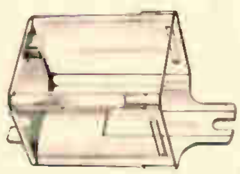
MODERN, COST SAVING TERMINALS

Quick-connect terminals mean faster installation on your production line . . . easier replacement in the field. Standard models have .187″ terminals, but .205″ may be ordered. All terminals are punched for those who prefer solder connections. Barriers molded into the sturdy front meet U/L and CSA requirements.

TRUE 10 AMP NYLON SOCKET

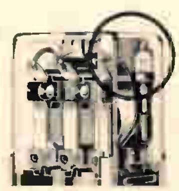
A nylon socket—rated for carrying 10-amperes—can be supplied to make the KU a handy plug-in relay. Covered (KUP) relays, incidentally, cost dramatically less than similar relays having octal-type plugs.

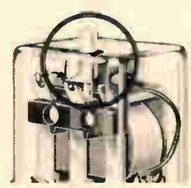
You may specify five- or ten-ampere KU relays. Longer movable arms and a unique method of staking the stationary contacts to the header contribute to the improved reliability and longer life of this new series.



WIDE CHOICE OF FEATURES

Two styles of heat and shock resistant polycarbonate dust covers are available. One, with slotted flanges, provides a quick, convenient method for mounting the relay directly to a chassis. A handy push-button which operates the movable contacts can also be supplied for manually checking circuits. KUP relays are available with a neon lamp wired in parallel with their coils to indicate that power is reaching the relays.





Longer life, improved reliability, exceptional versatility and, in the case of covered relays, substantially lower costs are all part of the KU Series. Interested? Call your P&B sales representative today, or get in touch with us direct.

KU SERIES SPECIFICATIONS

GENERAL:
- **Description:** 5 or 10 amperes General Purpose Relay.
- **Expected Life:** 10,000,000 cycles, Mech.
- **Breakdown Voltage:** 1,500V rms 60 Hz between all elements; 500V rms 60 Hz between open contacts.

CONTACTS:
- **Arrangements:** Up to 3 Form C.
- **Rating:** 5 or 10 amps @ 28V DC or 115V AC resistive.

COILS:
- **Voltage:** DC to 110V; AC to 230V 60 Hz.
- **Power:** DC 1.2 W; AC 1 and 2 poles 2.0 VA; AC 3 poles 2.7 VA.
- **Resistance:** 16,500 ohms max.

MOUNTING:
(open relay) 6/32″ mtg. stud, 7/32″ locating tab on 7/16″ centers. Socket available.

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Electronics Newsletter

April 4, 1966

Hewlett-Packard plans to build IC's at all its divisions

The Hewlett-Packard Co. has decided that it must have its own facilities for the production of integrated circuits. What's more, there must be separate facilities at each of the company's divisions, says David Packard, chairman of the producer of instruments, microwave equipment and medical electronics.

Packard's reason: the coordination between IC makers and equipment designers must be very close, much closer in fact than the coordination between circuit designers and the designers of equipment using discrete components; also, the company has been experiencing delays in getting special circuit orders filled by contractors (see Editorial, page 23).

Color tv recorder designed to sell for less than $500

The Illinois Institute of Technology's Research Center says it has developed a home color television tape recorder that could sell for between $300 and $500. Several companies have home black-and-white recorders on the market, selling for about $1,000, but no one is offering a home color recorder.

The institute's 30-pound recorder has a stationary recording and playback head, rather than a rotating head, which is used on typical black-and-white recorders. The quarter-inch tape moves at 120 inches per second; it has a two-megacycle bandwidth. In studio color tv recorders, the effective speed of the tape past the head is 1,000 to 3,600 inches per second.

The institute says it is negotiating license agreements with certain manufacturers; however, it declines to identify them.

Hybrid IC's due in '66 Philco tv's

This year the Philco Corp. will introduce black-and-white television sets that use hybrid integrated circuits. The disclosure was made following word that the Radio Corp. of America and the Admiral Corp. are introducing sets that use monolithic integrated circuits. Philco, a subsidiary of the Ford Motor Co., is already using thick-film IC's in car radios in the 1967 Ford line. Philco's IC's are made by bonding transistor and capacitor chips to ceramic-based passive circuits. The IC's are being used in tv receivers' horizontal phase comparators.

Philco has stopped producing all-tube color sets. A combination of tubes and transistors makes up the circuits in all its new color tv sets. A spokesman said that the use of IC's in color sets is under study.

Honeywell plans two acquisitions

Honeywell, Inc., plans two diversification moves: the acquisition of the Computer Control Corp. of Framingham, Mass., a maker of digital computers and digital computer equipment, and the purchase of Electro-Instruments, Inc., of San Diego, a producer of digital voltmeters and printers.

Electro-Instruments will probably become Honeywell's test instrumentation division, filling many gaps in Honeywell's commercial lines.

Three years ago Computer Control moved heavily into the integrated circuit field. During the past year the company introduced a line of monolithic IC logic modules, an all-IC computer and an all-IC core memory.

Honeywell has never set up in-house production of integrated circuits.

Electronics Newsletter

Gemini 9 to keep May date in space

The next Gemini space shot will meet its mid-May schedule despite Gemini 8's brush with disaster. Gemini 9 will dock with a new Agena and possibly also with the Agena that was launched for the Gemini 8 mission. The three-day flight will repeat Gemini 8 mission objectives. In addition, astronaut Eugene A. Crenan will "walk" in space with a rocket-powered backpack.

Gemini 8's near-disaster is causing space officials to reevaluate considerations for a space rescue service. Currently, officials of the National Aeronautics and Space Administration say they lack the techniques for space rescue. One major problem: the need for a way to fire a rescue craft into space on a few hours' notice; it now takes weeks of planning before a spaceship can be launched.

A moving thought

Future astronauts may have to think twice before they think because thought impulses may be used to activate systems and machinery. The National Aeronautics and Space Administration has awarded a contract to the Case Institute of Technology to study the possibility of using sensors to pick up a man's electromyographic signals and a computer to translate them into an order for a machine (see page 156).

Airlines may test system to bar midair crashes

By the end of the year domestic airlines may flight test a collision-avoidance system that would warn a pilot of an impending collision and tell him how to avert it, the Air Transport Association says. Its forecast is based on McDonnell Aircraft Corp.'s announcement that it has been testing a collision-avoidance system.

In the McDonnell system, each aircraft would transmit a signal at 1,545 megacycles every two seconds at an assigned two-millisecond period; this would provide 1,000 separate airplane-identification codes. One plane would determine the closing speed with another by measuring the doppler shift of the received signal. A warning would be flashed to a pilot 60 seconds before a possible collision. At 40-seconds-to-collision, the system would direct one pilot to climb and the other to descend.

About 60 ground stations throughout the United States may be needed to provide continual resetting of the "clocks" the planes would carry to maintain the millisecond accuracy of the transmitters.

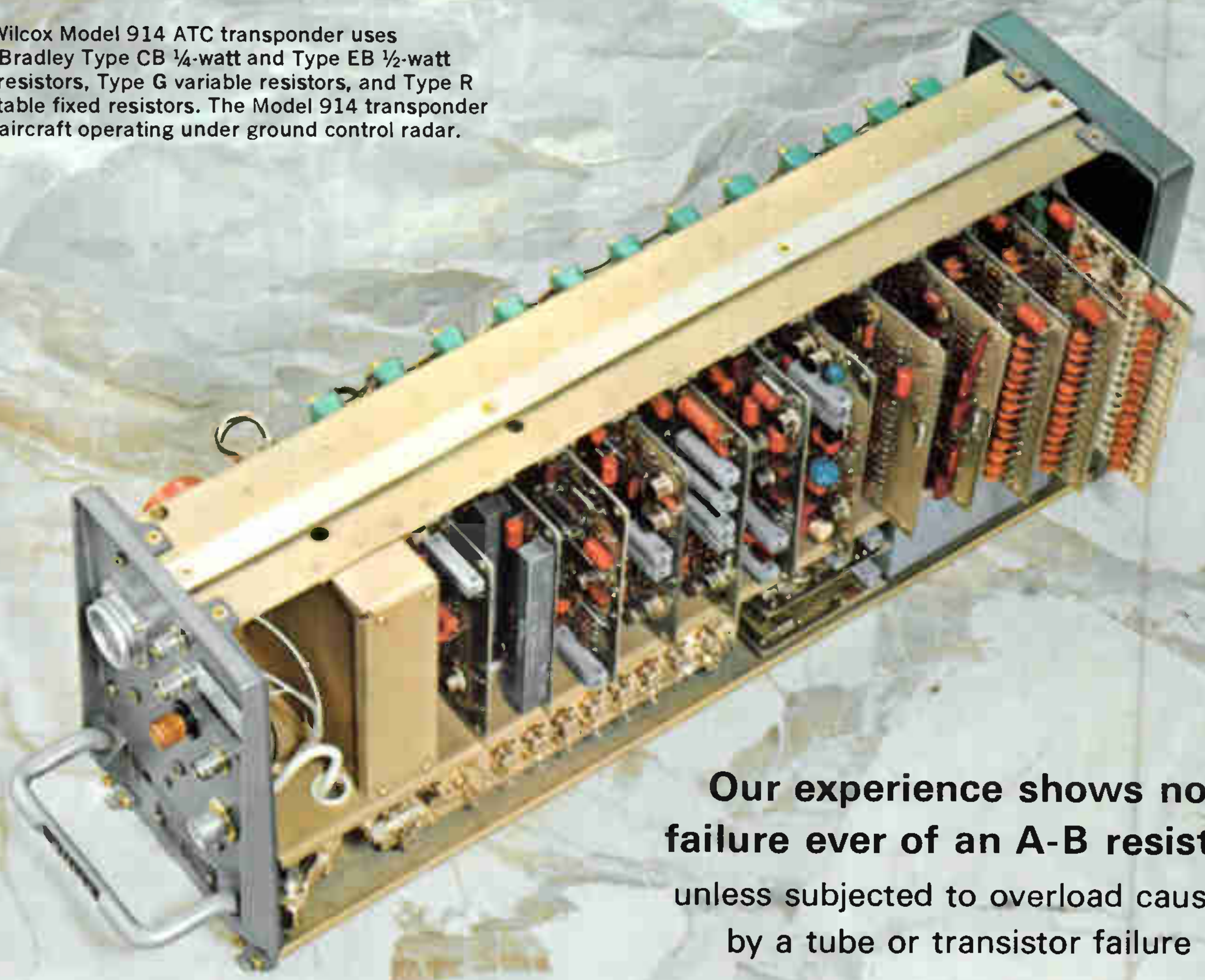
Others working on similar systems are the Collins Radio Co., Bendix Corp., National Co., Sierra Research Corp. and Control Data Corp. Installation of operational units could begin within three years.

Paris eases stand on U. S. investments

United States electronics companies apparently can count on special treatment when they apply for permission to build plants in France. Late last month the de Gaulle government made much ado about the fact that it had taken only two months for Motorola, Inc., to get a go-ahead for its plan to build a $10-million semiconductor plant in Southwest France. Ordinarily, French officials drag their heels for as much as two years when U. S. companies apply for plant-building permits.

All of the "Big Three" U.S. semiconductor producers will be represented in France when Motorola's plant starts up in late 1967 near Toulouse. Texas Instruments Incorporated has a plant near Nice; SGS-Fairchild, an affiliate of Fairchild Camera & Instrument Corp., has one at Rennes.

This Wilcox Model 914 ATC transponder uses Allen-Bradley Type CB ¼-watt and Type EB ½-watt fixed resistors, Type G variable resistors, and Type R adjustable fixed resistors. The Model 914 transponder is for aircraft operating under ground control radar.



Our experience shows no failure ever of an A-B resistor

unless subjected to overload caused by a tube or transistor failure

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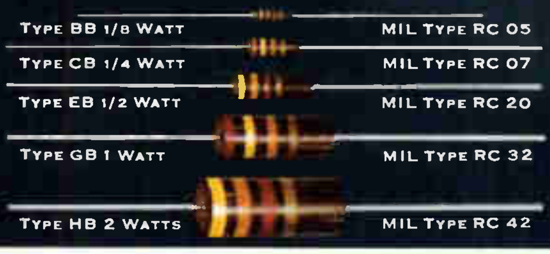
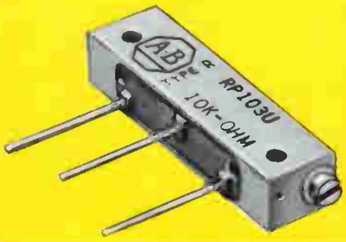


Type R Hot Molded Adjustable Fixed Resistors are rated ¼ watt at 70°C. Supplied in resistance values from 100 ohms to 2.5 megohms.



Type G Hot Molded Variable Resistors are rated ½ watt at 70°C. Resistance values from 100 ohms to 5.0 megohms.

"No failure ever" is an impressive record, especially since Allen-Bradley fixed and variable resistors have been used in Wilcox transponders for around ten years.

The reason for this consistently high performance is the unique hot molding process developed and used only by Allen-Bradley. In fixed resistors, it produces such complete uniformity that long term A-B resistor performance can be accurately predicted. Catastrophic failures don't occur with Allen-Bradley hot molded resistors.

Use of the hot molded resistance element in the Allen-Bradley Type G variable resistors assures very smooth operation—there are never any abrupt changes in resistance during adjustment. The Type G controls have a very low initial noise factor, becoming lower with use.

Type R adjustable fixed resistors also have a solid molded resistance track. Adjustment of resistance is so smooth, it approaches infinite resolution. Settings will remain fixed under severe vibration or shock. The Type R molded enclosure is dustproof and watertight—it can be potted after adjustment.

For more complete details on the full line of A-B quality electronic components, please write for Publication 6024: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204.

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A-B

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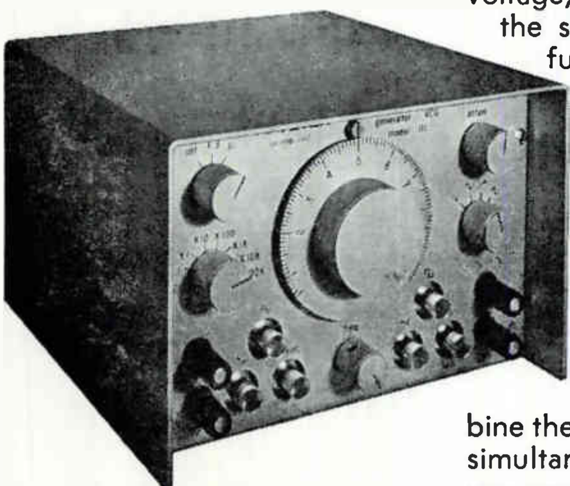


Voltage controlled generator.

Most everybody knows what a VCO is. The VCG is similar but it generates many functions over a very broad frequency range.

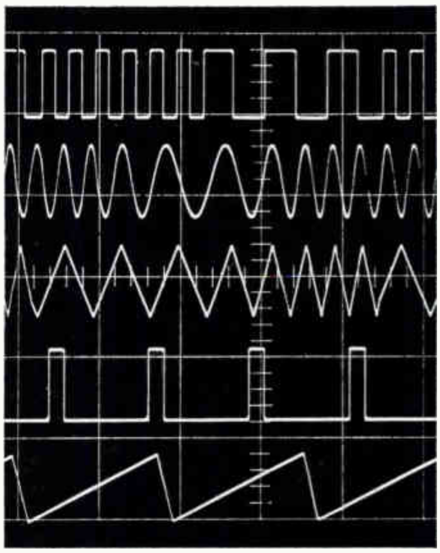
The new Model 111 VCG generates sine, square, triangle and ramp waves—simultaneously—in fixed phase relationships. It gives you precise control of frequency through external voltage input — either dc programming or wideband ac frequency modulation.

This voltage input operates in parallel with the panel controls. You determine the generated frequency by (1) the range selector switch and the frequency dial, and (2) the voltage applied to the VCG input. A positive voltage increases the frequency while a negative voltage decreases it. If you apply no voltage, the instrument operates the same as our Model 110 function generator ($395).

External programming with a square wave input results in frequency shift keying. A sine wave gives you frequency modulation. And a ramp input gives you frequency sweeping.

Also, you can combine the VCG capability with the simultaneous outputs. This lets you generate variable-duty-cycle square waves and sawtooth waveforms.

The Model 111 sells for just $545. And you can get a Model 111B with rechargeable batteries for just $595.



Frequency shift keying, frequency modulation, frequency sweeping, variable-duty-cycle square wave, and sawtooth.

Frequency range 0.0015 Hz to 1 MHz
and sync pulse
7 simultaneous calibrated outputs
VCG range 20:1 frequency ratio in 3 ranges
VCG linearity ±0.1% frequency vs. input voltage
Stability 0.05% short term
Sine wave distortion 0.5%

Now all you need to know is what it's like to use one.

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Circle 29 on reader service card

How to make sure you are not in the dark on the latest in Lighted Pushbutton Switches

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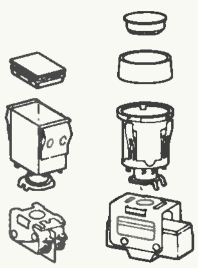
In addition to the popular Series 2 which started the modular trend, the line now includes Series 2N and Series 2C200. All three offer unequalled freedom of design—in sheer number of possible control and display combinations—in ease of installation—and in panel appearance.

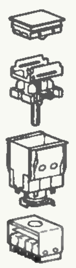
MICRO SWITCH gives you another bonus: application experience. Our specially trained field engineers will be glad to discuss your requirements. They are backed by the industry's most elaborate research and development facilities.

For information, contact a Branch Office or Distributor (see Yellow Pages, under "Switches, Electric") or write for literature.

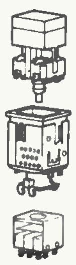
MICRO SWITCH—the line providing unequalled freedom of design with all this versatility



Series 2 offers both rectangular and round display, permitting shape-coding of stations or group functions. Snap-in mounting. Solenoid pull-in and/or hold-in coil for remote control.



Series 2C200. Snap-in mounting. Relamp without tools. Available with RFI shield, and solenoid pull-in or hold-in coil for remote control.



Series 2N. Shock-resistant spring-lock mounting. Hold-in coil. Relamp without tools. Molded-color housings.

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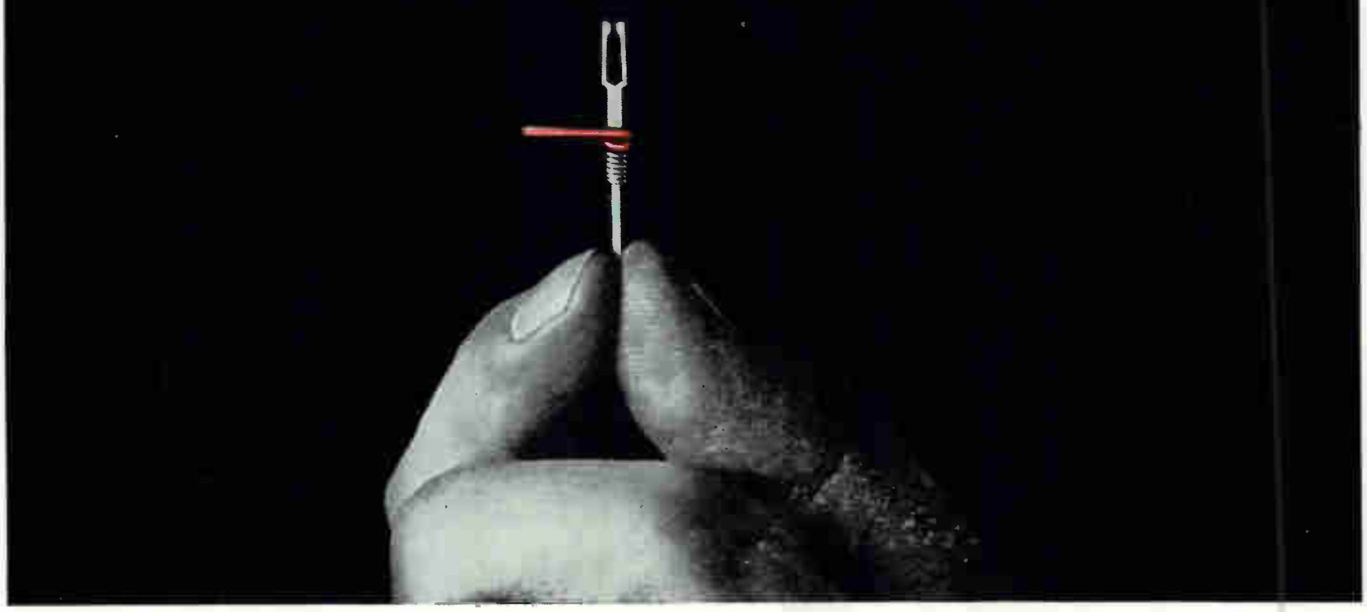

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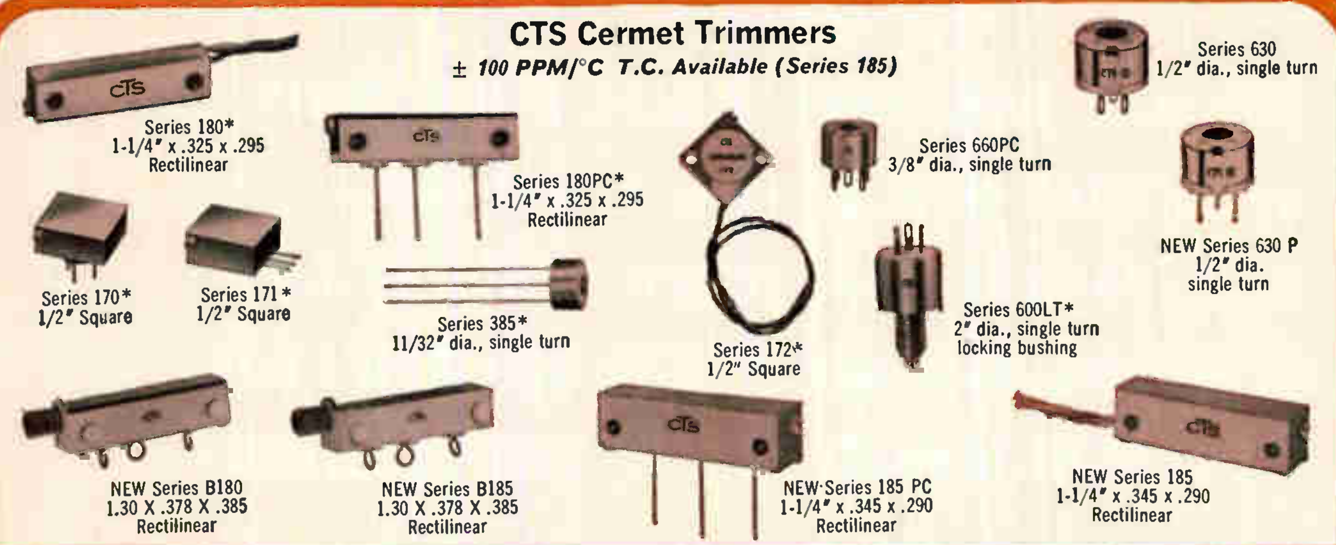

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MODEL TDH-9

PAR Waveform Eductor

The PAR WAVEFORM EDUCTOR extracts repetitive waveforms or transients from noise.

Experimental information in the form of repetitive waveforms can best be extracted from noisy signal channels by obtaining the cross-correlation function of the waveform-plus-noise with a train of delta-functions having the same repetition rate. The cross-correlation function will be the waveform of interest, noise having averaged to zero. Approximations of this operation may be performed digitally, but generally there are drawbacks in time efficiency, speed, and expense. The PAR TDH-9 WAVEFORM EDUCTOR is an analog averaging instrument having one hundred channels of capacitor memory. The cross-correlation approximation is obtained by dividing that part of the input waveform of interest into one hundred segments. These are switched sequentially and synchronously through a resistor to the memory capacitors where the average is obtained and stored. The information in the memory bank is continuously observable on a monitor scope and the average can finally be photographed or read out on an X-Y or strip-chart recorder. The TDH-9 has the advantages of speed, efficiency, and low price.

SPECIFICATIONS

Resolution: 100 channels. Output smoothing provides continuous output waveform rather than "stairstep."

Sweep Duration: Continuously adjustable from 100 μS to 11 Sec in five ranges. (Dwell time/channel: 1 μS to 110 mS.)

Characteristic Time Constants: 5 Sec to 100 Sec in 1-2-5 sequence. The characteristic time constant is that time constant with which the output waveform responds to changes in the input waveform. Because the stored waveform is held during the time between sweeps, the observed time constant can be larger than the setting of the Characteristic Time Constant Switch.

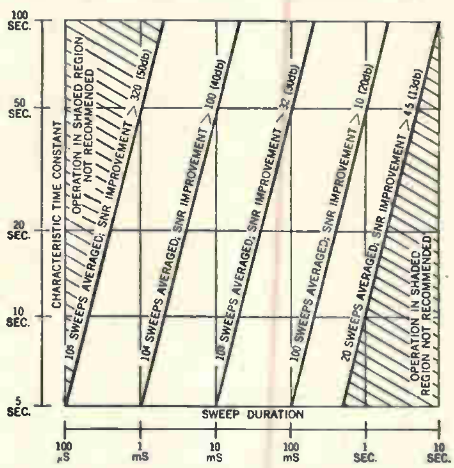
Sweep Delay: A delay of 10 μS to 11 Sec can be inserted between receipt of trigger pulse and initiation of sweep.

Output: Full scale is ±10 volts, capable of driving oscilloscopes, X-Y recorders, and strip chart recorders. Readout can be as slow as 100 Sec (dwell time/channel 1 Sec).

Dynamic Range: Noise and interference five times the full-scale input will not cause overload. Output noise with shorted input for most combinations of Sweep Duration and Characteristic Time Constant is below 0.2% of full scale.

Power: 105-125 or 210-250 volts AC, 50-60 Hz; 25 watts.

Price: $4200.00 Request Bulletin 126.



NUMBER OF SWEEPS AVERAGED AND VOLTAGE SIGNAL-TO-NOISE RATIO IMPROVEMENT AS A FUNCTION OF CHARACTERISTIC TIME CONSTANT AND SWEEP DURATION

PAR PRINCETON APPLIED RESEARCH CORP.
Dept. D
Box 565, Princeton, N. J., Tel. (609) 799-1222

April 4, 1966

Electronics Review

Volume 39
Number 7

Displays

A clear view

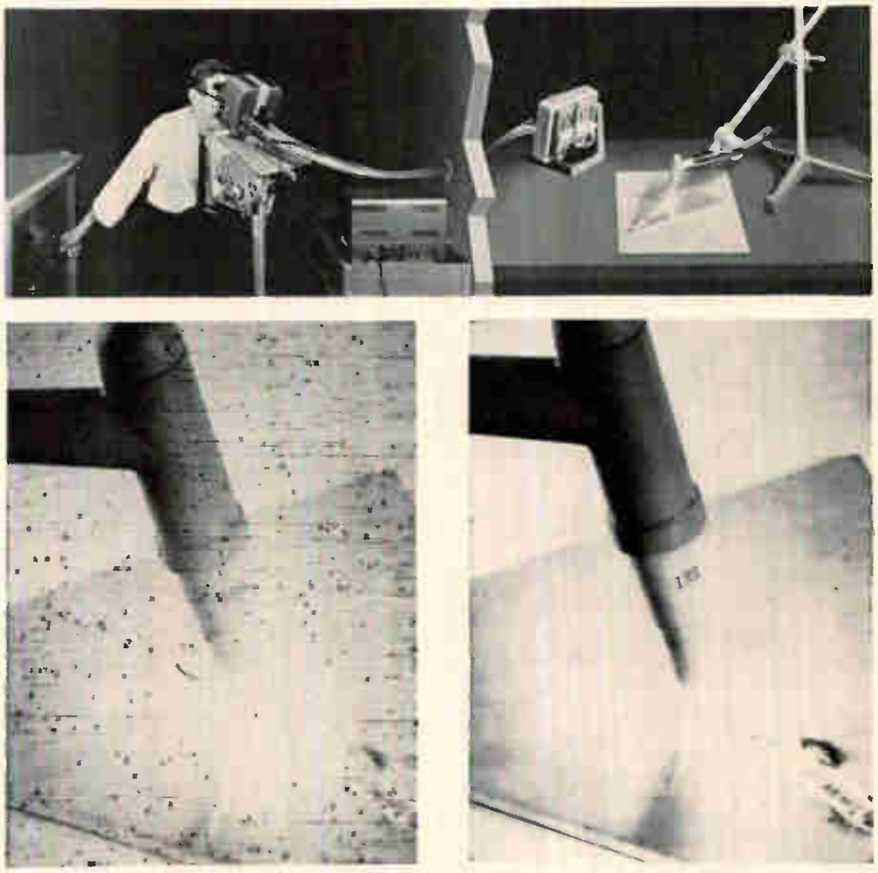
Images transmitted through fiber-optics cables generally lack resolution, and techniques for improving the images are costly and complex. Now, a small electronics concern in Plainview, N.Y., Optomechanisms, Inc., says it has developed a simple method of nearly doubling the resolution capabilities of the cable.

Spinning lenses. Basic to the image-enhancement system is a set of lenses—one at each end of the fiber-optics cable. Two synchronous electric motors rotate the lenses and keep their spin rates in phase. The president of the company, Andre R. Brault, explains that details on the lenses and the way they're rotated are proprietary because patents are still pending on many parts of the system.

He says the unit improves the resolution of images transmitted through fiber-optics cables. Ordinarily, resolution is limited by three factors: the size of each individual rod in the fiber-optics bundle, breaks in a rod and gaps between each rod. The gaps, or discontinuities, are caused by epoxy, which is used to bond both ends of the bundle. The effect is like seeing a picture through a screen door. What's more, broken rods in the fiber bundle cause black spots in the final picture.

With image enhancement, Brault says, these discontinuities are minimal. Without enhancement, most optical cables provide a resolution of about 35 line pairs per millimeter, but with Optomechanisms' enhancement system, resolution is boosted to 66 line pairs per mm.

'Not talking.' The image-enhancement system isn't really a new development, says Brault, but until now "we haven't been talking about it in public." The executive indicated that all sales had been limited to the military, presumably for classified reconnaissance projects.



Technician welding by remote control watches the operation through a stereoscopic unit connected to a fiber-optics cable. First he sees the "raw" image at the left, but after the image is "treated" by an image-enhancement system he gets the clear picture at the right.

Brault says that the National Aeronautics and Space Administration plans to use the unit in the Apollo spacecraft to peek around corners and look into places where it is difficult to position a camera.

Computers

More scratch pads

Less than a month after Scientific Data Systems, Inc., introduced its Sigma 7 (details on page 118), a computer that relies heavily on integrated circuit scratch pads, the Burroughs Corp. has announced that it, too, is going to offer computers that use many IC scratch pads.

The Burroughs' computers, the B2500 and the B3500, are compatible with the company's much larger B5500 and the B8500 [Electronics, July 12, 1965, p. 17], and will replace the older B200 and B300 series.

The central processors of both are built exclusively of monolithic integrated circuits made by the Fairchild Semiconductor division of Fairchild Camera & Instrument Corp. IC's are also used for memory decoding, driving and sensing. Only the core memory itself and the peripheral equipment use discrete components. Fairchild and Burroughs engineers worked closely in developing the IC's, which will be available in Fairchild's complementary transistor logic line.

Fast processing. The scratch-pad memories operate in a 100-nanosecond cycle and have capacities of 24 to 120 words; they reduce the machines' dependence on the main memory and permit significantly faster processing than similar machines without scratch pads.

The machines will compete with computers such as International Business Machines Corp.'s System 360, models 30, 40 and 44, and Radio Corp. of America's Spectra 70/25 and 70/35. Compatibility with the 360 requires installation of a modified read-only memory containing a special microprogram, called an emulator. The machines will rent for $4,195 to $20,720 per month.

Fast combination

The fastest commercial computer today is able to perform nearly three million calculations per second. But to Daniel L. Slotnick, a professor of computer science at the University of Illinois, that's slow going compared with his goal: a billion computations per second.

Although Slotnick is still a few years away from proving that his design, the Illiac 4, can reach that bewildering speed, neither he nor his sponsor—the Pentaton's Advanced Research Projects Agency—doubts he'll succeed. Seven computer makers, vying to build the giant machine, are also convinced.

Work in tandem. Slotnick's approach is based on the principle of repetition. He reasons that if one computer can perform several million calculations in a single second, then a few hundred computers, linked together and working simultaneously on parts of the problem, can operate at the rate of a billion per second. Admittedly, the cost will be high, but for some applications—like processing the rapid-sequence signals from a phased-array radar—the user will gladly absorb the cost.

A few months ago, bids to build the hardware were submitted by the Burroughs Corp.; General Electric Co.; International Business Machines Corp.; Radio Corp. of America; Sylvania Electric Products, Inc., a subsidiary of the General Telephone and Electronics Corp.; the Univac division of Sperry Rand Corp., and Westinghouse Electric Co.

This spring three companies will be selected to carry out a six-month study of details of the machine. After that, one of them will be chosen to construct it. Completion will be in late 1968.

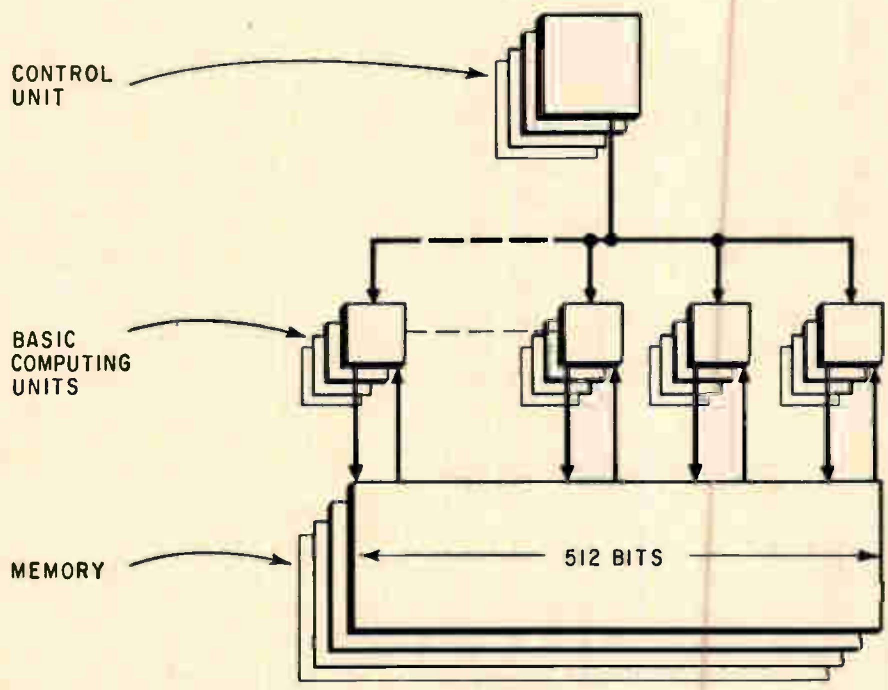
The basic building blocks of the Illiac 4 will be a relatively conventional group of circuits capable of executing simple arithmetic operations on 32-bit words or on 8- or 16-bit fractional words. However, the speed Slotnick expects is pushing the current state of the art: 250 nanoseconds for the basic cycle of each block.

Parallel construction. Sixteen of these basic blocks will be connected in parallel to the memory. This means that sixteen 32-bit words will have to be read out from the memory at once, so that the memory word length must be 512 bits—an extraordinary length. Slotnick asserts there is no technological barrier to such a word length.

Each of the 16 blocks will execute the same instructions on its own data; the instructions will come from a single control unit that will supervise all 16 blocks. The control unit, in turn, will receive sixteen 32-bit instructions from one 512-bit memory word, passing them in sequence to the 16 basic units.

This combination, or layer—one control unit, one long-word memory and 16 basic arithmetic units—all executing the same instructions on different data—is repeated up to eight times. The fact that all the units are operating in parallel produces an over-all system speed that's at least 128 times (that is, 16 blocks times eight layers) faster than the speed of any other machine now envisioned.

Swap data. The 16 basic blocks in each layer will swap data back and forth among themselves as well as to and from the memory. In addition, there will be commu-



Repetitive processing by a large number of relatively small processors adds up to a computer of extraordinary speed. The Illiac 4, being designed at the University of Illinois, will be able to perform a billion calculations a second. Words of 512 bits from the memory will provide each of 16 basic processors with a 32-bit word of data, all at once; the data is processed under control of a single unit. The combination of memory, control and 16 processors will be repeated up to eight times in the complete system.

nication among each of the blocks in the different layers.

Beyond the military applications, Slotnick sees Illiac 4's being used for such problems as the evaluation of high-order determinants, which requires an enormous number of simple calculations.

Conversational program

Soon anyone who can hunt and peck on a typewriter will be able to converse with a computer. An experimental software program, called Deacon, is already being used to help a computer understand and answer simple questions in colloquial English.

Deacon, which stands for direct English access and control, is being developed by Tempo, General Electric Co.'s center for advanced studies in Santa Barbara, Calif. Eventually, it will be possible for an operator to use a computer without any knowledge of computer language or programing.

Simple questions. GE says the final version of Deacon will answer questions asked in relatively complex conversational English, such as: "What are all the ways of generating microwaves?" For the time being, however, it will deal with simpler questions.

It will have no difficulty distinguishing among: "What is the location of the cruiser Phoenix?"; "Where is the Phoenix?"; Find the ship Phoenix!" Regardless of which way the question is asked, Deacon should be able to provide the correct answer.

Computer grammar. The Deacon system is based on the interaction of three parts of the program: a dictionary, which lists the words the computer can recognize; a rules catalog, which contains the grammar of the system; and a data base, which provides the interconnections among words that gives the system its "intelligence."

When queried, Deacon first searches for the important words in the dictionary. If a word is not there, the computer will ask the operator to rephrase his question or define his terms. Eventually, when all the words are found, linkages are established through the data base; this tells the computer what is being asked. For example, if the question is "What is the location of the cruiser Phoenix?", the computer would recognize that "location," "cruiser" and "Phoenix" are important words and search for linkages among them.

Linkages are often complex. For example, the memory might contain data about the Phoenix on weight or manpower; the locations and other facts on cruisers named Dallas, Cleveland or Miami; and data about a city, an insurance company and a mythical bird, all named "Phoenix."

The program may have to follow more than one track to make sure it doesn't give a correct but inappropriate answer. The question "Where is Phoenix?" could be answered: "The cruiser Phoenix is in San Francisco Bay"; the city Phoenix is in Arizona," and so on.

Recondite language. Most information-retrieval systems now in use require that questions be asked in a specialized language, using key words and standard forms. Also, many of them can tell only where to find the answer.

Deacon is being developed on relatively unsophisticated hardware. The computer is a GE 225 with one magnetic disk file that has a capacity of 18 million six-bit characters. Communication with the computer is through a teleprinter or a GE Datanet 760, which acts like a teleprinter but produces an image on a cathode-ray tube instead of printing on paper. The teleprinters and the Datanet 760 communicate with the GE 225 central processor through a GE Datanet 15.

Herbert R. J. Grosch, director of the project, says he does not think the kind of equipment being used will limit the Deacon project, "because I am certain that hardware development will keep ahead of our needs."

The system's speed and versatility could be improved, however, by giving it an associative memory—a development still in the experimental phase. An associative memory can pluck a bit of information from storage by making an adroit association rather than going sequentially through its memory until the information sought is reached. It would know immediately if it "recognized" a specific word in a question without having to look it up in its dictionary.

Instrumentation

Invisible sentry

Most electronic sentries have two crucial disadvantages: if they are active, an intruder can detect their radiation; if they are passive, they can't be detected but have a range of only one or two feet. A passive infrared sentry that can sense an intruder up to 250 feet away has been developed by the Huggins Laboratories, Inc., of Sunnyvale, Calif.

With the Huggins system, the intruder inadvertently does all the work, by supplying the two components that activate the alarm—motion and a radiometric signal. The front of the detector is covered with a grid. Any motion of an infrared source creates a low-frequency modulation of the radiometric signal as it is interrupted by the grid. The resulting signal is amplified and used as a d-c trigger for firing the circuit. No current flows in the system until an intruder comes into range. Before that, the system is dormant and safe from detection.

Target temperature. For the infrared sensor of the motion detector Huggins used a capacitor bolometer it had developed earlier. The capacitor bolometer's frequency response is at least five times greater than that of the thermistor bolometer usually employed in infrared systems, making the sentry responsive to rapid movement. The bolometer is arranged in a double-ended bridge circuit that adjusts to changes in the ambient temperature. It then will react to radiometric signals that differ as little as 1°F from the ambient temperature. Tests showed the differences between a person's clothing and ambient temperature were usually more than 1°F—even at the pants' cuff.

A lens with flat transmission characteristics from 4.2 to 15 microns is used to increase optical efficiency. The 9.3-micron wavelength of human infrared radiation is well within the lens' range. A filter in front of the lens prevents sunlight from affecting the detector. The sentry will function effectively at ambient temperatures from 25° to 120°F. This range can be lowered or raised by adjusting the detectors' electronics.

Other systems. Active intruder detectors, such as ultrasonic sentries, are detected easily with electronic sensors. Even acoustic systems, which are only partially passive because they limit r-f radiation, can be detected; they have the added disadvantage of being sensitive to random noises, such as the ring of a telephone or the sound of a passing car. Doppler radar systems, besides being very expensive, can be detected with a wide-band crystal detector. Systems that use a change in capacitance or inductance of a tuned oscillator circuit approach being passive but have a range of about two feet.

A disadvantage of the Huggins' sentry is that it would be triggered by any moving infrared source in the 4.2- to 15-micron range, and this includes everything from squirrels to grizzly bears. The Air Force has had a similar problem with a capacitance-type detection system for its Minuteman missile site at Ellsworth Air Force Base in South Dakota. The system is reportedly so touchy that high-leaping grasshoppers periodically set it off. A modified version of a doppler radar detection system at Titan II missile sites can distinguish between men and animals by measuring differences in frequency and intensity of the returning radar signal. [Electronics, Nov. 16, 1964, p. 32].

Friend or foe. William E. Osborne, chief scientist at Huggins, says the Air Force is interested in the infrared sentry for perimeter surveillance. The Army also sees a potential as a weapon: it could be used to trigger antipersonnel mines from a safe position.

"The next step," Osborne says, "is to develop a system that can distinguish between friend and foe.

Osborne says he has discussed possible traffic control applications with officials in several cities. Detectors could be used at highways to monitor traffic. If traffic slowed to a predetermined rate and stayed that way for a time, the sentry would trigger signs warning motorists of the congestion, would reroute traffic or would prevent more cars from entering the highway.

Data processing

Banking on computers

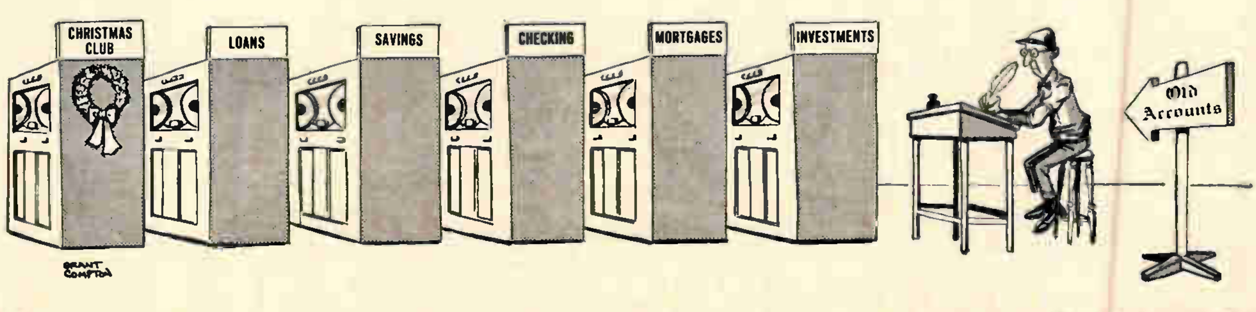
The banking industry is on the verge of being overwhelmed—by a mountain of checks. Some 70 million are now cashed daily, and each year the number grows. To move each of these millions of bits of paper—from the place where it is written to the issuer's bank for deduction—banks spend some $3.3 billion a year.

A solution, however, is in sight. Slowly, in still uncoordinated steps, the banking industry is establishing a nationwide financial utility that eventually will tie the money transaction of banks and customers into a vast computerized network. Some time from now, many bankers agree, checks will be as obsolete as Indian pennies.

Pay the phone. A precursor of the network was started last month in Wilmington, Del. [Electronics, Nov. 15, 1965, p. 41]. A person with an account at the Bank of Delaware can pay for a purchase at nearby Stroms department stores even if he has left his wallet home and has no credit account at Stroms. After a purchase, the salesman simply "dials" the number of the bank on a touch-tone telephone, enters a code that identifies the customer and then enters the amount of the purchase. Automatically, through a team of International Business Machines Corp. computers, the purchase amount is deducted from the customer's checking account—without the writing of a check.

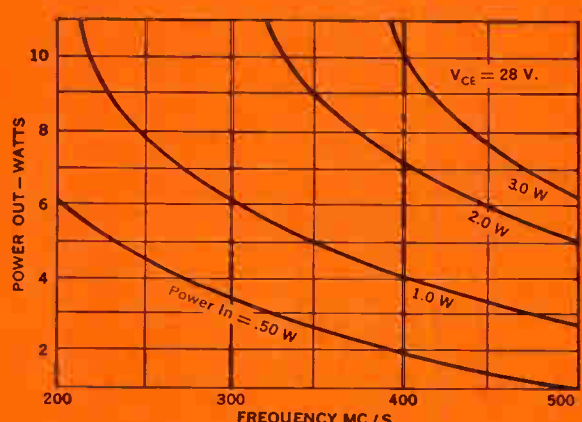
The Bank of Delaware is already planning a step beyond. This year it will conduct an experiment in which customers will use touch-tone telephones at home, paying bills to companies with accounts in the bank.

Novel as the system is, it gives only a hint of what's in store. Within a decade many bankers foresee a network in which banks will be tied to retailers through a central computer clearing house. From there, the banking network could expand. Employee payrolls, for example, could automatically feed from corporate accounts into individual accounts; and the employee's regular monthly payments —mortgage, utilities and savings— would be automatically deducted. The Treasury Department could tie in: income tax withholding payments and social security payments could be deducted. The Federal Reserve System, in a side benefit,



TRW ANNOUNCES

10 W 400 Mc 60% η



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TRW designs and manufactures high performance transistors for the communications industry and specialized types for military and industrial applications.

6-10

TRW SEMICONDUCTORS

could monitor the flow of money across the nation, gaining instant and precise information on the state of the economy.

In general, the federal government favors the trend. And, as George W. Mitchell, a member of the Federal Reserve Board, notes: ". . . these experimental operations will provide a solid foundation for a banking system of the future."

Seek a share. Plans to establish this financial utility are being pressed hard by the American Telephone & Telegraph Co., which already has the inside track: the terminals (touch-tone phones) and the communications lines. But other companies are seeking a share of the market. The major communications common carriers, including the International Telephone and Telegraph Corp. and Western Union, are trying to develop competing systems.

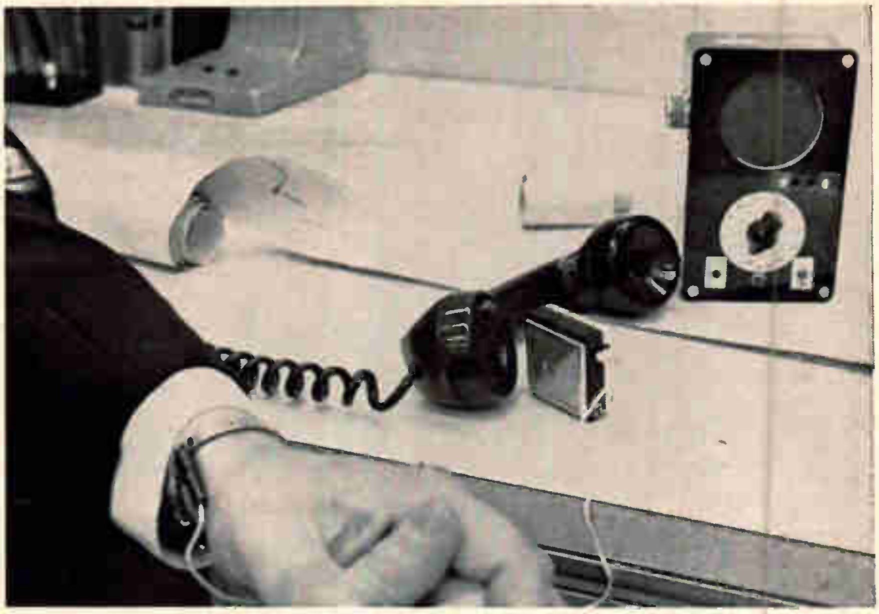
Bankers concede, however, that a fully computerized operation is still years away, and in the meantime they face that growing mountain of checks. One proposal, by W. Putnam Livingston of Bankers Trust Co. of New York, is to stop a check's movement at the first bank it is presented; then, rather than shipping the paper back to the check writer's bank and subsequently to his home, move only the information on the check by computer.

"The fact is that money is, basically information," says Martin Greenberger, an associate professor at the Massachusetts Institute of Technology. As such, he sees banking and finance as one component of the information business. Thus, the financial utility could easily tie in with marketing-research program, securities trading and credit control.

Medical electronics

Taking heart

Cardiac victims may soon have a simple wrist device that will be a heart line to expert medical attention. The wrist sensors are part of an electrocardiograph (EKG) telemetry system that links patient and EKG apparatus by telephone to a doctor.



Electrocardiograph by telephone. The patient connects two electrodes from wrist bracelets to a small transmitter that relays audio signals to a doctor's office. There, a demodulator changes the signals into a pulse that is recorded by an electrocardiograph. The larger transmitter in the background is a prototype.

With the proposed system, a patient takes his own electrocardiograph by clipping a pair of electrodes from expansion bracelets on each wrist into a transmitter. The EKG signals are sent by telephone to an EKG print-out machine in the doctor's office at the other end of the line. There, a demodulator turns the audio signal into a series of pulses that is recorded as a line graph.

Dr. Travis Winsor of the Winsor Memorial Heart Research Foundation in Los Angeles is developing the EKG telemetry system with technical assistance from the Missiles and Space division of the Lockheed Aircraft Corp. and the Electronics Systems division of TRW Systems, Inc.

Woman's compact. TRW has come up with an integrated-circuit version of the prototype transmitter that had more than 40 discrete components—transistors, diodes, resistors, capacitors and inductors —plus a battery power supply and a speaker, packed into a box about 3 by 4 by 5 inches.

The IC version has been cut to a loudspeaker, a battery, a few discrete components and three integrated circuits; it fits into a box that's the size of a woman's compact. But Donald McWilliams assistant chief of semiconductor technology at TRW's microelectronics centered isn't satisfied yet. He hopes to get the package down to the size of a wristwatch.

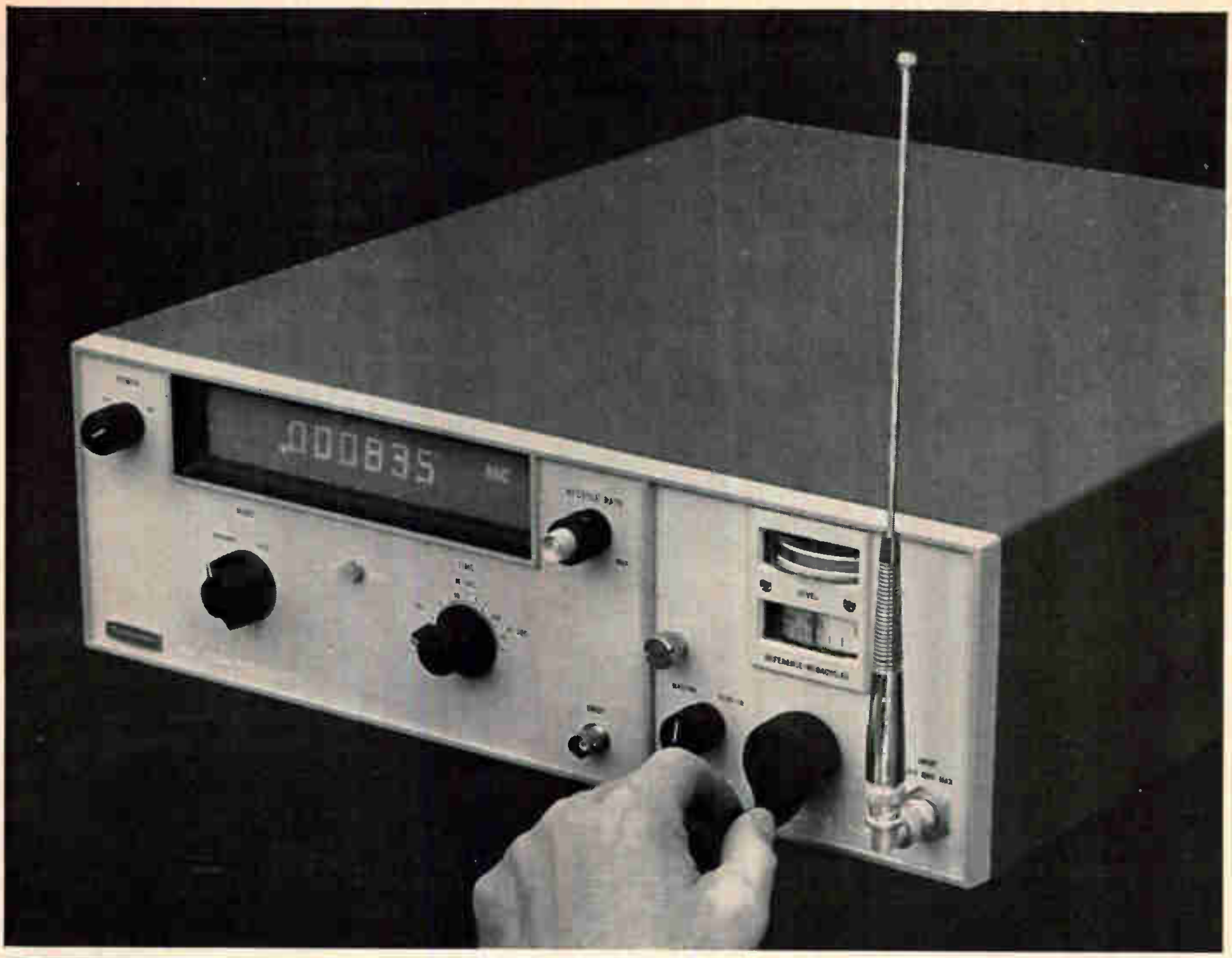
McWilliams also plans to replace the inductive coupling used in the Lockheed receiver with noninductive coupling to avoid picking up normal 60-cycle-per-second a-c noise.

Reports from cardiac patients testing the system already indicate it will be a success, Dr. Winsor says. He receives 40 or 50 "electrocardiograph" calls a day at the foundation from patients too far away to come and see him.

Communications

One-man tv crew

The Westel Co. of Redwood, Calif., says it has developed a television camera and audio-visual recording system that can be carried and operated by one man and yet



Circle 41 on reader service card

Taping for television: taking pictures on the go.

meets all broadcast standards.

The recorder unit fits into a small suitcase weighing 23 pounds. It includes nickel-cadmium rechargeable batteries and a 30-minute supply of one-inch video tape. The camera weighs seven pounds. All operating controls and indicators are on the back of the camera head for convenient operation.

First of its kind. Westel says the system is the first single-head helical-scan video-recorder with professional broadcast quality. In most helical-scan recorders, the tape is wrapped around a cylindrical drum in helical fashion as it passes from reel to reel. Inside the drum, two revolving heads in sequence sweep across the tape, recording the picture. Westel uses a drum, which is an inverted, truncated cone, so that the tape overlaps itself as it passes around the drum. Because of this overlap, only one head need be continually in contact with the tape, making it possible to eliminate all head-to-head switching circuitry. Westel calls its recording technique Coniscan.

To keep the weight of the WRC-150 recording camera down, Westel includes no playback, rewind or fast-forward capabilities. For playback of tapes recorded in the field, Westel has a much more elaborate studio-recorder, the WTR-100. It will accept video signals from any studio source and can be converted to accept color, says Westel, with the addition of only a small plug-in module. Westel claims that the studio model can maintain a color signal stability of less than 3° of phase error. A phase-error of 10° is considered the maximum allowable error for a complete studio-transmitter chain.

The 150 costs $10,500 and the 100, $15,000.

Advanced technology

Family planning

Will computers ever be able to breed computers?

"I don't yet see any specifics on the horizon, but I do smell the possibility of such a technological revolution," says Jerome Rothstein, senior staff scientist at Laboratory for Electronics, Inc., of Boston. "Maybe in five years we'll begin to see something in rudimentary form."

Rothstein's research in the field of molecular cybernetics, is sponsored by the Bionics Laboratory at Wright-Patterson Air Force Base in Dayton, Ohio. He will report on his work at the Bionics Conference to be held there May 3 to 5.

The concept of the computer-breeding computer has been applied to machines that help design the logic wiring diagrams or programs of a next-generation computer. But this is not the context in which Rothstein discusses the possibility of self-reproducing machines.

His goal is to discover how living systems store sufficient information to duplicate themselves, what laws of physics and chemistry make self-replicating information storage possible and how such information and control processes can be imitated in a man-made machine.

Evolution. Such a machine would be self-organizing, self-repairing,

Jerome Rothstein: it takes inspiration.

self-correcting and adaptive. In a word, it would be evolutionary.

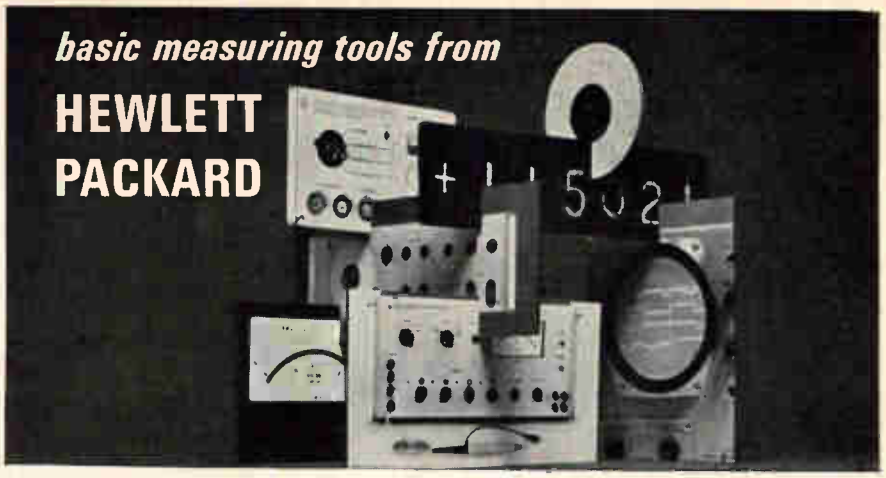
Much of the activity in bionics today consists of investigations of circuits and networks designed to perform biomorphic functions. But Rothstein is exploring information and control processes in biochemical systems at the molecular level.

In the face of a staggering complexity of variables, Rothstein plays it like a chess game—but not like a computer playing chess. The computer gets swamped trying to cope with the large number and combinations of variables. A skillful human player learns the principles, discovers tactics and strategies and throws out the time-consuming and irrelevant cases, he explains.

Using information. In genetic structures, from virus to man, there must be storage of information at the molecular level. Rothstein's investigations have led to grouping configurations of molecules into "families." Control actions determine whether a molecule can change its configuration from one family to another; catalysts exert such controls.

Rothstein investigates chain molecules—beads connected by links; the order of beads constitutes a message. Such messages are the catalysts that make control possible.

"It is this family structure—or something like it—an extra structure that may be exploited by the living organism to permit at a chemical level the control processes that we know in engineering,"



the physicist explains.

Through complex transition diagrams, Rothstein maps some of the ways in which molecules could form chains, migrate into varying configurations and otherwise manifest order and control.

A new math. If and when the replicating processes in molecules are sufficiently understood, it is believed they could be imitated by a computer with a sufficiently large number of elements.

With today's integrated circuits, Rothstein says, very rudimentary kinds of adaptive systems can be built. "But it is not yet worthwhile to try to do this for the complex systems envisioned. For a long time, the most sensible tactic is to model such systems, including the molecular structures under study, on computers." His lab has under development a thin-film matrix memory that makes modeling of growth and self-replicative behavior possible.

What will it take to make the transition from computer modeling to prototype self-reproducing machines capable of carrying out complex tasks?

"Inspiration," says Rothstein.

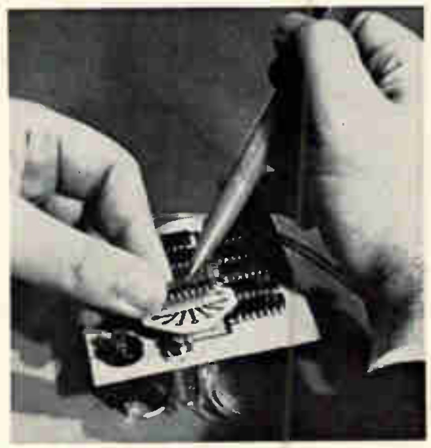
IEEE

TI DIP's in

Texas Instruments Incorporated has quietly joined its competitors in offering integrated circuits in the dual-in-line package style (DIP). The DIP was shown at TI's booth at the Institute of Electrical and Electronics Engineers show in New York. TI had been one of the last major IC manufacturers holding out against DIP's [Electronics, Aug. 23, 1965, p. 118]. The Signetics Corp., a subsidiary of Corning Glass Works, introduced a DIP just before the show.

The new TI package has the same pattern as previous DIP's—14 leads spaced 100 mils apart in two rows 300 mils apart. The company's regular plug-in package has 16 leads in two rows 200 mils apart. Each IC manufacturer has picked a slightly different body design for its DIP. TI followed suit, it is molding them in one piece with silicone plastic, instead of using the sealed sandwich of epoxy or ceramic that others have used. The body indexing aid is also different—a depression in the top of the package body.

DIP picker. Unfazed by the apparent inability of IC manufactures to standardize DIP bodies, the Universal Instrument Corp. has designed a machine that will be able to plug anybody's DIP into a circuit board. For a time, it seemed that systems manufacturers who wanted to assemble DIP's by machine would have to buy a different machine or a different pickup mechanism for each body style, because of the dimensional variations [Electronics, Sept. 6, 1965, p. 40].



A new plastic carrier for the Signetics Corp.'s DIP is used as a hand-insertion alignment jig. The carrier is positioned on the circuit board and the package pushed down to plug in the IC leads.

Universal Instrument's solution is one the company has been using in its machines made for automatic insertion of the hybrid-circuit plug-in modules of the International Business Machines Corp.'s System 360 computers [Electronics, Nov. 1, 1965, p. 90]. The machine—to be built on custom orders—won't grasp the package. Instead, it will pick up and insert the IC's with a suction tool applied to the top of the package bodies.

The different IC's required by an assembly will be loaded—facing in the right direction—into a series of slots in an inclined tray. A tape-programed numerical control unit will move the pickup head to the right slot and move the circuit board into the right position to accept the selected DIP.

Army drafts IC's

The Army is moving surely—but slowly—toward the use of monolithic integrated circuits in ground electronic equipment.

"Their use by the Army is no longer subject to question," declares Robert Geisler, a project officer with the Army's Electronics Research and Development Command at Fort Monmouth, N. J.

However, he thinks that for the next three years the Army equipment will continue to use the same number of conventional printed-circuit assemblies, with tubes and transistors.

Integrated circuits are already going into ground equipment, but primarily in digital systems and in the decoding and coding portions of gear with scramblers for secure communications.

Geisler expressed these views at a meeting in New York of the Institute of Printed Circuits on the outlook for printed circuits during the next five years.

Flatpacks or DIP's? Geisler predicted that three to five years from now IC's will be in general use in Army electronics. After that, monolithic arrays and complex integrated circuits will come into use [Electronics, March 21, p. 144].

Still unresolved, he said, is the type of IC package that the Army will settle on as a standard. Initially, the IC's are being bought in flatpacks and TO-5 cans, but Geisler thinks that the larger, dual-in-line package (DIP) type of plug-in will eventually win out. The reason is that the Army wants as few multilayer boards as possible in its systems. Not only are conventional circuit boards less expensive, he pointed out, but they make assembly and repair easier. The DIP's were designed for soldering into such boards.

Arrays will also reduce requirements for multilayer boards, Geisler believes, since much of the interconnections for the circuitry of systems built with arrays is done by thin-film wiring on the silicon chips.

Hot computers. Another speaker at the meeting, E. G. Lorenz of the International Business Machines Corp., predicted the continued use of multilayer boards in computers, with radical changes in wiring size, board materials and fabrication methods.

Besides the continued use of multilayer transmission-line interconnections [Electronics, Nov. 1, 1965, p. 90], Lorenz expects increased use of operational circuitry made by printed-circuit techniques. One example is capacitor type, read-only memories. These are made by etching wiring electrode arrays on either side of dielectric layers.

Because IC's result in increased functional density, he predicts that wiring line widths will shrink from present minimum widths of about 10 mils down to about 1 mil (0.001 inch). The wiring patterns will probably be fabricated by high-energy beams; he sees the boards being designed, made and tested under computer control.

The high circuit density, Lorenz says, may result in operating temperatures ranging from 400° to 600° F. Since the dielectrics will have to hold dimensional tolerances as tight as 0.1 mil, organic dielectrics may be discarded in favor of ceramics.

Ten-way masks

Thanks to some optical legerdemain, engineers at the Martin Marietta Corp.'s Martin division in Orlando, Fla., have invented a way to make as many as 10 different deposition or etching masks from a single master artwork pattern.

The process eliminates the tedious preparation of individual patterns for each mask needed to make a multilayer thin-film circuit or printed circuit. Because Martin uses a single master pattern, all the masks are automatically in near-perfect registration.

Now you see it . . . Martin's invention was described at the IEEE Convention by Burton J. Askowith during a session on microcircuit fabrication.

The master pattern is prepared with six different kinds of birefringent tape. Each time the incident angle of polarized light is changed, a different mask pattern on the master pattern becomes opaque. When different wavelengths of light are used, as many as 10 different patterns can be seen, one at a time.

This allows the entire pattern to be made as one piece of artwork. For a simple thin-film circuit one type of tape would be used for the resistor deposition mask; another type would be used for the electrode mask and a third for the interconnections.

Slow light. Birefringent tapes are made by stressing plastic materials so that they have two optical axes with different indexes of refraction. One axis passes polarized light faster than the other. Depending on the film thickness, the slow axis retards the passage of light one-half or one-quarter wave-length.

Martin cuts the tapes lengthwise to the fast axis, crosswise and on biases of 45° and 135° to get the six different kinds of tape. The masks are made by exposing photographic film to light shining through a polarizer, the pattern and analyzers.

The polarizer and analyzers are rotated to correspond with the kind of tape forming the pattern for each circuit layer.

Help!

The rules said "no recruiting" during the IEEE show in New York. But one company official summed up the intensity of the talent search when he said: "The show was a success. Our company lost only three men."

Outside the Coliseum a shouting match took place between recruiters and IEEE officials who tried to move the recruiters away from the entrance to the show. In hotels nearby, engineers awoke to find job offers stuffed under their doors. An agency representing 42 companies seeking talent ran a shuttle

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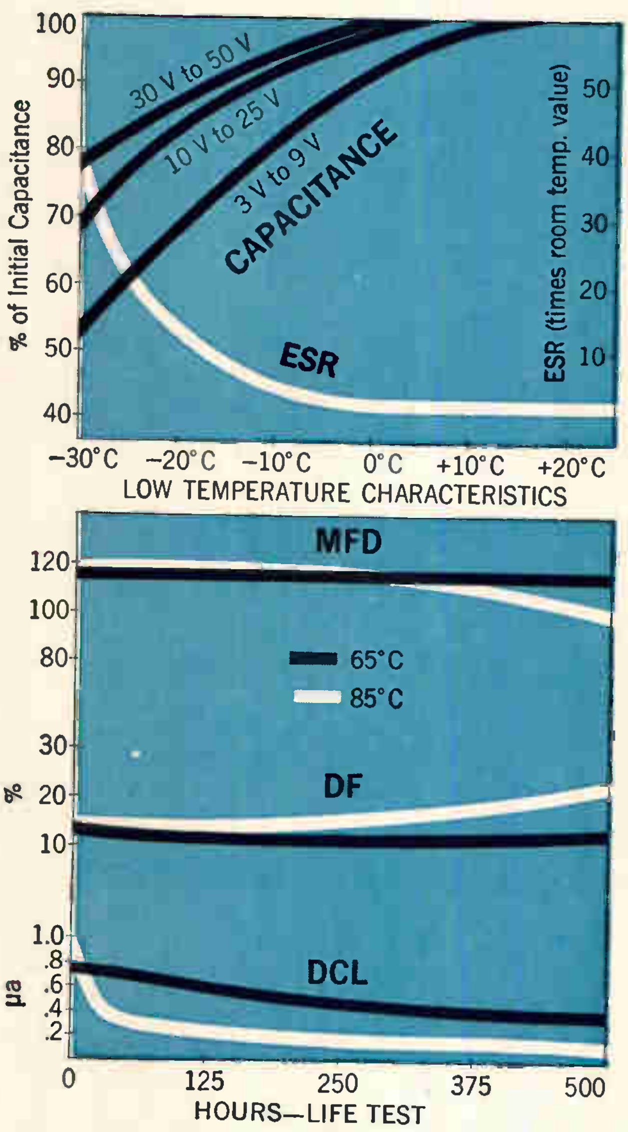

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bus from the Coliseum to the agency's headquarters.

The effort poured into recruitment left no doubt about the engineering shortage. It's here—and because of the upswing in business it probably will last.

One company reported losing several components people at twice the salary they had been making. Recent graduates with masters' degrees commanded up to $11,500.

Recruiters primarily sought the specialist—in integrated circuits, in microwave, in instrumentation—with 5 to 10 years' experience. But sales and marketing people were also approached.

IEEE jotting

Other items of interest:

- **Unijunction.** In the fall of 1964 Texas Instruments Incorporated introduced a plastic planar unijunction—the only one on the market. But in a short time TI discontinued sales, reportedly because it was having trouble obtaining good stability with it. Now, however, TI is trying again, this time using a technique that yields a one-piece package. The device, designated the TIS43, sells for 72 cents in quantities from 100 to 999. The new transistor has a maximum emitter leakage current of only 10 nanoamperes at 25°C; conventional unijunctions have leakage current of from 200 to 2,000 nanoamperes. The TIS43 can withstand 60,000 G's of constant acceleration without damage, the company says.
- **Triacs.** The first triacs priced at under $1 were introduced by the Radio Corp. of America. A triac consists of a pair of silicon controlled rectifiers connected back-to-back (sometimes known as a reverse-parallel connection) on a single chip. The RCA units, the TA2892 and the TA2893, need only one to three milliamperes of gate current for triggering. In many circuits, this will allow the elimination of the unijunction transistor normally required to initiate the conduction cycle.

The new devices have a 2.5-ampere current-handling capability and a steady-state anode-to-anode typical voltage drop of 1.1 volts.

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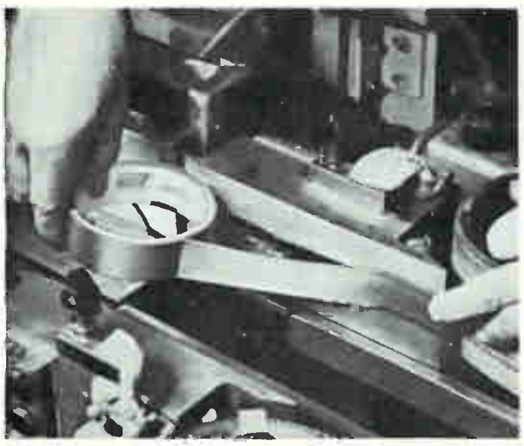

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These remarkable tapes are particularly useful in reducing friction on high speed equipment and as insulators of electrical apparatus, but they have many other applications in the electrical and electronic industry.

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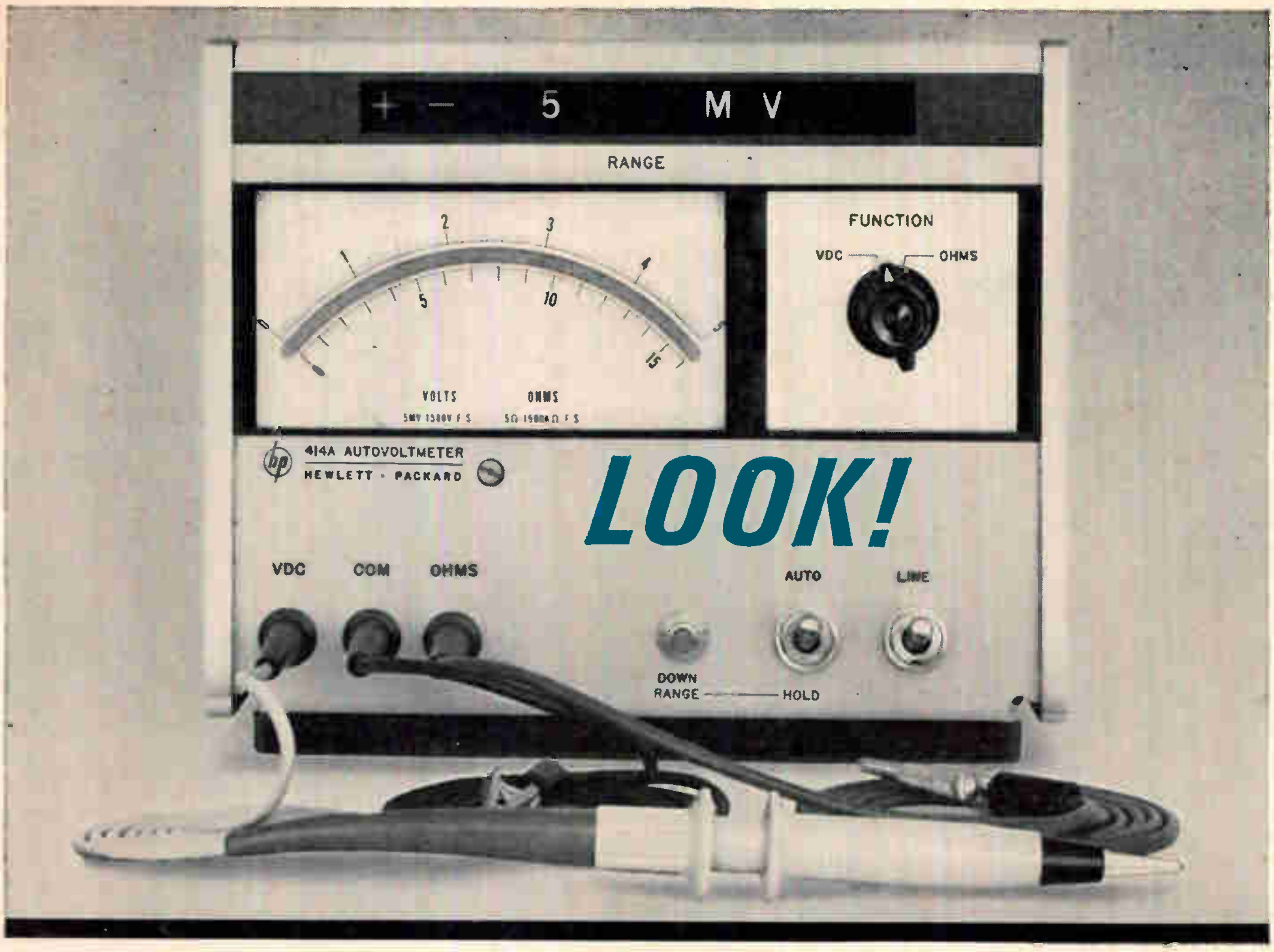

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Input resistance is 10 megohms on the 5 and 15 mv ranges, 100 megohms on 50 mv range and above. The 414A is insensitive to 60 cps signals with peak value less than 7 times the full-scale dc level of range in use in "Hold" position (rejection is 20% of reading when using Auto-ranging).

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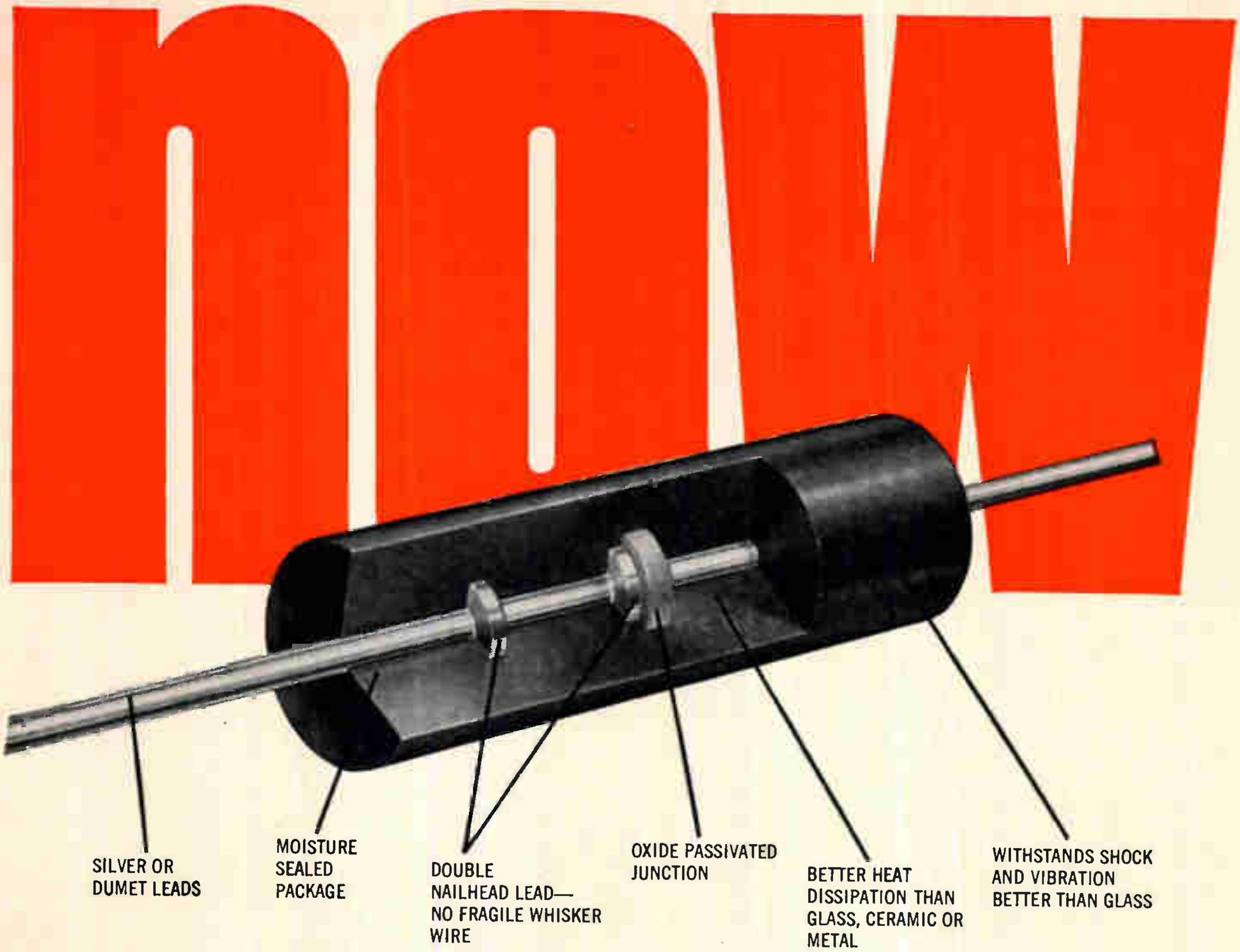

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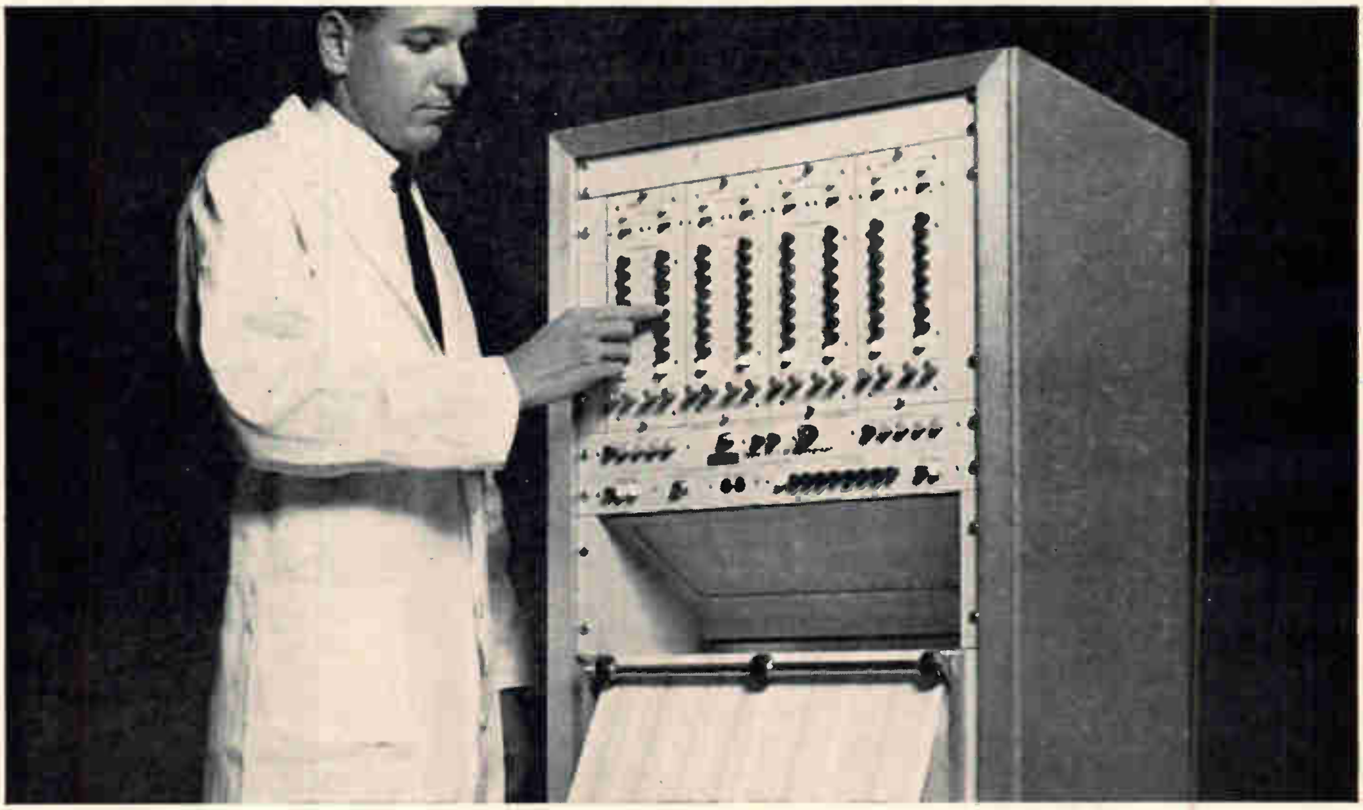

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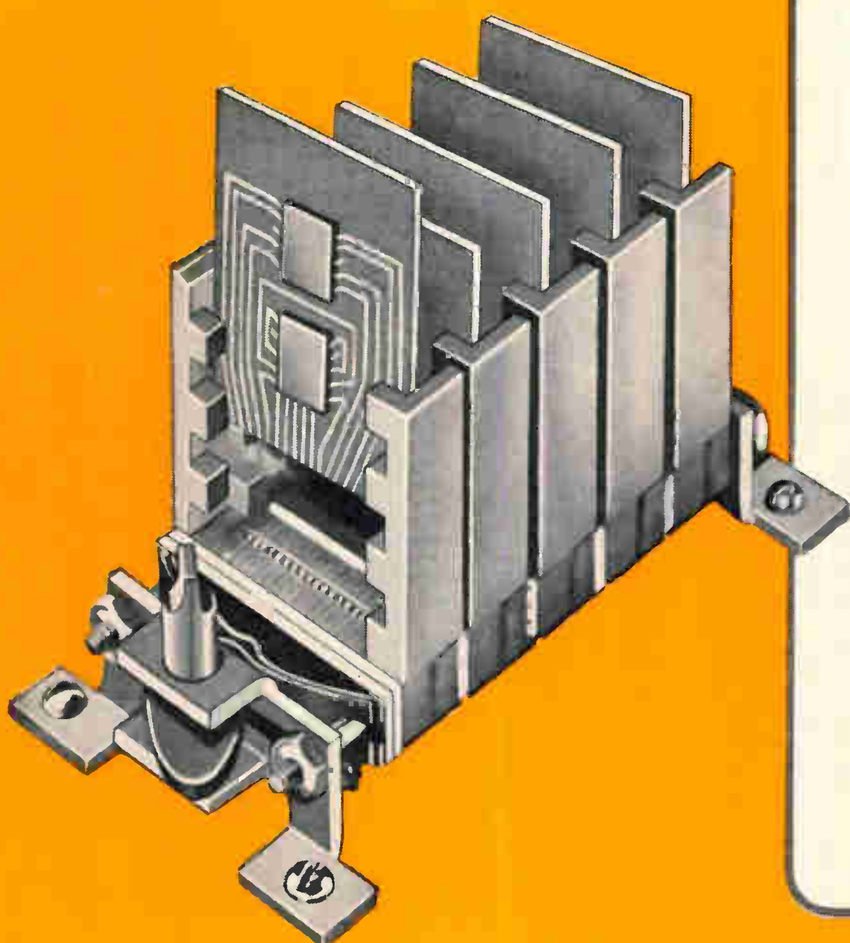
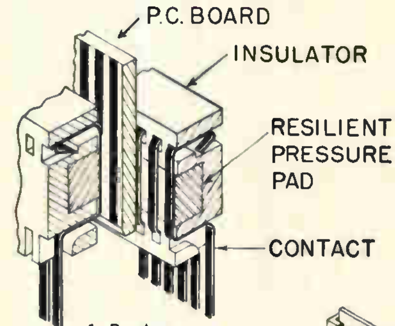
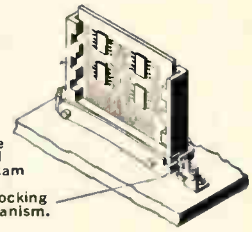
Cinch capabilities in micro-electronic interconnection can solve your packaging problems

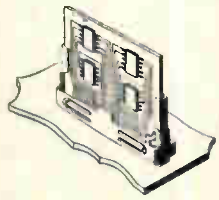




1. Preskam connector with PC Board locked in place.



2. Single board Preskam with side-locking mechanism.



3. Single board Preskam with "normally closed" construction. Board is released by relieving clamping pressure.

Ask Cinch about the new Preskam* System that permits connections that don't dwarf the circuits they join.

Either a board or male connector is dropped into place and then a cam actuated insulating bar clamps the board into the connector. High uniform contact pressure is maintained over an up to 70% greater contact area than in conventional connection means.

Contacts are on 25-mil centers and boards can be as little as 100-mils apart. Multiple boards may be controlled by the same locking device.

With contact disengagement before board insertion or withdrawal, the most fragile thin glass or ceramic substrate is undamaged even from repetitive insertions.

RELATE YOUR PRODUCT PLANNING TO THE STATE-OF-THE-ART INTERCONNECTION SYSTEMS WHICH ARE AVAILABLE FROM THE CINCH RESEARCH AND DEVELOPMENT PROGRAM. ASK CINCH FIRST: THEY MAY HAVE ALREADY SOLVED YOUR INTERCONNECTION PROBLEM.

Write Cinch Manufacturing Company, at 1026 South Homan Avenue, Chicago, Illinois 60624.

*Patent Pending

CINCH

DIVISION OF UNITED-CARR

Circle 55 on reader service card

Four low-cost compacts for 6 circuit functions

These little rotary stepping switches from Automatic Electric are as versatile as they are economical. Capabilities for counting, controlling, monitoring, selecting, indicating or timing are built into each switch.

They're remarkably reliable, too. When the armature steps the wiper assembly to the next position, it also *locks* the rotor. Overthrow is impossible, thanks to this *positive positioning*—a unique AE design feature. There are no armature pawl stops to wear out, or get out of adjustment. Also... improved shock-resistant spring assemblies; excellent low-maintenance record.

You can get these AE compact stepping switches in numerous variations—many available directly from stock. If you need a "custom" variant, we can tailor it to your specifications, quickly and economically.

For helpful application information, get the 160-page book, "How to Use Rotary Stepping Switches." Just ask your AE representative, or write Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Ill. 60164.

(A) TYPE 40 No bigger than a pack of king-size cigarettes. A decimal switch with up to five bank levels—but only 10 points per level. Eliminates extra steps when counting decimally.

(B) TYPE 80 A decimal switch with a larger capacity than the Type 40. From six to twelve 10-point levels.

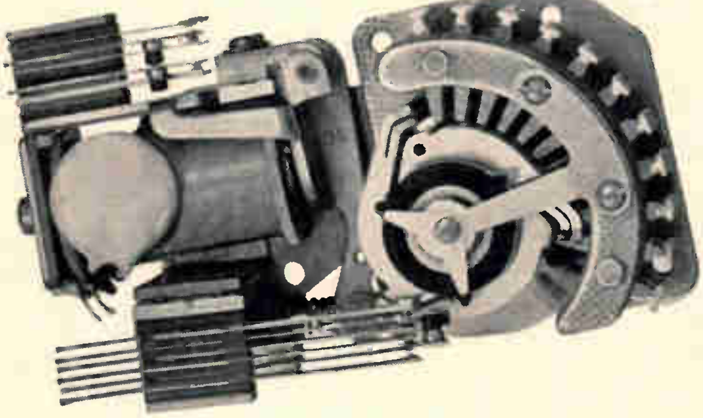
(C) TYPE 44 Available with up to eight 10-point levels—or 11 points on all levels where specified.

(D) TYPE 88 A larger-capacity version of the Type 44, with up to twelve 11-point levels where specified.

AUTOMATIC ELECTRIC

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E

A



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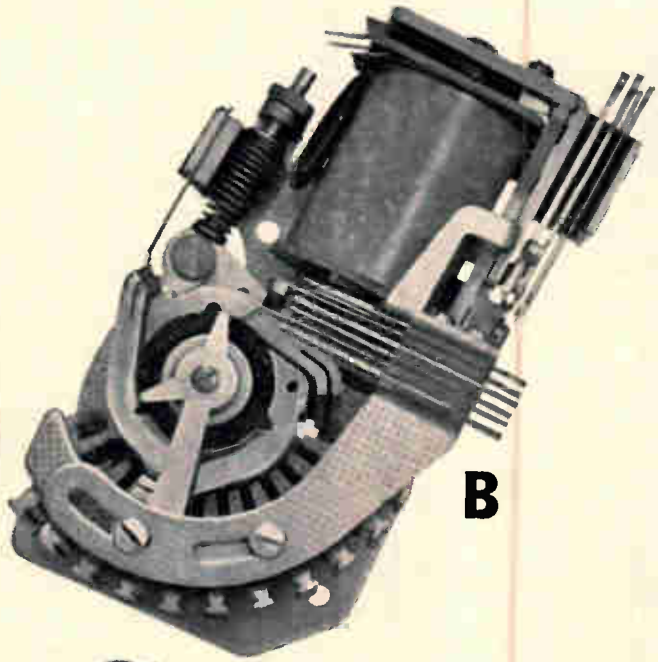

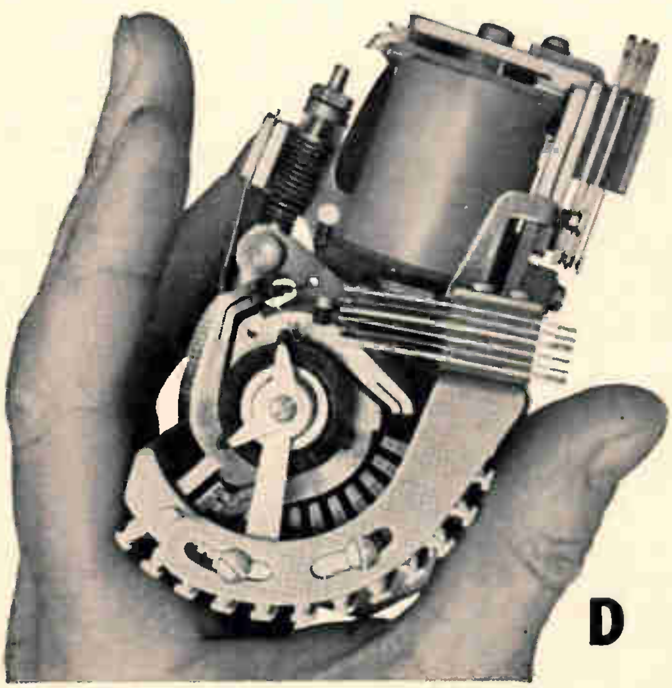

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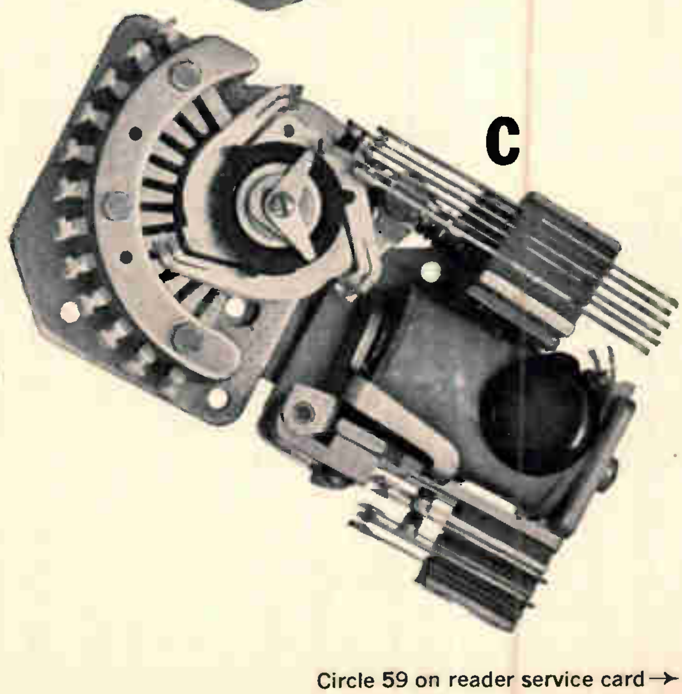


Circle 59 on reader service card →

If your blip is a blooper, you'll know it in 10 seconds.

Once you start using Polaroid Land film, you'll wonder how you and your oscilloscope ever got along without it.

In 10 seconds, you get an on-the-spot record. You can study it, attach it to a report, send it as a test record along with a product shipment, or file it for future reference.

You have a choice of 5 films for oscilloscope recording.

The standard film has an A.S.A. equivalent rating of 3000. You can get it both in pack film [Type 107] and roll film [Type 47]. They both give you 8 pictures 3¼ x 4¼ inches. This emulsion is also available in 4 x 5 sheets [Type 57].

And for extremely high-speed oscilloscope recording, there's Polaroid PolaScope Land film [a roll film, Type 410].

It has an A.S.A. equivalent rating of 10,000. It can discover traces too fleeting for the human eye: such as a scintillation pulse with a rise time of less than 3 nanoseconds.

Because these films are so sensitive, you can use small camera apertures and low-intensity settings. Every shot is a sharp, high-contrast image that's easy to read.

To put these films to work on your scope, you need a camera equipped with a Polaroid Land Camera Back.

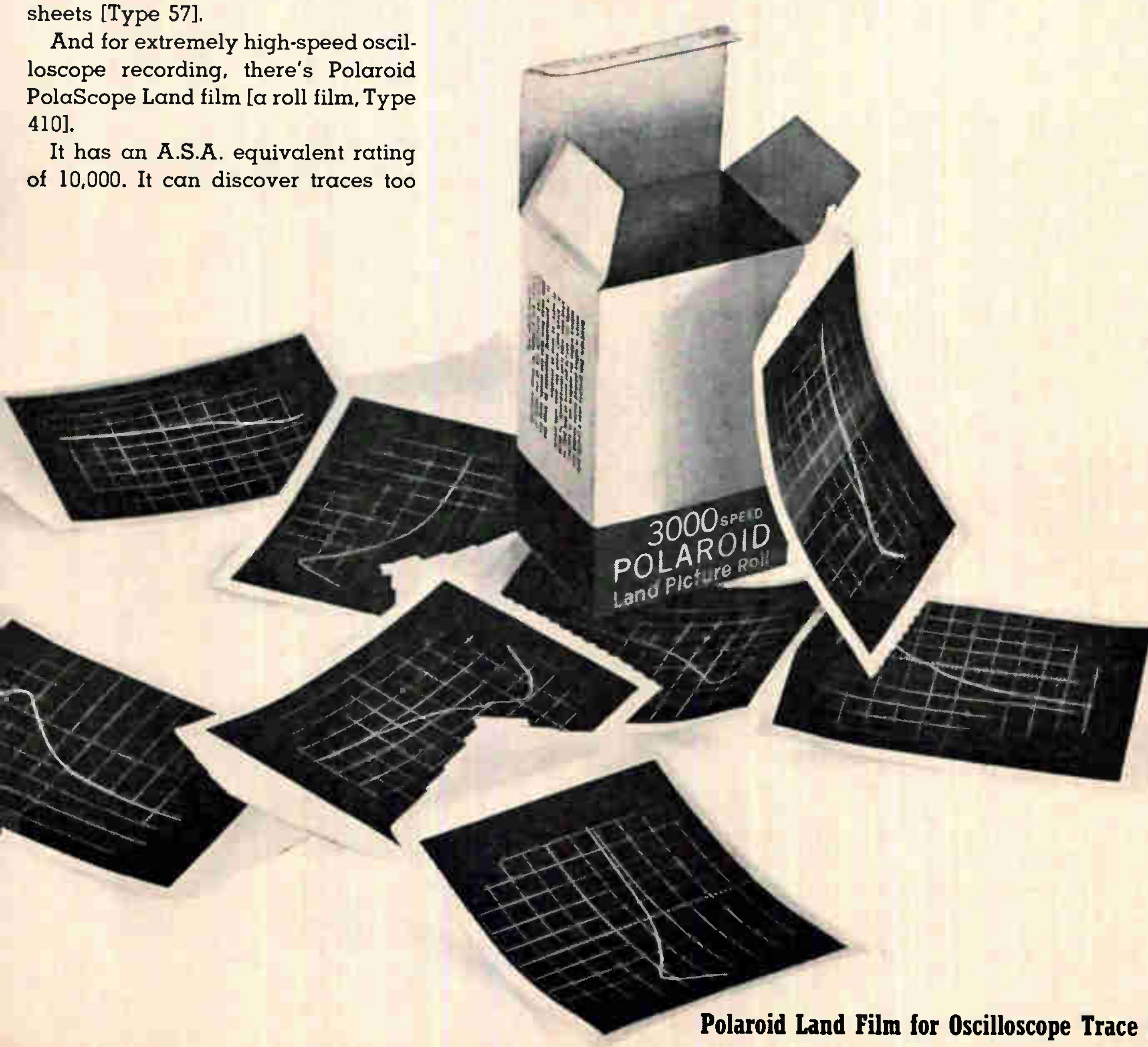
Most oscilloscope camera manufacturers have one.

For instance: Analab, BNK Associates, Coleman Engineering, EG&G, Fairchild, General Atronics, Hewlett-Packard and Tektronix.

You can get the full story by writing to Polaroid Corporation, Technical Sales Department, Cambridge, Massachusetts 02139 [or directly to the manufacturers mentioned above].

About the only thing we can't tell you is how to keep your blips from being bloopers.

"Polaroid" and "PolaScope"®



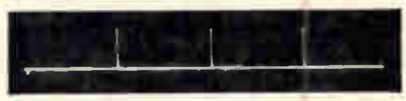
Polaroid Land Film for Oscilloscope Trace Recording.

GO ...20 Hz to 1 GHz

Kay 1500 Sweep & Marker Generator

TYPICAL PLUG-INS

Model	Center Freq.	Sweep Width
P-141	20 Hz-200 KHz	20 Hz-20 KHz
P-142	35 Hz-600 KHz	20 Hz-20 KHz
P-130	100 Hz-2 MHz	200 Hz-2 MHz
P-152	10 KHz-20 MHz	10 KHz-20 MHz
P-855	2-32 MHz	5 Hz-800 KHz
P-856	10-120 MHz	10 Hz-1 MHz
P-860	2-220 MHz	10 KHz-30 MHz
P-867	220-470 MHz	20 KHz-30 MHz
PI-123	100-1000 MHz ANY SINGLE OCTAVE	5 KHz-Octave
	Freq. Marker	
PM-7631	6 Pulse & Ext.	
PM-7632	6 Pulse & Ext.	
PM-932	30 Pulse	
PM-861	6 Harmonic and CW Osc.	


Pulse-Type Markers

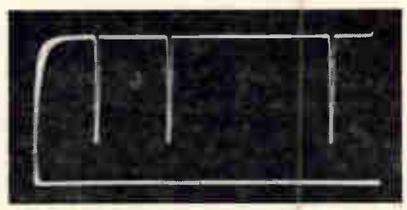

Harmonic (or Comb) Birdie Markers


Single-Freq. Type Birdie Markers

■ **VOLTAGE CONTROLLED OSCILLATORS**

■ **MARKERS**
- Pulse
- RF Turn-off
- Harmonic
- CW Birdie

■ **SWEEP**
- 0.2 to 60 cps
- Log and Linear
- External Input
- Manual Control


Detected Turn-Off Markers

The basic rack contains a variable, sawtooth sweep generator, a fast-acting AGC, frequency-marker control and output circuits, RF output circuits with precision attenuators, a calibrated output meter, an accurate RF detector, and carefully regulated power supplies.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 Circle 60 on reader service card

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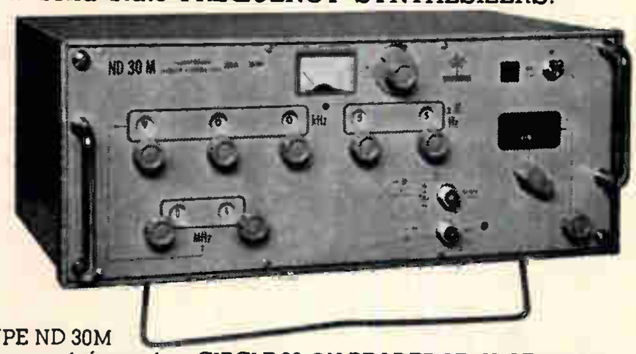
Since 1933, Rohde & Schwarz' group of unusually creative engineers have been designing electronic instruments that are truly unique. These instruments are constantly ahead of what is considered to be the state-of-the-art. They are more precise. They are easier to use and read. Many perform extra functions. 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—they 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!

Get extreme accuracy with these new solid state FREQUENCY SYNTHESIZERS!



TYPE ND 30M
For more information, CIRCLE 80 ON READER SERVICE CARD

A line of signal generators providing unusually high accuracy and ease of operation. Continuously variable over its range, each model provides a direct digital readout, with no tuning required. Perfect for bridge measurement, work with filters, networks, nuclear magnetic resonance, and as a source of reference frequencies for standards labs. All are fully transistorized and designed for AC or battery operation.

FREQUENCY RANGES: Type ND30M . . . 300 Hz to 31 MHz
Type ND1M . . . 300 Hz to 1.1 MHz
Type ND99K . . . 0 to 110 kHz

FEATURES:
- Built-in 1 MHz crystal has proportional oven and 5 x 10−⁹/°C stability
- Spurious and noise suppression better than 80 dB
- Decade tuning
- Modular construction
- Completely transistorized
- High resolution search oscillator — 130 divisions

A Crystal Measuring Set Built to IEC, IEEE & DIN Recommendations!

The Rohde & Schwarz RQZ Crystal Measuring Set provides a truly **uniform** method of measing equivalent circuit parameters of oscillator or filter crystals. Frequency range is 0 to 300 MHz, and measuring head will work over a range of −20° to +70°C. Provision is made for remote measuring.

TYPE RQZ

FEATURES:
- Measures motional capacitance, resistance, and inductance, and series resonance frequency.
- Measures crystals over wide range of drive levels
- Ranges of motional resistance 0 to 17 k Ω
- Built-in load capacitances of 12, 30, and 50 pF

For more information, CIRCLE 81 ON READER SERVICE CARD

Make rapid, reliable measurements of semiconductor parameters

TYPE TYM
For more information, CIRCLE 82 ON READER SERVICE CARD

The Rohde & Schwarz Transistor-Y Meter is a transistorized precision instrument which provides a complete measuring system for both dynamic and static parameters associated with diodes, transistors and other semiconductor devices and circuits. Also suitable for impedance measurements on other components, it is designed for low power consumption, thus reducing operating temperatures and increasing reliability.

FEATURES:
- Directly measures Y_{11e}, Y_{22e}, $|Y_{21e}|$, d_{12e}
- Measurements at 8 switchable fixed frequencies from 20 kHz to 37 MHz
- Test jigs for TO-5 and TO-18 packages; others available
- Output provided for measurement of phase (R&S Phasemeter Type PDF available as option)

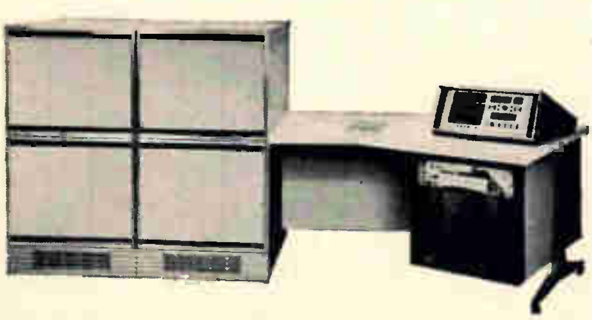
Use this Microvoltmeter for applications never before possible!

TYPE USVH
For more information, CIRCLE 83 ON READER SERVICE CARD

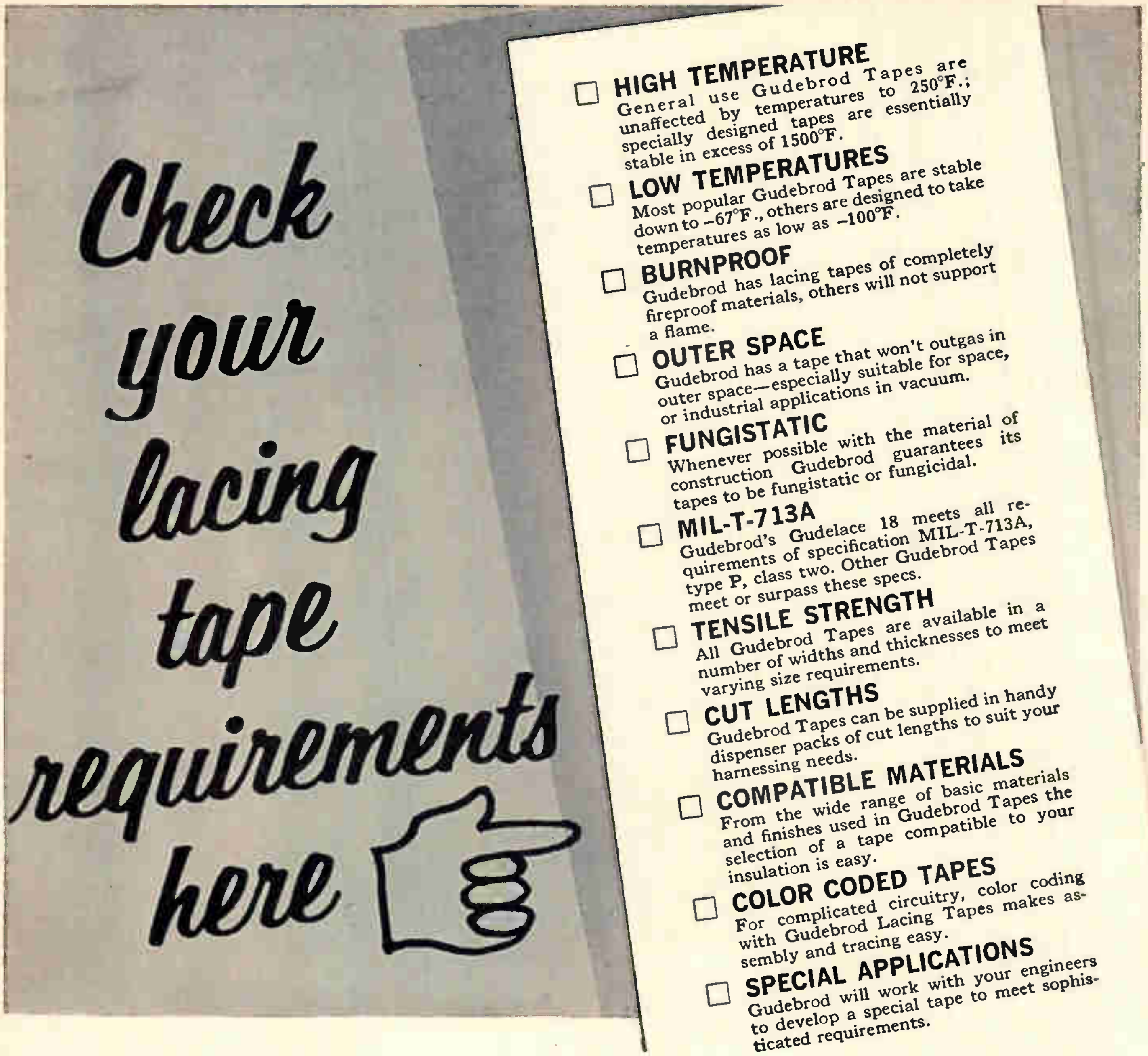
Rohde & Schwarz's USVH Selective Microvoltmeter features unusual sensitivity and sharpness in tuning that permits measurement of • selective attenuation and frequency response on 4-terminal networks • RF distortion and waveform analysis • depth of modulation • receiver and amplifier inter- and cross-modulation • RF leakage • spurious frequencies and noise—all without the need for additional equipment!

FEATURES:
- 10 kHz to 30 MHz frequency range
- Full scale deflections of 1µV to 1V
- Selectable bandwidth of 500 Hz or 5 kHz
- Six input impedances from 50Ω to 500 kΩ
- Expanded scale with suppressed zero for 3 dB point measurements

Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J., 07056 Phone: PRescott 3-8010
Inquiries outside the U.S.A. should be directed to: Rohde & Schwarz, Muehldorfstrasse 15, Munchen 8, West Germany.



Circle 65 on reader service card



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Perhaps you are regularly using Gudebrod Gudelace 18, the standard, wax impregnated nylon tape that's known round-the-world for its non-slip knotting (meets MIL-T-713A specs, too). You are doing well then—with the finest tape and saving money on harnesses, too!

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Electronics Division

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NEW
Auto-Torque
METERS
Now available in many styles!
This revolutionary new meter comes in conventional Bakelite models in 2½, 3½, and 4½-inch sizes — a modern, dull black model "45" with a picture frame window — brand new clear plastic 4½-inch square meter priced for the volume user — the distinctive Medalist series and the contemporary "MS" series, each in 3 standard sizes. Auto-Torque meters give you the widest selection of band-type meters available today.
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Auto-Torque's simplified design has 50% fewer parts. And since Auto-Torque meters are machine made, they give you uniform quality and precision never before possible in conventional meters. You can just about say good-bye to service problems!
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You save money!
Quantity-order prices for volume buyers are below comparable pivot and jewel meters!
Outlasts conventional meters!
Auto-Torque's moving system is suspended on metal bands under tension. As a result, there's no friction and wear.
Self-shielded mechanism
Auto-Torque meters can be mounted on any panel without special calibration; accuracy is unaffected by external fields!
For more information on the revolutionary Auto-Torque meters, write Honeywell Precision Meter Division, Manchester, N.H. 03105.

Because *one* data sheet — representing Motorola's new MR1120-30 series 12-ampere, 7/16″ stud rectifiers — now gives you the chance to replace any of more than 65 older EIA 3 to 12-ampere devices . . . *all* priced considerably higher than this new series (the lowest-cost counterpart to a $1.00,* 400-volt MR1124 unit is $3.05*)! And Motorola 12-ampere capability in lower-current sockets gives you an extra cost-saving bonus in lessened heat sinking needs.

But don't let the low price tags obscure the topnotch performance and efficiency advantages of these rectifiers:

- highest obtainable current/temperature capability — handles a 12-ampere load up to 150°C . . . superior to more than 4 out of 5 other 7/16″ stud devices
- greatest surge-current handling ability — 300-amperes (½-cycle) @ 150°C . . . at least 20% more protection than other 12-ampere units
- low forward voltage drop — 0.55 $V_{F(AV)}$ @ T_C = 150°C . . . less power loss in your circuit — minimizes thermal excursions and early device failure

*100-up

Contact your franchised Motorola semiconductor distributor now for evaluation units. For the latest word in comprehensive, low-to-medium-current-rectifier data sheets, write Dept. TIC, Box 955, Phoenix, Arizona 85008.

TYPE	$V_{RM(rep)}$ Volts
MR1120	50
MR1121	100
MR1122	200
MR1123	300
MR1124	400
MR1125	500
MR1126	600
MR1128	800
MR1130	1000
Reverse polarities available	

MOTOROLA
Semiconductors

Design in DC for ⅔ Less

(and throw out 27 data sheets)

Washington Newsletter

April 4, 1966

Congress likely to expand NSF's scope, not power

Congress is expected to approve a bill this year greatly expanding the scope but not the power of the National Science Foundation.

Because of strong White House opposition, the House Science and Astronautics Committee has decided not to push to have the foundation take over as chief scientific adviser to the President and as coordinator of all federal research activities. The drive to overhaul the foundation was initiated last February by Emilio Q. Daddario (D., Conn.), chairman of the committee's Science, Research and Development subcommittee.

Under the Daddario plan that Congress is expected to approve, the **foundation's area of interest would be expanded into such fields as engineering, scientific manpower and resources and scientific information.** Hearings are scheduled for April 19 to 21.

The science foundation once had much broader power but never fully exercised it. With the rapid growth of the military and space research programs, power was concentrated within the agencies involved, such as the Pentagon and the National Aeronautics and Space Administration. When President Kennedy took office, he created the Office of Science and Technology and conferred on it the responsibilities that the foundation never assumed [Electronics, July 12, 1965, p. 121]. Since this placed the Office of Science and Technology directly under the President's wing, **the White House saw the recent effort to change this line of command as a drive to usurp a power of the President.**

Pentagon to rate off-the-shelf dealers

Apparently satisfied with results of evaluating contractors' performance on major weapons systems, **the Pentagon is extending the report-card system to vendors of off-the-shelf electronic equipment.** The evaluations of past performance will help determine who will get future contracts. The program will cover military equipment supplied under contracts totaling $100,000 or more.

As a test, the Defense Supply Agency is evaluating producers of selected supplies and equipment. **Starting June 1, the Defense Electronic Supply Center, the Defense Construction Supply Center and the Defense General Supply Center will begin using the evaluations for new contracts.** By Jan. 1, 1967, the Defense Department will refine the evaluation program and put it on a permanent basis.

Contractors will be judged on the basis of how well they fulfill their contracts with respect to technical performance, milestones and cost levels. **They will be allowed to see the evaluations and comment on them.** In case of bad marks, they can advise the Pentagon immediately of corrective steps or make them evident in subsequent contract proposals.

Supreme court again tightens rules on patents

The Supreme Court is continuing to tighten the rules regulating patent applications by inventors. Setting a precedent that the Patent Office and lower courts will have to follow, **the High Court has ruled that commercial usefulness must underlie a patent request.** The court turned down the inventor of a process to turn out steroid chemicals. The process has no known usefulness—but could prove helpful to scientists doing further research.

Washington Newsletter

Immigration eased for skilled workers

Immigration of skilled workers has been eased by a Labor Department certification that there is a critical nationwide shortage of technicians, draftsmen, engineers and machinists. **Under the certification, companies in all regions will no longer have to document their own local shortages before going abroad for wholesale hiring.**

June 1 a deadline on accelerator site

The Atomic Energy Commission is trying to pick a winner in the "200-bev sweepstakes" by June 1. The AEC has been given a list of seven locales in six states as best bets for location of the proposed 200-billion-electron-volt particle accelerator.

Sites still in the running are Ann Arbor, Mich.; Madison, Wis.; South Barrington or Weston, Ill., near Chicago; Brookhaven National Laboratory, near Upton, N. Y.; Sierra Foothills, near Sacramento, Calif.; and Denver.

Unless the AEC meets the June 1 deadline for final selection, it may lose its chance to get about $7 million in a supplemental appropriation for fiscal 1967 to start engineering and design.

All-U. S. Early Bird proposed by AT&T

The American Telephone & Telegraph Corp, has asked the Communications Satellite Corp. to consider launching a satellite for domestic communications. **The request may open a battle over who owns the ground stations—Comsat or the common carriers.**

AT&T says there is a need to supplement its continental cable and microwave network with a large-capacity satellite.

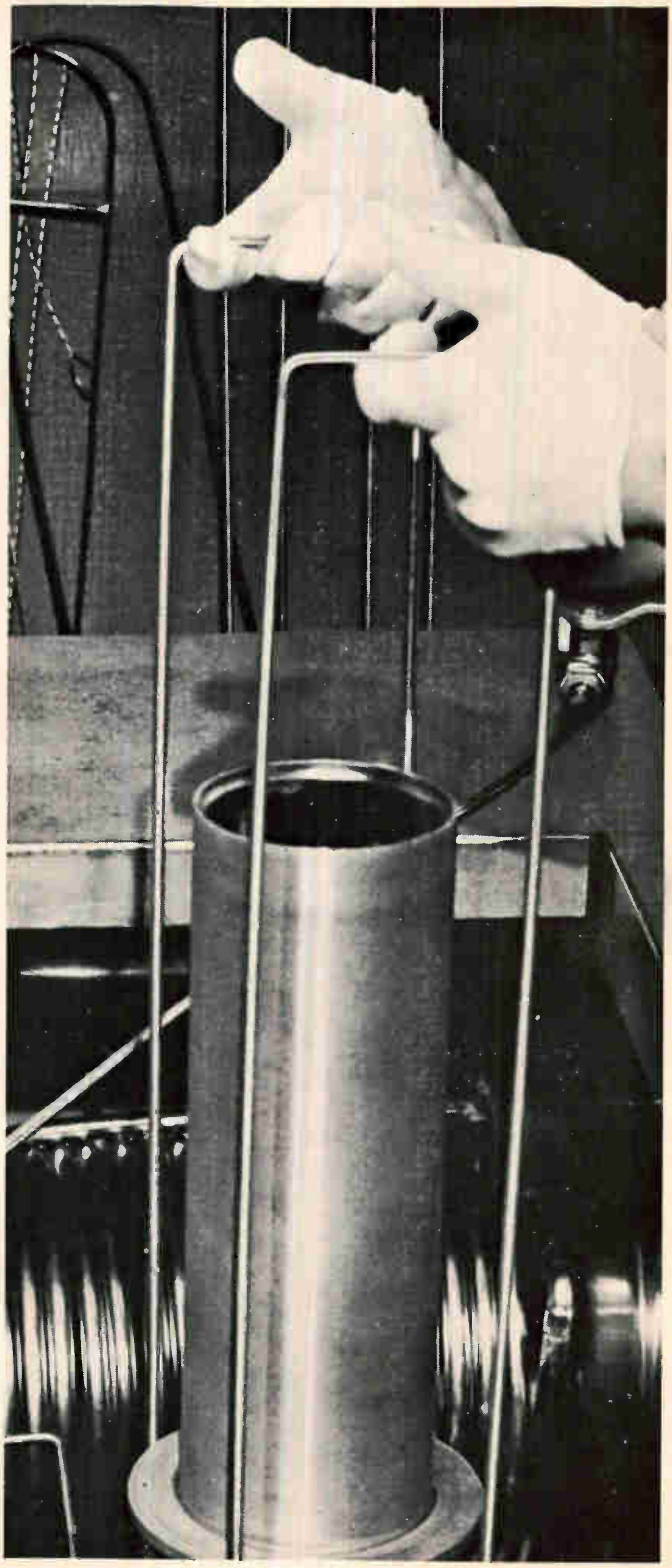
Comsat is interested in the plan; earlier it had invited industry proposals on a multipurpose satellite for domestic use. AT&T has suggested that ground stations for the system be owned by the carriers. But the Federal Communications Commission ruled earlier that domestic ground stations for Comsat's international network should be owned by Comsat —at least at first. **However, this decision is not likely to be binding on an entirely domestic network.**

Defense priority briefings scheduled

The Business and Defense Services Administration will begin a series of briefings April 11 to prepare industry for the speeded-up demand for priority deliveries of all defense goods at the expense of civilian orders. **A series of 20 or more sessions for defense contractors will be held by the Commerce Department agency to make sure contractors know what to expect and how to comply with the regulations under the Defense Production Act.** Firm dates for future briefings now include Dallas, April 11; Atlanta, April 18; Birmingham, April 20; Orlando, Fla., April 22; Cleveland, April 25, and Philadelphia, May 10. The briefings are in response to an increasing flow of requests from contractors for guidance on how to handle the priority requirements.

Addendum

By the end of April, the Federal Communications Commission is expected to propose rules governing the use of long-distance communications lines by time-shared computer-service operations. Any FCC action will influence the rates charged on the communications lines and the growth of the industry.



What increased chemical cleaning production 20% and cut solvent costs in half?

ITT says: FREON® solvents and Branson Ultrasonics.

At ITT's Electron Tube Plant in Easton, Pa., components are now cleaned in a Branson ultrasonic system using FREON TF solvent. Standard degreasing just couldn't do the job as efficiently. Time and money were lost through recleaning.

Now, FREON leaves components microscopically clean—the first time through. With its low surface tension it reaches into the smallest pores and crevices. With its high density, FREON carries off all traces of dirt, cutting oils and other contaminants. It dries quickly, leaving no residue.

The result: chemical cleaning production up 20% . . . solvent costs down 52% from $100 to $48 per week.

And, because FREON is nonexplosive and relatively nontoxic, no special exhaust system is needed. Its high stability permits recovery and reuse after simple distillation.

FREON solvents could be the answer to your cleaning problems. For more information, write Du Pont Co., Room 3679. Wilmington, Delaware 19898. (In Europe, write: Du Pont de Nemours International S.A., "FREON" Products Div., 81 Route de l'Aire, CH 1211 Geneva 24, Switzerland.)

Better Things for Better Living
. . . through Chemistry

DU PONT

Amelco's New TTL Logic With 8 Elements Really Flys!

INITIAL LOGIC ELEMENTS
- Five/Three Nand/Nor Gate
- Dual Three Input Gate
- RST Flip Flop
- Dual Shift Register
- Gated Buffer
- Flip Flop Driving Buffer
- Output Interface Circuit
- Input Interface Circuit

TTL LOGIC—TYPICAL SPEC'S

- Power Dissipation 1.3 mw/node
- Propagation Delay 50 ns/node
- Noise Immunity 800 mV (2.5 v with Interface Circuits)
- Fan Out 9
- Single Power Supply 4 v

Designed specifically for advanced avionics systems, AMELCO TTL permits exceptionally high packaging density because power dissipation is limited to 1.3 mw per node. In addition, the range of logic circuits available facilitates system design. ■ The low power dissipation has not been obtained by sacrificing other parameters. Propagation delay is only 50 nsec and fan out is 9. Noise immunity is 800 mV and is increased to 2.5v when interface circuits are used. ■ A group of 8 elements is presently available, and more are being designed. The initial group of 8 elements has been in production for several months and are now in stock at Amelco Distributors in both TO-5 and flat packages.

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DIVISION OF TELEDYNE, INC.

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LASERS IN THE COMPLETE COMMUNICATIONS SPECTRUM

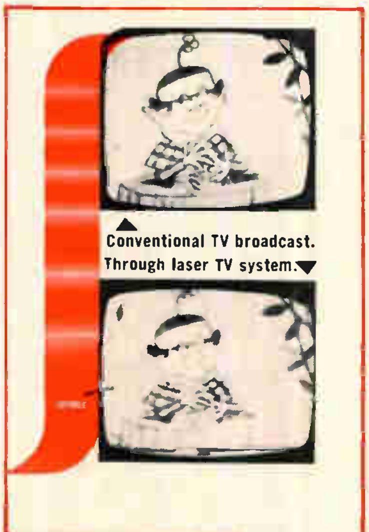
Optical missile tracking and laser — TV systems

Now in development at Sylvania Electronic Systems

■■ An optical radar system that will measure missile position to within a fraction of an inch during launch phase, yielding position and velocity data an order of magnitude better than now possible.

■■ A laser television system that has already produced excellent picture transmission over a 6000-foot link, and is being considered for use in an optical communications system to interconnect an 11-building complex over a six-mile radius.

Although stable CW gas lasers are the heart of both these systems, a much wider variety of electronics hardware is necessary to make the systems successful. And behind the hardware are the men and women of Sylvania Electronic Systems who bring tomorrow's dreams into today's engineering reality.



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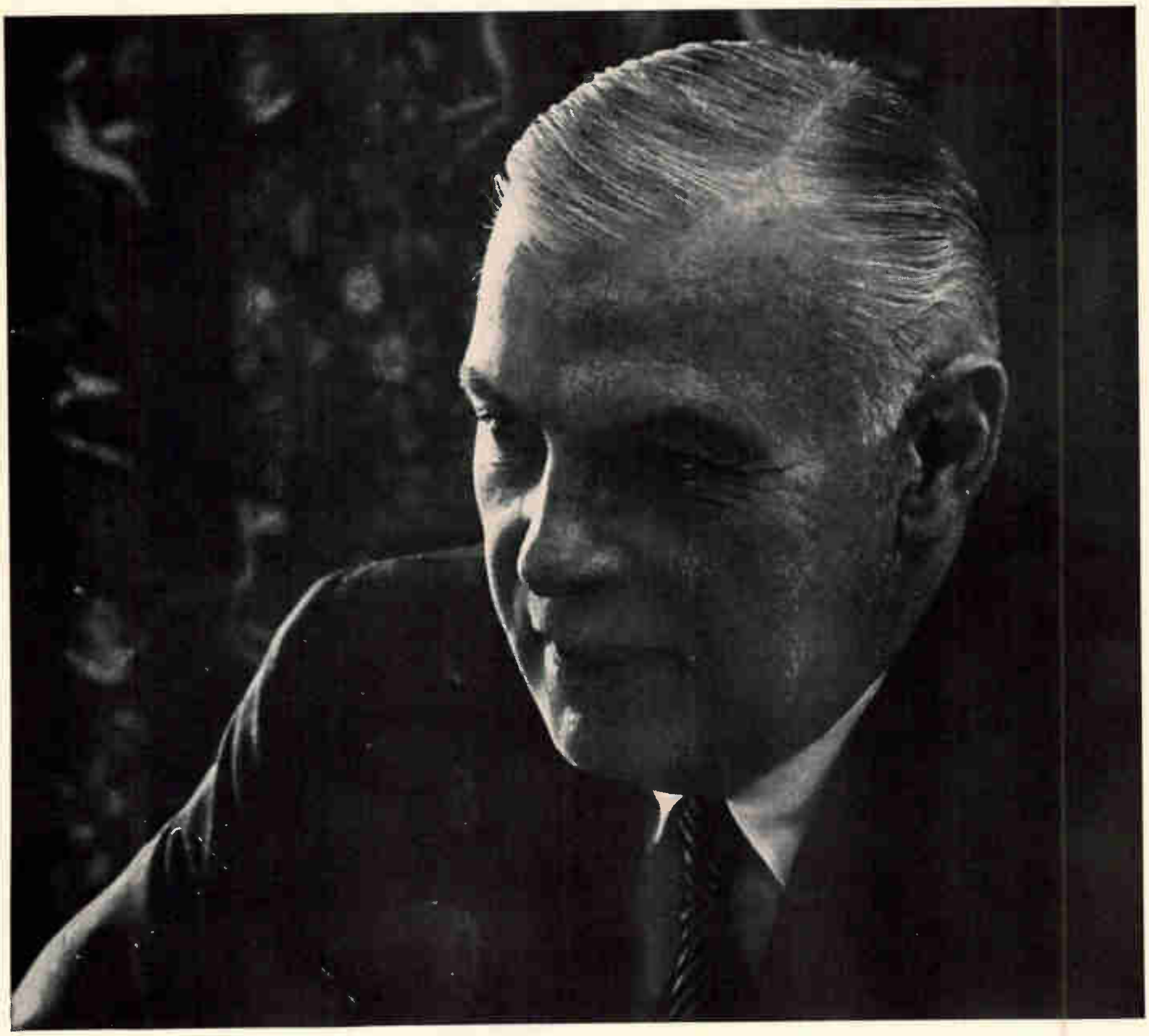

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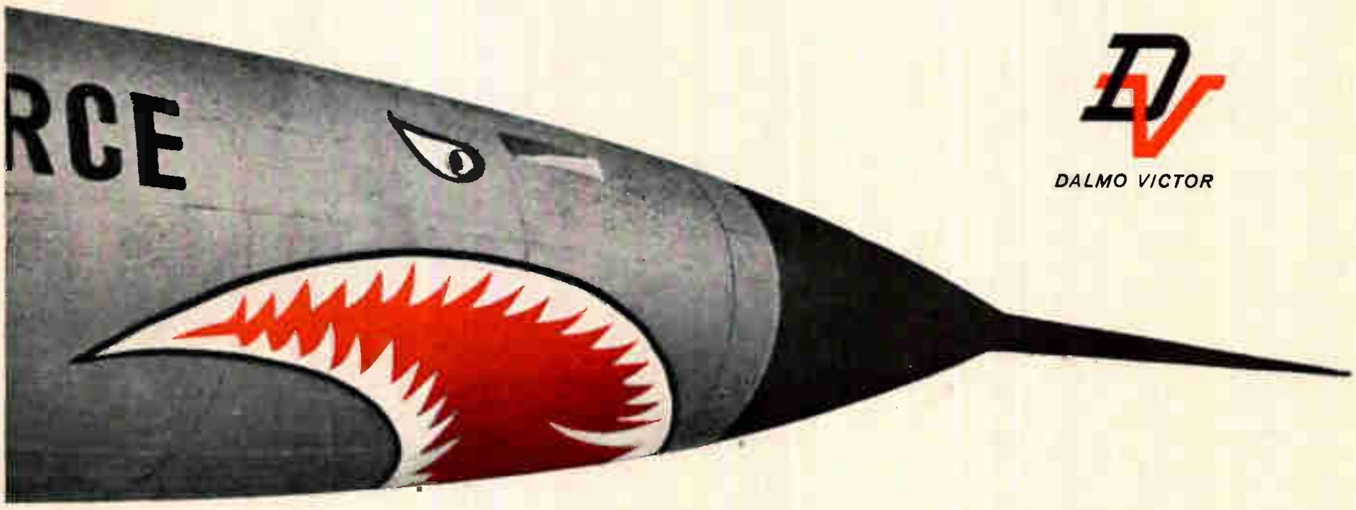

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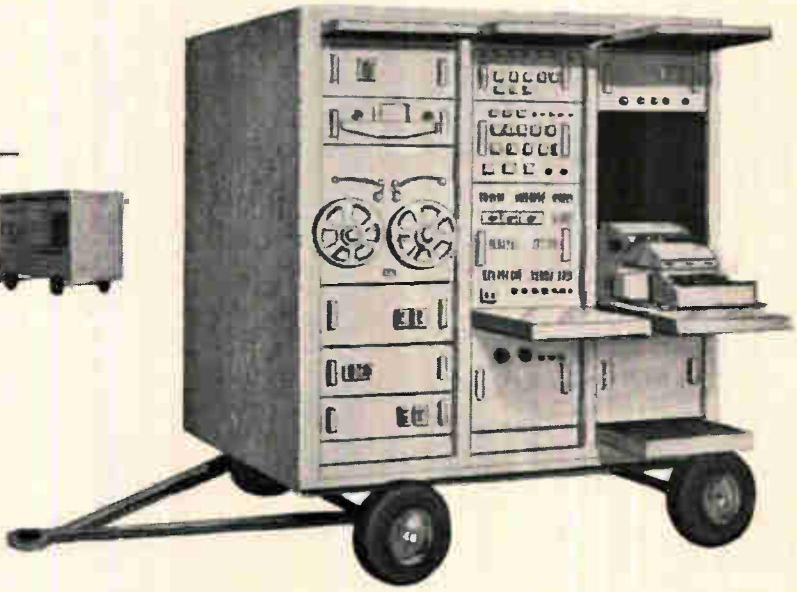

*AN/USM-185, completely militarized automatic wiring analyzer being developed by Dalmo Victor under contract to the Aeronautical Systems Division, Air Force Systems Command, USAF, Wright-Patterson AFB, Ohio. This analyzer meets or exceeds requirements of MIL-T-38218A, MIL-T-21200 and MIL-R-26667. Contract terms call for delivery of the first unit early this summer.

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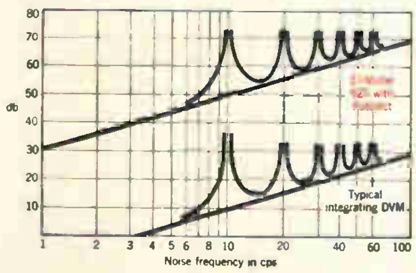

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Electronics
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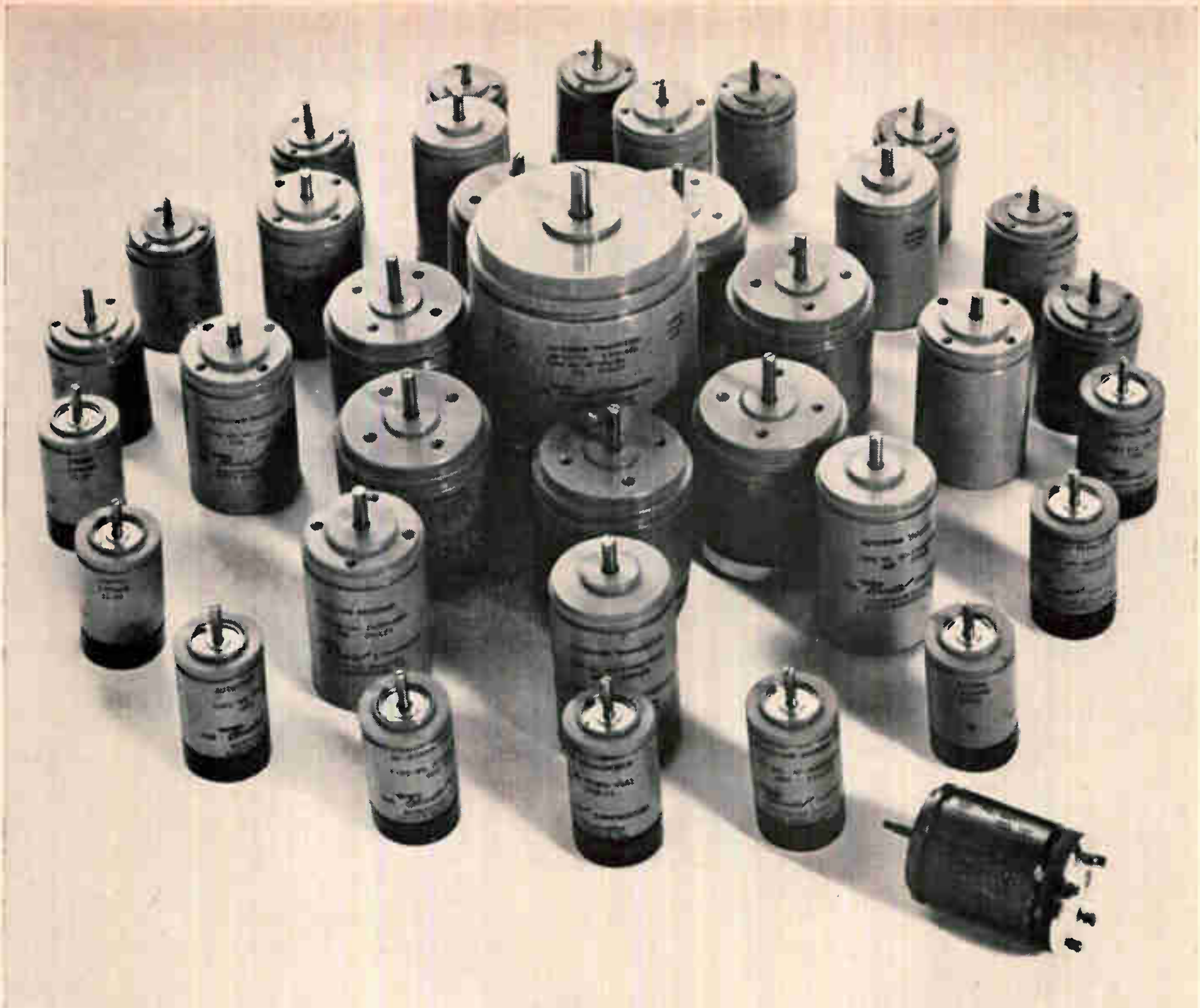

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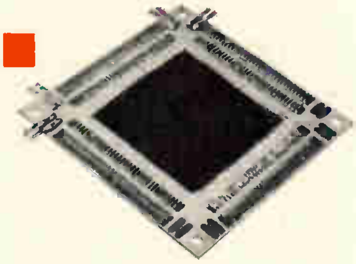

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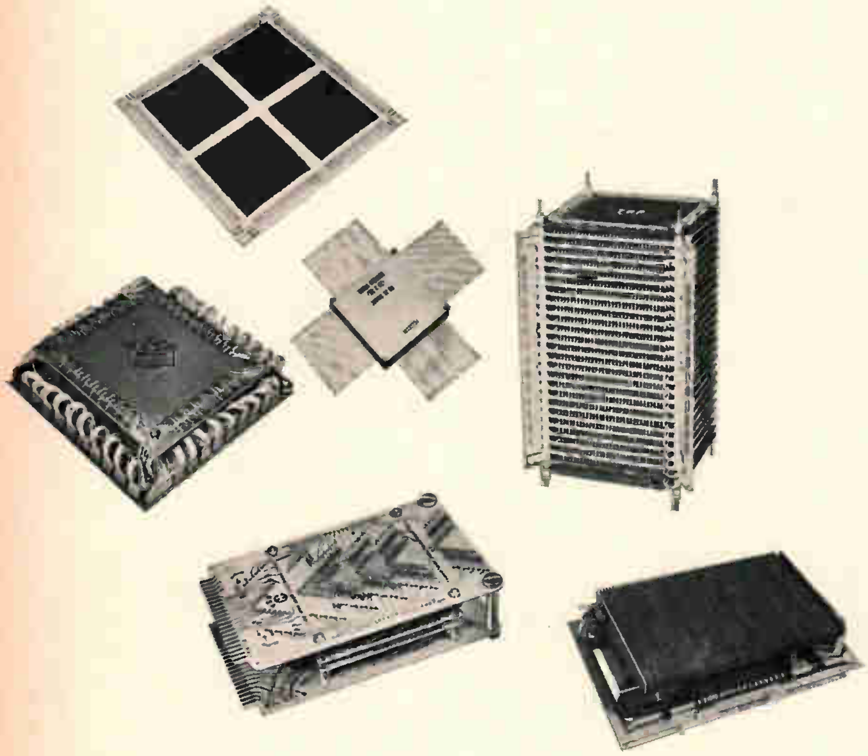

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Technical Articles

Selecting the right digital voltmeter: page 84

Three types of digital voltmeter—ramp, integrating, and potentiometric—are widely used, but each has its limitations. Now a fourth type has been developed combining potentiometric and integrating techniques. It measures d-c voltages with high resolution, even with noisy inputs.

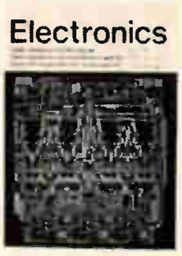
Automatic celestial guidance, part II: page 94

Although the principles of the electro-optical system have been worked out in detail, much must be done to develop hardware to implement them. Chief necessities are more versatile and accurate sensors and ultimately an optical computer to eliminate interface problems.

Using transistors to multiply and divide: page 109

Because a pn junction exhibits a logarithmic relationship between current and voltage, it can be exploited to perform multiplication and division just like a slide rule. These transistor circuits are simpler, more accurate and faster than other electronic means to compute analog functions. They are intended for equipment designs that require analog computation.

Integrated scratch pads sire new generation of computers: page 118



Scratch-pad memories for computers have been talked about for years, but used sparingly because they have tended to be expensive. Now a microelectronic scratch pad, containing eight bits of memory and their decoding networks on a single silicon chip, makes widespread use of such memories economically feasible. If many of the high-speed microelectronic memories are used, time-sharing becomes more economical. For the cover, art director Saul Sussman took negatives of the masks used to produce the IC's and created this stained-glass window effect of Signetics Corp.'s new eight-bit scratch pad microelectronic memory.

Coming April 18

- **Some experiments with nonlinear optics**
- **Solid state circuits for color tv**
- **Protecting against surge voltages**
- **Power supplies for d-c converters**

Selecting the right digital voltmeter

Three types of dvm's—ramp, integrating and potentiometric—are widely used, but each has its limitations. Now a fourth provides d-c measurements with high resolution, even when inputs are noisy

By Bill G. Kay

Loveland division, Hewlett-Packard Co., Loveland, Colo.

The ideal digital voltmeter—one that combines the lowest cost with high accuracy, resolution, sensitivity, stability, reading rate, superimposed and common mode noise rejection—just doesn't exist. Three basic techniques that enable a digital voltmeter to convert analog measurements to digital displays—ramp or slope, integrating, and the potentiometric or successive approximation—are widely used, but each has limited applications.

For example, the ramp type voltmeter is a relatively low-cost instrument, but is usually only accurate within 0.05%. If higher accuracy within 0.005% coupled with good stability is sought, the potentiometric technique is probably the most desirable—but its reading rate is low. And if a good reading rate combined with relatively high accuracy and good superimposed noise rejection is needed, then an instrument based on the integrating technique is the best but the most expensive.

Approaching the ideal is a new, relatively low-cost instrument that provides d-c measurements with high resolution, accuracy, stability, and reading rate even with noisy input signals. The instrument combines the potentiometric and integrating methods. This techniques employs a voltage-to-frequency converter to achieve noise rejection, while its accuracy depends on the potentiometric method with its precision d-c power supply and resistive divider. Still, not everybody wants this new type and the problem is which of the four kinds of digital voltmeter to use.

The author

Bill G. Kay has designed digital voltmeters since joining the Hewlett-Packard Co. in 1962. He is currently a digital-voltmeter project leader in H-P's Loveland research and development laboratory.

The ramp method

Digital voltmeters that utilize the ramp technique are in what can be considered the economy class of dvm's. These voltmeters measure the length of time it takes an internally generated ramp voltage with a precisely known slope, starting from a known level, to become equal to the unknown input voltage.

In a typical dvm of this type, the ramp voltage—shown in the diagram on page 85—is compared with two voltage levels: ground and the unknown voltage E_x to be measured. When the ramp voltage equals ground potential, the first comparator generates a coincidence pulse that opens the gate at time t_1. The second comparator closes the gate when the ramp and unknown voltage coincide at time t_2. The time $T = t_2 - t_1$ is proportional to E_x.

While the gate is open, a train of pulses from the fixed oscillator passes to decimal counters and the number of pulses counted during the gating interval is also proportional to E_x.

The relationship between the number of counts, N, entered into the counters and the gating time, T, with respect to the oscillator's fixed rate, R, is simply $N = RT$. Thus, the appropriate choice of ramp slope and oscillator frequency provides a direct readout in volts of the totalizing circuit. For example, a four-digit voltmeter might have a ramp slope $R = 60$ volts per second and an oscillator frequency of 600 kilocycles per second. With the dvm set on the one-volt range, if $E_x = 0.75$ volt, then $T = 0.75/60$ second, and the number of gated oscillator cycles—$N = RT$—is 7,500.

Integrating dvm technique

Ramp type meters are usually limited in accuracy to within 0.05% by the accuracy of the comparators and the linearity of the ramp, and are subject to false triggering by input noise. The outstanding feature of an integrating dvm is its inherent capability to reject superimposed noise signals without an input filter. Generally a filter is undesirable because its response time tends to degrade the instrument's maximum reading rate; and in instruments of high resolution, the filter capacitors can act as high impedance voltage generators after removal of an input voltage as a result of dielectric polarization, degrading the voltmeter's accuracy by adding a small d-c component to the next input signal to be measured.

The integrating voltmeter measures the true average of an unknown voltage over a specific time interval. The ramp type instrument measures the voltage itself at the end of a time interval. In most integrating meters, the unknown voltage, E_x, is first converted to a frequency—as shown in the diagram on page 86—then the frequency is counted over a fixed time interval. The simple relationship, $N = RT$, is still valid except that now the rate R, rather than the time T, is proportional to the unknown voltage E_x.

Eliminating noise

How the voltmeter integrates an input signal and thereby averages out noise signals, can be demonstrated with the aid of the graphs on page 86. Consider the case where the unknown voltage E is a sine wave with a period equal to the fixed gate time T.

The choice of starting time t_0 relative to $E_x(t)$ is inconsequential. The frequency generated by the voltage-to-frequency converter is proportional to the instantaneous input voltage. Thus at t_0, the frequency of the converter output is zero, and at t_1 and t_3, the frequency is highest. A graph of N, the total count stored in reversible decade counters, is shown in the lower figure on page 86. Between t_0 and t_1 the instantaneous output frequency increases as $E_x(t)$ becomes larger. Hence, the slope of N as a function of time continually increases. Between t_1 and t_2, the rate of increase of the converter frequency declines until it is zero at time t_2 $[E_x(t_2) = 0]$. During this period N continues to increase, but its slope decreases until it reaches zero at t_2. At t_2, N is proportional to the average value of $E_x(t)$ over the first half of its period; thus $E_x(t)$ has been integrated over the period t_0 to t_2. If the instrument is capable of observing the polarity change at the time t_2, and is equipped with reversible counters, then the integration may continue from time t_2 to t_4. With reversible counters, N at t_4 will be exactly equal to zero since the above steps are repeated with N now being decreased over the interval t_2 to t_4.

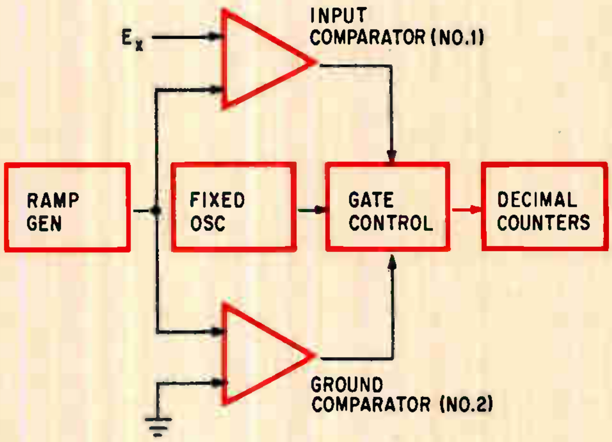
The attenuation versus frequency characteristic of the integrating type digital voltmeter is shown in the upper figure on page 87. Note that infinite input attenuation exists for the frequencies $= \frac{m}{T}$ where $m = 1,2,3, \ldots \infty$. The previous example, in which $m = 1$, can be extended to the case of $m = 2$. Here, two cycles of the input signal will be completed during gate time T and the net count will again be zero. This can be used to reject a specific a-c input signal by properly choosing T.

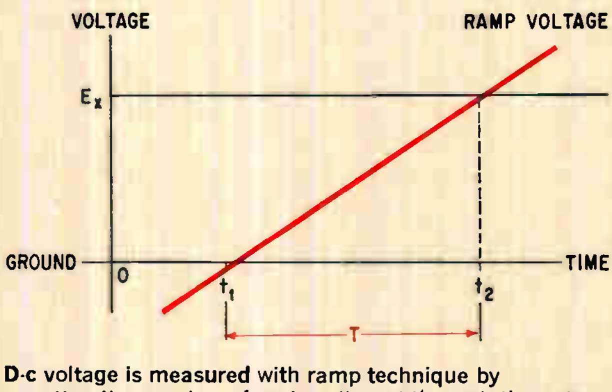
Usually the largest noise component present at the input terminals of the voltmeter will be at the line frequency. If the gate time T is chosen to be n/60 seconds ($n = 1,2, \ldots \infty$), the instrument will reject signal components which contain the 60-cps line frequency and its higher harmonics.

Increased sensitivity

The inherent noise rejection of the integrating voltmeter has one other very good use. Note in the graph on page 87 that as T is increased, the lower frequencies are attenuated by a larger amount. The net result is that the effective noise bandwidth of the voltmeter is smaller for longer T. Thus, at low frequencies down to d-c, the noise always present in the input circuitry is effectively reduced, making it possible to increase the sensitivity of the instrument.

For example, a voltmeter might have $T = 1/60$ second and an inherent amplifier noise of 10 microvolts over the resulting effective noise bandwidth. The ultimate lower limit on the instrument's sensitivity is therefore 10 microvolts. If T were increased to 1/6 second, the amplifier noise over the reduced effective noise bandwidth might reasonably be expected to decrease to four microvolts.





D-c voltage is measured with ramp technique by counting the number of cycles allowed through the gate during the time ($T = t_2 - t_1$) the ramp voltage requires to increase from ground to the unknown voltage E_x.

This is the technique used in integrating digital voltmeters to resolve low-level signals in the microvolt region, at the sacrifice of reading rate.

The ramp technique has an attenuation versus frequency curve similar to that shown on page 87. However, since T is proportional to the unknown input signal, the cusps of infinite rejection are not fixed with respect to frequency. Thus the ramp technique cannot easily be used to integrate out, or reject a specific a-c input signal.

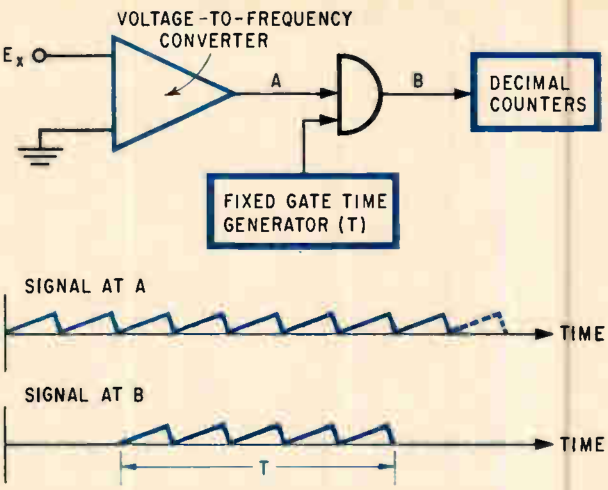
Although the integrating technique itself places no limit on reading rate, the limitations of the voltage-to-frequency converter and the selection of the cusps of infinite rejection do.

To reject noise signals at line frequency, T is chosen to be at least 1/60 second. This means that if no dwell time is required between readings for such operations as resetting the range, the maximum possible reading rate is 60 per second. Some three- and four-digit integrating voltmeters approach this rate, but in a five-digit instrument the reading rate is usually considerably slower because of the voltage-to-frequency converter's limitations. The outputs of typical voltage-to-frequency converters are 500 kc or less because of cost and linearity problems.

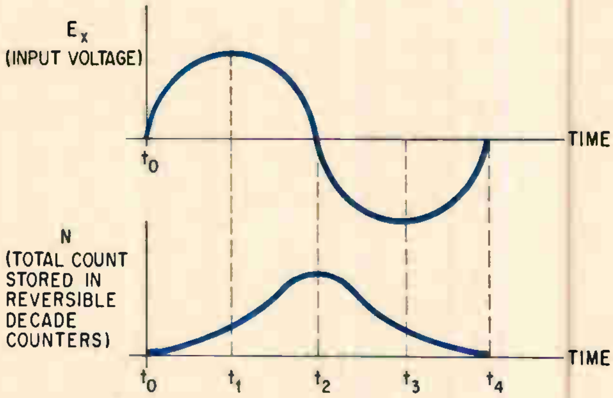
The maximum reading rate of a given instrument can be determined from the basic formula, $N = RT$. For a 5-digit instrument, a full-scale indication is equivalent to $N = 10^5$ counts. Thus if $R_{max} = 500$ kc, then $T = 10^5/5(10^5) = 1/5$ second. This implies that the maximum reading rate for the 5-digit instrument is 5 readings per second.

From the equation $N = RT$, the accuracy of the integrating instrument is obviously dependent upon the accuracy of both T and R. T may be controlled with great precision by using a crystal time base; essentially then, the accuracy of the instrument depends on R.

The ideal and realizable transfer curves for a typical voltage-to-frequency converter are shown on page 87. A detailed discussion of why the curves differ is beyond the scope of this article, but the linearity of a voltage-to-frequency converter becomes more difficult to control as frequency is increased, and the cost of building a converter rises rapidly as the maximum frequency output increases. Converter nonlinearity and stability are formidable design problems.



In an integrating dvm the time interval, rather than the frequency, is fixed. The unknown input voltage is converted to a proportional frequency, which is counted for a fixed period.



Integrating dvm has high immunity to noise since a-c signals are averaged out by reversible decade counters in the instrument. The number of counts builds up during one-half the sine wave. But during the second half of the cycle, the counts are subtracted. The net count is zero.

Successive approximation

The potentiometric or successive approximation technique is quite different in concept and implementation from the two methods already described.

Digital voltmeters of this type use a precision d-c power supply with a resistive divider to null out the unknown input voltage. As shown in the diagram on page 88, the resistor divider is controlled by a logical programer to quantize the output of the power supply. The discrete increments of voltage thus created are applied to a comparator amplifier whose other input is the unknown voltage, E_x. The amplifier output serves as the input for the logical programer, which drives the resistor divider in a prescribed sequence, adding or subtracting more voltage increments to null out the unknown input signal. The final setting of the divider can be sensed logically by determining whether the individual resistors are connected to ground or the reference supply. This simple code is then converted to decimal information that can be displayed.

Both the accuracy and stability of a potentiometric instrument depend upon the d-c reference supply and the resistive divider. Both the stability and temperature coefficient of the reference diodes or standard cell contribute to inaccuracies in the reference supply. As a result, the critical components associated with the supply are usually placed in an oven whose temperature is accurately controlled. The divider is generally constructed of precision wire-wound resistors. The linearity of the quantized output from the divider and the stability of this system are much more easily controlled than the linearity and stability of the voltage-to-frequency converters used in integrating dvm's.

Design compromises

Certain compromises must be made in the design of the potentiometric digital voltmeter. The primary compromise involves a trade-off between reading rate and superimposed noise rejection. The reading rate is limited by the rate at which the reference voltage may be quantized and compared to the unknown. It is not unrealistic to effect reading rates of 10,000 readings per second. However, without an input filter, the potentiometric instrument has no noise immunity at all because only the unknown d-c signal is nulled out by the resistive divider output. Thus, as soon as the total superimposed noise is greater than the minimum voltage increment generated by the divider, the sensitivity, resolution, and hence the accuracy of the instrument are degraded. Since very few unknown signals are noise free, an input filter is almost always used in a five-digit potentiometric instrument. The response time of the filter then lowers the reading rate considerably.

A potentiometric voltmeter with a five-digit display accurate within 0.01% of reading, has a reading rate of five per second with a filter on its input. How well does the instrument reject superimposed noise, particularly at line frequency, and how much superimposed noise can be tolerated before the accuracy of the instrument is significantly degraded?

In a five-digit instrument, the least significant digit represents a resolution of 10 parts per million. Thus, a signal with superimposed noise equal to 0.001% of full scale that reaches the input of the comparator amplifier will cause a one-count deviation in that digit.

Even so, jitter in the least significant digit is not the major limitation since the instrument's accuracy is not degraded significantly. The most important criterion is when an abrupt change or step in the d-c voltage occurs, the filter's response time must be fast enough so that within the time allotted for one reading, the error due to the filter is less than the rated instrument error of 0.01%. This is a rather idealized situation since the entire 200 milliseconds is not available to the filter because of the digitizing time in the instrument.

Most potentiometric dvm's use RC filters with up to three poles—frequencies at which the filter impedance is infinite. For example, an RC filter with three identical poles results in the maximum rejection of noise signals at the line frequency. Analysis of such a filter's performance with a step input, using Laplace transform analysis, shows that the filter must have a pole frequency of about 11.2 cycles per second to meet the basic accuracy requirement of a reading rate of 5 per second. Attenuation of the superimposed noise at 60 cps is calculated to be 44 decibels. This attenuation can be increased slightly more, without changing the other response characteristics, with a more sophisticated filter, one that has more poles.

Glossary of terms

Resolution—The smallest increment of a variable that can be read without ambiguity.

Sensitivity—The minimum signal to which an instrument will respond. For example, a dvm set for a full-scale range of 1.00000 has a sensitivity of 10 microvolts.

Stability—The ability of an instrument to maintain a constant error as a function of time and/or environment.

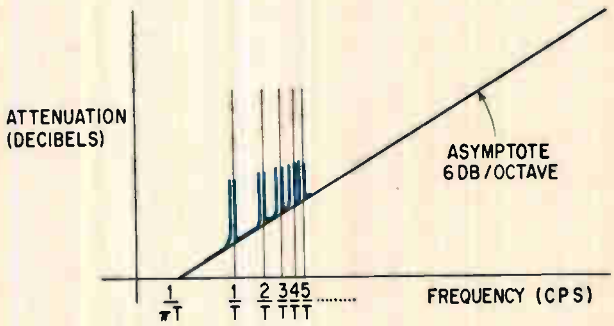
Reading rate—The rate at which an instrument is capable of performing continuous independent measurements and display them.

Superimposed noise rejection—The degree to which an instrument rejects unwanted signals in series with the unknown input voltage.

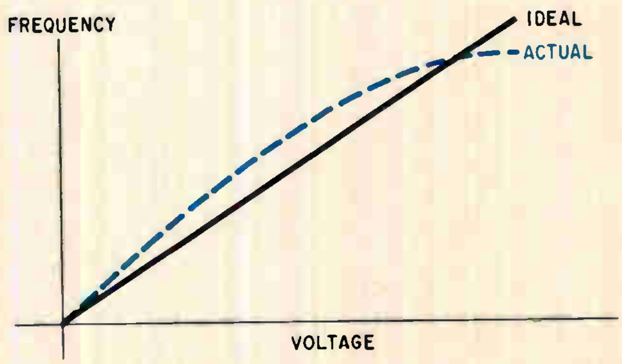
Common mode noise rejection—The ability of an instrument to reject unwanted signals caused by unbalanced voltages between input terminals and ground.

The amount of superimposed line-frequency noise that can be tolerated without significantly degrading the instrument's accuracy is more difficult to ascertain. Because the error is specified as 0.01% of reading, for a full-scale reading of 100,000, 0.01% error is equivalent to 10 counts in the least significant digits. However, for a reading that is one-tenth of full scale—for example, 10,000—0.01% error is equivalent to one count in the least significant digit.

For ease of calculation, assume the line fre-



Infinite attenuation exists for those frequencies that are multiples of the integrating dvm's period, 1/gate time. The gate time is therefore chosen to give the greatest possible rejection of the 60-cps line frequency.



Large source of error in integrating dvm's occurs because voltage-to-frequency converter characteristic curve is not perfectly linear.

quency is attenuated by 46 db. In this case, if the peak value of the superimposed 60-cps noise signal is 2% of full scale it will yield a jitter of 10 counts in the display. The magnitude of the 60 cps signal must be less than 0.2% of full scale to prevent more than one count of jitter in the display. This can be overcome if the reading rate is reduced and a large filter is used. What is left is a technique that allows d-c voltages to be measured accurately and has excellent long-term and environmental stability. But a technique in which the speed of operation must be greatly sacrificed to maintain accuracy and resolution in the presence of superimposed noise.

Best of two methods

A new method, the potentiometric/integrating technique, combines many of the advantages of its two namesakes while eliminating some of the more objectionable weaknesses, and at a cost competitive with either system.

The potentiometric/integrating technique combines integration with successive approximation to achieve a fast, highly accurate, stable system that is capable of rejecting superimposed noise signals. The new approach to voltage measurements is employed in the Hewlett-Packard Co.'s 3460A digital voltmeter. A simplified block diagram is shown on the next page. Each reading consists of two approximations or samples of the unknown voltage and two transfer periods.

At the beginning of the reading, a one-millisecond delay is introduced during which all the timing circuits are set and the reversible decade counters set to zero. Thus when the first sample is initiated, the stored count in the decade counters is zero and the output voltage of the programable resistive divider-precision d-c supply is zero. Initially, the unknown voltage E_x is applied directly across the terminals of the voltage-to-frequency converter. The converter's output frequency which is proportional to E_x, is transformer coupled through the guard to the logic section of the instrument. No counts are entered into the decimal counters until the gate time generator and the sample 1 timing signal coincide, opening gate 1 and allowing the transformer-coupled pulses to pass through the gate into the fourth decade counter. The counts are entered into the decades until the fixed gate time T has passed.

The count in the four most significant decade counters at the end of the first sample period represents a measurement of the unknown voltage within 0.3%, or three counts of error in the fourth digit. This error consists of a possible logic error of ±1 count, and the combined error of the voltage-to-frequency converter and gate generator, on the order of 0.1% or one count in the fourth digit. The count stored in the four decades is retained during the remainder of the reading cycle but is not displayed until after the second sample period during which it will be corrected.

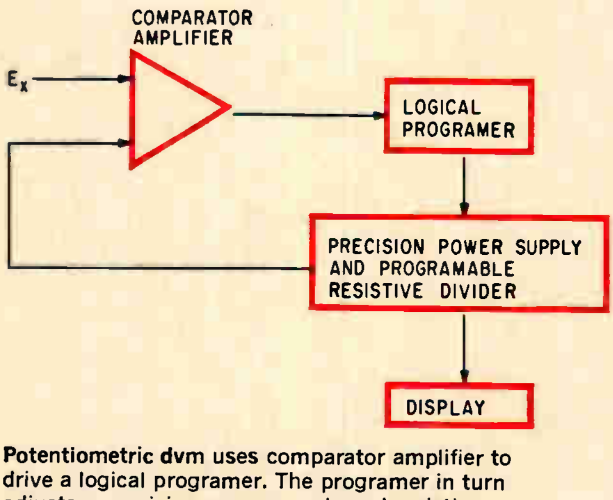
The transfer period occurs immediately after the first sample period is completed. During the transfer time, the counts stored in the four decades are used to quantize the reference supply voltage inside the guard. The information is relayed from the counters to the resistive divider through the guarded reed-relay switches. The c version accuracy of the resistive divider-reference supply is typically within 0.0015%, and its quantized output opposes the unknown voltage applied to the terminals of the voltage-to-frequency converter.

At the beginning of the second sample period, the output frequency of the voltage-to-frequency converter is proportional to the difference voltage across its input terminals. The gate generator and the sample 2 timing signals allow the transformer-coupled pulses to enter the more significant decades. The count is allowed to overflow from the fifth into the fourth decade to correct the error of the first sample as necessary. Because the error of the first sample reading may be either positive or negative, logic circuitry determines the polarity of the difference voltage relative to the unknown voltage. The circuitry also determines whether the pulses from the voltage-to-frequency converter during the second sample period are to be added to or subtracted from the original approximation of the unknown voltage.

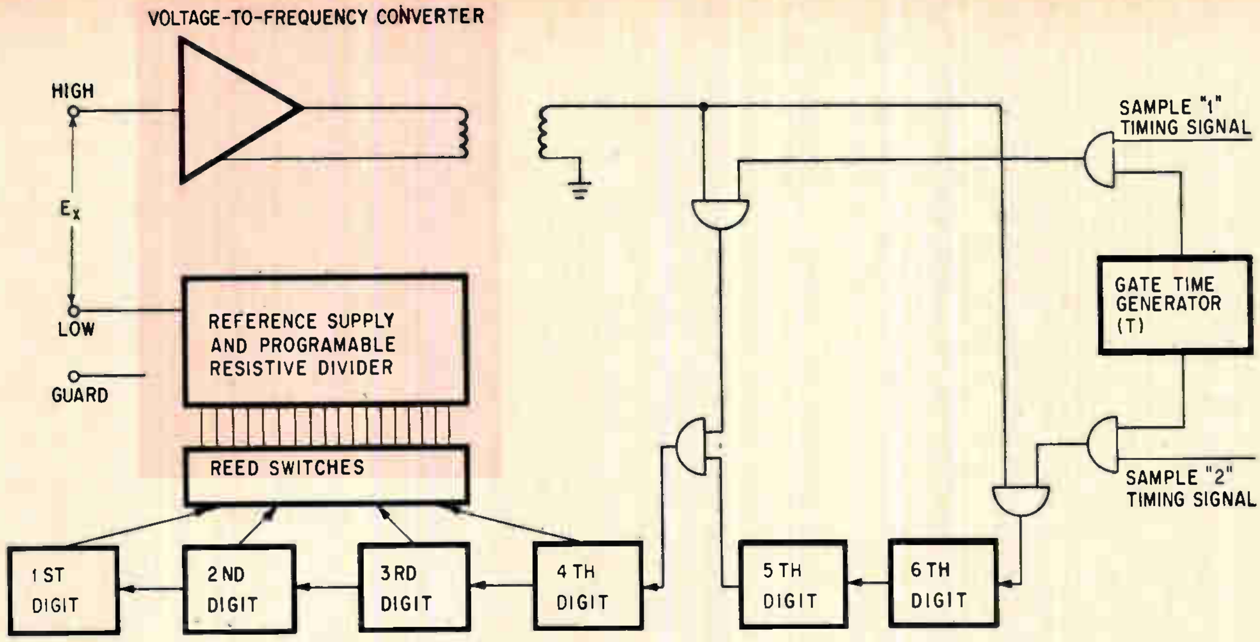
The second transfer period takes place at the end of the second sample. Its duration is adjustable from the front or rear panels of the instrument. During this time, the final count in the five decades—plus six digit overrange—is transferred to the in-line digital display tubes on the front panel, and a print comand is issued to permit accumulation of the stored count by an external digital recorder. The instrument has now completed one reading.

Still not perfect

An analogy may be drawn between the system just described and a measurement scheme that uses an inaccurate voltmeter and an errorless pro-



Potentiometric dvm uses comparator amplifier to drive a logical programer. The programer in turn adjusts a precision power supply and resistive divider to null out the unknown voltage at the comparator's input. The final setting of the divider in code form provides a readout of the input voltage.



Potentiometric/integrating digital voltmeter combines the noise immunity of the integrating technique and the accuracy and stability of the potentiometric method. Two samples of the unknown voltage are made: the first results in a measurement accurate to approximately 0.3% and sets the programable reference supply to this reading. The second sample measures the difference between the unknown and the first sample. The two measurements are then added and displayed on decimal counters.

gramable power supply.

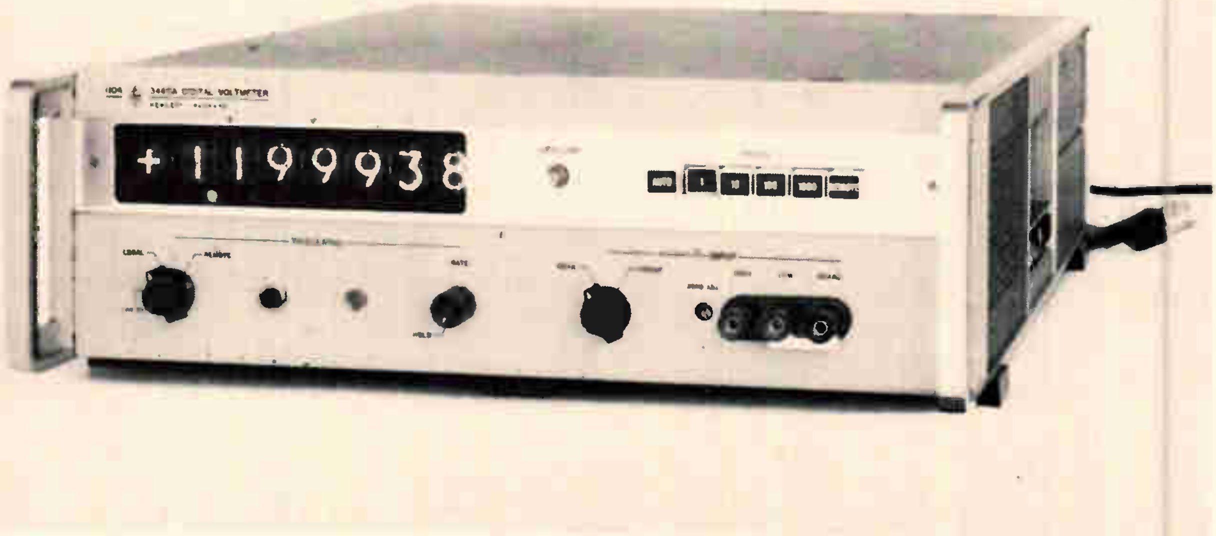
For example: a voltmeter that reads low by 1% and a perfect programable power supply are to be used to determine an unknown voltage E_x to within 0.01%. At the first measurement, the voltmeter reads low by 1%; this initial measurement is equal to 0.99 E_x, which is not within the desired accuracy. The programable power supply is then set to 0.99 E_x, and the output of the supply is used to "buck" E_x. The difference is $0.01E_x$. Since the voltmeter is still 1% low, the second measurement equals $0.01E_x - (0.01)0.01E_x$, or $0.0099E_x$. By adding the two approximations, the final reading, $0.9999E_x$ is obtained and is accurate within the desired 0.01%.

While this technique may, in a broad sense, be called successive approximation, it differs from the technique used by successive approximation voltmeters in that the power supply in the example was programed to exactly the voltmeter reading. In the successive approximation voltmeter, E_x is approached by quantizing the power supply voltage and then by deciding logically whether E_x was large or smaller than the bucking voltage.

In the HP 3460A, the voltage-to-frequency converter and time base, which alone constitute a truly integrating voltmeter, are analogous to the inaccurate voltmeter of the previous example; the reference supply-resistive divider combination is the equivalent of the ideal power supply. In the example, the error contributed by the voltmeter to the final reading was simply the voltmeter error squared—the 1% voltmeter with two samples yielded E_x to within 0.01%. Similarly, if the voltage-to-frequency converter and time base are accurate to within 0.1%, then with a two-sample technique, the error of the final reading due to the voltage-to-frequency converter and time base is only 0.001^2 or 0.0001%. This represents one-tenth of one count in the least significant digit of the instrument. Thus the accuracy of the voltage-to-frequency converter and the time base need not be as closely controlled as in the basic integrating technique.

The instrument's accuracy is determined primarily by the reference d-c power supply and the resistive divider which has a typical conversion error of 0.0015% of reading. This error is not reduced by the multiple sample technique as in the basic potentiometric technique. As a result, its error and the possible logic error in the sixth digit represent the accuracy limit of the instrument.

The voltage-to-frequency converter achieves superimposed noise rejection, but its performance requirements have been drastically reduced by the new techniques involved. First, its accuracy is now of secondary importance. Secondly, the maximum frequency output of the converter may be quite low without appreciably affecting the instrument's reading rate. As shown previously, a voltage-to-frequency converter capability of 500 kc with a gate time of 1/60 second enabled a five-digit integrating voltmeter to read at a rate of five readings per second. With the new technique, the voltage-to-frequency converter is never asked to fill more than three decades—plus a 20% overrange—during a given sample period. Thus the converter needs only to operate linearly up to 72 kc with a gate



Latest in H-P line of digital voltmeters is model HO4-3460A. The meter extends basic potentiometric/integrating technique and results in instrument with a resolution of one part per million and a sensitivity of one microvolt.

time of 1/60 second to achieve an instrument reading rate of 15 readings per second. Because of the reduced requirements of the converter, its cost is considerably lower than a similar instrument employing the basic integrating technique.

Limit on superimposed noise

The only compromise concerning the voltage-to-frequency converter pertains to the magnitude of superimposed noise that may be applied to its terminals. Even though a 60-cps noise signal may be completely rejected by the converter, the magnitude of that signal could not be increased indefinitely. The limit on the magnitude of superimposed noise is established as follows: during the second sample period, the voltage-to-frequency converter has the d-c difference voltage between the unknown input and the reference supply's output applied to its terminals. However, the unattenuated superimposed noise signal also is applied to it. Unlike the basic potentiometric digital voltmeter, the difference voltage may be smaller than the noise without a loss of instrument accuracy as long as the noise is properly integrated. If the noise signal becomes too large, however, the required frequency out of the converter exceeds the maximum design frequency and the converter becomes non-linear. The compromise that must be made is a trade-off between the cost of the converter and its maximum frequency output with respect to the noise handling ability of the instrument. In the HP 3460A, the maximum allowable magnitude of the superimposed noise has been chosen to be 6% of full scale.

Just how much superimposed noise a voltmeter should be capable of handling cannot be stated with certainty. Application may range from the measurement of a noise-free standard cell voltage to an aircraft engine test measurement where noise may exceed 100% of full scale. In addition to the basic problem of how much superimposed noise may exist, there is always the possibility of large common mode signals being present. Although a fully guarded instrument is able to reject common mode noise signals of up to 500 volts, a great deal of confusion exists about how to properly use the guarding capability. Consequently, what often appears to be superimposed noise in a test set up is, in reality, a common mode signal that could be eliminated by the proper use of the guard.

New breed emerges

The new potentiometric/integrating technique lends itself to the development of a new breed of digital voltmeter—the full six-digit instrument, with seventh digit overrange, that is capable of making highly accurate measurements with a resolution of one part per million at a relatively fast reading rate.

One more significant digit is added and the gate time T for the second sample period is increased. By increasing T, the maximum rate of the voltage-to-frequency converter need not be increased since the time required to fill the seventh decade can automatically be accounted for. Also, by increasing T, it is possible to take advantage of the resulting effective noise bandwidth reduction that occurs in integrating voltmeters as the gating time is increased. Thus, it is quite possible to measure and read one volt with a resolution of one part per million and a sensitivity of one microvolt.

This extension of the basic technique has been incorporated into the Hewlett-Packard HO4-3460A voltmeter shown above. In addition to having high resolution, the new meter is accurate within 0.002% of reading. It is a fully guarded instrument with high common mode noise rejection—160 decibels.

Circuit design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Overload protection for d-c amplifier

By Leander Payerl,

Visolux-Electronic GmbH, Berlin

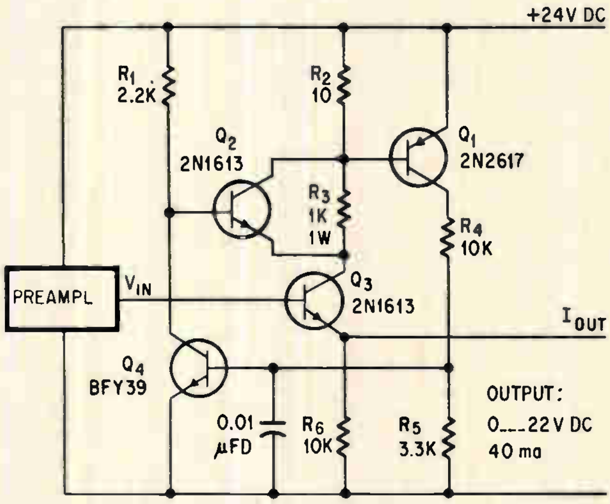
In spite of the loss which occurs, a high series resistance is often included in a d-c amplifier to protect it in the event of an overload. In the d-c amplifier circuit at the right however, an electronic fuse switches the high series resistance R_3 into the circuit only when an overload or short circuit actually occurs. This circuit restores the full output voltage immedaitely after the short circuit or overload is removed.

During normal operation, there is only a small resistance in the load, formed by R_2 and the collector-emitter resistance of Q_2. In this state the voltage drop across R_2 is less than the turn-on base-emitter voltage of Q_1. Hence, Q_1 and Q_4 are off, and Q_2 is on, shunting R_3.

If I_{out} increases beyond a certain level because of short circuit or overload, the voltage drop across R_2 increases and Q_1 turns on. Simultaneously, transistor Q_4 turns on and zero-biases the base of Q_2. This cuts off Q_2 so that R_3 limits the current.

Switching will occur when $I_{out}R_2 \geqq V_{BE1}$. In this circuit, maximum output current is 40 milliamperes.

When Q_2 turns off, voltage R_2 may decrease enough to turn off Q_1. This circuit will thus oscillate at an amplitude and frequency determined by R_3 until the fault is removed. In the circuit shown, the amplitude of the oscillation is 1.5 volts peak to peak; its frequency is about 250 kc. The base of Q_4 is shunted by a small capacitor to prevent oscillations that might be excited by fast load changes.



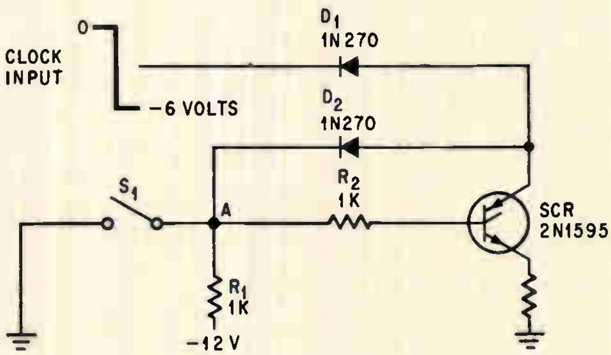
Electronic fuse in d-c amplifier cuts in high series resistance R_3 when there is an overload or short circuit and bypasses R_3 instantly when they are removed. All resistors 0.5 w unless otherwise specified.

Latching gate removes counter ambiguity

By Roy A. Wilson

Hycon Manufacturing Co. Monrovia, Calif.

Clock pulses being gated into a register require positive gating action to avoid putting an extra count into the register. The ordinary diode gate provides this positive gating action with the addition of a silicon controlled rectifier.



Adding latching feature to diode gate allows output to follow clock input when S_1 is closed. When S_1 is opened, output will be fixed at existing clock level.

The latching gate on page 91 allows the output to follow the clock input when S_1 is closed and, after S_1 is opened, the output remains indefinitely at the level of the clock input at the time the switch opened.

Closing of switch S_1 grounds point A; this forward-biases the gate-to-cathode terminals of the scr every time the clock input is at —6 volts. When the clock returns to zero, the scr has no voltage across it and thus turns off.

If S_1 is opened during the time the scr is off the output will remain at zero as long as S_1 remains open. This is because point A is now at —12 volts, precluding any possibility of the gate becoming forward-biased.

If S_1 is opened when the scr is conducting, the output will remain at —6 volts. Opening of the switch applies —12 volts to the scr cathode through R_1 and D_2. This reverse-biases D_1, maintaining the voltage across the scr. The scr will continue to conduct and maintain the output at —6 volts until S_1 is again closed.

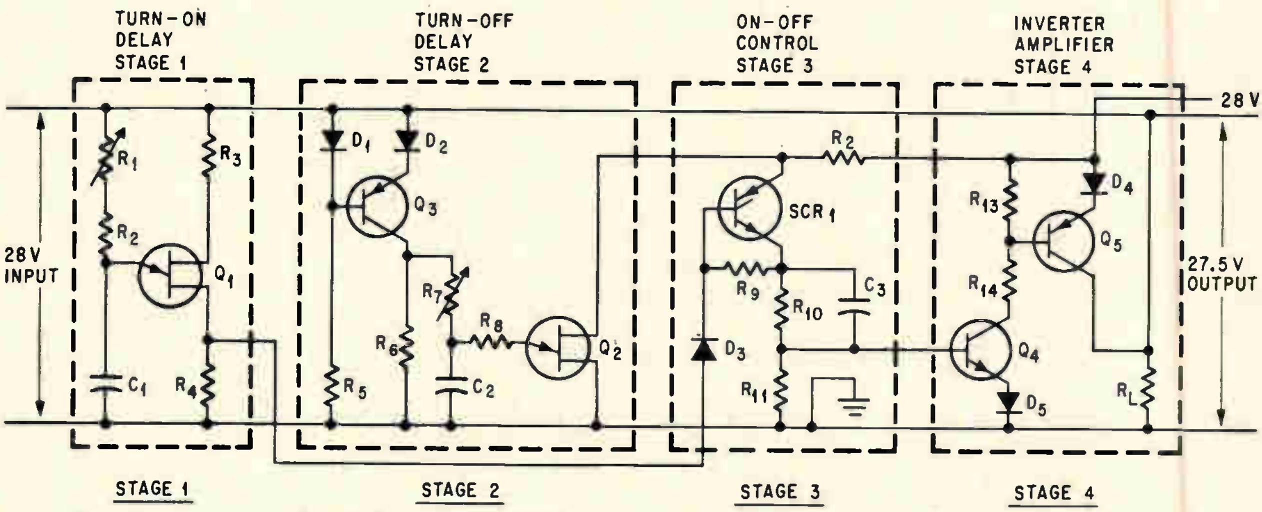
Delay circuit varies turn-on, turn-off

By Cruz R. Mora

North American Aviation, Inc., Downey, Calif.

Turn-on and turn-off delays, independently and continuously variable, are achieved with the four-stage circuit shown below. Both input and output delays are variable from 1.5 to 1500 milliseconds; a limitation on the maximum turn-on delay is the duration of the input pulse, which it can never exceed.

An input voltage of 28 volts d-c is applied to the turn-on delay circuit, a relaxation oscillator. The turn-on time for the unijunction transistor Q_1 is set by adjusting R_1, which controls the charging rate of C_1. As C_1 is charging, the emitter voltage of Q_1 rises exponentally towards the supply voltage. When the emitter voltage reaches its peak, the emitter becomes forward biased, providing a discharge path for C_1 and briefly turning on Q_1. The resulting voltage pulse across R_4 is coupled through D_3, to the gate of SCR_1. This turns on SCR_1, resulting in a voltage drop across R_{11} which provides forward bias to Q_4. In turn, Q_4 provides forward bias to Q_5 turning it on. The resultant output volt-



STAGE 1

R_1 — 1 M
R_2 — 680
R_3 — 330
R_4 — 100
C_1 — 2.5 μF
Q_1 — 2N1671

STAGE 2

R_5 — 82 K
R_6 — 22 K
R_7 — 1 M
R_8 — 75
C_2 — 2.5 μF
D_1 — 1N645
D_2 — 1N645
Q_2 — 2N1671A
Q_3 — 2N1132

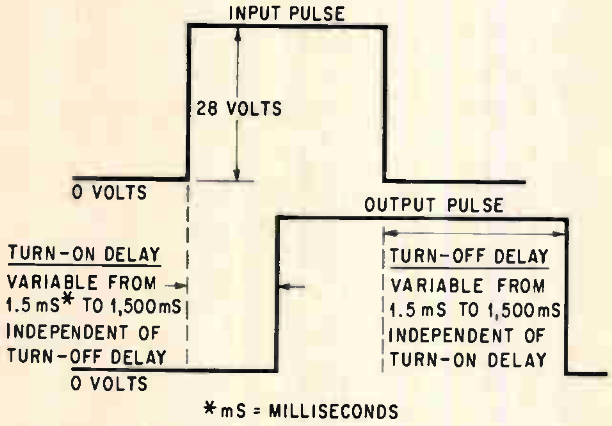
STAGE 3

R_9 — 1 K
R_{10} — 1.2 K
R_{11} — 220
R_{12} — 470
C_3 — 0.056 μF
D_3 — 1N645
SCR_1 — 2N1595

STAGE 4

R_{13} — 390
R_{14} — 3.3 K
R_L — LOAD RESISTOR
D_4 — 1N645
D_5 — 1N645
Q_4 — 2N388
Q_5 — 2N1132

Increasing time constants R_1C_1 and R_7C_2, in conjunction with unijunction transistors having higher intrinsic stand-off ratios, increases possible time delays up to four minutes. See pulses at top of page 93.



Time delay capabilities of the circuit are represented by the pulses. The maximum input delay is limited by the width of the original pulse.

age across R_L is slightly less than 28 volts because of voltage drops across D_1 and Q_5.

The turn-off operation is started by transistor Q_3. While the input voltage is present, the collector of Q_3 is at nearly zero volts and almost all the input voltage appears across R_5. When the input voltage drops to zero, Q_3 turns on and a voltage of about 25.5 volts appears across R_6. The turn-off delay time is controlled by the setting of R_7 which governs the charging rate of C_2. When the peak emitter voltage of Q_2 is reached, C_2 discharges, turning Q_2 on. The conduction of Q_2 connects the anode of SCR_1 to nearly ground potential; at the same instant, the cathode of SCR_1 is above ground potential because of the charge on C_3. The reverse bias on SCR_1 simultaneously turns it off and also Q_3 and Q_4 off.

Transistors control small d-c motor

By James B. Tiedemann

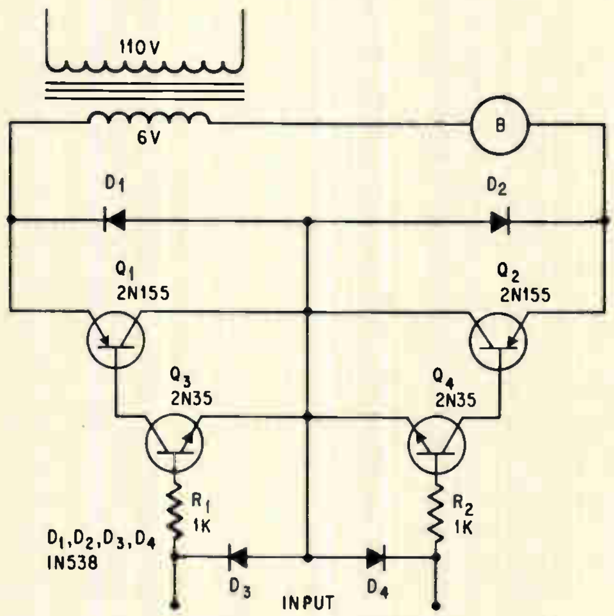
University of Kansas, Lawrence, Kan.

A versatile transistor servo-control circuit combines the functions of a rectifier and a power amplifier while providing directional control of a small direct-current motor.

The direction of the motor's rotation B is determined by the polarity of the input signal. This input, or error signal, provides the base current to turn on Q_3 or Q_4. These transistors in turn supply the base drive for either Q_1 or Q_2. Current from the six-volt transformer will drive the motor in either direction, depending on which of the p-n-p power transistors, Q_1 or Q_2 is conducting.

Input impedance and sensitivity are determined by resistors R_1 and R_2. They must be large enough to prevent excessive base current in Q_3 and Q_4 at the highest input-signal level anticipated. A value of 1,000 ohms will cause a typical six-volt motor to start with a one-volt signal. If the source is not limited by current, Q_3 and Q_4 can be protected without sensitivity loss with zeners at D_3 and D_4.

A six-volt, d-c motor, such as a Pittman DC85A-6, requires several hundred milliamperes for reasonable power output. Rectifiers D_1 and D_2 and transistors Q_1 and Q_2 should therefore be capable of handling at least 750 milliamperes. Because the grounded collector configuration of Q_1 and Q_2 provides a high base impedance, control transistors Q_3 and Q_4 and rectifiers D_3 and D_4 need only handle a few milliwatts of power. An ordinary filament transformer, with a secondary current rating of one ampere, is satisfactory for T_1. Heat sinks are not required unless sustained operation at full power is required. A center-tapped battery and potentiometer can be used as the signal source.



Six volt d-c motor B is energized by rectified voltage from filament transformer T_1. Motor's direction of rotation is controlled by the polarity of the input signal which determines whether Q_1 or Q_2 is conducting.

Automatic celestial guidance, part 2: new challenge to designers' ingenuity

An electro-optical system for space flight has been proven out in principle. Still needed are further advances in microelectronics, and computers that work directly with optical data

By Robert L. Lillestrand, Joseph E. Carroll and James S. Newcomb
Control Data Corp., Minneapolis, Minn.

Early on the bitter-cold morning of Dec. 1, two busy silhouettes could be seen on the roof of the Control Data Corp.'s Government Systems laboratory near Minneapolis. Below, in a warm and comfortable computer room, three men were watching data coming through, culminating five years' work.

The five researchers were demonstrating a new concept for space systems: celestial, in place of inertial, guidance. Randomly pointing a sensor at the sky, they succeeded in obtaining position and attitude measurements accurately from the stars, without the need for an external reference or any previous assumptions about orientation. The men on the roof were George Zenk and Robert Willey, electronics specialists.

The experiment showed further that the system could provide its accurate measurements rapidly, on-line, eliminating the need for gyroscopes in travel beyond the earth's atmosphere. By adding a strapped-down gyro to the already strapped-down celestial sensor, the range of applications to guiding a vehicle's ascent and descent can undoubtedly be extended.

The principles of this system, described in the first part of this article [Electronics, March 21, p. 115], are now well established. Results of the rooftop experiment are described in detail on page 103. Still needed, however, are final versions of the hardware that can implement these principles. The hardware consists chiefly of two pieces of equipment: a three-axis attitude sensor (TAAS) that can perform many measurement and control tasks in space, and a small but fast computer.

The electro-optical sensor

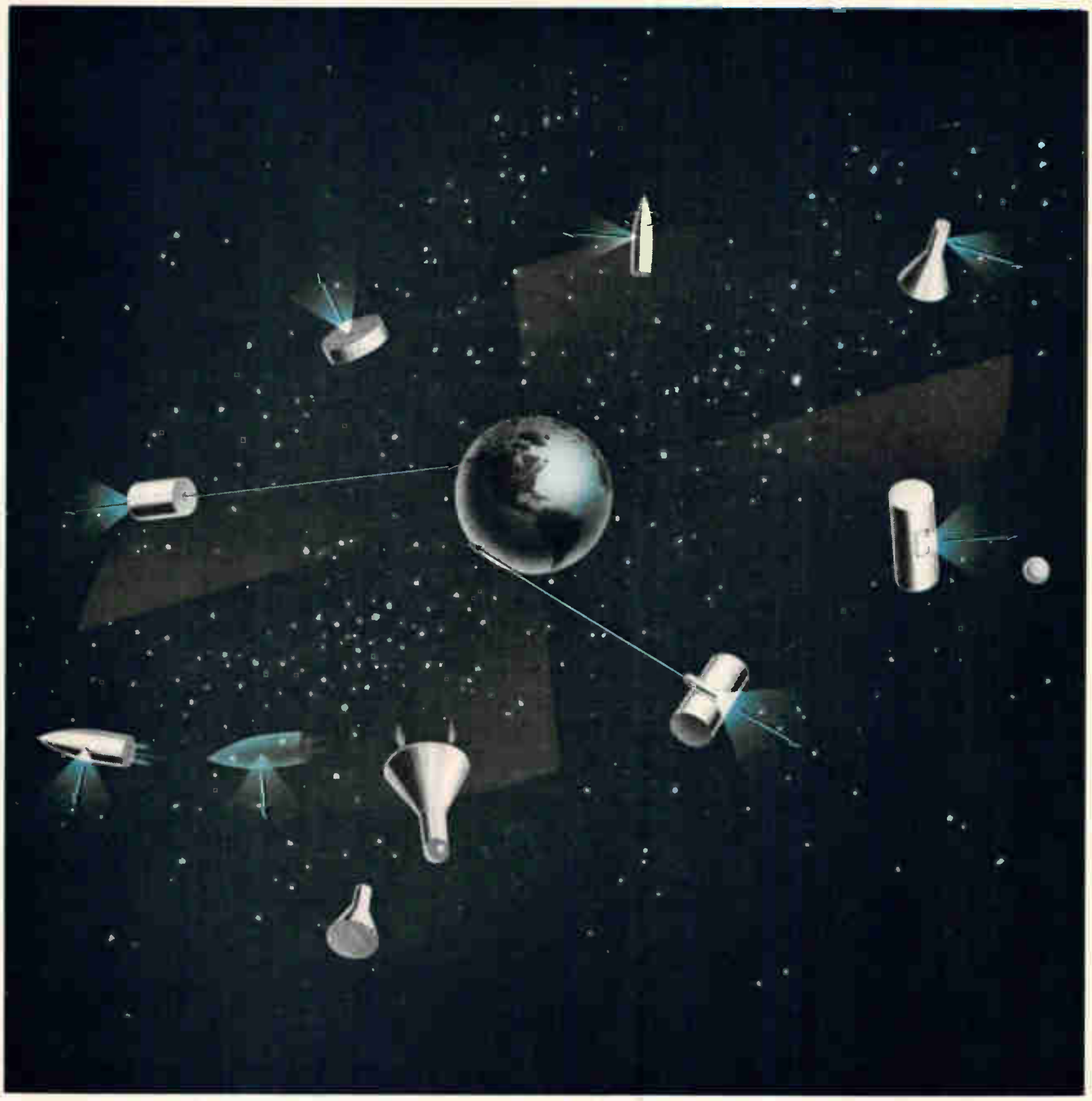
Celestial guidance, the ultimate successor to inertial guidance for space applications, is achieved in four steps: attitude detection, attitude control, navigation and guidance. For the most general problem, the system operates with 24 unknowns—12 for measurement and 12 for control—as shown in the table below the chart on page 95; the chart gives more detailed descriptions of various applica-

The authors

Robert L. Lillestrand is CDC's staff specialist for aerospace research. He is a member of the Committee on Guidance and Control of the American Astronautical Society.

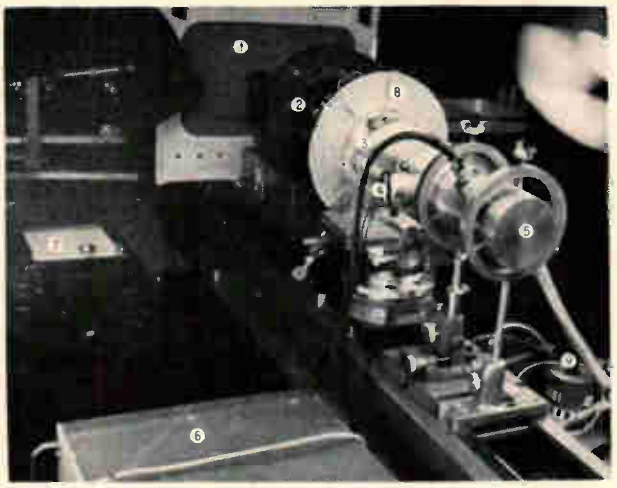
Joseph E. Carroll specializes in mathematical studies of satellite and interplanetary navigation systems. He holds a master's degree in physics from the University of Minnesota. He is a senior research scientist.

James S. Newcomb was responsible for the mechanical design and construction of the three-axis attitude sensor. He has a master's degree in physics from Brown University, and is a senior research scientist.



Celestial guidance for various space operations. For attitude control, top left sector, TAAS controls local vertical without horizon sensors if its orbit is known; upon completion of maneuver, realignment will carry optical axis of disk-shaped vehicle to local vertical. TAAS can also control yaw orientation relative to the orbit plane. Surveillance of the earth or another planet can be achieved by driving the optical axis relative to the stars so that sensors pointed at the planet are stabilized on a specified target area. For attitude detection, in top right sector, when spacecraft is spinning, TAAS provides star-transit data; this permits computer to determine vehicle's time-dependent orientation, including processional and nutational motions. When spacecraft is not spinning, sensor provides celestial orientation. For navigation, at lower right, TAAS can either sense the position of another body relative to the stars, or, with the help of a periscope, lock a ground tracker onto a point on the surface while the TAAS sweeps across the sky. For guidance, at lower left, TAAS with hyperhemispheric field of view senses position of another spacecraft and controls its own vehicle's propulsion system to accomplish rendezvous. Note that the two bright upper sectors represent attitude measurement and control, while the bright lower sectors represent navigation and guidance; also that the two sectors at the right represent measurement functions while those at the left represent spacecraft control functions. Table below shows classes of problems entailed in performing various operations in space.

	UNKNOWNS	FUNCTIONS		
		MEASUREMENT	COMPUTATION	CONTROL
UNKNOWNS	ORIENTATION $\psi_i, \dot{\psi}_i$ $i = 1, 2, 3$	ATTITUDE DETECTION	NO. OF UNKNOWNS ← 6 6 →	ATTITUDE CONTROL
	POSITION $q_i, \dot{q}_i$ $i = 1, 2, 3$	NAVIGATION	← 6 6 →	GUIDANCE
			24	



Experimental three-axis attitude sensor. Parts are: 1, simulated star field; 2, collimating lens; 3, mounting tube for lens and angle encoder; 4, synchronous drive motor; 5, photomultipler housing; 6, variable filter; 7, strip-chart recorder; 8, plate for gimbal mounting; 9, battery.

tions. The system's computer must process varying amounts of information on-line. Attitude sensing and navigation involve only 6 unknowns; attitude control, a maximum of 12; for guidance, at least 18 parameters are necessary to describe the state of the system.

An experimental TAAS is shown above. The system consists of a lens, a rotating disk with three slits, a photomultiplier, a drive motor, and a 16-bit angle encoder. When one slit passes under the image of a star on the focal surface of the objective lens, the starlight is transmitted to the photocathode of the multiplier, and the resultant electrical pulse gates the angle encoder's output to the digital computer. Each detectable star generates three pulses. The computer also receives noise pulses produced by the stellar background and the photomultiplier's dark current.

Measurement and control

One objective of the TAAS design is to provide a single sensor for many applications. Studies are being conducted to determine whether one TAAS design can be used both for measurement and as part of a control loop. This dual capability would be particularly valuable in electro-optical designs without moving parts, in which accuracy can be traded for scanning rate when switching from measurement functions to control functions. Versatility is essential for a high degree of standardization.

To circumvent the blocking effect of the earth or to avoid exposure to the intense light of the sun, two TAAS sensors may be necessary in a space vehicle. As an alternative, the computer's attitude program can be arranged to cause the spacecraft to turn about an axis perpendicular to the sensor's optical axis until an acceptable pointing direction is found.

Computer subroutines also can be standardized because most applications for the sensor pose certain common problems: pattern recognition, manipulation of trigonometric functions, matrix inversions and orbit computations. By tying these subroutines together with additional logic, various operating modes can be added.

To accomplish these functions, it is necessary first for the system to recognize patterns of stars; this task, like that of determining the spacecraft's attitude and later of guiding the vehicle, requires a general-purpose digital computer that can fulfill a variety of input-output requirements. Such a computer is being developed. If present advances in microminiaturization continue, an operating computer may be built in five years that occupies only five cubic inches.

Whenever the sun, earth or moon lies in the field of view, a shutter can protect the photodetector. The shutter design varies from one application to another, but generally the type required follows the pattern shown on page 117 of the March 21 issue. For optical and mechanical shutters, sensing and actuation would be accomplished with a small photocell. Self-actuating photochromic shutters have been described by G. H. Brown and W. G. Shaw.[6] The Kerr cell and Pockels cell require a separate photosensor to drive them; this system has been described by Bruce H. Billings and Robert O'B. Carpenter.[7] The electrical shutter would be actuated when the signal output from the photomultiplier exceeds a preestablished level. The circuitry is described in detail on page 103.

Looking ahead, the next step should be a TAAS which is purely electro-optical, with no moving parts for any mode of application. Later, optical computers will be necessary, to which information will be transferred directly from an optical sensor. These prospects are discussed on page 104.

In recognition of guiding stars

Man identifies the stars from three characteristics: their relative positions in the sky, their intensities and apparent colors. Researchers at CDC studied all of these approaches before deciding to rely entirely on geometry for pattern recognition. The decision was based on the fact that most applications for TAAS require highly accurate measurements of star position if the vehicle's attitude is to be determined accurately; since these measurements are available, the researchers reasoned, they might as wll be used also for pattern recognition. Furthermore, the problem of obtaining absolute intensity measurements accurate to about 1% would be extremely difficult, requiring periodic calibration, more sophisticated detection electronics, and an additional analog-to-digital converter.

If the TAAS's approximate orientation is known, it is possible to solve the three-axis problem with only θ measurements, in which case the scanner disk needs only one radial slit. For random orientation, however, each star's polar coordinates (ρ, θ) must be determined.

But is the geometric approach to pattern recognition feasible? Given a minimum of stars for all fields of view, how accurate must be the measurements of their relative positions if the pattern is to be recognized without ambiguity?

The problem was simulated on a Control Data 1604 computer for an optical system with a 46° field of view, "pointed" at 2,580 positions across a "sky" studded with 789 simulated stars.

When only two stars were used, the angular separation had to be measured to an accuracy of about one second of arc, as shown below in the graph of results. With a third star, the allowable error was increased to about 100 seconds of arc. As more stars are added, the allowable error increases, but at a diminishing rate.

For celestial guidance, a typical field of view—in this case 46°—requires the detection of at least three stars for all pointing directions, with root mean square errors in angular separations held to 30 arc-seconds.

The seven steps in pattern recognition are shown in the figure on page 98, and may be summarized as follows:

1. Angle storage. The computer memory receives angle data generated by pulses from stars, background noise, dark current, planets, airplanes, satellites and other sources.

2. Slit matching. A star which is detected at each of the three slits produces pulses at two equally spaced intervals, designated Δij and Δjk. The computer logic then searches through a list of angular measurements which have the property that $\Delta ij = \Delta jk \pm \epsilon_0$, where $\epsilon_0 << \Delta ij, \Delta jk$. Whenever this condition is met, three angles are stored in the memory. This technique eliminates most noise pulses, false targets and inaccurate data about stars. It has been shown experimentally that nine signal pulses (from three stars) can be readily identified by this method from as many as 30 associated noise pulses.

3. Target positions. For each set of three angles, the computer finds the polar coordinates of the hypothetical target. At this point, it is not known whether any of these targets are stars. In fact, it would be possible—though highly unlikely—for a "target" to be indicated by three noise pulses accidentally spaced in accordance with the criteria of step 2.

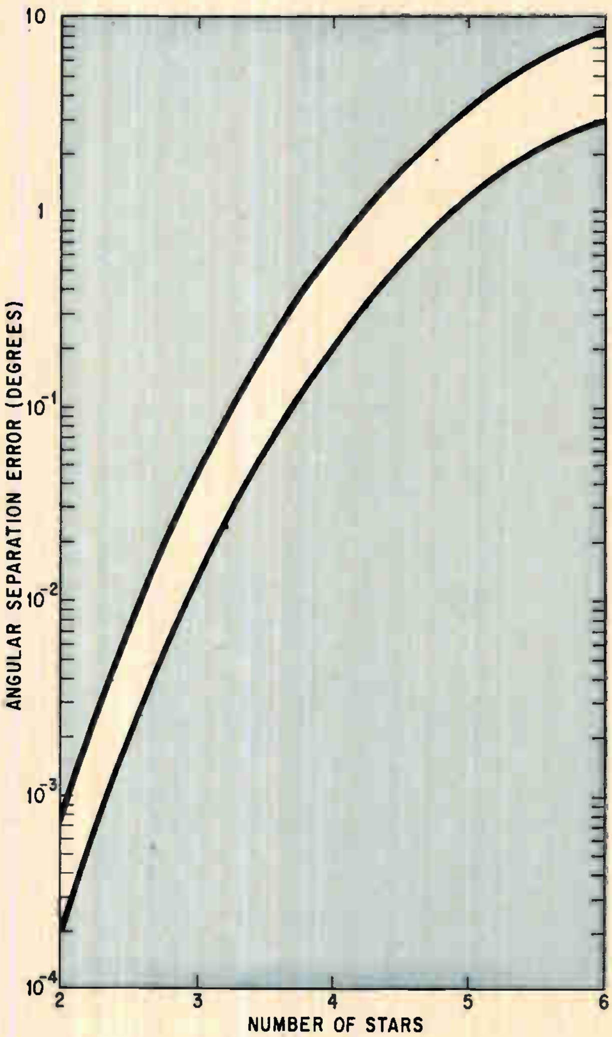
4. Angular separations. The angular separations between all of the targets are computed and stored in memory. The number of these separations is the combinatorial $\frac{n!}{(n-2)!\,2!}$ where n is the number of targets. The process cannot begin unless $n = 2$; however, because of possible ambiguities in the angular separations, it is preferable that $n \geq 3$.

5. Matching of angular separations. The next step is to search through the computer memory for stars whose angular separations are similar within $\pm\epsilon_p$ of each of the angular separations computed in step 4. Usually, more than one pair of stars will meet this criterion; this potential ambiguity is removed in step 6.

6. Linking of pairs. If S_1, S_2 and S_3 represent the star numbers for three detected stars, then when the pair numbers are written out they must have the following cyclic property: first pair, S_1, S_2; second pair, S_2, S_3; third pair, S_3, S_1. When this requirement is met, the ambiguities in step 5 are removed.

7. Computing sensor's orientation. When the stars have been identified, their positions can be determined from star lists stored in the computer's memory and the three axes of orientation of the sensor can be determined.

If a pattern has not been recognized, the values of the parameters ϵ_0 and ϵ_p must be enlarged. During the rooftop experiments, values for ϵ_0 and ϵ_p were determined empirically, and done frequently; the process always converged on the correct answer when enough stars were detected. However, each time ϵ_0 and ϵ_p are increased, the danger of an erroneous pattern recognition is enhanced. Another approach which has been success-



When more stars are used in pattern recognition, larger errors are permissible in measurements of angular separations between the stars. Shaded area gives approximate values for a 46° field of view and a 99% probability of unambiguous pattern recognition.

Seven steps in pattern recognition

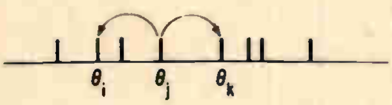
1. Angle storage. Photomultiplier transmits to computer pulses from stars, also false targets and noise.

2. Slit matching. Finding the three pulses from a given star

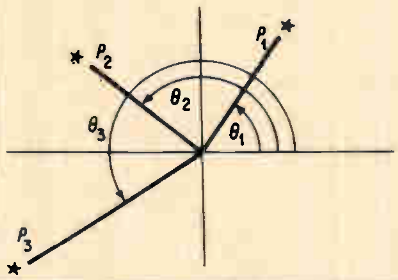
$\Delta_{ij}=\Theta_j-\Theta_i$

$\Delta_{jk}=\Theta_k-\Theta_j$

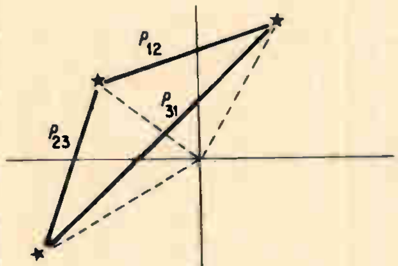
Test condition: is $\Delta_{ij}=\Delta_{jk}\pm\epsilon\theta$?



3. Target positions. The three pulses from a given target define the polar coordinates of its position.



4. Angular separations. Computing the separations of the stars based on TAAS measurements.



5. Matching angular separations. From a stored catalog, selecting star pairs which have similar angular separations.

ρ_{12}	ρ_{23}	ρ_{31}
29 — 43	13 — 19	92 — 29
71 — 62	24 — 60	
	35 — 80	
	43 — 92	

6. Linking angular separations. Searching for a linked triad among the lists in step 5

29 — 43   43 — 92   92 — 29

7. Computing sensor's orientation. α=right ascension, δ=declination, β=azimuth relative to north celestial pole.

ful, especially when scintillation problems are severe, is to discard the data and scan again.

Pattern recognition for a randomly oriented TAAS requires detection of at least three stars. If only two targets result from step 2, then ϵ_θ might be increased to see whether a third target can be found. In certain cases, where the pointing direction of TAAS is known to within about 5°, two stars are sufficient. When ϵ_ρ is too large and an ambiguity remains after performing step 6, ϵ_ρ can be reduced and the recognition program returned to step 5.

A problem in star-pattern recognititon is size of the computer memory necessary to contain the star data. At the minimum, the right ascension and declination of each star must be stored. For a typical system with 100 stars, about 4,200 bits of memory are required, including star-identification numbers. Ultimately, angular separations are required; the system may carry a list of these separations, or they may be generated from the data in the basic star list. If the list of angular separations is carried, the size of the computer's memory is enlarged but the solution time is reduced; if the list is not available, the converse is true. Experience indicates that a minimum list of angular separations is usually desirable; the list may include up to 3,000 separations, depending on the size of the optical system's field of view.

The computer memory can be reduced by about one-half if the star pairs are listed in order of increasing angular separation, even if the separation values are not included. An interpolation scheme then helps to approximate the location of the correct star pairs and to start a process of angular-separation calculation, which becomes the basis for more refined interpolation. This process is similar to that of opening a book to a certain page. It is not necessary to start at page 1. The list of angular separations corresponds to the number of pages; if the total is known, four or five attempts will usually be sufficient to find the correct page.

Processing the sensors' outputs

The pattern-recognition and navigation techniques are complex enough to require the help of a general-purpose electronic computer for data reduction. The digital nature of the TAAS outputs makes them ideally suited to digital processing.

The computer's size, weight, power and reliability depend chiefly on the speed and memory needed. To estimate these, it is necessary to count the elementary operations which the computer is likely to perform while executing a particular task, and to calculate the amount of data and number of instructions to be stored.

But what operations should be elementary, requiring complex hardware? And which should be synthesized by programing, increasing the size of the computer's memory? This trade-off is illustrated in the chart below.

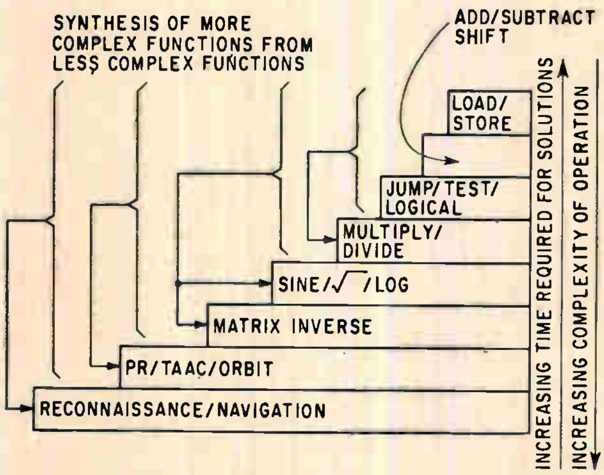
The practice is to synthesize with subroutines all operations at the "sine" level of complexity and above. Whether this should be done for more basic operations, such as multiply/divide, requires further consideration of machine organization and the complexity of the problem to be solved.

Complex programs, such as recognizing patterns of stars and determining a space vehicle's orbit, require a large computer memory, but can tolerate slow solution. In contrast, controlling attitude and position requires a high-speed computer. In practice, this can be accomplished only by selecting a starting point such that the computer needs to process only the incremental changes in the state of the entire system. Such computers can be relatively simple.

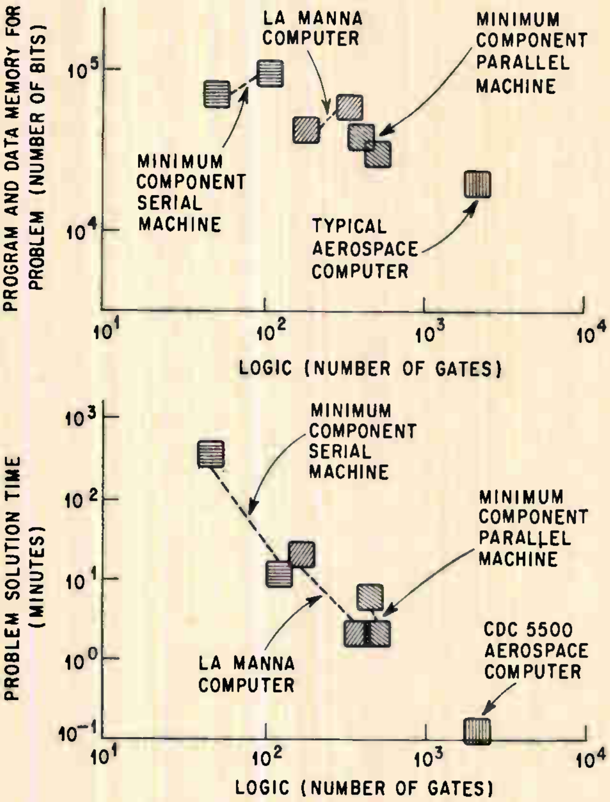
Two examples of very simple organizations (one serial, one parallel) are shown on page 100. The serial design is effected using only 14% as many gates as required of the simple parallel design. However, the serial machine is a bit-by-bit device with only eight fundamental instructions. Thus, even such simple operations as the addition of two 24-bit numbers must be constructed as subroutines out of these bit-oriented instructions. In effect, a set of such subroutines simulates a machine of higher basic capability on the minimal machine. Then the programing need only be accomplished using the more sophisticated simulated machine. Programing the original device for problems of the complexity of those discussed here would be almost impossible.

In contrast, the parallel computer shown is more powerful, containing even a multiply (but not a divide) instruction. This increased capability to perform more complex operations is achieved in slightly over 500 gates, by two techniques: the 24-bit arithmetic is performed in 12-bit bytes, and a "register file" is used. The register file eliminates as many as four full-length (12-bit) registers from the hardware by assigning them to specific locations in the memory. The resulting reduction in complexity is achieved in exchange for an increase in running time, caused by the need to refer to memory several times during each instruction.

The two designs thus form an interesting contrast: the serial operations are so fundamental that it was deemed too complicated to execute an add



Hardware vs. software. As machine's logical complexity increases, computation time is reduced at the expense of additional computer hardware.



Computer trade-offs for navigating along the moon's surface with TAAS. Increasing each computer's complexity reduces solution time considerably; surprisingly, this tends to make the computer smaller because the reduction of memory size is greater than the increase in logic volume. This is true because most aerospace computers require memories that occupy 60% to 80% of the design volume. In bottom graph, as complexity of computer logic is increased, memory requirement is gradually reduced. Problem solution times refer to initial pattern recognition and to three-axis attitude determination.

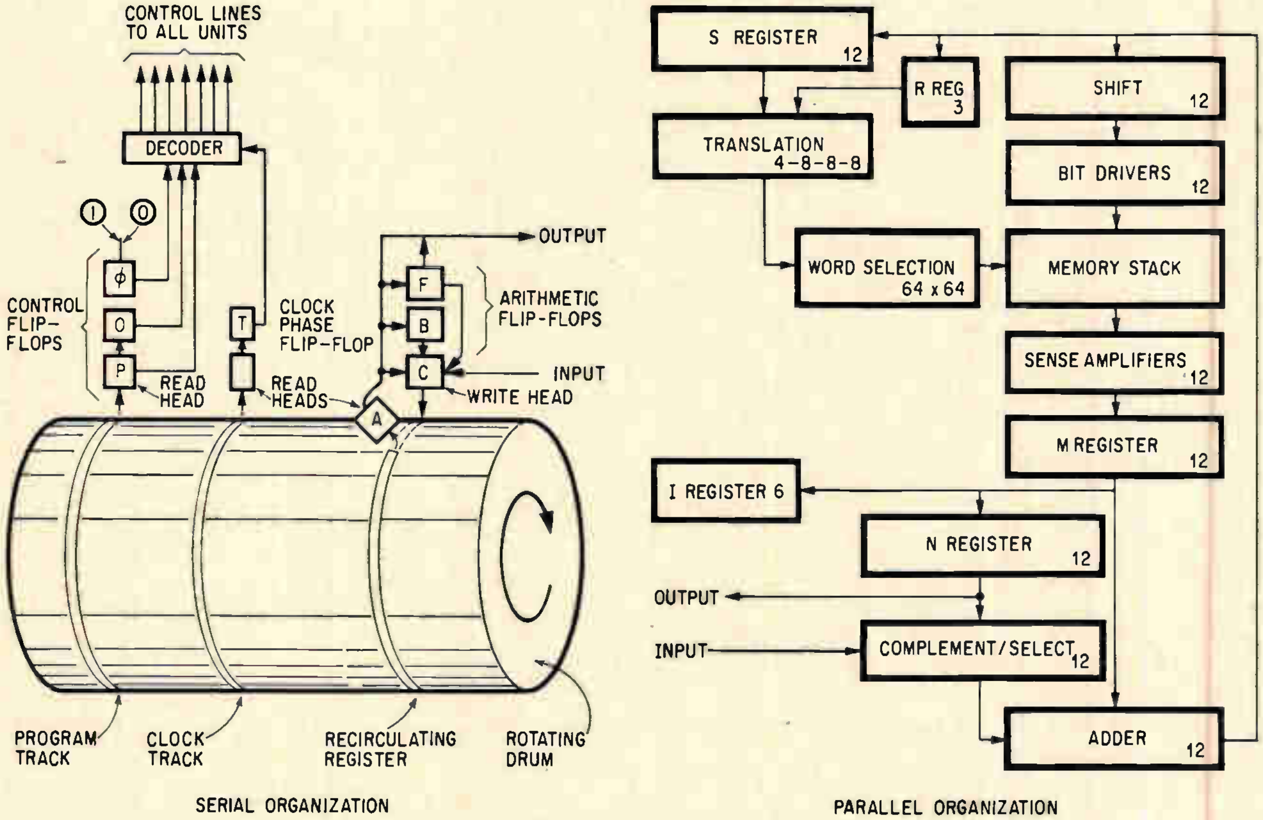
with hardware; in the parallel design, a multiply could be included easily from existing, complex functions. In the parallel organization, a little extra hardware buys much more power than in the serial organization.

An illustration of the data-processing problem is provided by the TAAS's potential use in navigating on the surface of the moon, as described in the panel on page 101. If several computer schemes are compared as to logic complexity, memory size and solution time, results of the type shown in the diagram above will be obtained.

The block diagrams of the computers labeled "minimum component" are on page 100. The La Manna machine is a serial computer with 16 instructions designed according to principles laid down by T. J. LaManna.[4] The fourth machine is the CDC 5500—a high-capability space computer for general-purpose data processing.

There are two boxes for each type of computer, representing two versions; they indicate the range of parameters for each type.

The class of digital computers discussed here is simpler than the typical aerospace computer under development. This is principally because the



Serial vs. parallel organization of computer. Serial design is simpler but slower and more difficult to program for problems of the complexity encountered in celestial guidance.

TAAS is a versatile instrument whose outputs are readily convertible to meaningful attitude and navigational information. This permits fewer subprograms and fewer input-output channels, and results in significant reductions in size, weight and power. The type of computer required to process the outputs of a TAAS can be fabricated in less than 20 cubic inches, and will require no more than three to four watts. Technological advances over the next two to five years are expected to reduce these numbers by about one-half.

Filtering signals from the sky

The electro-optical detection system is basically a series of filters. As outlined in the first part of the article, the optical system and photodetector constitute a spectral filter for incoming electromagnetic radiation, and the scanner disk with its slits is a mechanical filter. There are also two types of electrical filters: digital and analog; the pattern-recognition logic in the computer constitutes a digital filter, and the filters immediately behind the photodetector are analog.

The optical test bench for scanning the stars is shown on page 96. The major design characteristics of the sensor are summarized in the table at the left.

In the rooftop experiment, the signal from the photomultiplier contained two kinds of noise: shot noise from the instrument itself, and optical "noise" from the sky. The sky noise was mostly reflection of lights from Minneapolis and St. Paul. The shot noise consisted of short pulses of random amplitude; the sky noise produced a relatively continuous signal that changed somewhat as the pointing direction was altered, also changing slowly even when the pointing direction remained constant.

Unwanted short pulses were removed by an active low-pass filter with a constant phase shift over the pass range. An active filter, rather than passive, was chosen to avoid bulky inductors and impedance-matching problems. The filter was a modified sixth-order Bessel type, called a Paynter filter; such a device has been described by P. J. Hansen.[7] The filter's characteristics and operation

Sensor-design summary

1. Optical system	
Objective diameter (inches)	1.8
f-number	1.1
On-axis blur circle (seconds of arc)	20
2. Scanner system	
Number of slits	3
Shape of slits	pie-section
Field of view (min. and max.)	16, 38
3. Detection system	
Photomultiplier	EMI 9514S
quantum efficiency	0.075
dark current (pulses per second)	300
Filter	Paynter
Bias level	floating (on noise)

Exploring the moon

After a landing on the moon or on a remote planet, a three-axis attitude sensor can be used for surface navigation. Supported pendulously on a roving lunar vehicle, the TAAS might quickly check position and heading each time the vehicle stops. Early exploration of the far side of the moon will almost certainly require such celestial measurements.

For these measurements, the position fix is based on astronomic coordinates represented by 1 on the drawing. This type of measurement is subject to local deflections of the gravity vertical, caused by the irregular distribution of the moon's mass, and by physical librations which are on the order of 10^2 seconds of arc. On earth, specifically in the United States, average rms deflections of the vertical are approximately five seconds of arc; deflections on the moon are unknown.

An alternate method of navigating on the moon is to sense the position of a satellite of known orbit, perhaps the vehicle's mother ship as it moves overhead, as represented by 2. These measurements can be used to provide the lunar vehicle's selenocentric coordinates—based on the center of the moon—and would not suffer detectably from errors associated with local deflections of the vertical.

For another application, a pendulously supported TAAS could be mounted on a lunar excursion module for computing its coordinates relative to the orbiting command-and-service module; these computations would be vital in planning a reunion in space.

A scientific application of TAAS is for comparing astronomic coordinates with selenocentric coordinates as a means of investigating geologic processes on the moon. Comparative position fixes, made by a roving vehicle, could be used to obtain a grid-type measure of the deflections of the vertical in any region of the moon's surface. By comparing these deflections with the topography, subsurface variations in density could be studied; this principle is already followed in geologic studies of the earth. These measurements would aid considerably in attempts to understand the relative role of meteoric and volcanic action in creating the visible features of the lunar surface.

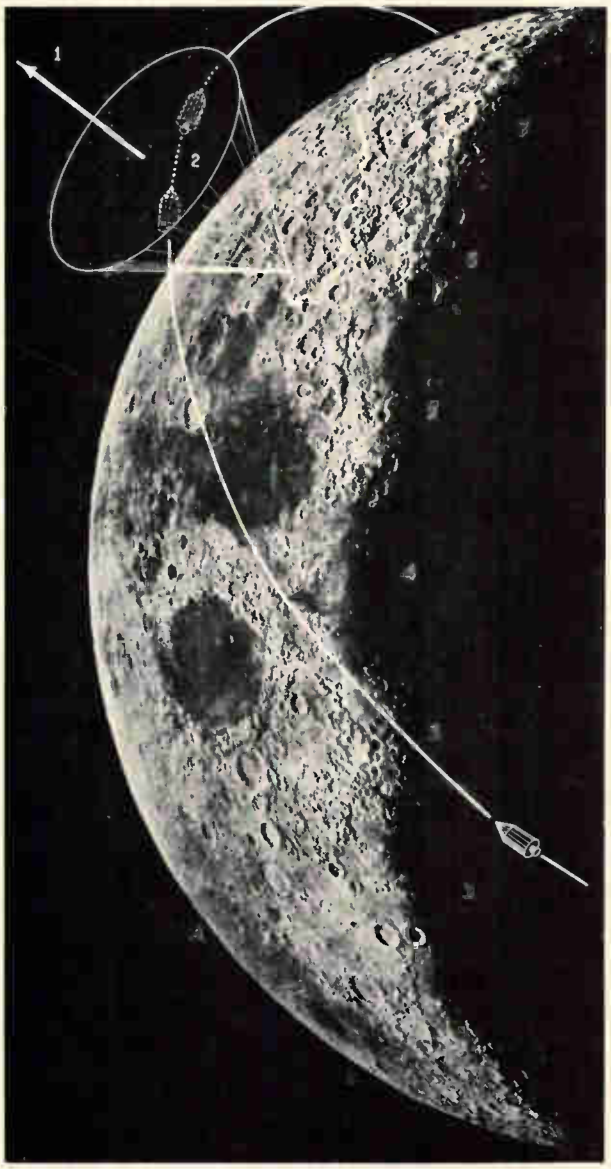


Photo courtesy of University of Chicago Press

are shown in the drawings and photos on page 102.

Background noise from the sky was controlled by a threshold-detection system. Unwanted signals were kept out by manually setting the detector's threshold higher than the level of background signals but lower than the level of star signals.

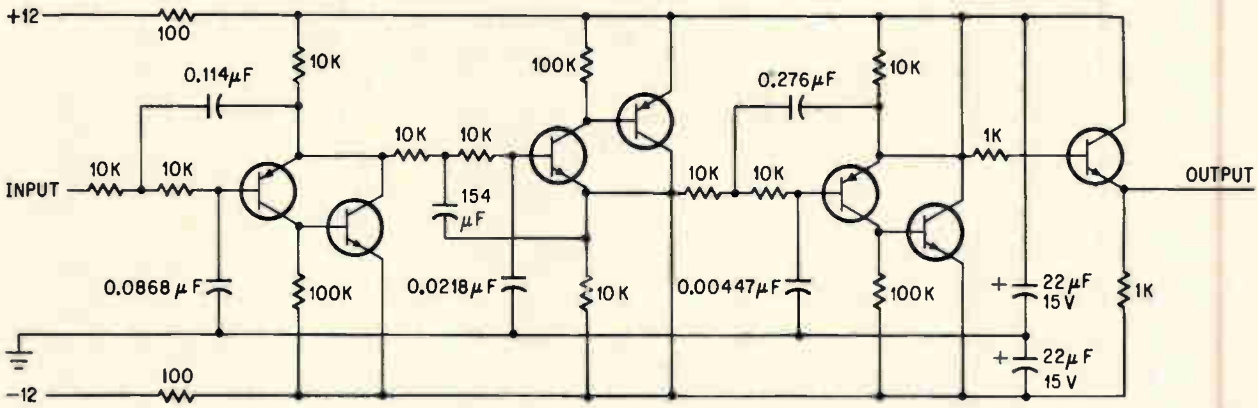
In various pointing directions, particularly near a bright target such as the moon or the planet Jupiter, the background signal was found to be much stronger than in other regions included in the same scan. Therefore a fixed-threshold setting high enough to reject background signals in the vicinity of the bright targets would also reject faint but valid star signals in other parts of the scan. The circuit provides a varying threshold-control voltage that causes the detection threshold to operate at a level slightly higher than that of the background signal. The input of the variable threshold control is the output of the Paynter filter.

The operation of the circuit can be understood from the block diagram on page 103. The signal enters an amplifier, which clips any signal that is more than a few tenths of a volt stronger than the long-term average signal. Thus any fast-rise pulse, such as the signal from a star, is clipped and, in effect, removed from the threshold circuit.

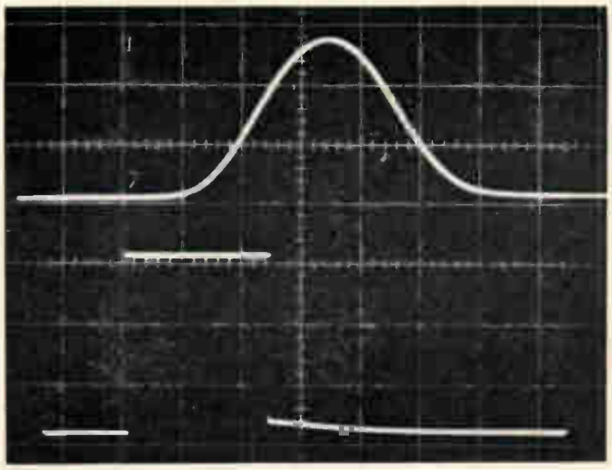
This signal is passed to the threshold-shaping unit, which operates as a fast-rise, slow-fall automatic gain control. A constant of 2.3 milliseconds was chosen for the rise time; this is about 10 times the star signal's pulse width and fast enough to follow changes in background, but too slow to respond to the clipped star pulses. The discharge time constant was chosen to be about one-tenth the speed of the attack time constant.

An isolator, shown in the block diagram between the threshold-shaping circuit and the gain-control circuit eliminates any positive feedback to the signal amplifier from the reference return.

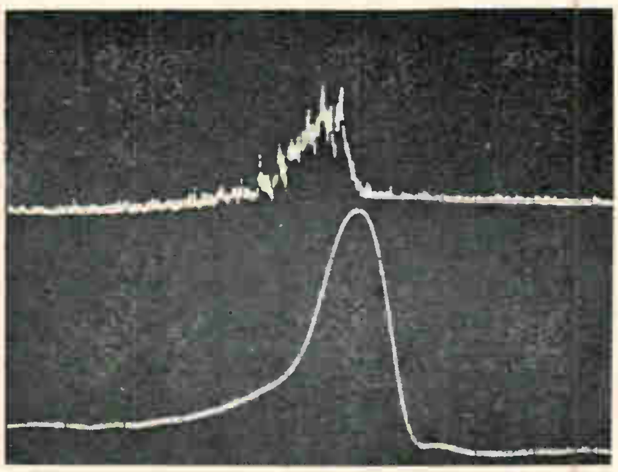
The gain-control circuit allows manual adjust-



Active low-pass filter with constant phase shift

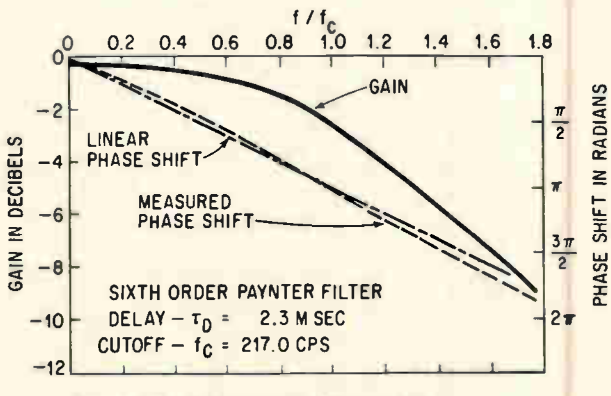


Response to 2.5-millisecond pulse



Star signal noise (bottom) and filtered (top)

Low-pass filter for celestial sensor with 15-second scan period and 2.3-millisecond delay between input and output signals. Graph at right shows frequency response and phase shift. Oscillogram at left above shows filter's response to a 2.5-millisecond pulse; upper trace is filter output, lower is input. Oscillogram at right above shows circuit's pulse-shaping and delay properties; top trace is a noisy star signal, bottom one is the amplified and filtered pulse with a constant time delay.



Frequency response vs phase shift

ment of the range of variable threshold control.

The manual bias control sets the direct-current level from which the automatic control operates. The d-c bias voltage and the threshold-control voltage are added in the operational amplifier labeled "mixer."

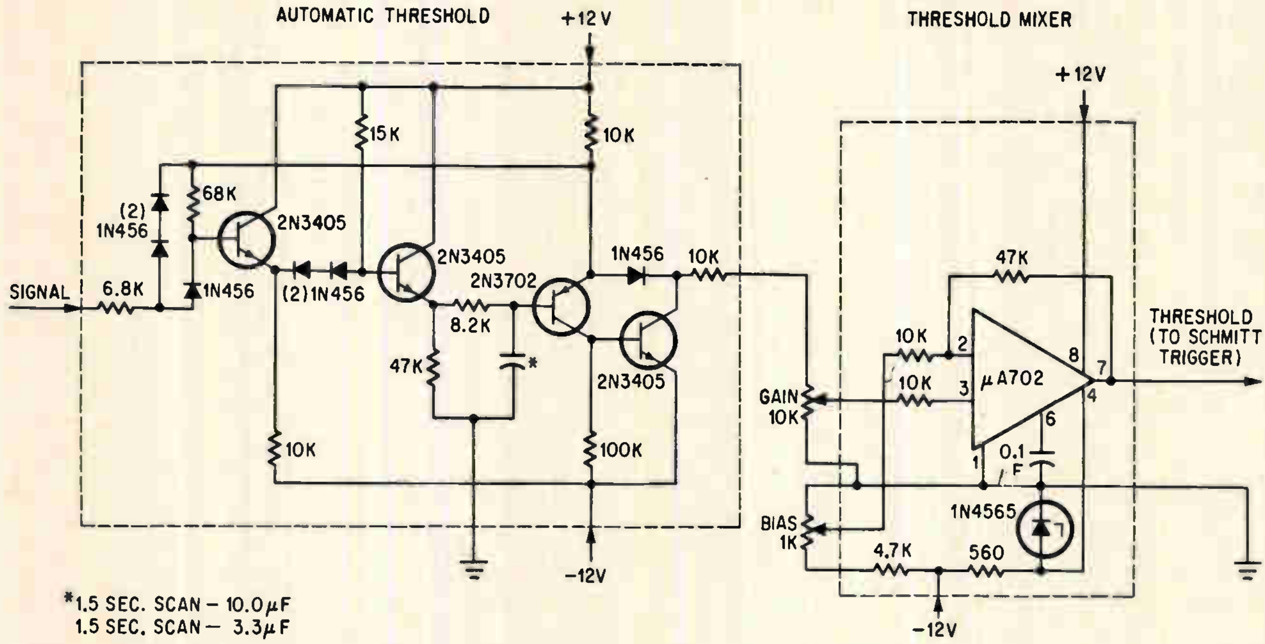
A detailed circuit diagram of the system is shown at the top of page 103; below it at the right is an oscillogram showing the effect of the automatic threshold control.

The relationships of the various members of the analog detection system are shown in the diagram on page 105. Typical oscillogram traces for test points A, B and C are included.

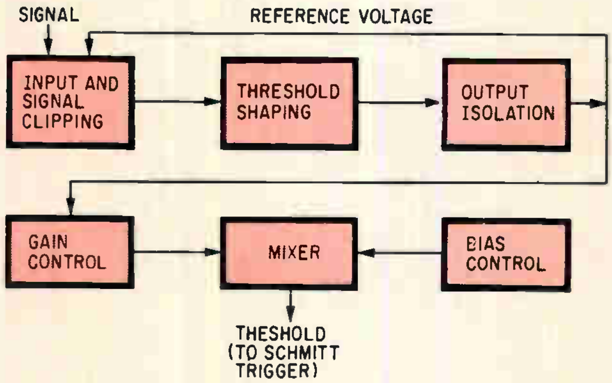
This analog system sends three classes of information to the computer:

- The encoder reading at the time each star entered the slit.

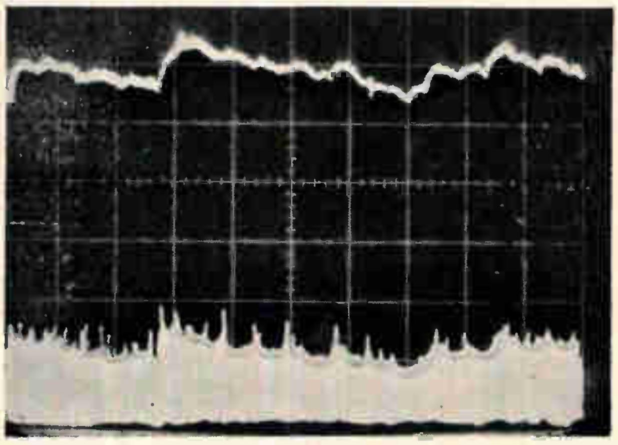
. . and automatic threshold control to reject background noise



Threshold control's input is output of Paynter filter



Six steps in automatic threshold control



Star signal (top) detected through noise (bottom)

Automatic threshold control keeps detection threshold slightly above the level of background signal. Oscillogram shows how circuit detects star signals through noisy sky background; upper trace is threshold-control voltage, lower is sky background plus star-signal spikes. Note that threshold-control voltage "follows" the background, not the signal spikes. For clarity, static position of automatic threshold trace has been displaced from its position relative to background signal.

- The number of encoder counts that occurred while the star was in the slit.
- A digital indication of the relative height of the star pulse; this is obtained from a peak detector and an analog-to-digital converter.

Experimental results

To evaluate the results of the rooftop experiments, the output of a TAAS sensor was processed on-line on a Control Data 160-G computer installed about 100 feet from the observatory. Pattern-recognition tests, based on random pointing, were performed with real stars. To evaluate the system's potential accuracy in space, free from the degradational effects of the earth's atmosphere, tests were performed with an artificial star field.

A computer printout, resulting from a single scan of the sky from the roof of the Government Systems building, is shown at the top of page 104.

The sensor was pointed at both artificial and real stars, with various accuracies. Typical values are shown in the table at the bottom of page 104.

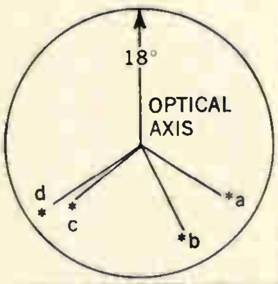
Errors (σ) in azimuth are significantly greater than errors in latitude or longitude, as might be expected with a sensor whose field of view was only 36°. With a larger field of view, the value of σ_θ would have been smaller.

When a satellite or aircraft crossed the field of view, the pattern-recognition technique discriminated successfully against these false targets.

Another class of problems was caused by the earth's atmosphere, particularly background radia-

1. DATA ACQUISITION

DATA POINT NO.	ANGLE ENCODER MEASUREMENT
1	9596
2	35071
3	38900
4	40059
5	41359
6	42725
7	44438
8	47523
9	49442
10	51446
11	57005
12	58548
13	60502
14	61077
15	61141
16	63738
17	63997
18	64792



2. SLIT MATCHING

($\varepsilon_{\Theta} = \pm 30$ counts)

a.	2 —	3 —	6
b.	5 —	7 —	8
c.	11 —	13 —	17
d.	12 —	15 —	16

3. TARGET POSITIONS

(Radians)

	ρ	Θ
a.	0.21973	3.73095
b.	0.26843	4.26115
c.	0.23902	5.80209
d.	0.31530	5.86282

4. ANGULAR SEPARATION

STAR PAIR	°	′	″
a — b	7	44	42
b — c	20	10	25
c — d	4	28	16
d — a	26	53	25

5. ANGULAR SEPARATION MATCHING

($\varepsilon_{\rho} = \pm 6$ minutes of arc)

a — b	b — c	c — d	d — a
18971-18458	8833-6937	8302-8969	8302-4633
6681-6029	8302-7078	19728-18971	5605-6937
22558-21332	10438-9947	10120-10438	10438-7543
7543-7557	17374-14842	16942-16724	18144-19033
23693-22677	10120-8633	9443-9886	1117-4427
8969-8675	7557-10120	16953-16724	11105-9307
17029-16618	16952-18809		20029-16268
	6960-8223		1400-3664
	6681-4688		18458-14842
	4041-2572		19656-22845
	16953-18809		27354-28295
	127-32149		23693-26386
	17262-17179		20128-23708
	18133-19607		8969-9307
	25024-22677		8969-13506
	6029-4427		25024-21982
	17179-21332		19975-20926
	20926-22845		13443-15340
	9307-10040		
	4633-8941		

6. ANGULAR SEPARATION LINKING

a — b	b — c	c — d	d — a
7543-7557	7557-10120	10120-10438	10438-7543

7. COMPUTED POINTING DIRECTION

Right ascension: $\alpha = 106°$ 26.490′
Declination: $\delta = 44°$ 50.907′
Azimuth: $\beta = 319°$ 27.240′

8. IDENTIFIED STARS

G. C. No.	Constellation	Name	m_B	m_V
a. 7543	β Auriga	Menkalinan	1.92	1.90
b. 7557	Θ Auriga	—	2.55	2.63
c. 10120	α Gemini	Castor	1.61	1.58
d. 10438	β Gemini	Pollux	2.13	1.13

POINTING DIRECTION ASSUMPTION: α=NONE δ=NONE

Computer printout from a single scan of the sky made Dec. 1, 1965, at 2:37 a.m. Step 1 shows raw data from 16-bit angle encoder (360° = 65,536 parts). Steps 7 and 8 show the stars which were recognized and the completed three-axis attitude determination. In step 8, m_B and m_V refer to the blue and visual magnitudes of the stars detected. Note in step 8 that the sensor detected Castor and Pollux, the twin stars that constitute the Gemini constellation.

tion caused by scattering of radiation from city lights and by atmospheric turbulence causing scintillation or twinkle.

The future of celestial guidance

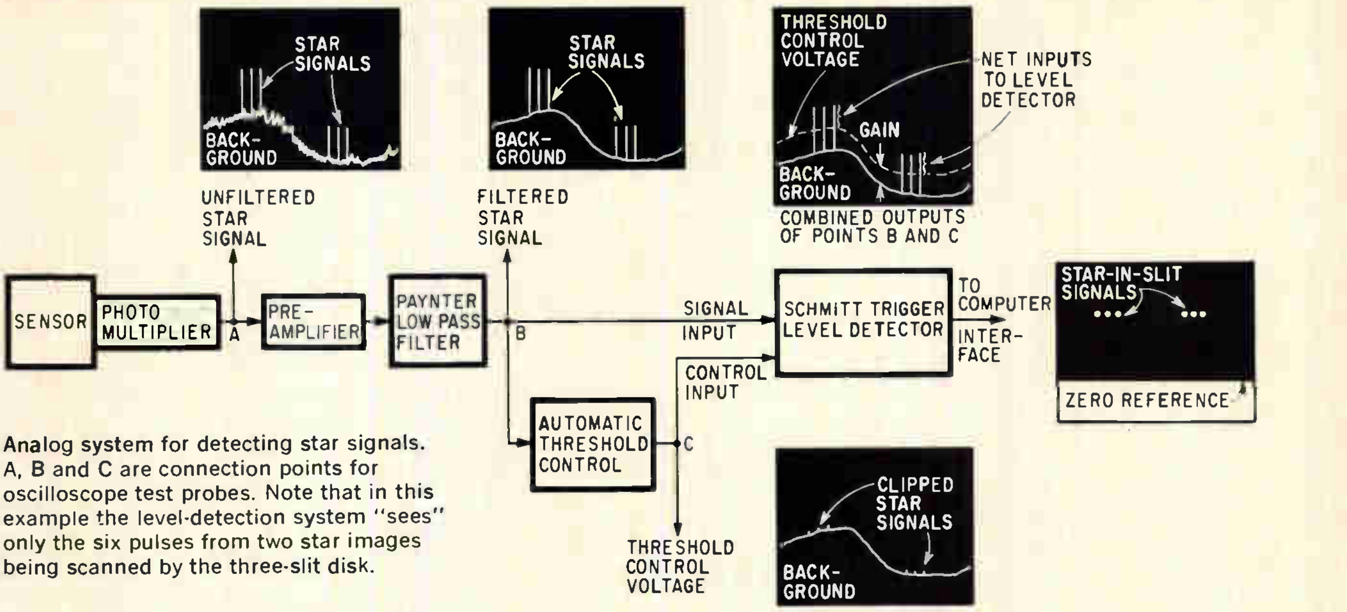
What is the next step in the evolution of celestial sensors? What effects will the TAAS and its associated computer have on future space systems? Is the present state of computer technology adequate to cope with the high information rates of optical sensors operating close to their theoretical limits? Some of these questions can be answered accurately today; others must wait.

Type of error	Type of star field: Artificial	Real
$\sigma\alpha$ (longitude)	3.8	26
$\sigma\delta$ (latitude)	3.7	38
$\sigma\beta$ (azimuth)	13.8	97
Pointing errors:		
Single-scan	5.3	46
Ten-scan	1.7	15

Pointing accuracy with artificial stars was 5 to 10 times greater than with real stars; the main reason is the error introduced by atmospheric effects which would be absent in space. Errors are measured in arc seconds. Artificial stars were matched with real stars in intensity.

Certainly a next step in the development of strapped-down celestial systems will be the fabrication of a TAAS which is purely electro-optical, containing no moving parts for any mode of application. In the next few years small sensors without moving parts are likely to achieve accuracies to within one second of arc with apertures of approximately one inch and with sampling periods of one second. With a single optical element whose field of view is 40°, these sensors will be able to recognize star patterns anywhere in the sky, and provide a complete three-axis attitude capability.

Once approximate attitude control is achieved with TAAS, improved systems will attain pointing accuracies to 10^{-2} second of arc with one-inch apertures in a few seconds of integration time.



Analog system for detecting star signals. A, B and C are connection points for oscilloscope test probes. Note that in this example the level-detection system "sees" only the six pulses from two star images being scanned by the three-slit disk.

This will be accomplished by information-limited angle interpolation of optical images. Most passive electro-optical sensors—such as star trackers—now fall short of their information limit by several orders of magnitude.

A great deal of progress can be expected in the next few years in reducing the number of sensors and the number of kinds of devices required for space systems. The TAAS sensor already provides solutions applicable to all 24 variables in the general guidance problems. For example, a system based on a strapped-down TAAS functions without gimbaled star trackers or gyros. TAAS replaces the star tracker because of its ability to solve the pattern-recognition problem; it replaces the gyros because of its high potential sampling rate when using multiple-slit autocorrelation techniques.

Other sensors can also be eliminated. If the orbit is known, the system can control a spacecraft's orientation relative to local vertical better than horizon sensors can—and TAAS also controls yaw. By using TAAS to sense the position of a released test probe relative to the stars, autonomous satellite navigation systems accurate to within 500 feet can be achieved. These would do away with the need for ground-tracking or horizon-sensing equipment.

Present electrical analog filters unavoidably degrade the observational data from stellar sources. As the computer's data-processing capacity is increased, designers will be able to use purely digital filters. Thus, each measurement of angle or time, corresponding to a quantum event at the photocathode, can be transmitted to the computer. Because of the intrinsic complexity of the statistical hypotheses to be tested, digital data-processing techniques can be used to improve the ability to extract useful information from the radiation environment.

One of the greatest needs is for optical computers to which information can be transferred directly from an optical sensor with no intermediate electronic elements. The information at the lens's focal surface will then directly actuate an alterable memory matrix in the computer. In this way the boundary between the computer and the sensor of electromagnetic radiation will begin to vanish and one of the major bottlenecks in the input section can be eliminated.

The evolution of guidance techniques has progressed from instinct to dead reckoning to inertial guidance. The logical next step for space systems is celestial guidance. The mechanical simplicity and versatility resulting from application of modern electro-optical technology makes the approach particularly attractive.

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Acknowledgment

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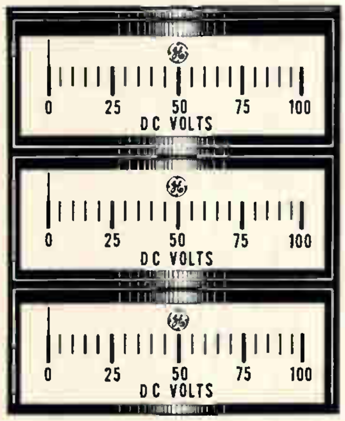

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Using transistor circuits to multiply and divide

They effectively employ the transistor's current-voltage characteristics to raise numbers exponentially and extract roots

By George E. Platzer Jr.

Chrysler Corp., Detroit

Because a pn semiconductor junction exhibits a logarithmic relationship between current and voltage, it can be exploited to perform calculations such as multiplication, just as a slide rule does. Since the junctions may be used to take antilogarithms as well as logarithms, it is possible to multiply, divide and raise to exponents in the logarithmic domain by simple addition and subtraction. Thus, in instrumentation and control systems, transistor circuits can perform the same function as a slide rule, but with the advantage that the mathematical operation is performed continuously and rapidly as the input quantities change.

Although there are other electronic ways of performing analog operations, these transistor circuits[1,2] generally have advantages of simplicity, accuracy and faster response time. For example, conventional servomultipliers, which use ganged potentiometers to perform multiplication, operate more accurately but the frequency response is generally poor. Other devices require complex circuits. Analog circuits most closely equivalent to transistor circuits in performance utilize Hall effect devices and magnetoresistors. Compared with these, the transistor circuits are generally more accurate and less sensitive to temperature.

The author

George E. Platzer Jr. heads the physics group of Chrysler Corp.'s physics-instrumentation research laboratory, where he directs the development of solid state circuitry for automobiles. His background includes degrees in physics and in electrical and automotive engineering.

Engineers at the Chrysler Corp. use the transistorized computers for controlling the input energy of a resistance welder, for calculating the average of squared values and root mean square values, and for direct computation of efficiency and slip in mechanical systems. In the welding application, a multiplier computes the instantaneous power delivered to the weld area. The frequency response of the multiplier is high enough to respond to the transients caused by the welder's phase controlled transformer. Within limits, the circuit is able to compensate for line voltage variations, electrode wear, and dimensional variations of the workpiece.

Log and antilog

The basic principle of the electronic slide rule is that for low-level input signals, the current and voltage in an ideal diode junction are related by

$$I = I_R\left(\epsilon^{\frac{qV}{kT}} - 1\right) \approx I_R\epsilon^{\frac{qV}{kT}} \qquad (1)$$

where I = the diode current in amperes
I_R = the diode reverse-saturation current in amperes
V = the voltage across the diode in volts
q = electron charge in coulombs
k = Boltzmann's constant
T = temperature in degrees Kelvin

At the current levels used for logarithmic computations, the approximation in equation 1 is in error by less than 1 part in 10 million.

The diode's saturation reverse current, I_R, is temperature sensitive and is given by[3]

$$I_R = I_{RO}\left(\frac{T}{T_O}\right)^{1.4}\epsilon^{-\frac{E_G}{k}\left(\frac{1}{T_o}-\frac{1}{T}\right)} \qquad (2)$$

where I_{RO} is the reverse saturation current at temperature T_O in amperes and E_G is the energy gap of the material at 0° Kelvin in electron volts.

Taking the logarithm to the base ϵ of both sides of equation 1, and rearranging terms results in

$$\log_\epsilon \frac{I}{I_R} = \frac{qV}{kT} \quad (3)$$

From equation 3 are derived the two fundamental statements expressing the characteristics of an ideal diode junction:

▪ The voltage across the diode is proportional to the logarithm of the current through the diode. The corollary to this statement is:

▪ The current through the diode is proportional to the antilogarithm of the voltage. For an ideal transistor, the foregoing is reworded to read:

The base-to-emitter voltage of a transistor is proportional to the logarithm of the emitter current. As a corollary statement:

The emitter current is proportional to the antilogarithm of the base-to-emitter voltage.

Simple multiplier

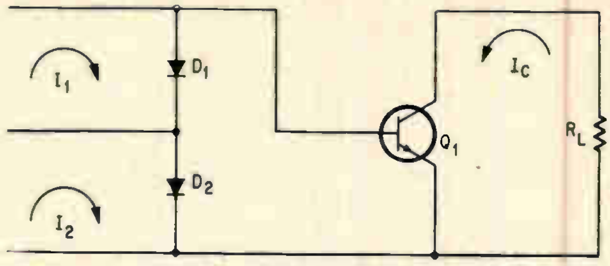
The multiplier circuit on this page won't work well in practice, but it clearly shows the principle of the slide rule. Input currents I_1 and I_2 flow through diodes D_1 and D_2. The voltage across each diode is proportional to the logarithm of the current. Because the diodes are in series, the voltage at the emitter-to-base junction of the transistor Q_1 is proportional to the sum of the logs or equivalently to $\log_\epsilon I_1I_2$. By the corollary statement already given, the emitter current is proportional to the antilogarithm of $\log_\epsilon I_1I_2$ or simply to I_1I_2. If the junction characteristics are ideal and the transistor has infinite current gain, the multiplication is exact and the collector and emitter current are proportional to the product of the diode currents.

With a bit more complexity, the circuit can be made practical with excellent accuracy. As a multiplier operating over an output range of 500 microamperes to 5 μa, maximum error is about 0.5% full scale, while the maximum absolute error at any point is about 2% of the reading. In other words, accuracy is maintained even at the low end of the current range.

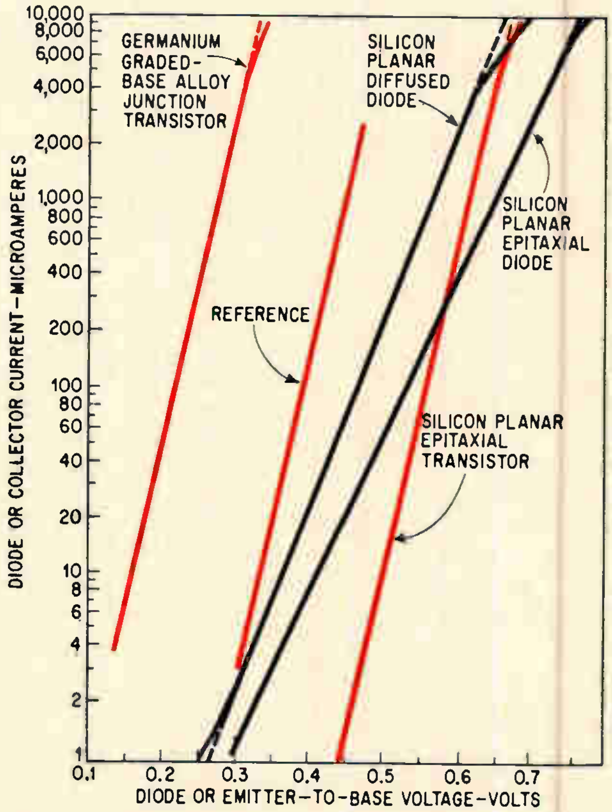
Transistors and diodes

Characteristics of transistors and diodes must be more closely examined to select devices that will function properly in practical circuits; diodes are not suitable in this application.

In these computing circuits, the junction device must exhibit an exponential characteristic over an extensive range of input voltages or currents. Since equation 1 is for an ideal junction, it does not indicate any bound on the exponential region. However, series resistance within the junction modifies the exponent in equation 1, preventing the device from operating ideally. In addition, the value of the exponent also varies with current density and temperature. All these factors limit the range over which practical junction devices will exhibit an exponential characteristic.



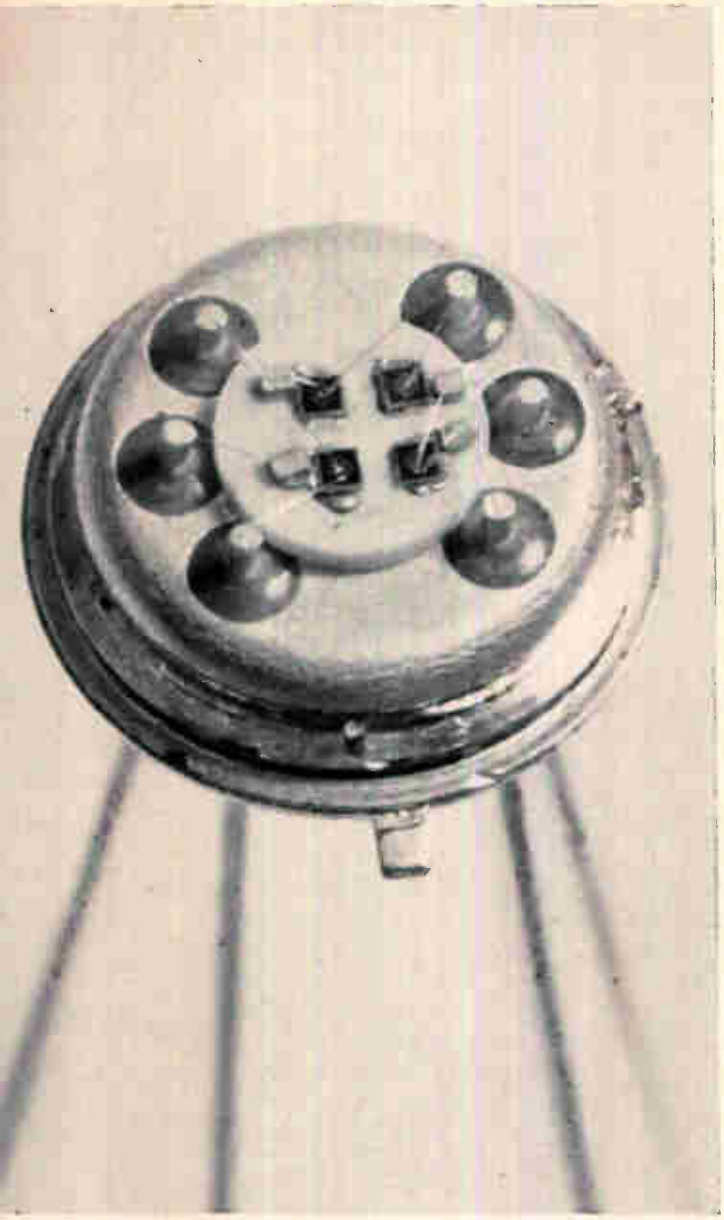
In simple multiplier, the voltage across D_1 and D_2 is proportional to $\log_\epsilon I_1I_2$. Collector current I_c is proportional to I_1I_2.



Diodes and transistors exhibit exponential characteristics represented by linear section of this semilog plot. Transistor curves, in color, have a slope equal to qV/kT. Reference line parallel to transistor curves is computed from equation I for an ideal junction at 298°K.

The departure from ideal operation is illustrated above in the graph, which plots the voltage current characteristics measured in several commercial diodes and transistors. In this semilogarithmic plot, the exponential regions are represented by the linear segments of the curves. Since the silicon planar epitaxial transistor is linear over three decades of current, it is used in the output of the multiplier circuits.

In a transistor, a linear semilogarithmic relationship is possible only at relatively low-power levels. This happens because a few milliwatts of collector dissipation are sufficient to increase the junction temperature and to make the emitter-base voltage a significantly strong function of collector dissipa-



Multichip transistor multiplier contains four silicon planar epitaxial, pnp transistors in a TO-5 case.

tion, as well as current. However, using a transistor to take the antilogarithm of a voltage presents no problems as long as the base-to-emitter voltage is scaled to the capabilities of the transistor.

Though they may have a large exponential region, commercial diodes are not suitable for an application in these analog circuits. The primary reason is that the value of the exponent in equation 1 is smaller than the value for transistors. A difference in exponents is represented as a change in slope in the graph on page 110. In a multiplier circuit, this would mean that the output would be proportional to some power of the input, rather than to the product.

Therefore it is necessary to find a device that has an exponent that matches that of the transistor. Although conventional diodes do not qualify, the emitter-base junction of the transistors might qualify, but the exponential characteristics are satisfactory only at extremely low-current levels.

The solution is to operate a transistor as a diode with the collector connected to the base, so that $V_{CE} = V_{BE}$. Operated in this manner, the current-voltage characteristics is substantially the same as the amplifier connection. This occurs because the collector-base barrier potential is still large enough to collect the charge carriers that diffuse across the base to the collector. Although the collector-to-emitter voltage is lower than usual, currents and voltages at the terminals have the same range of values found in normal amplifier operation.

Transistors that have been tested and found satisfactory for this application include silicon planar epitaxial types 2N3053, 2N1711, 2N2904 and 2N2905A. In the multiplier circuits, only the output transistor must have high current gain. One multiplier has been constructed in the multichip transistor in the photograph at the left. Called the SC-286 it is manufactured by Motorola Inc.

Multiplier theory

A more exact multiplier circuit at the top of page 112 is similar to the simple multiplier, except that transistors are used in place of diodes. The output current I_C, proportional to the product I_1I_2, is determined using the basic equations.

From equation 2, the sum of the voltages across the diode-connected input transistors

$$V_1 + V_2 = \frac{kT}{q} \log_e \frac{I_1I_2}{I_{R1}I_{R2}} \qquad (4)$$

where I_{R1} and I_{R2} are the reverse saturation currents of Q_1 and Q_2

Taking the antilogarithm

$$I_1I_1 = I_{R1}I_{R2}\epsilon^{\frac{q(V_1+V_2)}{kT}} \qquad (5)$$

For the output transistor Q_3,

$$I_E = I_{RE}\epsilon^{\frac{qV_{BE}}{kT}} \qquad (6)$$

where I_E is the emitter current and I_{RE} is the reverse saturation current of the output transistor Q_3.

From the diagram on page 112

$$V_{BE} = V_1 + V_2 \qquad (7)$$

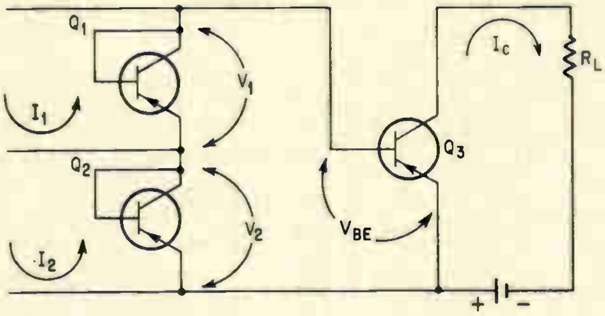
Substituting equation 7 into equation 6, and the subsequent result into equation 5

$$I_E = \frac{I_{RE}}{I_{R1}I_{R2}} I_1I_2 \qquad (8)$$

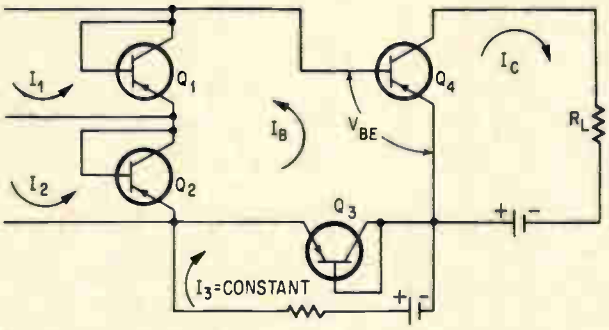
Because $I_E = I_C/\alpha$ (9)

$$I_C = \frac{\alpha I_{RE}}{I_{R1}I_{R2}} I_1I_2 \qquad (10)$$

where α = common-base current gain



In improved mutliplier circuit, Q_1 and Q_2 are connected as diodes to match exponential characteristics of Q_3.



Practical multiplier adds circuit consisting of Q_3 and its current supply to permit increased input levels and to provide thermal compensation.

For equation 10 to define a useful multiplier. signal currents I_1 and I_2 must be independent of the output circuit. This occurs if the current gain, β, of the output transistor, Q_3, is high so that its base current is much smaller than the signal currents, I_1 and I_2. Ideally, I_B should be zero.

Even this multiplier circuit may not be entirely satisfactory. First, all the transistors may not operate in the same current range. This occurs when the same type of transistor is used for generating both the logarithm and the antilogarithm values. Secondly, to operate with reasonable current levels in the logarithmic region of the transistors requires input and output currents of the same order of magnitude. This requirement cannot be met with this configuration. For example, if 1 ma is set as the upper limit of output current, the circuit at the top of the page would allow maximum input currents of only 0.01 μa in each of the input transistors. This is easily seen on the graph on page 110, which shows that V_{EB} must be approximately 0.6 volt at 1 ma.

For equal voltage across each of the input transistors, V_{EB} would only be 0.3 volt. The current at this voltage is about 0.01μa. This is not only an unreasonably low signal current to work with, but it is also comparable to the base current of the output transistor. This difficulty may be avoided by increasing V_1 and V_2 and using a constant series voltage in the circuit to subtract from $V_1 + V_2$. If each of the input currents is 1 ma, V_1 and V_2 each will be about 0.6 volt. For V_{EB} to be 0.6 volt, a bucking voltage of 0.6 volts must be provided.

Another difficulty—indicated by equation 10—is that the highly temperature-dependent reverse-saturation currents are unbalanced since they appear once in the numerator and twice in the denominator. This will make the multiplier temperature sensitive. Using a transistor for the bucking voltage source compensates for the temperature dependence.

In the lower circuit, left, which incorporates these improvements, current I_3 is maintained constant. Following a procedure similar to that used to develop equations 4 to 10 results in

$$I_C = \frac{\alpha I_{RE} I_{R3}}{I_{R1} I_{R2} I_3} I_1 I_2 \qquad (11)$$

where I_{R3} is the reverse saturation current in the diode-connected compensating transistor Q_3.

Now the saturation currents are balanced, and I_C is reduced as compared to equation 10 for given values of I_1 and I_2.

This multiplier will be stable and accurate over a wide range of currents and temperature.

Equation 11 indicates that if I_1 or I_2 are constant, and I_3 is a variable signal current, the multiplier may operate as a ratio or dividing circuit, in which the output current is given by

$$I_C = \left[\frac{\alpha I_{RE} I_{R3}}{I_{R1} I_{R2}} I_2 \right] \frac{I_1}{I_3} \qquad (12)$$

As a divider, the output current, I_C, decreases as the signal current, I_3, increases. As a result, both range and accuracy are reduced because the base current may become a significant part of the input transistor current. However, good accuracy can still be maintained over a 20-to-1 range.

Another valuable operation is extracting roots. The circuit at the bottom of page 113 will produce the square root of an input signal, I_X. Diode-connected transistor Q_4 is placed in series with the emitter of Q_3 to make the output circuit perform the square root operation. Current I_2 is constant. Transistor Q_2 provides thermal equalization and balances the voltages in the input and output circuit. The input circuit acts as a multiplier so that

$$V_1 + V_2 \propto \log_\epsilon I_X I_2 \qquad (13)$$

where V_1 and V_2 are the voltages across Q_1 and Q_2 and $\propto$ is the proportionality symbol. $V_1 + V_2$ equals the sum of the base-to-emitter voltage drops across Q_3 and Q_4. The voltage drops across each of these transistors is proportional to the log of the collector current developed by Q_3. Therefore

$$V_1 + V_2 \propto 2 \log_\epsilon I_C = \log_\epsilon (I_C)^2 \qquad (14)$$

Since I_2 is constant, combining equations 13 and 14 results in

$$(I_C)^2 \propto I_X \qquad (15)$$

More exactly, the collector current is

$$I_C = \alpha \left[\frac{I_{RE} I_{R4} I_2}{I_{R1} I_{R2}} \right]^{1/2} \sqrt{I_X} \qquad (16)$$

where I_{R4} is the reverse saturation current of Q_4.

Generalized logarithmic computer

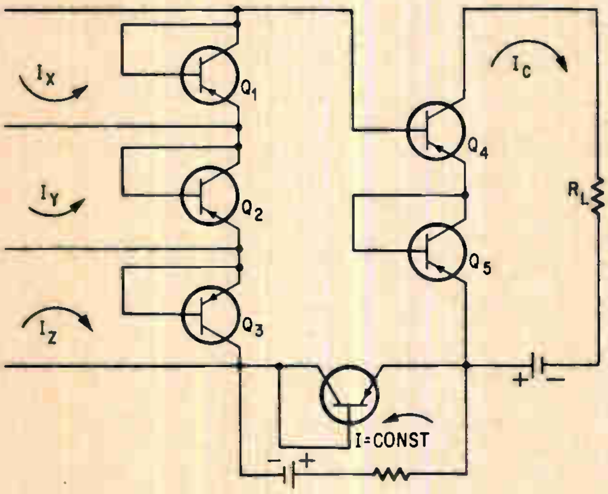
A valuable feature of this transistorized slide rule lies in its ability to perform combined operations of the basic functions. For example, the circuit shown below will perform the computation $\sqrt{XY/Z}$, which is useful in computing mass flow of a compressible fluid. In this circuit, Q_1 and Q_2 form the log of the product $I_X I_Y$; Q_3 subtracts the term $\log_\epsilon I_Z$; and Q_4 and Q_5 perform the antilog and square root operation.

A generalized statement of the operations that these circuits can perform is

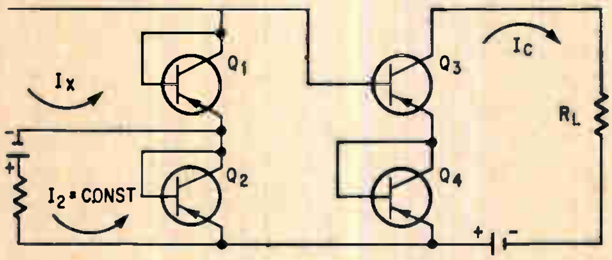
$$Z = \left(\frac{X_1X_2 \ldots X_m}{Y_1Y_2 \ldots Y_n} \right)^{1/r} \qquad (17)$$

If m is the number of multiplying factors, there must be m transistors connected in such a way as to increase conduction in the output transistor when the signal current increases. If n is the number of dividing factors, there must be n transistors connected in such a way as to decrease conduction in the output transistor when the signal current increases. If r is the order of the root to be taken, there must be (r-1) transistors in the emitter circuit of the output transistor connected so that the emitter current flows in the forward direction for that element.

The number of diode-connected transistors required for temperature stabilization will be equal to n + r — m. If this sum is positive, the compensating transistors are connected as multipliers; if the sum is negative, they are connected as dividers. The constant current through the compensators is made large enough to assure that all the transistors are working in their logarithmic range.



Functions of the form $\sqrt{XY/Z}$ are computed by combining the multiplying circuit Q_1 and Q_2, the dividing circuit Q_3 and the square root circuit, Q_4 and Q_5.



Square root of the input I_X is produced by transistor Q_3 in series with diode-connected transistor Q_1.

A four-quadrant multiplier.

All of the circuits shown so far have been one-quadrant types in which only positive signals are accepted and only a positive output is available. With the multiplier circuit on page 114, four-quadrant operation can be obtained. The circuit consists of two basic multiplier units connected together. A bias current I_{Bi} must be supplied to each of the input transistors and inverted signal currents to one side of the unit. Summing the individual output currents in the load resistor yields

$$I_L = I_{C1} + I_{C2} = [2\,(I_{Bi})^2 + 2\,I_1I_2]\,K_1$$

where K_1 is a function of the saturation currents that are assumed equal for both sides of the circuit and I_L is the load current. The product may, of course, be easily separated from the constant term $2(I_{Bi})^2$.

Sources of error

The capabilities and limitations of the circuits depend on the simplifying assumptions that were made. In the development of equations 4 to 10 it was assumed that:

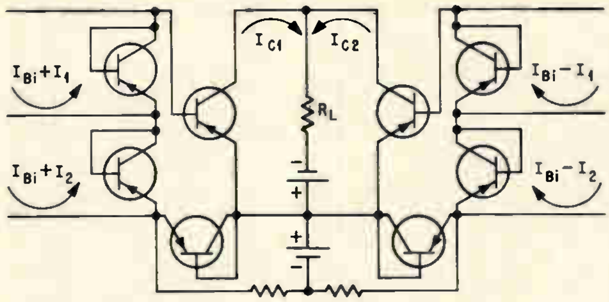
- Transistors are accurately described by equations 1 and 2;
- Transistors are all operating at the same temperature;
- The base current of the output transistor is very small compared with the input currents; and
- The current gain, β, of the output transistor is constant.

In addition to these assumptions, system capacitance and its effect on frequency response have been ignored.

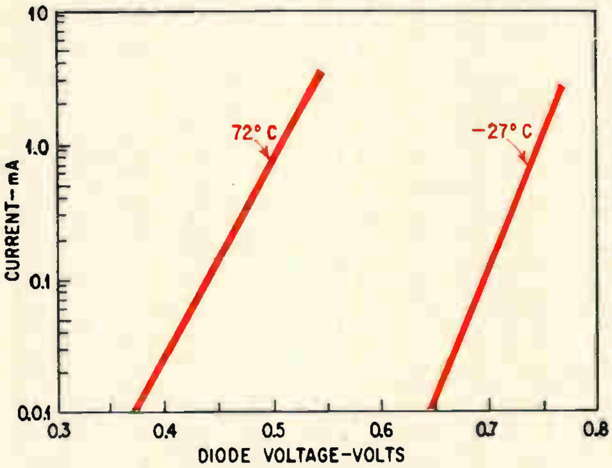
Silicon planar transistors, have been proved best for these applications. Equation 1 is accurate in the forward conduction region if a saturation current is calculated from some point in the linear semilog portion in the graph on page 110. At 27°C, the slope of the exponential region is approximately 59.5 millivolts per decade of current and is nearly the value predicted by equations 1 and 2. As the temperature increases, the slope decreases, as indicated by the graph on page 114.

There are also slight slope variations at a fixed temperature and from one unit to another. For instance, at 25 C, variations in excess of a millivolt per decade of current have been observed among several units. In addition, the change in slope with temperature is not always uniform.

At a fixed temperature, a difference in slope of 1 millivolt per decade of current between a multiplier's input and output transistor causes an absolute error of 4% over a decade of current. To



Four-quadrant multiplier performs multiplications for any combination of negative and positive inputs. Circuit consists of two multipliers connected in parallel. I_{Bi} is a bias current.



Increasing temperature shifts the transistor's exponential characteristics and also reduces the slope.

minimize this kind of error, it is necessary to carefully match the transistor's slope.

Furthermore, if the device is to work over an extended temperature range, matching will also be necessary at the lower temperatures, where slope variations are particularly accentuated. However, from 0°C to 100°C, slope variations in the absence of any special matching results in a 0.02% change in the output current per °C.

Reference shift

Another effect arises from the different transistor temperatures in a given circuit. At a constant current, the diode voltage shifts approximately —2 millivolts/°C as indicated by the graph directly above. If a one-degree difference exists between an input and output transistor, the reference point will shift by about 8% resulting in an error in the calibration of the readout.

To prevent a reference shift, all transistors are placed on an isothermal mounting pad. This pad is either an anodized aluminum-block, drilled to accept individually packaged transistors, or it is an alumina disk with the transistor dice mounted on it and interconnected by multichip integrated circuit techniques. For individually packaged transistors the aluminum pad must be anodized for electrical isolation.

Some temperature variation among transistors is unavoidable because of the differences in power dissipation. A low collector supply of 1.5 volts with a 1,000-ohm load keeps the output transistor's dissipation sufficiently low to avoid difficulty.

Base current

If it is not valid to assume that the base current I_B of the output transistor is small, then an error, ϵ_r, will be developed at the output even if all the junctions are ideal. An expression for the error that can occur in a multiplier will be determined. For analysis, the base current in the circuit on page 112 is assumed to be small, but not negligible compared with I_1, I_2 and I_3.

With this new assumption, equation 11 becomes

$$I_C = \frac{\alpha I_{RE} I_{R3}}{I_{R1} I_{R2}} \left\{ \frac{(I_1 - I_C/\beta)(I_2 - I_C/\beta)}{(I_3 + I_C/\beta)} \right\} \qquad (18)$$

where $I_B = I_C/\beta$.

Because I_C/β is small,

$$I_C \simeq \delta \frac{I_1 I_2}{I_3} \times \left\{ 1 - \frac{\delta}{\beta} \left[\left(1 + \frac{I_1}{I_3}\right)\left(1 + \frac{I_2}{I_3}\right) - 1 \right] \right\} \qquad (19)$$

where

$$\delta = (\alpha I_{RE} I_{R3})/(I_{R1} I_{R2})$$

Assuming that the output collector current is at some reference current I_{CC}, determined by the input reference currents I_{11}, I_{22} and I_{33}, then from (19)

$$I_{CC} \simeq \delta \frac{I_{11} I_{22}}{I_{33}} \times \left\{ 1 - \frac{\delta}{\beta} \left[\left(1 + \frac{I_{11}}{I_{33}}\right)\left(1 + \frac{I_{22}}{I_{32}}\right) - 1 \right] \right\} \qquad (20)$$

Now the operating currents are written

$$I_1 = xI_{11} \qquad (21)$$

$$I_2 = yI_{22} \qquad (22)$$

$$I_3 = zI_{33} \qquad (23)$$

In these equations, x, y, and z are the factors by which I_1, I_2 and I_3 are related to I_{11}, I_{22}, and I_{33}, respectively. These factors may be either greater or less than unity.

Substituting equations 21, 22 and 23 into 19

$$I_C = \delta \frac{xy}{z} \frac{I_{11} I_{22}}{I_{33}} \times \left\{ 1 - \frac{\delta}{\beta} \left[\left(1 + \frac{xI_{11}}{zI_{33}}\right)\left(1 + \frac{yI_{22}}{zI_{33}}\right) - 1 \right] \right\} \qquad (24)$$

The relative error of any point referred to the reference currents is defined as

$$\epsilon_r = \frac{I_{CC}\frac{xy}{z} - I_C}{I_{CC}\frac{xy}{z}} = 1 - \frac{I_C}{I_{CC}\frac{xy}{z}} \qquad (25)$$

where the term $I_{CC}\, xy/z$, represents the output current for the values x, y, and z when it is valid to assume that the base current is negligible.

Substituting equations 20 and 24 into 25 and ignoring second order terms

$$\epsilon_r \simeq \frac{\delta}{\beta}\left[\frac{I_{11}I_{22}}{(I_{33})^2}\left(1-\frac{xy}{z^2}\right)+\frac{I_{11}}{I_{33}}\left(1-\frac{x}{z}\right)+\frac{I_{22}}{I_{33}}\left(1-\frac{y}{z}\right)\right] \quad (26)$$

Circuit performance

The table on the right shows the results obtained from a multiplier constructed with Motorola's SC-286 multichip integrated circuit. Input signals I_1 and I_2 both have full-scale values of 500 μa. I_3 is adjusted to give 500 μa of collector current in the output transistor. The output signal varies over a 100-to-1 range in response to a 10-to-1 input variation. In this table, the calculated value of I_C is 1/500 of the product I_1I_2.

For this unit δ was 1.1 and β was 275. The small discrepancy between the observed and calculated errors is attributable to variations in parameters between the transistors, the approximation previously discussed, and instrument errors.

Measurements were made at room temperature and at $-50°$C and at $100°$C with equally good results. At the temperature extremes, the only observed variation was in the value of I_3 required to produce 500 μa of output current with I_1 and I_2 at 500 μa. At $0°$C, the value of I_3 was approximately 510 microamperes. It increased at a rate of 0.19 μa/°C. The required I_3 varies not only with temperature, but also from unit to unit because of the difficulty in selecting perfectly matched devices.

Two calculations involving division are tabulated on the right. In the first calculation, the reference input current I_{33} was 300 μa and I_{11} and I_{22} were adjusted to 290 μa to give a reference output current I_{CC} of 300 μa. I_3 was then varied above and below the reference current. In the second calculation, I_{33} was 100 μa and I_{11} and I_{22} were adjustable to 96.5 μa for a reference output current of 100 μa.

If the data in the table were plotted, the absolute error of any point would be within 2% of the correct value over nearly a 10-to-1 range for the first case and nearly a 20-to-1 range for the second case. The improvement in the second case occurs because the output transistor's base current is a small fraction of I_3. While the second example exhibits a greater range, it is achieved at the expense of output current.

Frequency response

The frequency response of these circuits is limited by both junction and external capacitances. In the case of medium-power, individually packaged transistors that have their collectors bonded directly to the header, considerable external capacitance is introduced by mounting these transistors on an anodized aluminum heat sink. The mounting used in the multichip version is the best way to reduce external capacitance.

The frequency response of only one multiplier was checked. The test was performed on a circuit that used individually packaged transistors mounted on an anodized aluminum heat sink. Its response was essentially flat out to one megacycle, falling off 3 db at 20 megacycles. The response of the multichip version should be considerably better.

I_1 (μA)	I_2 (μA)	I_c (μA) Calculated	I_c (μA) Measured	% Error Measured	% Error Calculated
500	500	500	500.0		
400	500	400	401.57	.39	.14
500	400	400	401.33	.33	.14
300	500	300	301.91	.64	.27
500	300	300	302.65	.88	.27
200	500	200	202.03	1.01	.40
100	500	100	101.45	1.45	.54
50	500	50	51.01	2.02	.60
100	100	20	20.33	1.65	.87
50	50	5	5.06	1.36	.95

Calculated and measured errors in a multiplier circuit indicate an error of about 2% over a 100-to-1 range in output current.

	I_3 (μA)	I_c (μA) Calculated	I_c (μA) Measured	% Error Measured	% Error Calculated
I	1500	60.0	59.5	− .8	+ .8
	900	100.0	100.6	+ .6	+ .7
	600	150.0	151.1	+ .7	+ .6
	300	300.0	300.0	0	0
	200	450.0	443.7	−1.4	− .7
	150	600.0	582.4	−2.9	−1.5
	100	900.0	843.1	−6.3	−3.8
II	1500	6.66	6.50	−2.4	+ .9
	800	12.50	12.40	− .8	+ .9
	400	25.00	25.05	+ .4	+ .8
	200	50.00	50.30	+ .6	+ .6
	100	100.00	100.00	0	0
	50	200.0	195.8	−2.1	−1.6
	25	400.0	370.3	−7.5	−6.7

Error in a divider network is approximately 2% over at least a 10-to-1 range in output current. Values are for two experimental conditions.

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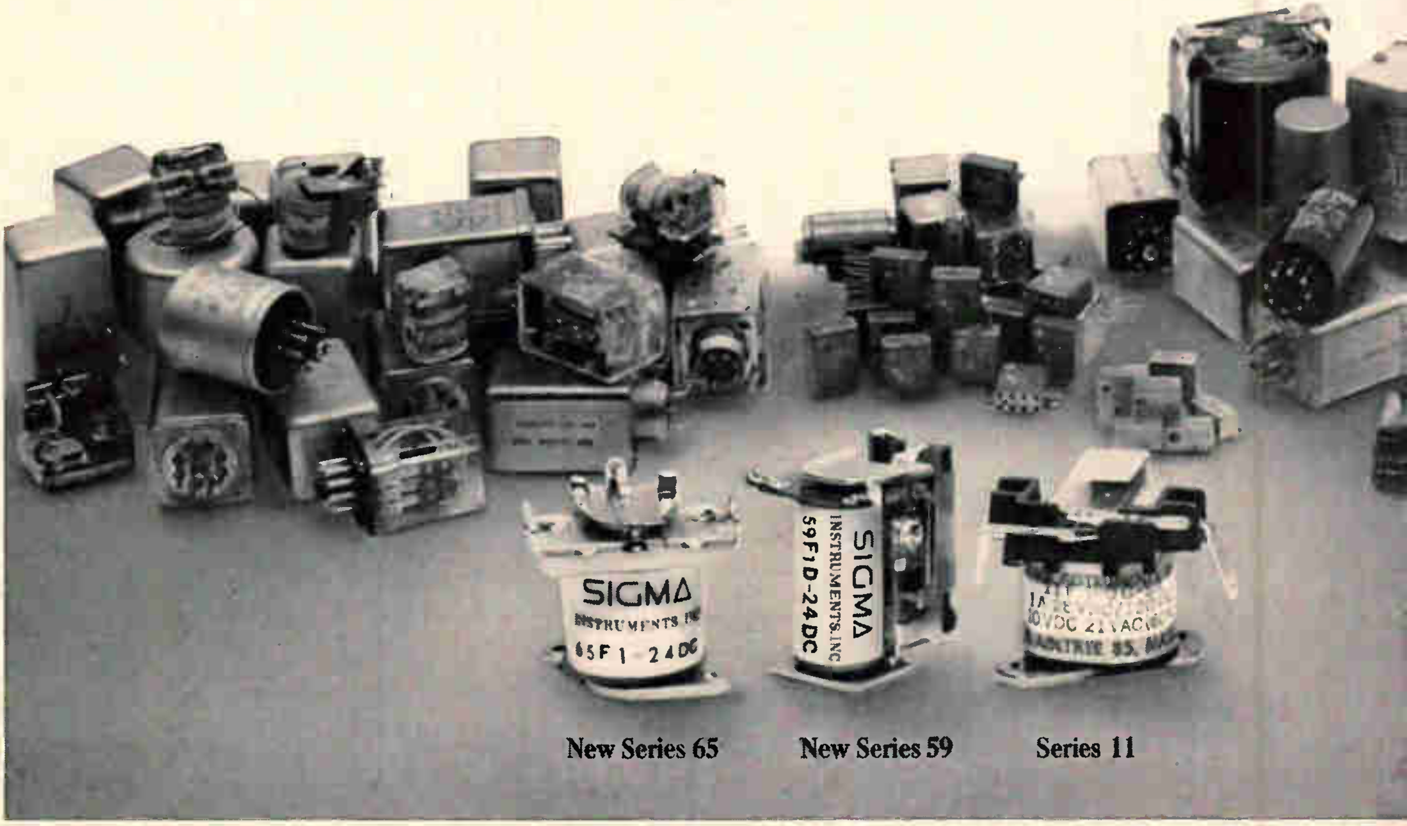

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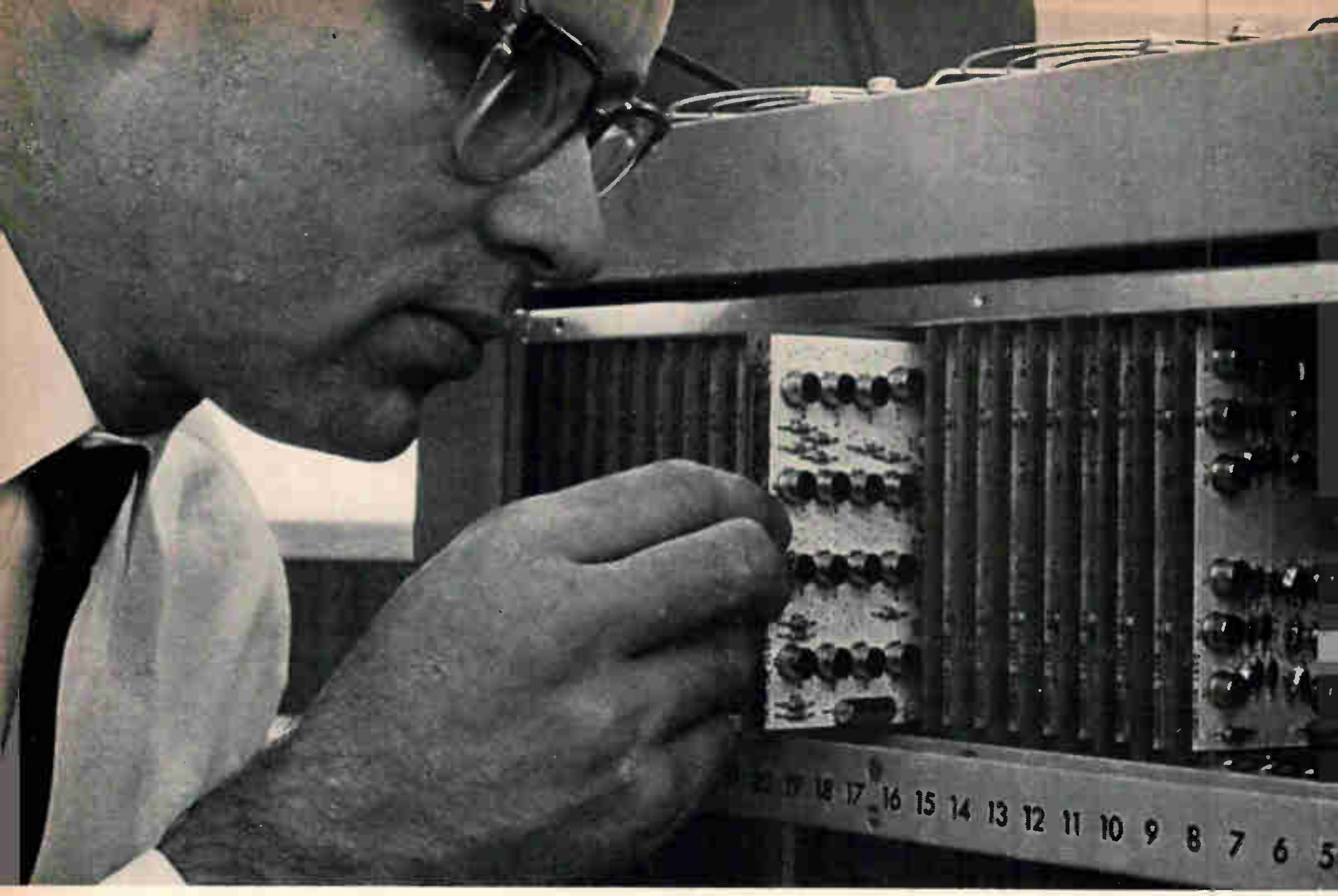


Gene Potter plugs a 16-byte memory module into one of the standard logic-module cages of a computer. Each cage can contain 128 words, each 32 bits (4 bytes), of scratch pad memory.

Computers

Integrated scratch pads sire new generation of computers

When a single chip of silicon carries eight bits of memory and their buffered decoding network, numerous high-speed memories go into a computer and time sharing becomes economical

By Gene B. Potter and Jerry Mendelson, Scientific Data Systems, Inc., Santa Monica, Calif.
Sam Sirkin, Signetics Corp., Sunnyvale, Calif., a division of Corning Glass Works

The mass production of integrated circuits containing several bits of memory—complete with decoding and output circuitry—makes practical a new generation of computers. With the IC's, many small memories, called scratch pads, operating at the speed of the logic circuitry, can be built economically into workaday data-processing systems.

The scratch pads enable moderately priced computers to provide the speed, capacity and versatility once available only in huge, expensive systems. As a result, the cost of processing large amounts of data can be halved.

An example of the efficiency that can be obtained when scratch pads are the keystone of the computer organization is in the Sigma 7 family of computers, which Scientific Data Systems, Inc. (SDS) introduced March 15 [Electronics, March 21, 1966, p. 37]. A typical Sigma 7, costing about $500,000, has an input-output rate of some 160 million bits a second.

The high efficiency results from a new control memory and an arithmetic organization based upon the use of from two to a dozen scratch pads. The scratch pads are modular plug-in units, ranging in size from 16 to 512 words. The memories are made with the monolithic integrated circuits pictured on the cover and on page 122. The IC's were developed in a cooperative effort of SDS and the Signetics Corp. and are being produced by Signetics for SDS. Each circuit contains eight flip-flop storage bits and their encoding, decoding, control and buffer circuits.

A printed circuit card, carrying 16 IC's plus the drive circuitry pictured on page 121, forms a 16-byte module (8 bits per byte) that is the basic building block for all Sigma 7 scratch pads. For example, four such modules make up a 16-word scratch pad. If more capacity is needed, more boards are plugged into the computer's address and data buses. The modules are self-contained, having address-decoding circuits for up to 128 words.

The main job of the scratch pads is to quicken the response of the system to multiple inputs by reducing its dependence on the main memories for many operations and by allowing it to react instantly to priority requests. The Sigma 7 can service up to 200 users at remote consoles while simultaneously performing several routine chores such as inventory control and while operating peripheral equipments. The functions of the scratch pads are outlined in the block diagram on page 125.

The multiple-register architecture of the system, with its indexing, mapping (program relocation) and memory-write protection, requires multiple accesses to scratch pads within the main memory cycle. Therefore, to be effective, scratch pads must operate at least five times as fast as the main memory. Otherwise their operation would not mesh effectively with logic and control circuitry.

The Sigma 7 scratch pads typically have a writing speed of about 90 nanoseconds and a reading speed of 60 nanoseconds. The main memories, built of ferrite cores, have a cycle time of 1.2 microseconds and an effective cycle time of 700 nanoseconds when the operation of the main-memory modules is overlapped.

The cost problem

The costs of scratch pads appeared to be a crucial problem when development of the system began two years ago. Designers of time-sharing machines have long known that unrestricted use of scratch pads would immeasurably improve system performance, but the expense limited their use in commercial systems.

Except for a few systems, new at the time, which had scratch pad-like registers composed of logic IC's, scratch pads were made of magnetic storage elements and transistor circuitry. In contrast to large, ferrite-core memories, scratch pads were inefficient in space used, power consumed and access time per bit. The cost was more than 50 cents per bit compared to a few pennies per bit for mass memories.

At that time, these problems were being attacked through the development of batch-fabrication methods, among them monolithic circuits, various forms of thin-film matrices, the weaving of magnetic wires and the molding of multibit ferrite elements.

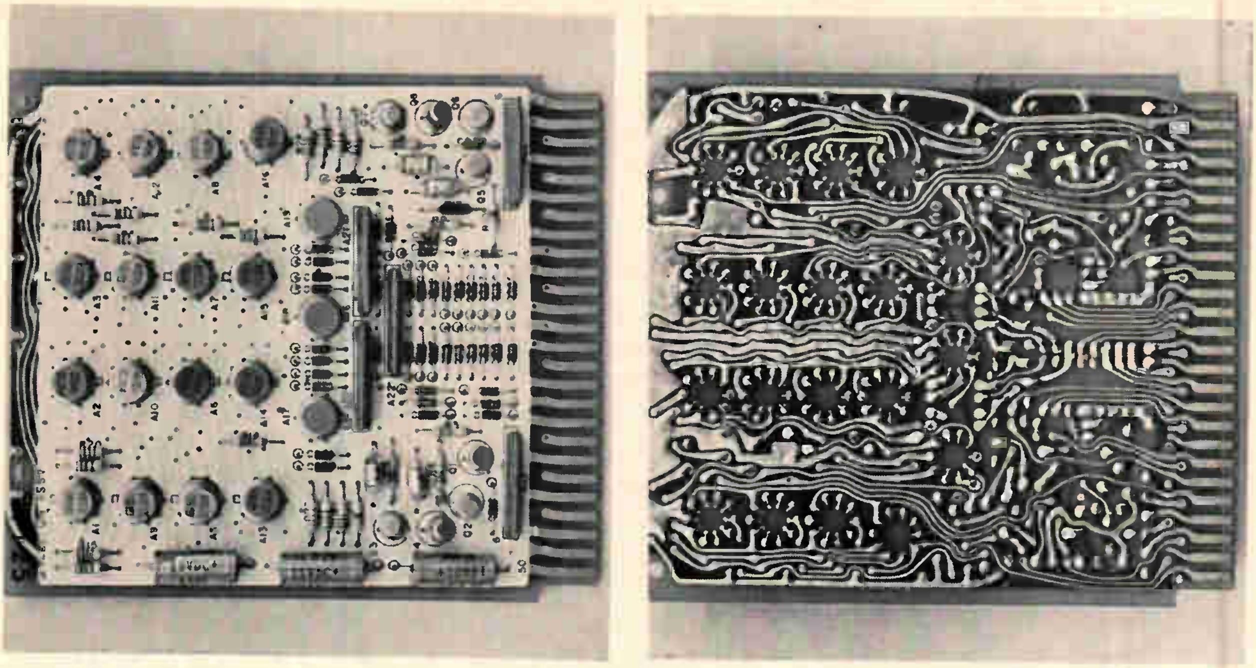
IC's were the most attractive solution. Production processes were established. Functional density was high and could be made higher. Power and voltage requirements were compatible with the other IC's planned for the system. The ability of the IC's to operate at normal logic levels and provide useful logic drive simplified application. The eight-bit design selected provided the best trade-offs among power, packaging and system-design constraints and semiconductor-manufacturing capabilities.

Today, IC's containing 16 bits of storage with internal decoding, or 32 bits without it, probably can be made. If the system constraints on power dissipation and packaging can be eased, they may be used. One advantage of the present IC design is that it can be packaged in a 10-lead, TO-5 can, which is low in cost, easily assembled and reliable.

The design selected has 178 components on a silicon die measuring 104 by 95 mils. The components are bipolar transistors and diodes, and diffused resistors. Considerably higher functional density could have been obtained with circuits composed of field effect transistors made by the metal-oxide-silicon technology. But MOS circuitry was less developed at the time of design selection and is still too slow for scratch pads in the Sigma 7.

How big a scratch pad?

As the system design took shape, it became apparent that scratch pad modules could be used with significant gains in several places in the system, most of which are discussed on pages 124 to 126. To take full advantage of the savings possible with high-volume production of IC's, all the scratch



Scratch-pad module, front and back. On the front (left), the wiring—coated with an insulation—runs in a direction generally vertical to plug-in position. On the back, wiring is generally horizontal. The design avoids the need for expensive multilayer printed circuits. The bar-shaped objects are thick-film resistors.

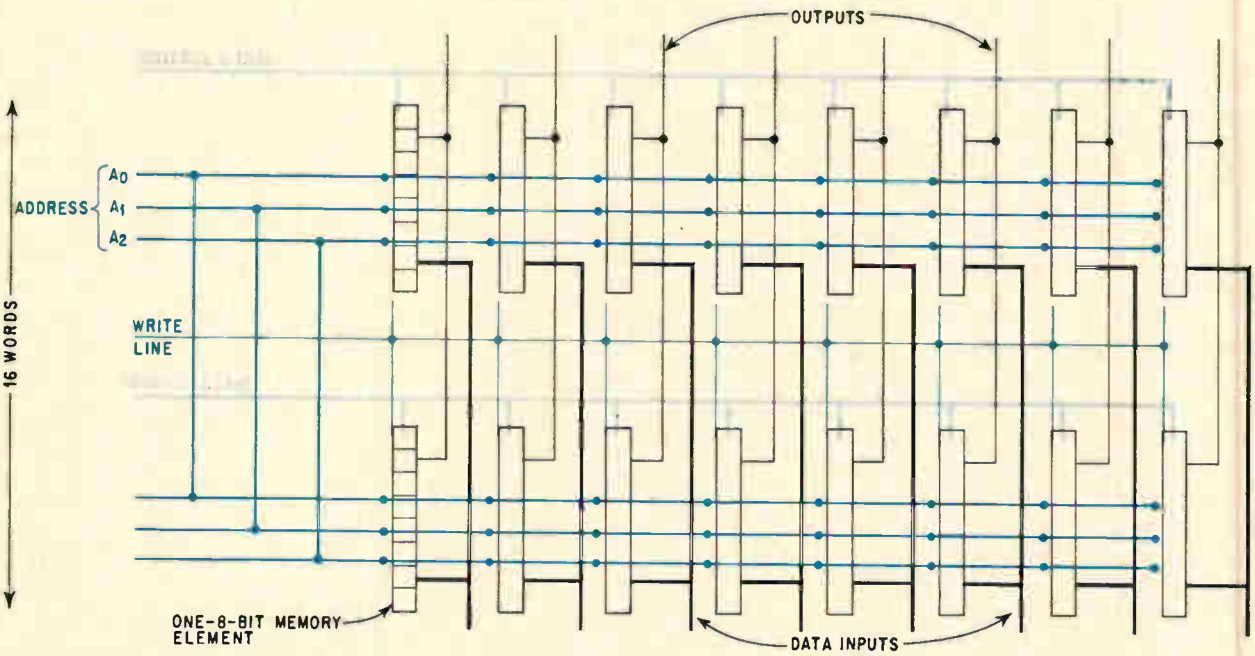
pads should use the same IC and be assembled in similar configurations.

Since even large machines need only a few one-word registers, a scratch-pad size of 16 bytes appeared ideal. This number meshed with system word lengths, nominally 32 bits composed of four 8-bit bytes. It also meshed with the main memory, which can be addressed in bytes, half words, words, and 64-bit double words.

A linear-select (word-organized) form of memory was required. This is an advantageous form for IC storage because bits are positioned within a regular, two-dimensional wiring network. The coincident (bit-organized) form requires three wiring planes.

The two-dimensional matrix is easily provided by printed circuit cards, as illustrated above and below. The wiring runs in the X direction on one side of a card and in the Y direction on the other side. In a register memory, four 16-byte cards are placed side-by-side to form a 16-word block. These are organized so that a single set of control lines are shared by each row of IC's. Without that sharing, packaging would be expensive.

The memory module operates in a parallel manner, obtaining one bit from each of eight separate IC's, as part of a linear-select memory scheme.



Module wiring configuration that is one byte wide by 16 words high. Ground and voltage lines are not shown.

The monolithic choices

IC-processing and scratch pad design constraints pointed toward an eight-bit or 16-bit IC design. For economy and reliability, the circuits had to fit into the 10-lead, TO-5 cans, which had also been chosen for the other IC's in the system. Four-bit IC's were rejected as too small and not economical; they would require a doubling up of the number of circuits and the amount of processing and assembly.

If 16 bits were used, the buffered decoding network and the group of storage flip-flops would have to be made as two types of IC's, costing some of the mass-production advantages of one type. With external decoding, the individual flip-flops would present a heavy current load, requiring more and higher-current drive circuits. Also, the bits would be sensitive to the noisy environment they would create, due to the fast switching of heavy current and capacitive loads. Since these and other design factors would increase over-all cost, eight bits appeared optimum.

Volatility and compatibility

In a large IC scratch pad, power consumption tends to be high and heat dissipation becomes a problem. Unfortunately, IC scratch pads are volatile, so that power cannot be removed from those portions not in use. A unique circuit design minimized the difficulty. Standby power is provided to only the actual storage flip-flops of an IC when that IC is not in use.

This was accomplished by using one of the required address lines as a control line. It switches a transistor, in the IC, which in turn gates power to all internal logic except the elementary storage flip-flops. The technique saves 60% of the power that would ordinarily be consumed.

IC scratch pads are extremely convenient to use in a computer because they can be matched electrically to the rest of the system. The machine's normal logic-voltage and current levels can interface directly with the inputs and outputs of the memory IC's. The nondestructive readout (NDRO) operation of the scratch pad makes character regeneration unnecessary, producing highest system speed. Writing is simple since the memory need not be cleared or reset; when the voltage on the write-enable line rises, the address lines steer the data to the proper locations and force the storage flip-flop to the proper state.

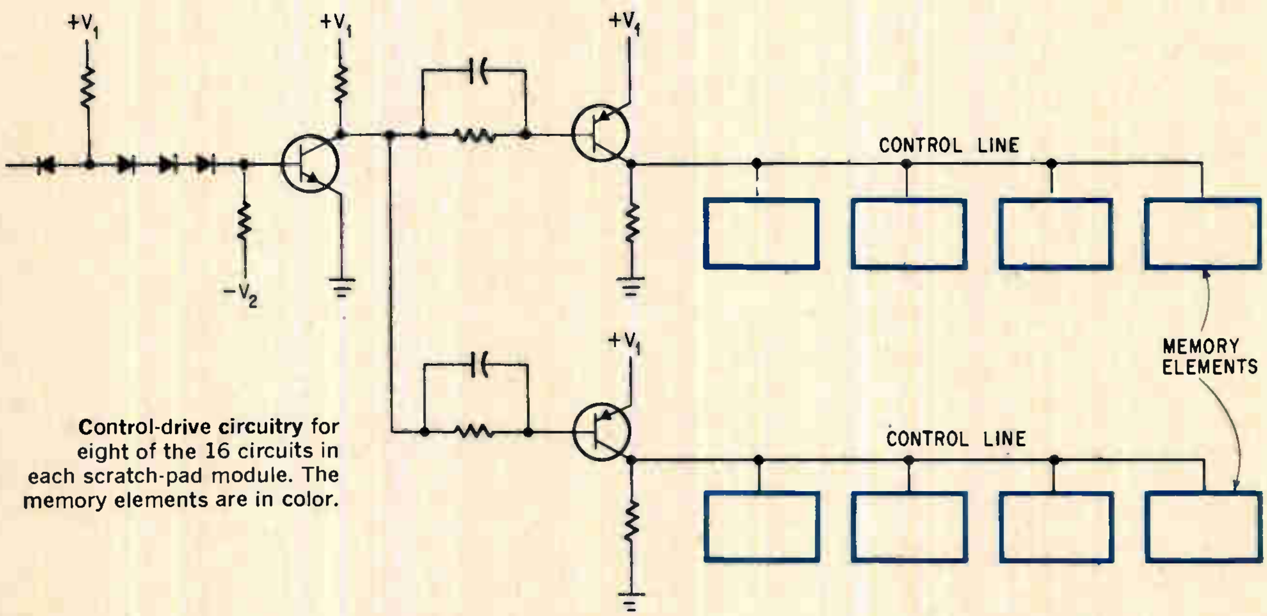
Electrical specifications for the IC's are given on page 124 and the schematic is on page 122. The circuitry is transistor-transistor logic, which is the fastest type for the logic-voltage levels employed.

Note that the tenth lead of each IC is not used; this allows addition of a mass-reset function. The other nine leads are for an address-control line, three address-decoding lines, write-enable line, input, output, supply-voltage and ground lines.

Power-saving circuit

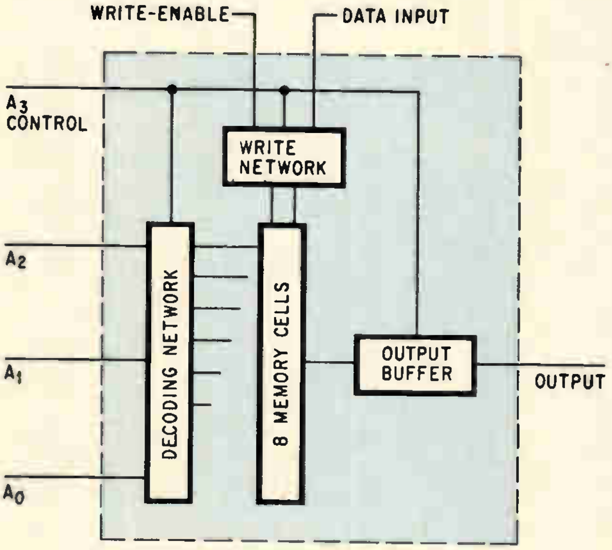
A data bit pulse enters a given IC, is gated by the write line and directed to the selected bit by the three address circuits (three variables will identify any location). The control line deprives the decoding and write circuitry of power, when they are not in use, suppressing noise and saving up to 60% of the power. It also provides the option —essential, since the outputs of a column of IC's are tied together—of not altering or looking at the state of any flip-flop.

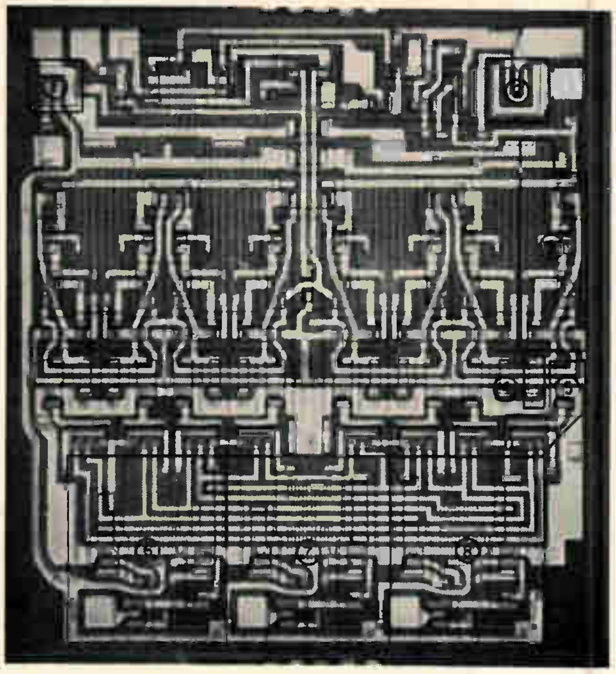
The address-control line switches a transistor Q_1 (in the IC schematic), which feeds supply cur-



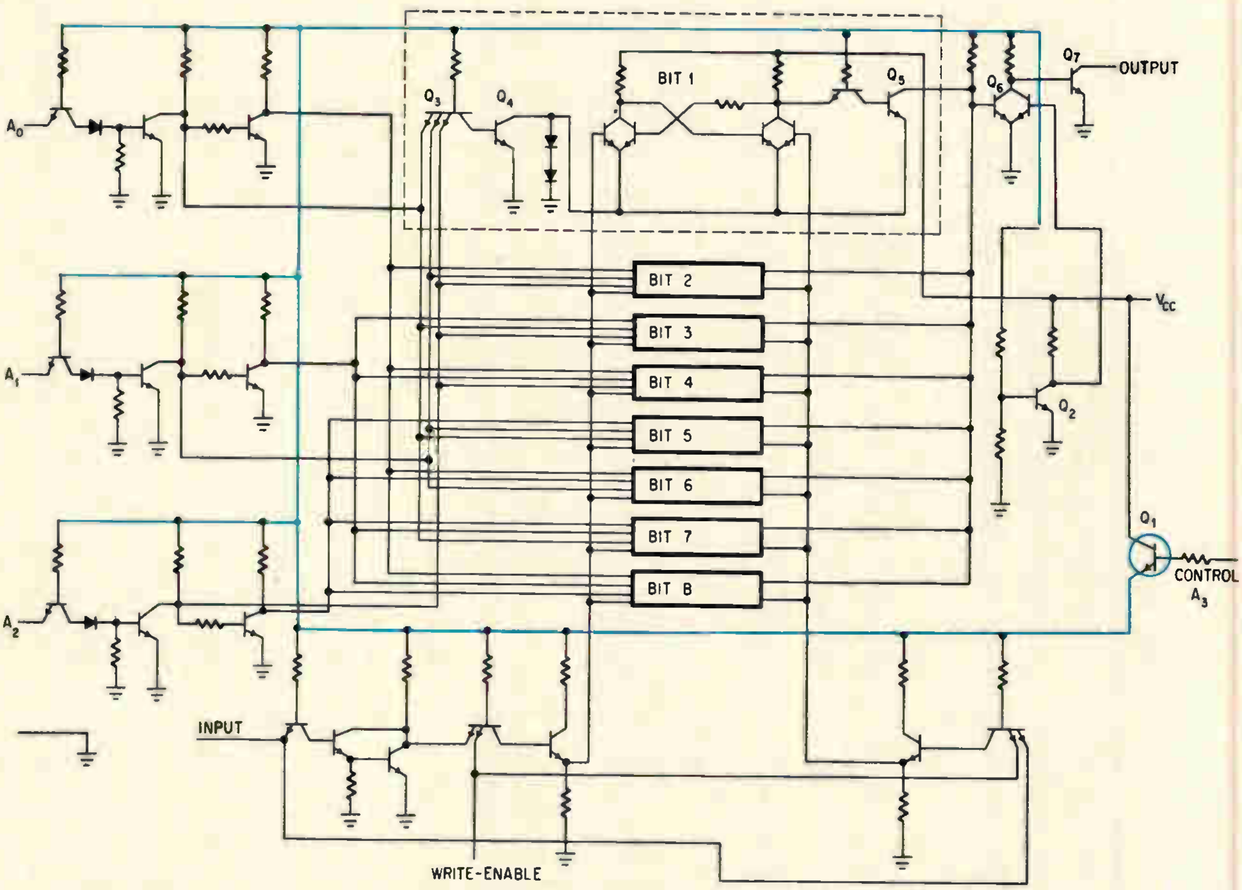
Control-drive circuitry for eight of the 16 circuits in each scratch-pad module. The memory elements are in color.

Reading, writing and eight bits on a chip



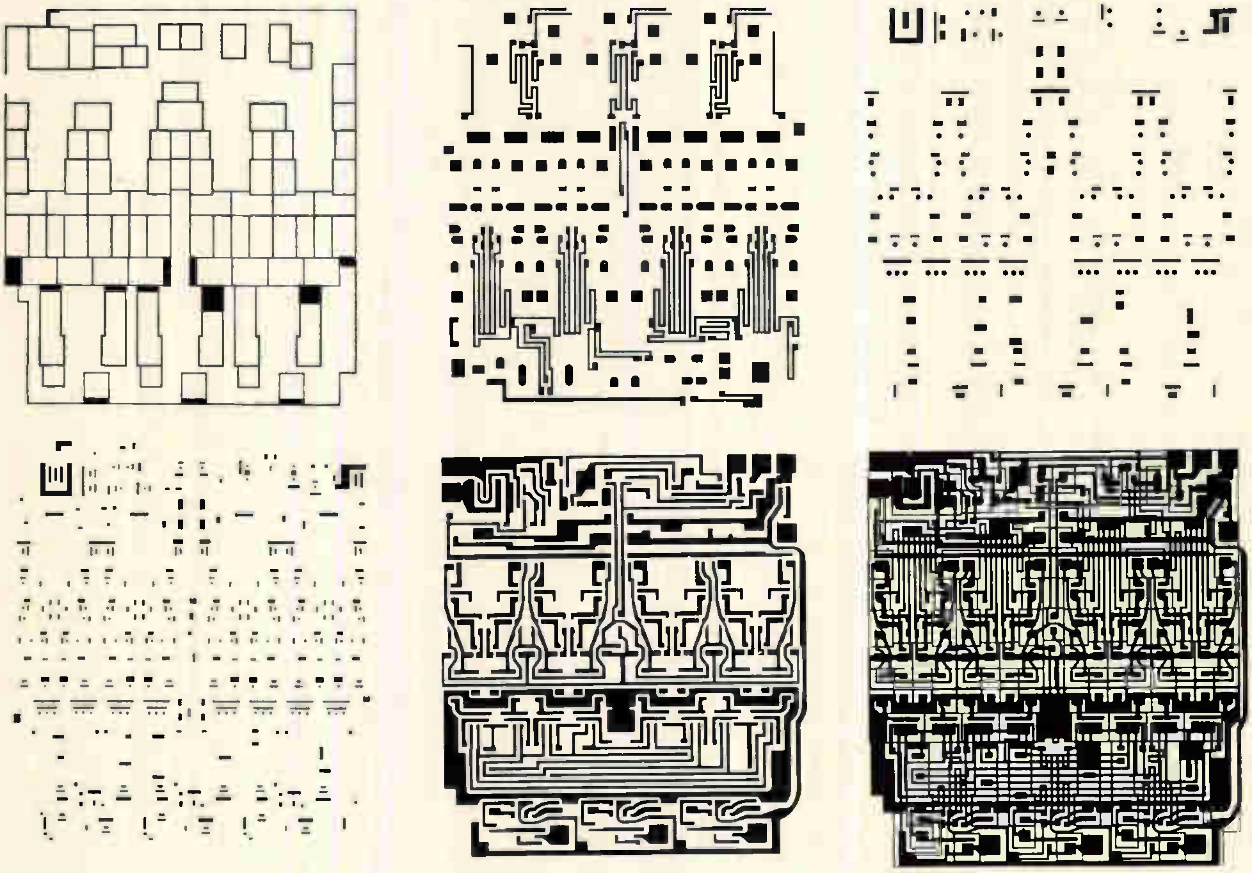


Layout of memory circuit, shown schematically at the left, is rearranged to pack the 178 components compactly on a single chip measuring 104 by 95 mils. The circuitry is transistor-transistor logic. Key areas of the chip, outlined on the photograph, are: 1, 2. Control and output transistors
3. One of the eight flip-flop storage cells in a band across the center of the chip
4, 5. Cell's clamp diodes and three-input AND gate
6, 7, 8. Address-decoding circuits.



Power consumption of the memory elements is sharply reduced by control transistor Q_1, which shuts down the power line (color) to deprive unused circuits of power, and by the flip-flop design. When one bit is on line, it prevents the others from receiving power they can't use.

Evolution of a memory circuit



Processing stages that produce the monolithic memory circuits can be traced in these patterns. They are a series of masks for etching the oxide passivation coating of the silicon crystal and the thin-film metal layer. The patterns etched in the oxide bare the silicon for diffusion of isolation moats and the resistors, diodes and transistors. The next to last pattern produces the thin-film interconnections. These patterns were superimposed to create the composite pattern at the lower right and the color illustration on the cover.

rent to 20 other transistors. When Q_1 is on, current flows to the decoding and write logic and to the output buffer. When Q_1 is off, these circuits are deprived of power. The flip-flops draw power directly from the supply-voltage lead V_{cc}. Signals on the data-input line cannot be inserted by the write circuitry, since that is not functioning.

The output buffer is also deprived of power. When the control line is down, Q_2 is deactivated. This holds the buffer off because the right-hand side of transistor pair Q_6, which feeds Q_7, is turned on. The voltage swing for the control line is between 6.6 volts and ground.

Q_1 and Q_7 are the biggest and most powerful transistors in the IC. They are oversized so they can carry large currents without excessive loss and overheating of the IC.

Low-power flip-flops

So that decoding can be done on the chip, the address circuitry subjects only the selected bit to a write-line input. Likewise, only that bit controls the output of the memory. The decoding design also reduces the unselected bits' power consumption about 30%. The power saved is used to speed up the address and write circuitry.

If it is assumed that a diode drop equals approximately 0.75 volt, a transistor's $V_{be(sat)}$ equals 0.70 volt and $V_{ce(sat)}$ equals 0.20 volt, the operation of the circuit can be described as follows:

The base reference of a selected bit is only $V_{ce(sat)}$ above ground, while that of all the unselected bits is equal to two diode drops above ground, thus reducing their apparent supply voltage 1.5 volts. The selected bit clamps the write lines at $V_{be(sat)} + V_{ce(sat)}$, or 0.9 volt. The other bits cannot be written into because a write pulse has to be at least three times the diode voltage drop or 2.25 volts, to get into a flip-flop.

For example, if bit 1 in the schematic on page 122 is not selected, its base reference will be about +1.5 volts. That is the voltage drop across the two clamp diodes that are connected in series from the collector of Q_4 to ground. However, if bit 1 is selected, the base reference is only about +0.2 volt, the collector-to-emitter saturation voltage of Q_4. All the emitters of Q_3 are high.

The state (on or off) of the selected flip-flop is reflected by Q_5 and detected by Q_6. Q_5 can turn Q_6 off only if Q_5's emitter has been grounded through Q_4. Q_6 is normally on. It can be switched off by Q_5 only if bit 1 has been selected and bit 1 is in the off state. Since the system already knows which bit it is looking at, the presence or absence of an output from the IC (through Q_7) tells the state of the bit.

If bit 1 has not been selected, the collector of Q_5 will be at a high enough level in either state to tend to keep Q_6 on. With Q_4 shut off, the emitter of Q_5 is at 1.5 volts and Q_6 is on regardless of the state of Q_5. Thus, Q_6 has to look elsewhere for a turn-off signal.

Third generation

The IC's qualify Sigma 7 as a third-generation computer since the design goes beyond that of tube and transistor systems. In another sense, it is a "third-and-a-half-generation" system because the scratch pads represent a move toward the expected organization of future generations. Many computer designers feel that when huge arrays of circuits can be batch-fabricated cheaply, it will be practical to make self-programing and self-organizing systems, or systems composed of many small computers working in parallel, or even machines composed of thousands of cells in which the system's control, logic and memory functions are combined.

IC specifications

V_{cc}	4.0 volts± 10%
I_{cc}	50 ma maximum
A_3 "1"	6.6 volts maximum
Output current	60 ma at 0.5-volt maximum
Operating temperature	5° to 70° C

There are strong resemblances between Sigma 7 and the "fourth generation." It can do any combination of time-sharing, multiprograming and multiprocessing [Electronics, Nov. 29, 1965, p. 71]. It can operate in real time, run several programs asynchronously, correct errors when programs are being run and automatically adjust its internal operation to changing user demands.

The scratch pads helped make this possible by avoiding the need to build a large quantity of fixed-capability hardware into the system. In each of their four major applications, described below and outlined in the block diagram on the facing page, the scratch pads have various optional applications and sizes.

Scratch pad I

The first application of the scratch pads is as general register blocks that implement the Sigma

Other scratch pads, other systems

The integrated circuits of today do not end the search for the ultimate component for scratch-pad memories. As the authors of the Sigma 7 article point out, it should be possible soon to double or quadruple the storage content of each IC. Furthermore, competing forms of high-speed memories are being sought by researchers.

The breadth of the development effort was indicated in February at the Solid State Circuits Conference when four companies gave reports on four distinctly different scratch-pad designs. A common theme—high-speed memories produced by low-cost techniques —emerged:

- Bell Telephone Laboratories, Inc. is developing a diode-selection matrix, with performance comparable to that of a transistor matrix, for a 1,024-word magnetic memory. The magnetic-storage elements are wires plated with magnetic alloy.
- Univac division of the Sperry Rand Corp. and Motorola, Inc. described a 64-word memory built by vacuum-depositing magnetic films and interconnections on a small glass plate and then attaching to the plate integrated circuits and other semiconductor components. An earlier report described the fabrication techniques [Electronics, Oct. 4, 1965, p. 102].
- Nippon Electric Co., Ltd. of Japan, is preparing an associative memory of integrated circuits made by the metal-oxide-semiconductor technique (MOS). The active elements in the storage cells are p-channel MOS transistors. With p-n-p transistor sense amplifiers, the cycle time is 150 nanoseconds, unusually fast for MOS circuitry.
- The Radio Corp. of America is also developing a high-speed MOS memory. The storage cells, constructed of complementary n-channel and p-channel MOS transistors, operate in 20 nanoseconds. A 16-word array containing 1,080 MOS transistors, including decode and drive circuitry, is expected to read in 50 nanoseconds and write in 75 nanoseconds.

Bipolar IC's. Several companies, in addition to Signetics Corp., are making scratch pad IC's with bipolar transistors. An IC containing 16 bits of storage and their associated circuitry will soon be introduced commercially by Texas Instruments Incorporated [Electronics, March 21, 1966, p. 144]. Sylvania Electric Products, Inc., a subsidiary of the General Telephone & Electronics Corp., will soon offer a 16-bit chip. Transitron Electronic Corp. is making them on custom order. Signetics also has a 16-bit project. Motorola, Inc. is developing storage arrays.

General Micro-electronics, Inc., is making large-capacity MOS IC's on custom order and GMe and other companies are also making off-the-shelf circuits, such as shift registers [Electronics, Oct. 4, 1965, pp. 84 and 96]. One GMe custom circuit stores 64 bits in a flatpack. One of its main features is low standby power, typically 10 microwatts per bit; the read-write cycle time is 500 nanoseconds.

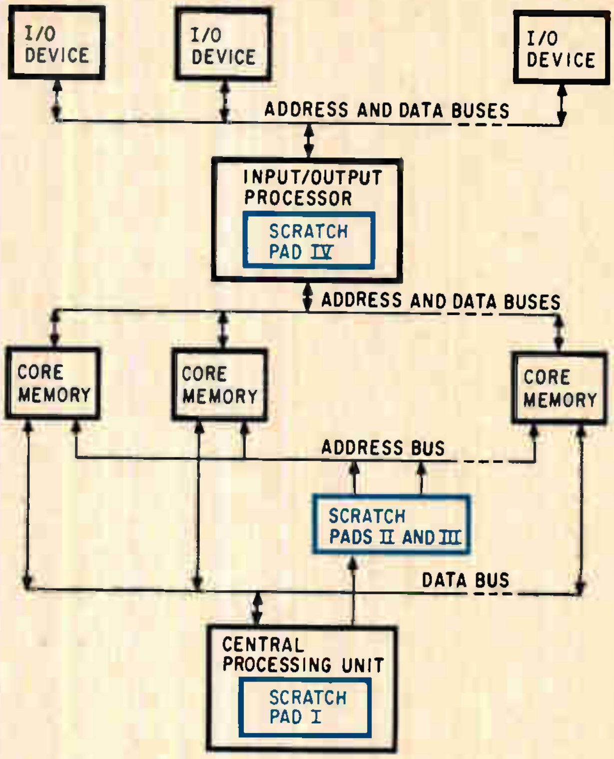
For future use in its own computers, the International Business Machines Corp is readying monolithic memory circuits that are compatible with the hybrid IC's now used in its System 360 computers. One research IC, described

7's instruction set. Each set of registers, termed a register block, has 16 registers and is made up of four 16-byte modules. One such 16-word scratch pad is standard; there can be as many as 32 blocks, or 512 words.

A five-bit block-pointer register designates which of the 32 blocks is active: that is, which block is to be employed in the execution of an instruction.

These registers greatly improve the speed with which the computer responds to interrupts. Interrupt requests can be honored instantly by aborting long instructions in midexecution without loss of information, because operands come from storage into active circuit registers for instruction execution. Moderately long instructions (10 to 30 microseconds) are aborted and restarted upon return from an interrupt. Instructions longer than 30 microseconds are designed so they may be aborted almost instantly and then resumed from the point of interrupt upon return from the interrupt routine. Even though some instructions take 500 microseconds, it takes only 2 to 20 microseconds to initiate an interrupt response. The total response time is never more than 25 microseconds and it may be as short as 6 microseconds.

In conventional systems, interrupt processing requires the content of the general registers to be stored in core memory to preserve the operating



Main applications of scratch pads: I, as registers; II and III, memory mapping and protection; IV, addressing and local storage.

last fall, contains 16 storage cells and their control circuitry on 0.07-inch-square chip of silicon [Electronics, Nov. 1, 1965, p. 31].

The Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp. has been working for more than a year on IC scratch pads [Electronics, March 8, 1965, p. 46]. Its latest model, a test bed for circuit, system and packaging design, is a mix of the company's standard logic circuits and special 36-bit storage cells. Four printed circuit cards, each carrying 160 IC packages, form a memory that stores 256 words that are 72 bits long.

Other systems. Scratch pads have been employed in small quantities in computers for years. Some small airborne computers make do with simple delay-line storages. Others have high-speed magnetic storage assemblies. Univac and the Burroughs Corp., for example, have been putting high-speed thin-film memories into their computers. The plated-wire type of thin-film memory is also in commercial use. Woven-wire scratch pads, resembling a piece of cloth, are built into France's newest computers, the Bull-General Electric Gamma 140 and 141 [Electronics, March 7, 1966, p. 304].

Computer manufacturers began using conventional logic IC's as scratch-pad elements about two years ago. One of the earliest applications was in Electronic Associates Inc.'s EAI 8400. The central processing and input-output control sections are made with discrete components, but built into the circuitry are stacks of IC registers that also handle several scratch-pad functions.

The EAI 8400's central processor has eight 32-bit registers, split into 16-bit halves. Four of these are "save" registers that act as bookmarks in computer programs. They permit interruptions and store intermediate results of programs. Another register stack in the input-output section aids in memory control and buffers variations in data-transfer speeds.

To improve the speed of the larger models of the IBM 360 computers, the register and scratch-pad circuitry is scattered throughout the logic circuitry. Instead of making separate plug-in modules, IBM puts storage circuits a few at a time onto the logic-circuit cards to shorten lead lengths and control wiring delays. The arrangements are designed by computers [IBM's design-automation techniques and the organization of the System 360 are described in the April, 1964, issue of the "IBM Journal of Research and Development"; the wiring techniques are detailed in Electronics, Nov. 1, 1965, p. 90].

The Models 65 and 75 of the System 360 have 25 registers that are each 36 bits long (four bytes of eight bits plus a parity bit for each byte). Among the functions which qualify the registers as scratch pads are working storage and local provision of instructions. In the larger Model 90, there are 76 one-word registers. Scratch pads in three smaller models are separate ferrite-core arrays. Twenty-four of the registers in each can be manipulated by the computer users.

IBM has been using hybrid integrated circuits. It is expected to use monolithic circuits, such as the 16-bit memory chip, as these emerge from the IBM labs and go into production.

George Sideris

environment of the interrupted program. The registers must also be loaded from the core memory to establish the operating environment of the interrupt process. Later, the interrupted program has to be returned to the registers.

The Sigma 7's multiple-register blocks preserve the status of the interrupted program in register by simply changing the content of the block-pointer register. The change takes place within the six-microsecond execution time of a single instruction that stores in memory the control state of the interrupted program and obtains from memory the corresponding control states for the interrupting program. In effect, the program-switching instruction causes the system to walk away from one block of registers and step into another with no additional time cost.

Scratch pad II

Scratch pad II stores constants, assigned by the supervisory program, for program relocation (main-memory mapping) and memory protection.

Mapping is essential for time-shared or multi-programed operation. It allows programs to flow continuously in and out of the main memory, occupying different fragments of the memory each time it is entered. The user's instructions generally call for a contiguous block of memory at one location, but honoring such reservations for room wouldn't be efficient. Instead, the system files the program parts as though it had a loose-leaf notebook. At one time a word may appear on page 8, word 9, and at another time at page 88, word 9. A memory of 131,072 words will have room for 512 words on each of 256 pages.

The system keeps track of the program's actual addresses in core by storing address-change constants in the scratch pad. The system refers to these each time it initiates an access to memory. The validity of each reference is controlled by 2-bit access-protection codes stored in the scratch pad.

The access-protection codes prevent one program from interfering with another. They also prevent snooping. One user can't get at another's proprietary information, such as the pay rates for key personnel, since the codes can be set to prevent it.

The memory-mapping scratch pad is provided by 16 cards, each carrying 16 bytes' worth of IC's. That works out to one byte per page for the 131,072-word addressing range. Core memory size is expandable to eight 16,384-word modules. If main memories faster than those now used become available, they can be plugged into the system.

The 512-bit scratch pad for 256 pairs of access protection bits is provided by four 16-byte modules. The map scratch pad and these modules are addressed concurrently.

Scratch pad III

Another 512-bit scratch pad stores 256 2-bit "locks" that provide write-protection control for a main memory of the maximum size, 256 pages. Each program is given a 2-bit "key" when it is given control of the computer. Write access is permitted a program when its key opens the lock assigned to a page (512 words). The key and lock codes must have values of 00 or some nonzero value.

The speed of the scratch pads allow the access-protection and the write-protection techniques to be performed sequentially without slowing down system operation.

Scratch pad IV

In the multiplexing input-output processor (IOP), the scratch pad speeds up I/O processing and avoids idling of the central processor unit (CPU) while data is read into or out of relatively slow peripheral equipment. Each IOP can handle 32 peripherals and there can be eight IOP's in a system.

The IOP gets its initiating instructions from the CPU, but operates independently thereafter. The CPU specifies the peripheral, the direction of data transfer and where transfer should begin in memory, and the number of words to be transferred. The CPU proceeds with the program, while the input-output control information remains in the IOP scratch pad until the data arrives.

The basic IOP scratch pad provides for eight channels. It is built with five cards, providing 16 words of 40 bits. Generally, 10 bytes control a channel. The scratch pad can be expanded in sets of sixteen 40-bit words to a maximum size of 64 words. That size will control concurrent operations on 32 channels.

The authors

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Sam Sirkin, a naval aviator from 1957 to 1962, joined Signetics, Inc., in 1964 after graduation from the University of California. He was responsible for the design of the SDS memory circuit and is now working on ultrahigh-speed designs for digital integrated circuits.

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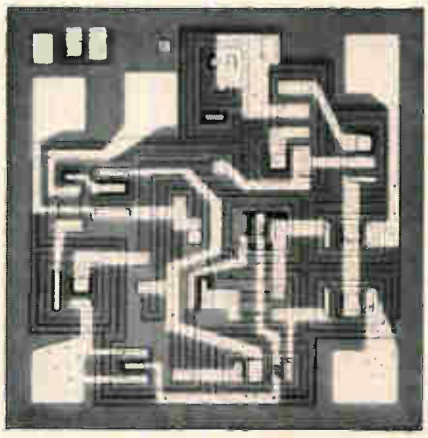

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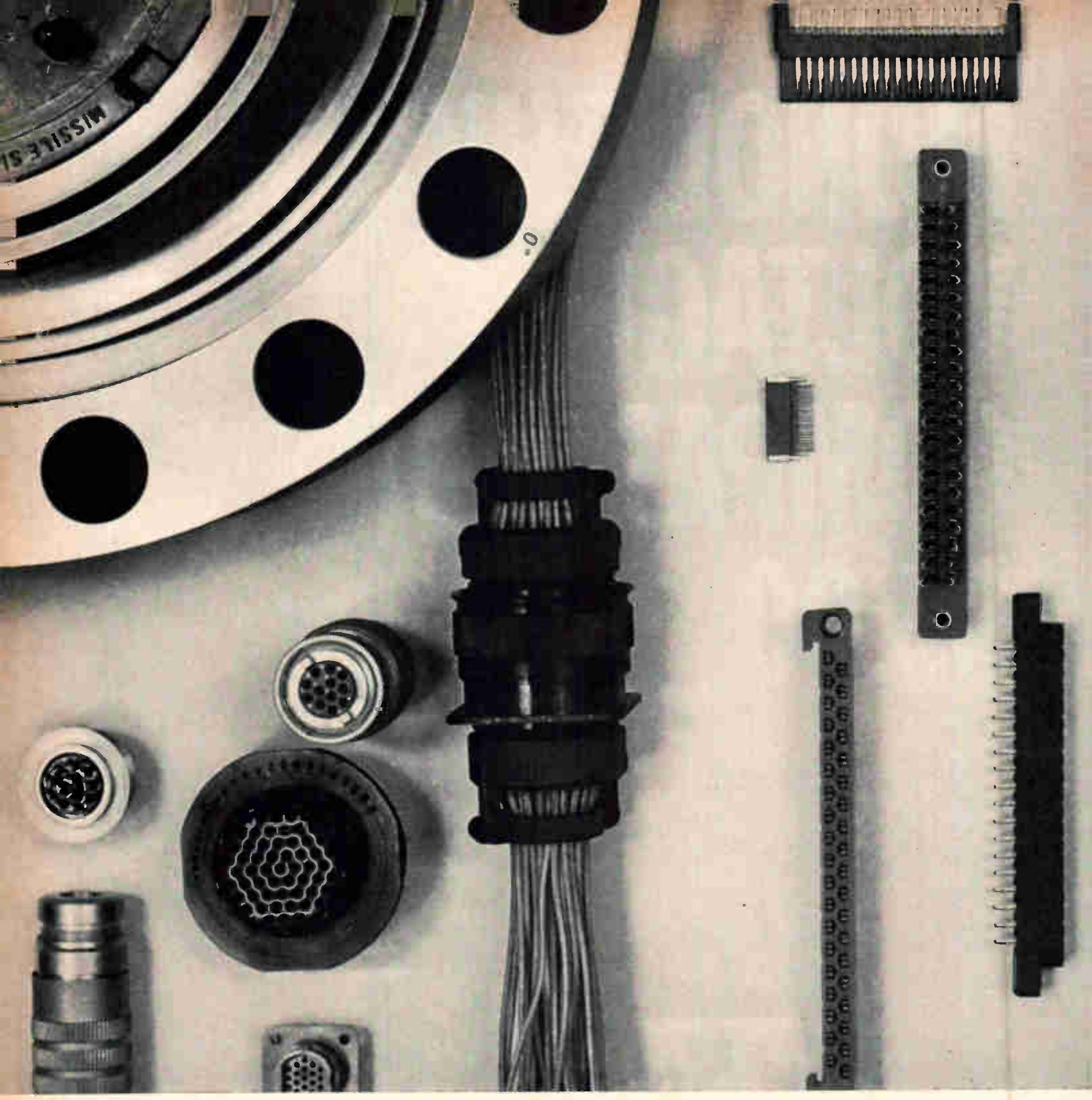

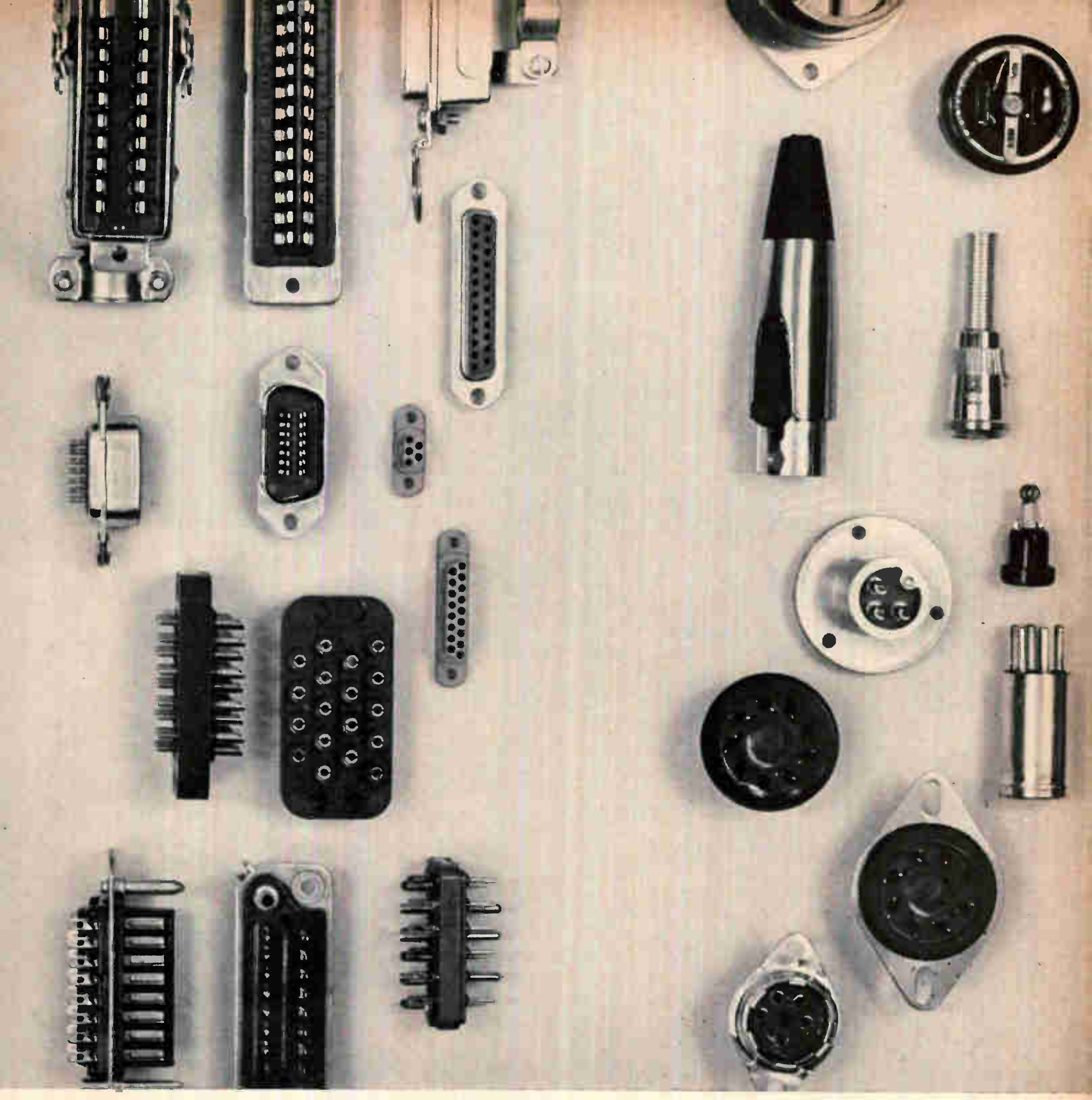

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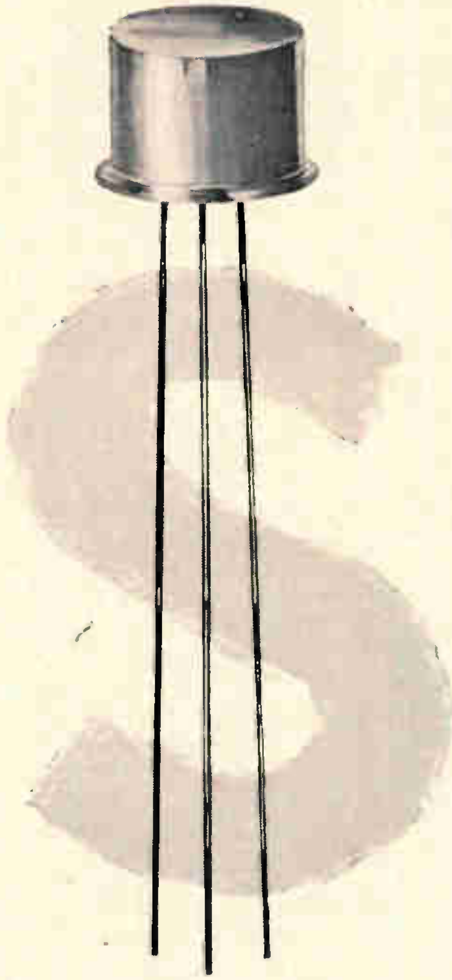

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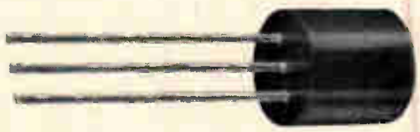

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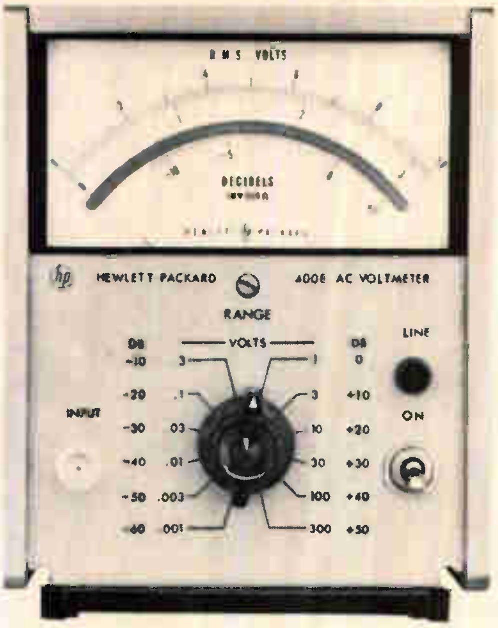

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At full scale	+4 −10	±2	±1	±2	±4	+4 −10

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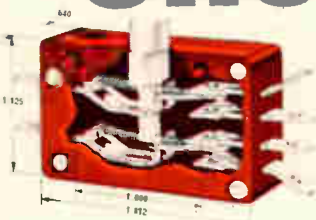

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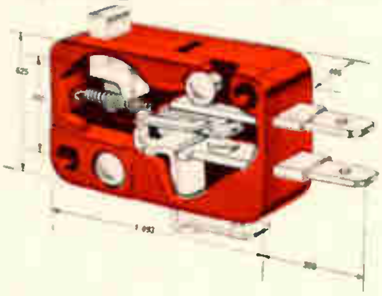

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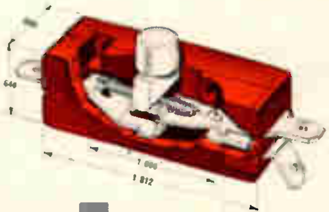

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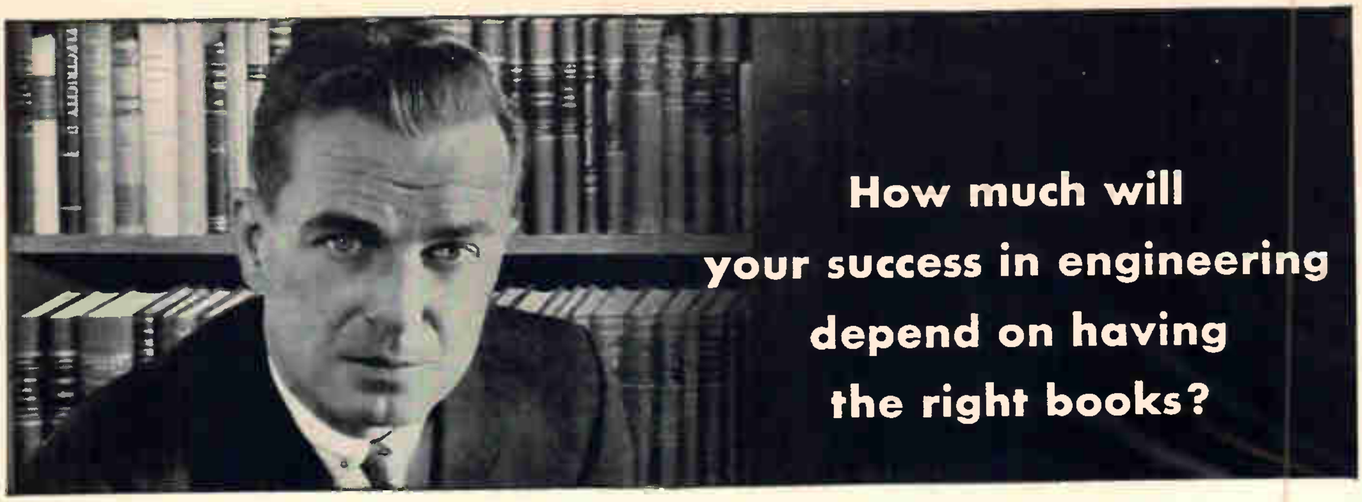

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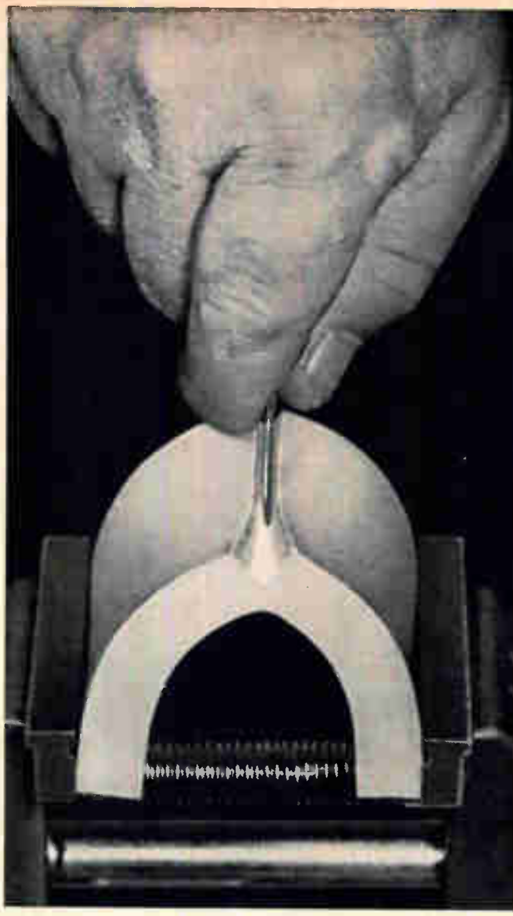

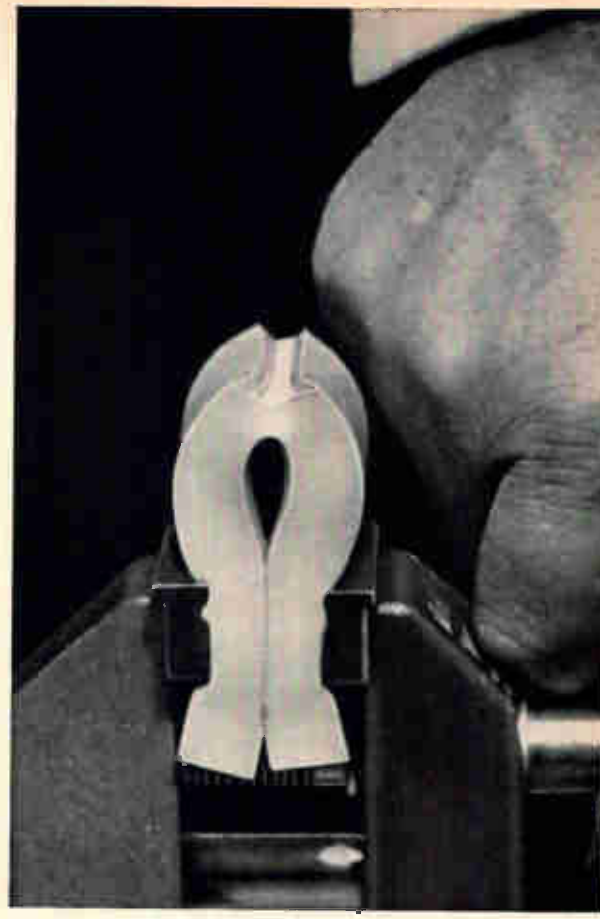

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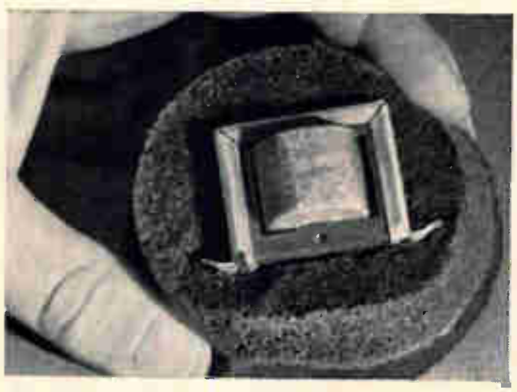

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GENERAL ELECTRIC

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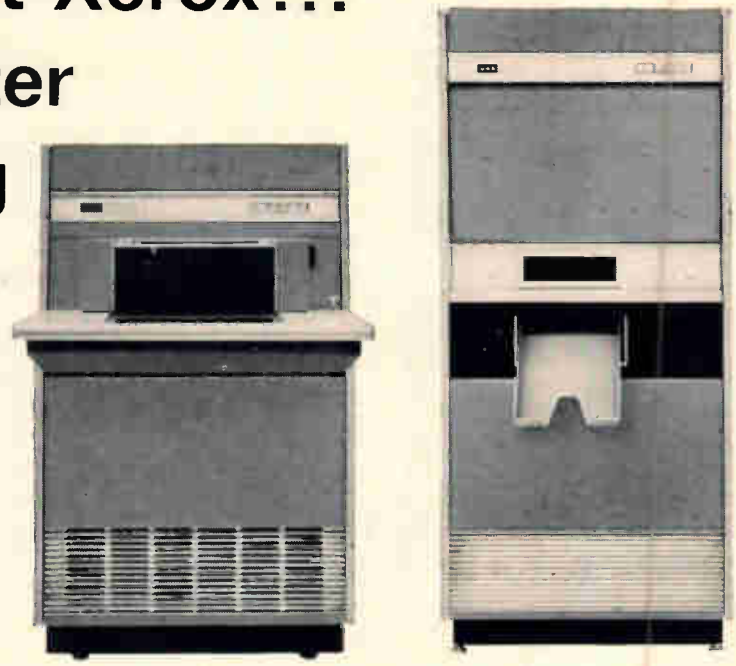

Sometimes people are puzzled when we say that Xerox is in the business of graphic communications. Let's try to clarify. (It could be important, especially if you're intrigued with Xerox, but not perfectly sure why.)

We define graphic communications as the entire spectrum of communications in a graphic sense — the formulation, reception, transmission, recording, storing, retrieving, processing, copying, or presentation of any meaningful images. As you can imagine, graphic communications transcends copying equipment, no matter how advanced. LDX (Long Distance Xerography) suggests something of our future. The current system recently sent an 8½" x 11" xerographic image 3,450 miles over broadband telephone lines in 7 seconds. For what LDX implies, re-read the definition of graphic communications above. You'll get the picture.

The openings outlined below are abstracts from our current list of immediate vacancies. In most cases they are new, expansion-created spots. In others, the man has been promoted. Isn't this the best way to come on board in any organization?

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Electrical or mechanical engineers, with experience in the peripheral equipment area for data systems or computer systems including development work on magnetic tape, magnetic drums, punched card equipment, electro-mechanical printers. Should also have been involved with systems planning and/or systems integration of computer peripherals with computer systems.

ELECTRONIC DEVELOPMENT ENGINEER

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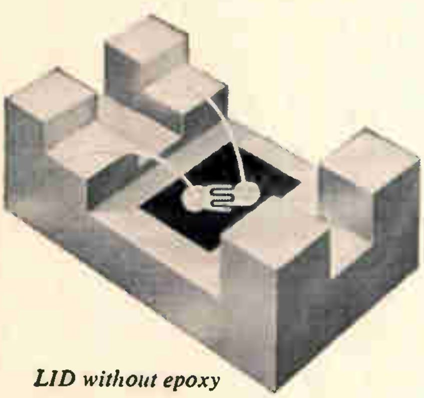
As a start, Amperex is offering two high-performance silicon planar epitaxial transistor families in the new Amperex LIDS: high-speed switches similar to the 2N2369 and low-noise, high gain amplifiers similar to the 2N930. Dual-diodes will be available next, followed by the entire Amperex line of small signal RF, AF and switching types.

The Amperex LID is an all-ceramic package that is smaller (0.075" x 0.045" x 0.032") and less costly than any existing metal package. Its smaller size permits the manufacturer to reduce costs by reducing the substrate size.

Having no external wiring, expensive wire-bonding machinery and the skilled labor to operate it are no longer needed; handling is simpler, breakage is eliminated and production yields of the integrated circuits will be higher.

For complete protection before, during and after assembly, the transistor chip is coated with epoxy after it is mounted in the LID.



LID without epoxy

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In place of delicate, external wire leads, LIDS have four contact legs that are an integral part of the ceramic package. Their surfaces are coated with metallized solderable gold. This construction permits the LIDS to be positioned on the substrate by automatic jigs, without the need for micro-optics for orientation.

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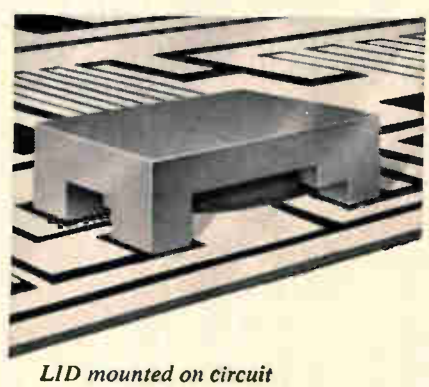
To learn more about Amperex LIDS, write: Amperex Electronic Corporation, Semiconductor and Receiving Tube Division, Dept. 371, Slatersville, Rhode Island 02876.



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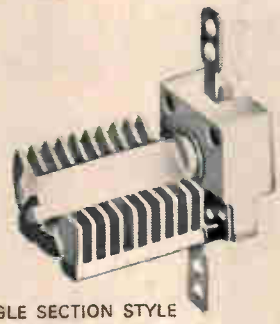
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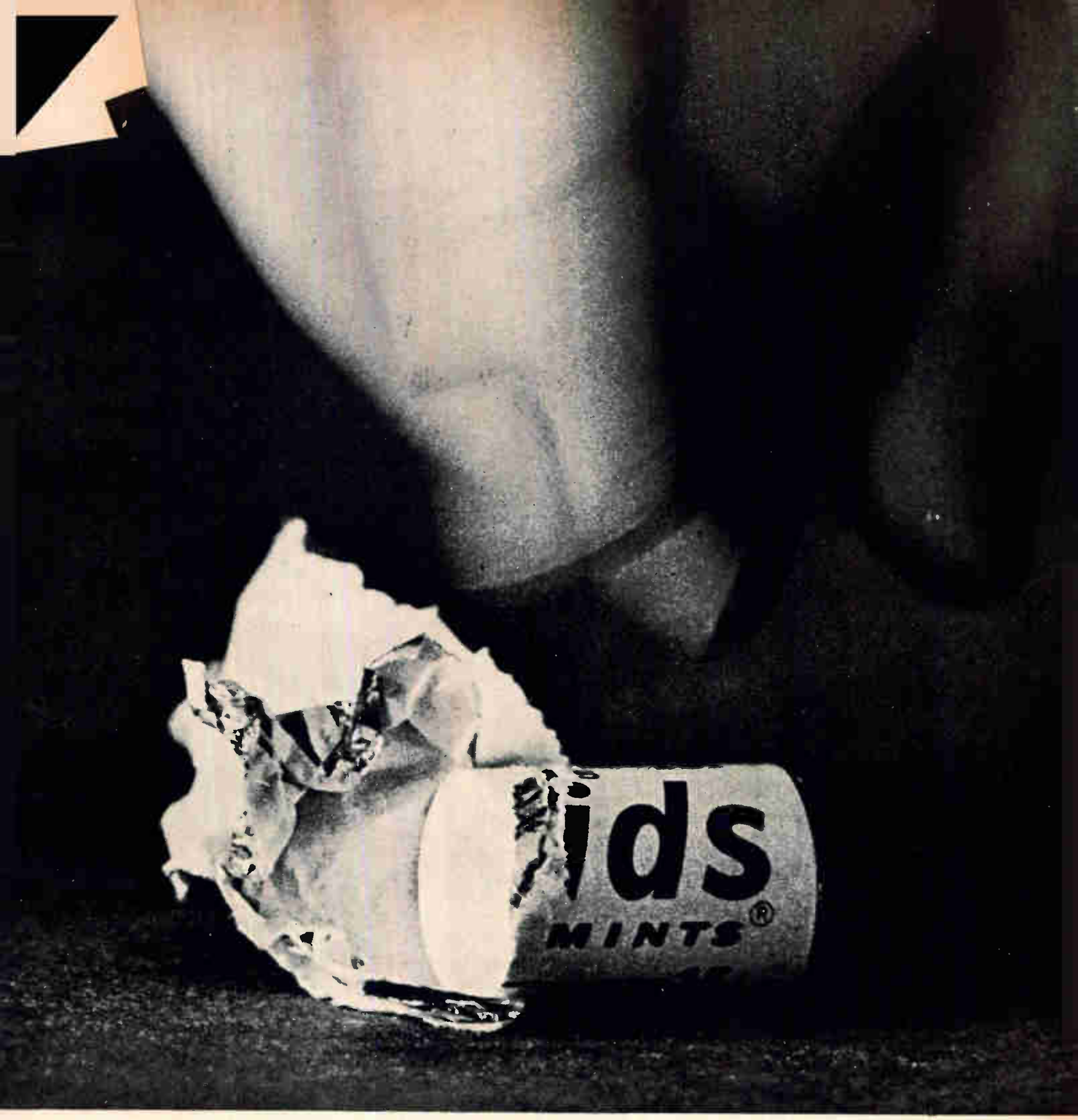
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2. GRID LINES: Guaranteed to .100 inch tolerance. Hoffman's photo masking technique assures complete mechanical tolerances.
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Test Temperature: 28°C ± 2°C.

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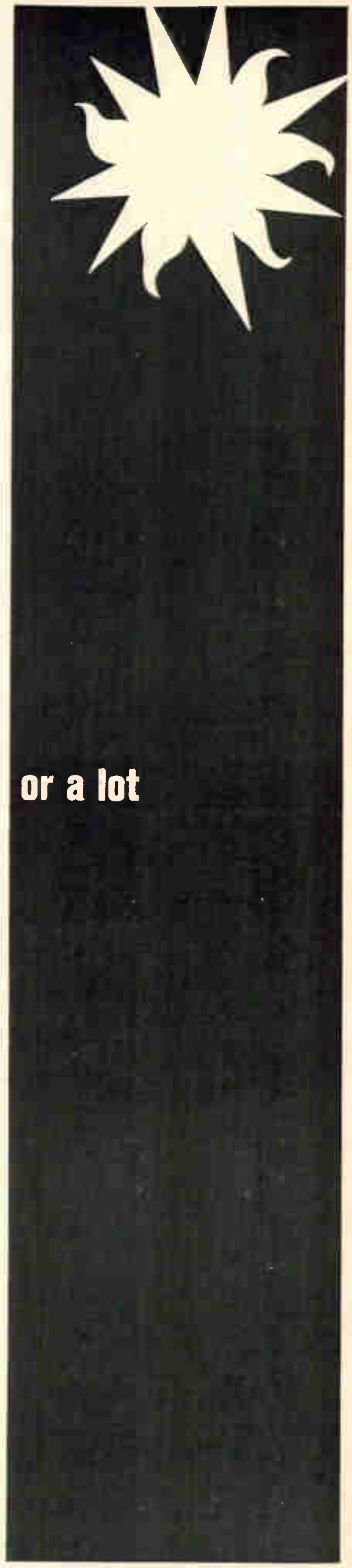

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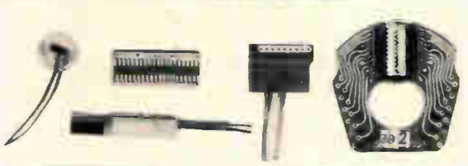

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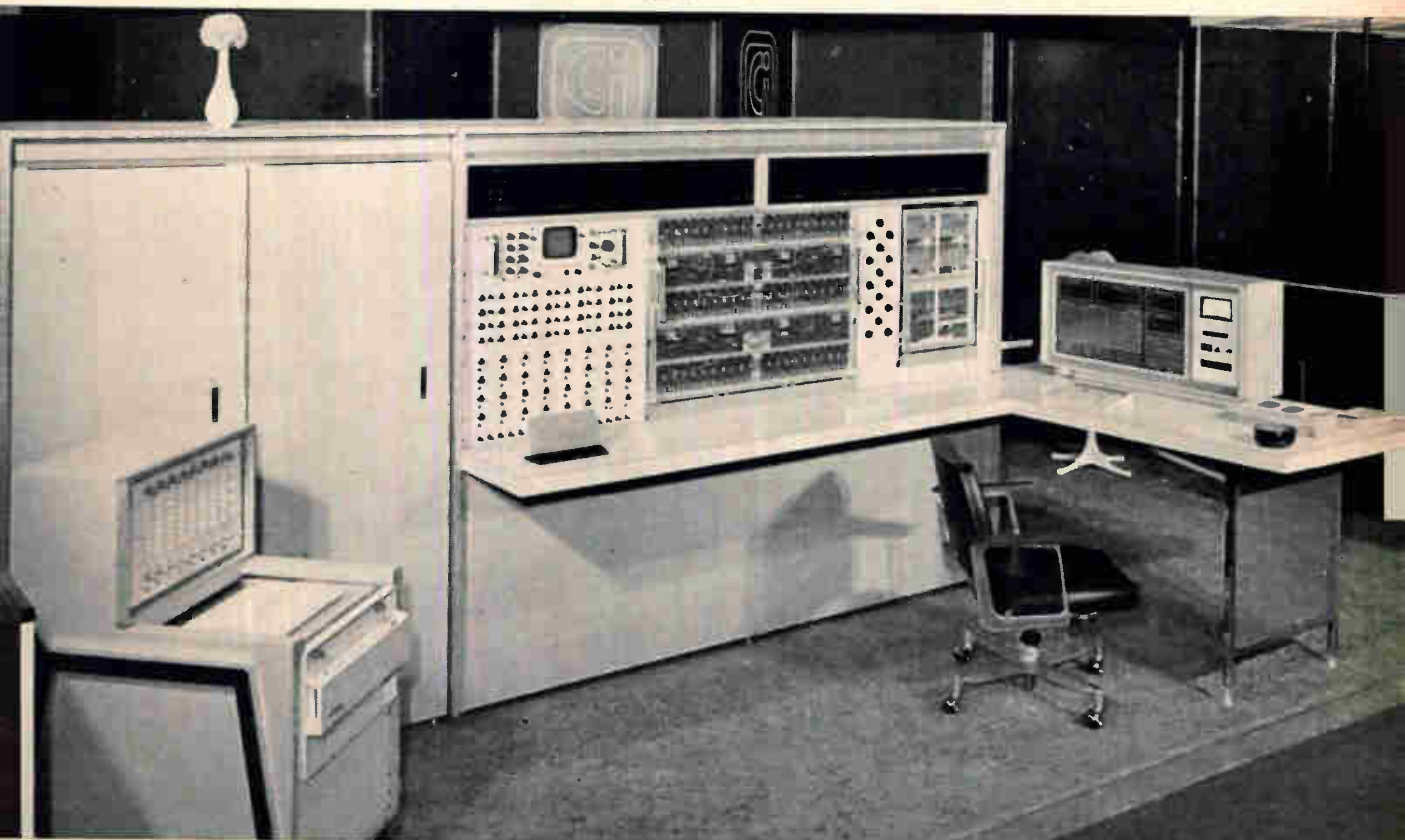

1965 Fall Joint Computer Conference

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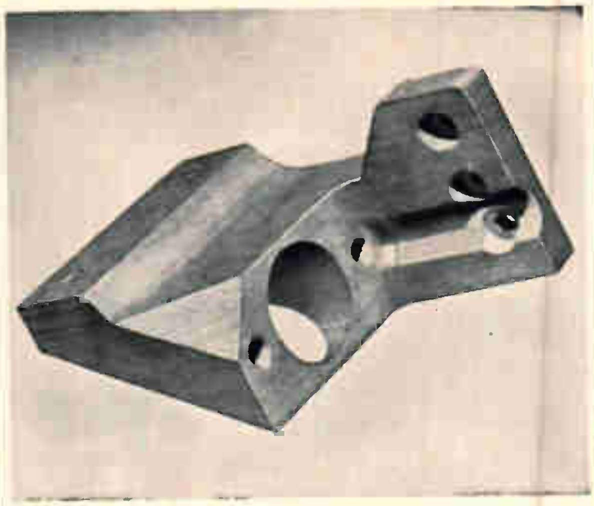

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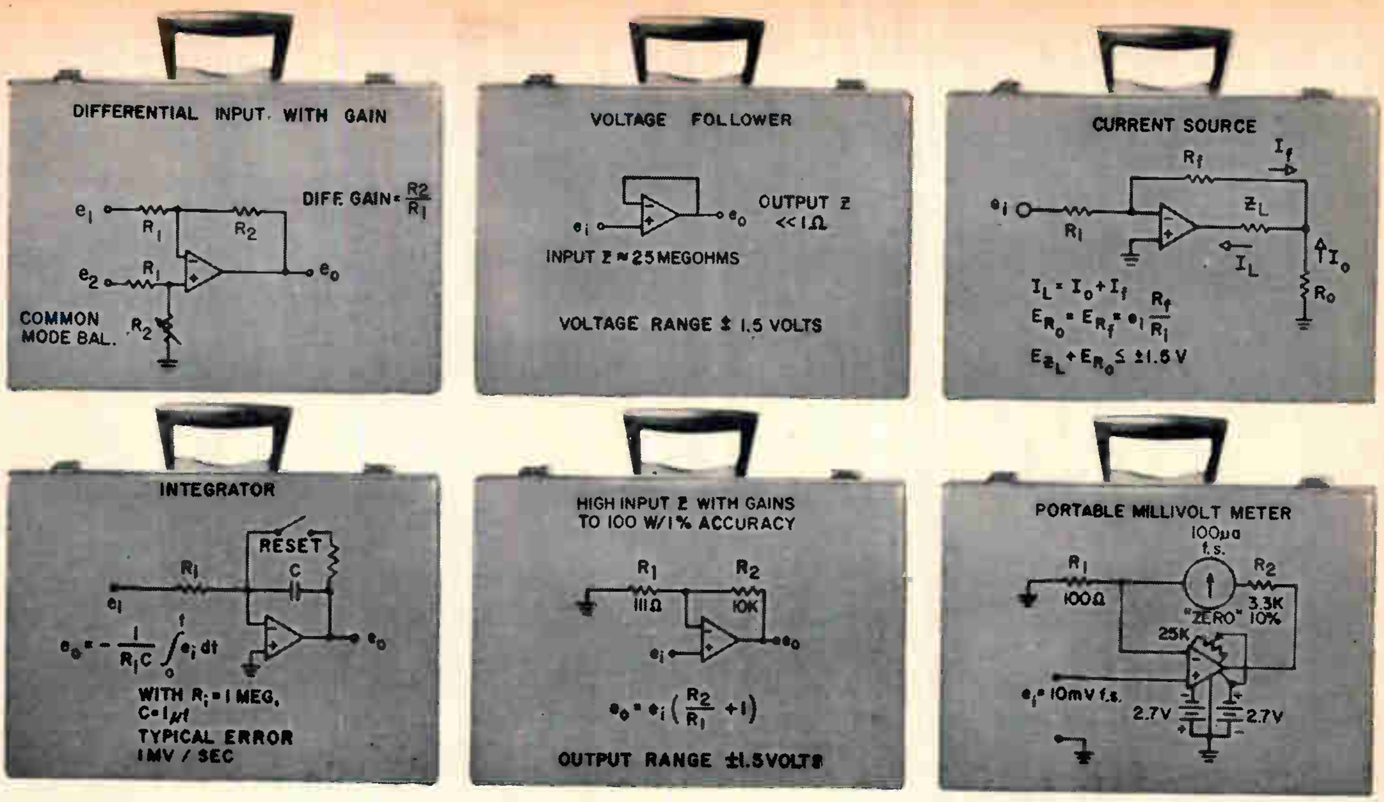

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I_{os}	±1.0na
$\Delta I_{os}/\Delta T$ (−25°C to +85°C)	±0.5na/°C
A_o (R_L = 1K)	10K
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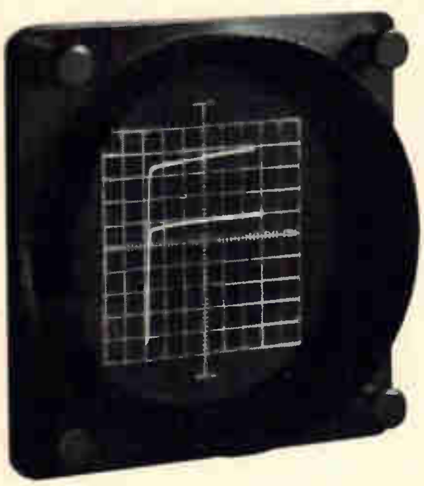

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Probing the News

Military electronics

Avionics for a more mobile army

Vietnam has shown the need for more improved airborne surveillance and communications systems. New aircraft will have these built-in

By W. J. Evanzia
Avionics Editor

Army helicopters in Vietnam have carried almost two million passengers and 84 million pounds of cargo. Fire support helicopters have made over a million sorties. Surveillance airplanes — fixed-wing Mohawks—have brought back vital intelligence that couldn't have been obtained in any other way. And forward air-control planes, directing ground battles, have often meant the difference between victory and defeat.

Although many officials were skeptical when the Defense Department decided to let the Army support the foot soldier with its own aircraft, they have now been won over to the concept of air mobility. And the Army is hard at work to improve its airborne operations. Having determined that six kinds of aircraft will do the job, the Army plans to build and equip its new aircraft with advanced avionics systems.

Observation. Already well along in development is the light observation helicopter, a small chopper that will fly over enemy territory, spot artillery and troops, and transmit this information to combat forces on the ground and in the air. The first production order is for 714 of these aircraft. The LOH will replace the aging L-19 and O-1F fixed-wing planes now used in Vietnam. The Hughes Tool Co. is building a prototype which has been designated UH-6A; the Sylvania

Station-keeping system, developed by the Sierra division of the Philco Corp. The scope in the control panel is the system's plan position indicator.

Electronic Systems division of the General Telephone & Electronics Corp. is working on the avionics package.

Fire-support missions. The advanced airborne fire support system will be the Army's first helicopter specifically designed for fire-support missions. Scheduled to be in the field in 1969, it will replace the UH-1B armed escort helicopter, which was hurriedly outfitted with machine guns and 2.75-mm rocket guns for combat in Vietnam. The Lockheed Aircraft Corp. is developing the prototype airframe. The new helicopter will have the integrated helicopter avionics system (IHAS). Although it is being developed by the Navy, the Army is funding 40% of the production contract for IHAS avionics.

Surveillance. In the development phase is a surveillance and target acquisition system (Stass) that will replace the hardworking Mohawk which is equipped with side-looking radar, infrared, ultraviolet and other detection devices. Stass will be equipped with advanced versions of Mohawk's equipment.

Transport. The Army is not planning to replace its present transport aircraft, but as new avionic systems are developed, planes built within the same time period will utilize them. The Army has divided its rotary-winged transport aircraft into three categories: utility tactical transport, typified by the Bell Helicopter Co.'s UH-1D Huey; light tactical transport, such as the Vertol division's CH-47A Chinook; and heavy-lift transport helicopters, like the Sikorsky Aircraft division's CH-54 Flying Crane. Sikorsky is a subsidiary of the United Aircraft Corp. and Vertol is a division of the Boeing Co.

I. Light observation helicopter

The prime purpose of the LOH is to provide company commanders with more information. In addition to artillery and troop spotting, the helicopter will be used for radio relays, psychological warfare missions, target marking, flare dropping and supply hauling. Although human eyes, rather than electronic sensors, will do the observing, the helicopter's communications system will be able to communicate with other supporting aircraft as well as ground troops.

Radio links. Frequency-modulated radio equipment will link the flying observer with infantry, armored and artillery forces; very high frequency and ultrahigh frequency amplitude-modulated sets will mesh with supporting Air Force, Navy and Marine aircraft. The helicopter's communications system will also work with radio equipment used by terminal air traffic controllers and ground-based forward air controllers.

LOH avionics will not be available for installation until about the third procurement year of the airframe, when the Army will decide how many of the operating LOH aircraft will be retrofitted. Until that time, conventional avionic subsystems will be used.

The new equipment is much smaller. In many instances, all of the electronics for the new sets fits into the same space as the old unit's control box. This eliminates the need for bulky cabling and reduces the failure rate.

One set that typifies the new aircraft's avionics is the AN/ARC-114, a multichannel vhf/f-m transceiver. It weighs only 8 pounds, takes up 150 cubic inches of space and has a power output of 10 watts. The transceiver operates over a frequency range of 30 to 75.95 megacycles with 920 channels spaced every 50 kcs. Because solid state circuitry is used, the mean time between failures is about 1,000 hours. This set is designed to replace the AN/ARC-54 radio, which weighs about 26.5 pounds, is less reliable and takes up about three times the space.

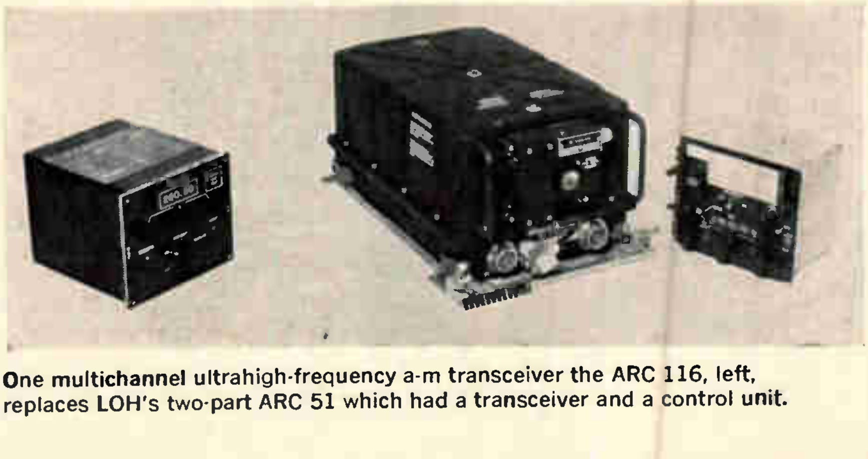
The homing capability of the ARC-115 will enable the LOH to operate efficiently out of jungle air fields. It uses keyed tactical ground transmitters for orientation.

Smaller transceivers. The AN/ARC-115, a lightweight vhf/a-m multichannel set with retransmission and homing capability, will replace the 30-pound AN/ARC-73. This new transceiver, about one-fourth the size of the old one, weighs 10 pounds and has an effective transmitted power output of 10 watts. It covers a frequency band of 116 to 150 Mc in 1,360 distinct channels (channel spacing is 25 kc).

LOH's will also carry the AN/ARC-116, a lightweight uhf/a-m transceiver. Slightly smaller than the ARC-114, it will replace the 36-pound AN/ARC-51 radio and will cover a frequency range of 225 to 399.95 Mc in 3,500 channels (50 kc channel spacing). Army engineers are designing a flush-mounted integrated antenna for it.

The helicopter will also carry a five-pound radio receiver—R-1297/ARC—an auxiliary vhf/f-m radio receiver for voice communications that covers a frequency range of 30 to 75.95 Mc. In addition, the aircraft will have automatic low-frequency, medium-frequency airborne direction finders. Two models are being produced, one covers a frequency range of 190 to 1,750 kcs in three bands: 190 to 412 kc, 410 to 850 kc, and 850 to 1,750 kc. The second model will cover the range from 100 kc to 3,000 kc in four bands. This equipment will be a functional replacement for the present-generation AN/ARN-59 and AN/ARN-83 directional finders.

Although the helicopter will not carry long-range communications systems, a high-frequency, single sideband system will be installed



One multichannel ultrahigh-frequency a-m transceiver the ARC 116, left, replaces LOH's two-part ARC 51 which had a transceiver and a control unit.

Light observation helicopter, packed with new communications equipment, will spot enemy artillery and troop movements. It will replace the fixed-wing planes now in use.

if one can be made that meets the Army's requirements.

II. Airborne weapons platform

Army engineers consider the LOH avionic subsystems a transition between transistor technology and complete integrated circuit implementation. But the IHAS avionics in AAFSS will be the first Army system to take advantage of advanced microelectronics and integrated circuit component development. The Army will receive two experimental IHAS systems from Teledyne Inc., in early November for evaluation in the Army's tactical avionics system simulator. The systems will be flight tested this fall aboard Sikorsky CH-53A helicopters. Teledyne is about midway through the two-year IHAS avionics development program.

A roll-stabilized doppler radar navigator made by the Canadian Marconi Co., will be IHAS's primary navigation subsystem. It will use both digital and analog microcircuits and weigh about 37 pounds. Backing up the doppler radar will be a modified ASN-50 inertial platform, to be built by Lear Siegler, Inc. High accuracy synchros and low drift gyros will replace the ASN-50's standard components, and a Sperry SYT 110 transfer alignment system will be used to set up heading references. A digital converter will convert synchro analog output to digital for computer use.

The IHAS system, like the Navy's integrated light attack avionics system (ILAAS), being built by the Sperry Gyroscope Co., a division of the Sperry Rand Corp., uses a functional modularity approach. This has resulted in some similarity of subsystems. Therefore the Army will probably use the Sperry display subsystem designed for the light attack system in its version of IHAS.

Three displays. The Sperry subsystem, which is scheduled to be delivered to Teledyne in early spring, will have three displays. The vertical situation display, with individual monitors for pilot and co-pilot, operates in four modes; it functions as a flight instrument command display, a shades-of-grey display for terrain avoidance, E-scan, and as a display for low light level television system.

The horizontal tactical display also works in two modes: one for navigation and a second for radar. In the navigation mode, a map is superimposed over the cathode-ray tube and the display shows heading, ground track, and command heading. In the radar mode a plan position indicator scan is obtained from the terrain radar.

The advanced airborne fire support system is also expected to use the same computer subsystem as IHAS, because the computer has modular construction and used microcircuits, it can be physically expanded or contracted to meet most of the fire control requirements. The computer also will use various pressure, temperature and other air data inputs for dead reckoning navigation. A tactical air navigation system will employ ground or sea-based beacons to update both the computer and ASN-50 platform.

IHAS will have a terrain-avoidance radar system made by Norden, a division of the United Aircraft Corp. This radar system meets the Navy requirements but the Army has not yet decided whether it will use the system for AAFSS. IHAS is expected to be ready before the airframe.

Problem for AAFSS. Both terrain-avoidance and station-keeping radar were in the original list of specifications for the Army's airborne fire-support system. Both of these control radar systems have advanced rapidly enough to be included in the prototype aircraft. The Army expects to have operational terrain-avoidance and station-keeping radars in the late 1960's.

According to the Army, the need for terrain avoidance radar had not been acute until now. But the change in military tactics brought about by Vietnam has made the radar mandatory. Therefore, the Army is investigating terrain-avoidance radar systems for both rotary and fixed-wing aircraft.

The Army is evaluating the AN/APN-165 on the Mohawk. But the radar developed by the Air Force for its drone aircraft has thus far failed to meet requirements. So the Army is taking a close look at other systems being developed for its sister services.

The Army wants station-keeping radars to help huge flotillas of helicopters to maintain their relative positions throughout an operation. This would result in greater safety and a more effective concentration of firepower, say Army tacticians. The Army is interested in both manual and automatic station-keeping systems. Four firms are working on developing them: Teledyne, Inc.; the Sierra division of the Philco Corp.; the Lockheed Electronics Co., a division of the Lockheed Aircraft Corp.; and TRG Inc.

The Army has bought four systems from Sierra for evaluation. Engineers at the Avionics Laboratory are using Sierra's systems to determine the station-keeping requirements for the fire-support system.

The Sierra SN-64/2A provides manual and automatic station-keeping at ranges from 75 feet to 3 miles (with an expansion capability to 10 miles). It has a range accuracy of ±10% and a bearing of accuracy of ±2°.

But the system does not have the operational capability needed for fire support. Only range and bearing are presented on a plan-position indicator scope, which the Army says is too hard to read. Equally as important as range and bearing, is relative altitude. The Army wants to be able to resolve altitude differences of less than 20 feet.

The Army will also evaluate two Teledyne station-keeping systems. The Navy is now testing early models of the IHAS subsystem at the Naval Air Development Center in Johnsville, Pa., but the Navy's problem is different from the Army's. The Navy can make do with a 500-foot separation between aircraft instead of the Army's 20-foot requirement. Also, the IHAS station-keeper weighs about 85 pounds; the Army's weight limit is about 30 pounds.

The Air Force is evaluating a manual station-keeping system for its C-130 transport aircraft. The C-130's must maintain station at ranges from 2,500 feet to 10 miles.

In the cockpit. The Army has under way a program designed to develop cockpit instrumentation to display the information generated by advanced avionics systems such as IHAS. The goal of the program, called the advanced Army aircraft instrumentation system, is to provide equipment that will take over time-consuming cockpit operations such as continuous instrument scan, navigation computation and fuel management.

An analog system will be used to determine the physical and psychological stresses faced by a pilot. The primary displays in the system are a 14-inch vertical situation display which gives the pilot the view below him, and a horizontal display which presents the side, front and rear view—all in real time. Inputs into the system could be from television, infrared or other types of scanners.

Transports. The CH-47 Chinooks have become the mainstay of the 1st Air Cavalry Division. They fly an average of 850 missions per day carrying 550 tons of equipment and 1,500 passengers. Avionics for transports like these need not be as sophisticated as those in the fire-support system or as compact as those on the LOH. It is therefore unlikely that the Army will retrofit any of its transport family with advanced systems. However, as the systems become generally available, certain subsystems will be included in new aircraft.

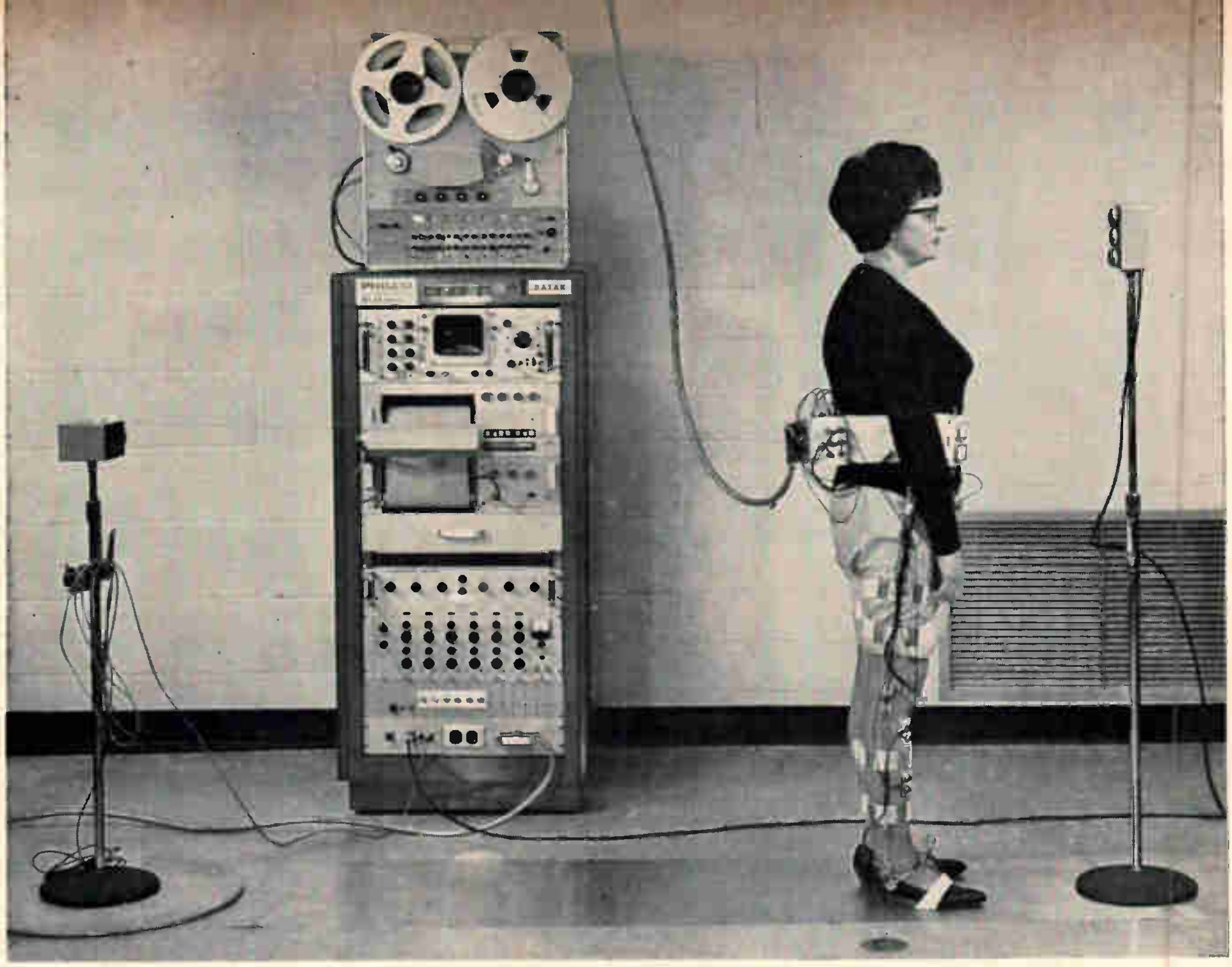
III. Surveillance program

The surveillance and target acquisition system is about two years behind the advanced airborne fire-support system in the Army's timetable. The Army has not chosen either the airframe or the avionic subsystems, although one Army official has said that the avionics will probably be an optimized mix of the subsystems for the light observation helicopter, the integrated helicopter avionics system and the integrated light attack avionics system. However, the surveillance and target acquisition system will have some requirements that the three other systems cannot now fulfill. Several types of airframes—vertical short take-off and land (V/STOL), STOL, tilt wing, tilt prop and jet aircraft—are all prime candidates for the system.

The Research Analysis Corp. in McLean, Va., is now completing a study of the surveillance concept, including techniques of acquiring surveillance data, the optimum location of the aircraft to the front lines, types of aircraft—VTOL versus conventional or short take-off types—runways and the time required to get collected surveillance data to Division or Corps headquarters.

Quite apart from the Research Analysis study is a request for a surveillance program sent in February to the Pentagon by the Combat Surveillance and Target Acquisition Laboratory of the Army Electronics Command at Fort Monmouth. The Army's Chief of research and development is scheduled to take action on this request soon.

Whatever form the system takes, its surveillance and data collection equipment will be very different from that which the Mohawk OV-1's now carry. Lasers and optoelectronics will be used extensively and its electronics subsystems will be almost exclusively microminiturized and/or molecularized. Side-looking and forward-looking radar antennas will have low silhouettes; some systems will use the aircraft's skin as a radar reflector. Night vision systems—low-light level television and infrared sensors—will be standard equipment. The surveillance aircraft of the 1970's also will have new high-speed panchromatic cameras and have on-board photo-processing, recording, pattern recognition and reconnaissance analysis equipment.



Gait-study subject. When she walks, she will create velocity signals and timing signals for comparison with EMG. Tachometer in housing at left generates the velocity signal as she walks. Lights at right tell her when to walk.

Medical electronics

Why some people fall often: EMG signals studied for clues

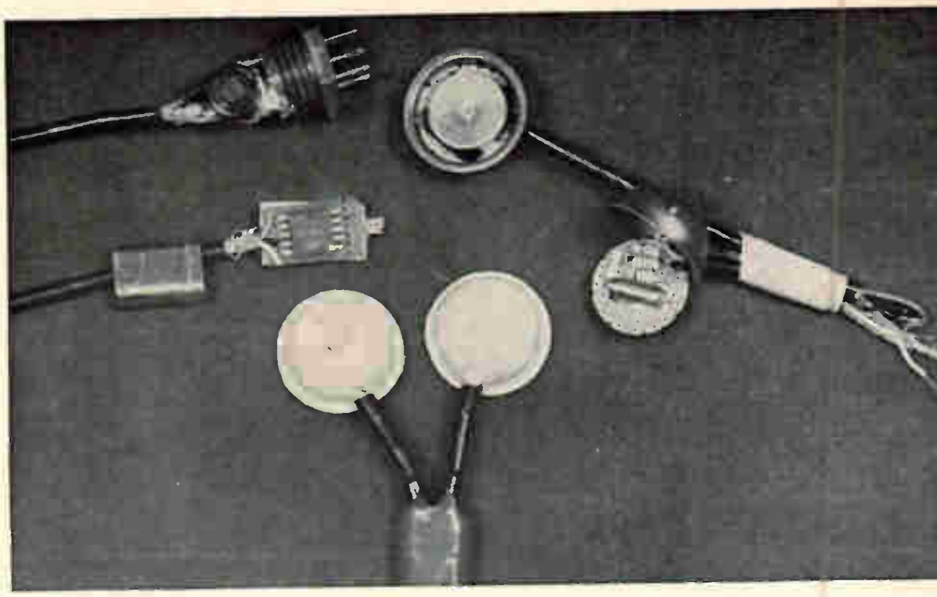
Muscle signals already control experimental prosthetic devices. Soon they may help researchers learn why older women fall down more often than young ones, and how these accidents can be reduced

By Carl Moskowitz

Instrumentation Editor

For centuries, the male of the species has observed intriguing differences in the ways various women walk. Analyses of these differences have been largely subjective; now scientific study is being made with the help of computer analysis of the tiny electrical signals associated with muscle contraction. The work at the Moss Rehabilitation Hospital in Philadelphia is designed to learn why women fall more often when they get older. If falls are a result of changes in gait, as some researchers suspect, teaching older women how to walk differently might prevent painful injuries.

Until now, these signals—called electromyographic or EMG—have found many applications in controlling damaged or artificial limbs. Two years ago the Philco Corp. demonstrated a way to use the signals, which are measured in microvolts, to control an artificial arm or leg [Electronics, Nov. 30, 1964, p. 74]. Last year Case Institute of



Differential electrodes, top and bottom views. Blocking capacitors behind each electrode prevent any d-c component from appearing at the signal processor.

Technology found a way in which EMG signals from a shoulder muscle can help to restore the use of a disabled muscle in an arm [Electronics, Sept. 20, 1965, p. 110].

I. Starting gait

When the subject begins to walk along a 30-foot copper sheet backed with mylar, small electrodes on her heel and toe make contact with the sheet. Each time the heel or toe touches this ground plate, a reference is created from d-c potentials on the electrodes, for timing with EMG, kinematic and velocity data gathered by more delicate methods.

The Philco Corp., which is conducting the study for the Public Health Service, collects EMG information from six muscles by means of electrodes on the skin and a data-collection system called a Datak, which consists of an oscilloscope, signal conditioners, a graphic recorder and a tape recorder. The data is fed to the tape recorder, then played back through a signal analyzer-processor for digitizing. Kinematic data also is collected by an electrogoniometer, an angle-measuring instrument strapped to the leg. The instrument, which resembles a leg brace, has five potentiometers which are positioned at the foot, ankle, knee and side and frontal hip joints. Readings from the potentiometers give the angular displacements of these joints. Velocity is measured by a tachometer.

Sorting the signals. It is the analyzer-processor, called a Myocoder, which permits EMG signals to be separated from the tens of thousands of others generated in the body. Recently, Philco improved the two-year-old system so that the Myocoder not only detects the signals that accompany muscle movement, but also reduces the data to a digital format automatically and punches it onto cards. This advance has made the gait studies possible, says Miss Rona Finizie, a senior scientist in Philco's bio-cybernetics group. "Otherwise it would be impossible to process all the data that will be accumulated during the test," she explains.

At present, the computer receives the values of EMG signals at only four stages of a stride: when the heel makes or breaks contact with the ground plate, and when the toe makes or breaks contact. Philco is working on equipment which it hopes will be able to analyze, automatically, velocity and the position of various leg joints; at present this information is read directly from the recorder charts and punched manually onto the computer cards.

Wiring the subject. To obtain a signal, Philco uses pairs of electrodes to detect changes in potential on the surface of the subject's skin. By removing the ground reference, these electrodes minimize the effect of line noise.

To overcome resistance changes

between skin and electrode, caused by shifting of the contact as the subject walks, electrodes had to be designed with input impedance high enough to overcome the effect of the changes on the signals. To solve the impedance problem, Philco chose a microminiature amplifier with an emitter-follower first stage. Besides providing the necessary high-input impedance, this amplifier boosts the EMG signal to a level that overcomes the attenuation caused by the long cable that connects the subject to the data-collection system. Another network on each electrode prevents any d-c portion of the EMG signal from passing through to the processing equipment.

II. Before the countdown

The time required to get a subject ready for a test still has to be reduced. She must stand on a raised platform for about an hour; first the electrogoniometer is strapped in place, with each potentiometer adjusted to make sure it is at exactly the right spot. When all the instruments are in place, they are checked out; while the subject walks about 10 feet, the instruments indicate the level of her EMG signals, and the Datak operator sets the attenuation levels of the 12 data channels accordingly.

For the study, data from 200 women over 65 years of age will be compared with data from a control group of 35 women of 18 to 25.

Beyond the Philadelphia project, broader applications are envisioned for Philco's approach to the study of electromyographic signals. Walter Wasserman, director of the company's biomedical development laboratory, sees it helping in the design of automobile seats by studying driver fatigue. He notes that some researchers believe that tired muscles may exhibit differences in their EMG patterns. If this is true, changes in the levels of an individual's EMG signals may provide a measure of his fatigue as he sits behind the steering wheel hour after hour.

EMG is also the subject of another Philco study whose goal is to learn whether electromechanical machinery for automobile assembly plants could be designed more efficiently if their motions followed those of human limbs more closely.

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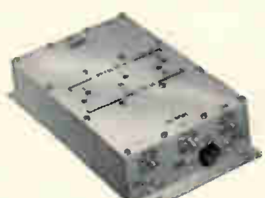
Max. Input Signal for Linear Operation	−15 dbm
Input Impedance	50 ohms
Output Impedance	50 ohms
Power Required	160 ma @ −20 VDC AGC: 0 to +10 VDC
Phase Match	2.5° (max)*
Gain Match	1.0 db (max)*
Dimensions	7″ L x 1½″ H x 2½″ W
Weight	1¼ lb. max
Chassis Adjustments	Gain and Phase Trim



Triple Channel Amplifier

Center Frequency	30, 60 or 70 Mhz
Bandwidth (3 db)	10 Mhz
Gain (IF)	65 db
Gain Reduction	40 db (min)
Max. Output Signal for Linear Operation	+10 dbm
Max. Input Signal for Linear Operation	−15 dbm
Input Impedance	50 ohms
Output Impedance	50 ohms
Power Required	240 ma @ −20 VDC AGC: 0 to +10 VDC
Phase Match	3.5° (max)*
Gain Match	1.5 db (max)*
Dimensions	7″ L x 1½″ H x 3¾″ W
Weight	2 lb. max
Chassis Adjustments	Gain and Phase Trim

*These data are maximum variations within temperature range of −50°C to +75°C and over the full specified gain control range, for a signal spectrum greater than 60% of the IF bandwidth.

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Broadcast equipment like these studio television monitors has helped the East Germans move into world markets. Gear rates high for quality but it's bulky.

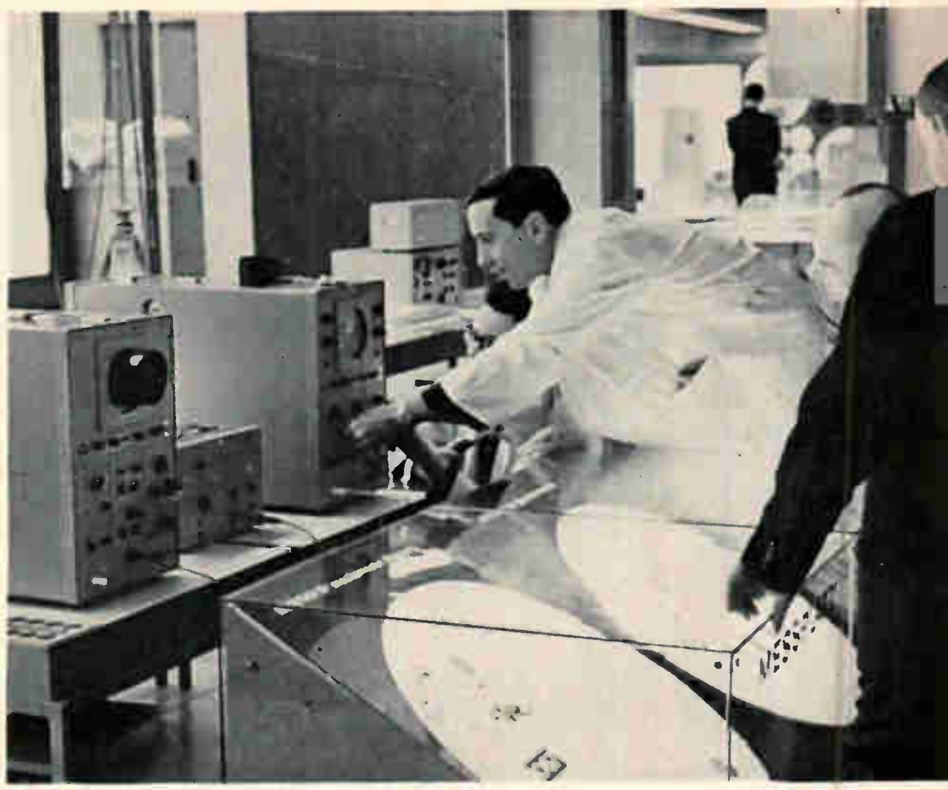
Markets

Electronics booming in East Germany

Production of hardware continues to rise with emphasis shifting from consumer goods to industrial and commercial products, but lack of access to Western technological advances is still a major drawback

East Germany's communist boss Walter Ulbricht traditionally opens the Leipzig Spring Industrial Fair with a whirlwind trip through the pavilions. This year, though, Ulbricht and his official party slowed down when they reached the Hall of Electronics. Ulbricht even stopped to chat at the stand of Siemens & Halske AG; usually he stares straight ahead as he strides past the displays of West German companies.

Ulbricht's change of pace illustrates the ruling hierarchy's growing awareness of the need to develop the country's electronics industry. Up against a labor shortage, East German economic planners are pressing hard to step up productivity, under the circumstances about the only way to keep the output of goods climbing. Strengthened electronics capabil-



One-shot waveforms persist up to a week on the tube of a new oscilloscope developed by a "people's own" instrument maker in East Berlin.

ity, especially in industrial equipment, is crucial to this effort.

What's more, the planners count heavily on electronics exports to earn sorely needed foreign exchange. About one-fourth of the industry's output now goes to other countries.

Little wonder, then, that in the rigidly planned East German economy the fastest growing sector is electronics. Production of electronics hardware has bounced up 10% annually in recent years. Industry officials say they can maintain that rate during the next few years, especially since technical support from Russia seems likely.

All the same, they're itching for access to Western electronics know-how. But there's small prospect of that in the offing; the best they can hope for is a slight easing in the North Atlantic Treaty Organization's embargo list that keeps advanced Western hardware out of countries that belong to the Council of Mutual Economic Assistance — the Eastern equivalent to the Common Market in Western Europe.

Number 2. By Comecon standards, however, East Germany has progressed swimmingly in electronics. Over-all, she ranks second only to Russia. East German planners don't disclose figures that pin down the size of the industry, but Western experts estimate it's now running at a level of $600 million yearly. That, of course, is a far cry from the $2.257 billion worth of business the West German industry expects to do this year.

Inevitably, the concern over electronics development has shifted the emphasis from consumer goods to industrial and commercial products. A former television manufacturing facility, for example, now turns out data-processing equipment. In fact, only one plant produces television sets. East German planners hold the view that with three million sets in service for a total population of 17 million, the country is saturated by socialist standards; so a single plant can handle replacements and exports.

East meets West. At Leipzig, communists meet capitalists at spring and fall fairs and out of the encounters comes a profile of the East German electronics industry. The East German stands bristle with equipment the industry thinks it can peddle to its Comecon partners and in world markets as well. This pinpoints the industry's strong sectors.

Western manufacturers, on the other hand, make capital of East Germany's weak spots. They show equipment—within the range permitted by the NATO embargo—that the East Germans can't produce for themselves.

I. The positive side

Visitors to last month's spring fair came away with a strong impression that the industry is doing best with communications equipment and instrumentation. In these two sectors, the East Germans have made big strides. Some 29 factories, backed up by the research efforts of university institutes and government science centers, turn out more than a thousand different items of equipment. Over the past five years, output of measuring and control equipment has tripled, industrial officials boast.

The "people's own" companies sell instruments such as sweep generators, oscilloscopes, high- and low-frequency signal generators and transistor-characteristic curve tracers to more than 50 countries, many of them in the West. The East Germans also have moved into world markets with radio and television broadcast equipment. They are now delivering to Indonesia, for example, a short-wave facility worth several million dollars.

High marks. Western observers give the East Germans high marks for the quality of their equipment. Some items, in fact, can stand comparison both in price and performance with instruments made in the United States. A case in point is a recently developed oscilloscope that can store signals up to one week (see photo). It's designed for work with single, nonrecurring waveforms like those encountered in mechanical, electrical and acoustical engineering problems. With this oscilloscope engineers can analyze a waveform long after it has vanished, without photographing it.

To be sure, items like the long-store oscilloscope—sophisticated enough to have a potential market in technically advanced Western countries—are few and far between. But the East Germans have spotted some gaps in the lineup of production equipment made in the West and moved to fill them. They've developed, for example,

automatic stator-winding machines, program-controlled equipment for forming wiring harnessess, and computer-controlled resistor-making machines.

Another sector where the industry is going full steam ahead is shipboard equipment. Despite a dearth of advanced devices, East German engineers have managed to develop complete navigational radar systems, automatic ship-control equipment, cargo handling equipment, ultrasonic fish spotters, and communications gear. The thriving East-German shipbuilding industry supplies completely equipped vessels to both Western and Eastern countries.

Office equipment, too, is a mainstay of East German electronics. The annual output is estimated at close to $100 million. Soemtron, Ascota and Optima electronic calculating and invoicing machines are exported to some 80 countries including the United States.

The Soemtron 220 shows how far along the East Germans are with small electronic desk-top calculators. This machine can add, subtract, multiply, divide or raise to powers 15-digit numbers at an average speed of 0.5 second. VEB Büromaschinenwerke Soemmerda, the largest office-machine manufacturer in the country, sells the calculator for about $2,250. The VEB in the firm's name is the acronym for "people's own factory" in German.

II. Where they lag

Although it has done well with small office machines, the East German industry has a lot of catching up to do in computers. It has developed a small computer and made much of it last spring at the Leipzig fair. But mass production won't start until later this year.

This state of affairs leaves the industry far behind neighboring Poland and hopelessly outdistanced by West Germany and the United States. Along with high-quality solid state components, medium and large computers at the moment are a leading market for outsiders in the country. Reiner Staehr, deputy director of the industry association for data-processing equipment, says East Germany needs at least 10 complete installations in the large-machine category. All will have to be imported.

The need for medium computers is even greater. Hundreds, planners say, are required to push industrialization of the country. But Staehr hopes much of the demand can be met in the future by the industry.

Kingpin. To that end, the East Germans have developed the Robotron 300. The machine presumably will be a kingpin attraction at next fall's Leipzig fair. Officials hint it will be unveiled then. They say it will be three times as fast as its predecessor, the Robotron 100, which has serial addition and subtraction time of 0.5 millisecond.

The Robotron 300, then, will be comparable to the Siemens 3003 computer, made by Siemens & Halske of West Germany. Until the Robotrons start coming off the production line, though, Siemens can almost surely count on more orders for its 3003 model; one already is installed in a warehouse in Leipzig.

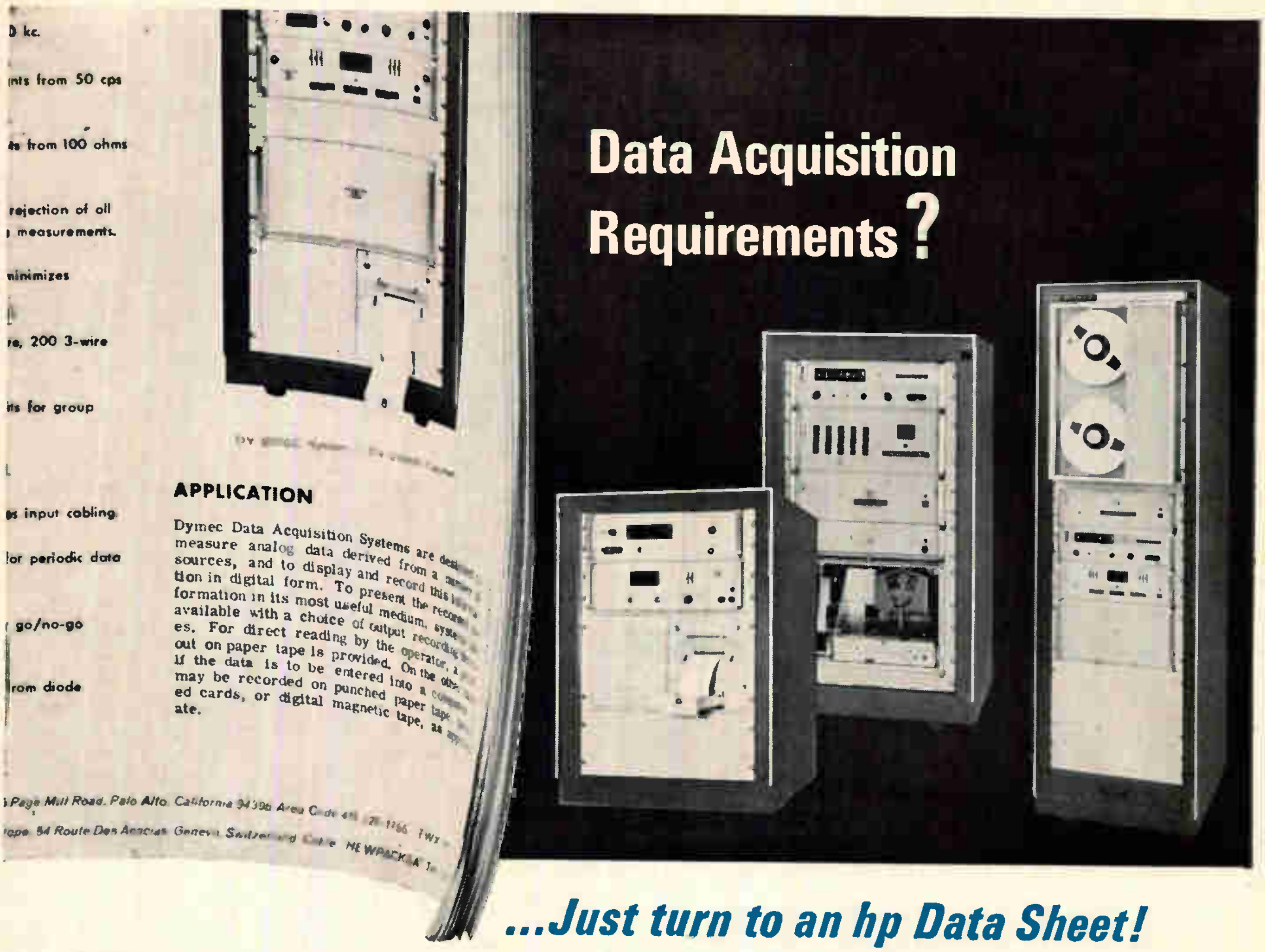
One computer East Germany will have in production later this year is a small machine for scientific problems and statistical applications. It's called the Cellatron SER 2c and sells in the $16,000 to $20,000 range. Büromaschinenwerke AG of Zella-Mehlis makes it.

For their money, buyers get a punched-tape controlled machine with addition and subtraction time —without address—of 2.5 milliseconds. With an address, the same operations take 50 milliseconds. Speeds for multiplication and division, with or without address, are 140 and 180 seconds, respectively. The memory is a magnetic drum with access time of 11 seconds.

On the heels of the Cellatron SER 2c will come the Cellatron D4a intended for administration, industrial, and scientific applications. It has a maximum computing speed of 2,400 operations per second. This machine sells for $22,500 to $30,000, depending on peripheral equipment.

Semiconductor woes. The East Germans can make the conventional components and the memory devices for these small computers, but they have to buy high-quality transistors and diodes outside the country. Chief suppliers are Russia, West Germany and Japan.

This dependence on foreign imports points up one of the sore



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	25 (3-wire) expansible to 100 2013 J-M	200 (3-wire) or 100 (6-wire) 2010C, D, F, J	200 (3-wire) or 100 (6-wire) 2015C, D, F, J	200 (3 wire) or 100 (6-wire) 2017C, D, F, J
Noise Rejection NMR	30 dB at 60 c/s (filter)	inf. at 60 c/s (integrating)	inf. at 60 c/s	20 db min. all freq. (integrating)
Noise Rejection ECMR		At least 105 dB, all frequencies (floating)		
DC Voltage Range	10, 100, 1000 V. fs	0.1, 1, 10, 100, 1000 V. fs	1, 10, 100, 1000 V. fs	0.1, 1, 10, 100, 1000 V. fs
Resolution (mV/digit)	100 μV 10 μV with amplifier	1 μV standard 0.1 μV with amplifier	10 μV	1 μV standard 0.1 μV with amplifier
Accuracy (% rdg.)	.05%	.015%	.005%	.015%
Max. Speed, Readings/Sec, DC Volts	1.7 (4 digits)	18 (3 digits) 7 (4 digits) 1 (5 digits)	12 (5 digits)	18 (3 digits) 7 (4 digits) 1 (5 digits)
Optional Measurement Capability	AC voltage, resistance, dc current	AC voltage, resistance (frequency is standard)	AC voltage, resistance	AC voltage, resistance (frequency is standard)
Programming		standard with DY-2901A; add DY-2911C or DY-2560A with DY-2911		
Types of Output Recording	Printed strip, typewriter, punched tape, cards	Printed paper strip, perforated tape, punched card (IBM 526) magnetic tape		
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spots in East Germany's electronics industry. Production of semiconductor devices lags well behind advanced Western countries' capability. Devices like photodiodes, tunnel diodes and some types of high-frequency transistors still are in the development stage.

East German officials frankly admit there's a lack of adequate transistor-making equipment and a shortage of semiconductor materials. But they're hopeful. Says one, "With Russian help, these problems will be overcome."

III. Barriers are still up

But it isn't Russian help alone the East Germans want. They're aching—without much hope for relief—for licenses to produce equipment developed in the United States and other Western countries. Licensing deals would bring a double benefit. For one thing, they'd help immensely in the effort to catch up with the West in electronics and generally stimulate the industry. For another, they'd save foreign exchange, in tight supply in Comecon countries, which otherwise would have to be spent to buy Western hardware.

To be sure, the NATO embargo and other Western-government restrictions aren't air-tight. A lot of restricted items wind up in East Germany by circuitous routes [Electronics, Jan. 10, 1966, p. 242]. But contraband components and hardware are costly.

Minority view. A few East German engineers say the embargo policies have stimulated rather than deterred the industry. "You have been helping us rather than hurting us," says Hansgeorg Laporte, a physicist. He points out that the industry built a special type of sampling oscilloscope after a much-needed model couldn't be had from the West.

But Laporte is one of a small minority. Time and time again U.S. visitors to the Leipzig fair heard East German engineers single out as the industry's major drawback its lack of access to Western electronics advances. "We can't get to know the true state of the art by going to the Soviet pavilion," moaned one East German. That statement sums up the feeling that prevailed throughout the industry generally.

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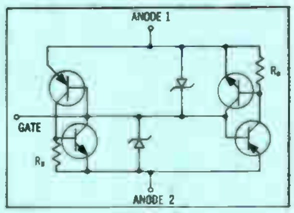
We call it the Silicon Bilateral Switch. You'll find it just about eliminates power output fluctuations caused by temperature effects on the triggering voltage. The switching voltage of this new device is virtually unaffected by temperature. What's more, G.E.'s new SBS has extremely low switching voltage—a mere 10 volts. Use G-E SBS's to trigger SCR's and bi-directional thyristors (Triac's). They're available in unilateral form as well as bilateral form. Circle **Number 90** for more details.



Silicon Bilateral Switch Equivalent Circuit

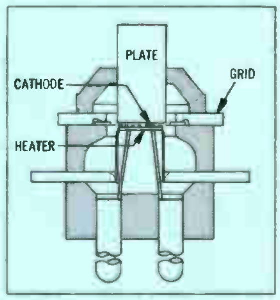
G-E thermistor probes solve many design problems

Here's the answer if thermistor probes are your problem:

- **G-E H-series probes** give you trigger-fast response in a truly rugged, hermetically sealed unit . . . operate up to 400C in air, gas and non-conductive liquids.
- **G-E ¼" diameter probes** range from 50 to 100,000 ohms resistance, Grade 1 through 4 materials.
- **G-E bead probes** are designed to fit into nearly any circuit package. Easy-to-mount and operable up to 400C, you can even use them in liquid media. Circle magazine inquiry card **Number 91.**

New bonded heater-cathodes for planar ceramic triodes

Now you can meet all these design goals: ■ faster warmup . . . 3 to 5 seconds without heater over-voltage ■ tolerance to extreme mechanical environments . . . up to 50 g's RMS ■ extremely low microphonic output . . . quietest of any known tube design ■ improved life, reliability . . . heater temperature is sharply reduced ■ predictable thermal transfer between heater and cathode . . . permits precise control of cathode temperature through heater-voltage control ■ circuit simplicity . . . indirectly-heated cathode needs no special heater circuitry or voltage. This new heater-cathode technique can be applied to all recent tube designs. Circle **Number 92** on the magazine inquiry card.



More and still more G-E economy transistors

Switch to the low-cost way to solid state. Try the famous planar passivated economy line. Try new G-E 2N3973-76 transistors for example. They're tops for medium speed industrial switching and large signal RF amplifiers. And they feature excellent h_{FE} holdup at collector currents between 0.1mA and 500mA. Or try our new 2N3858A and 2N3859A transistors . . . excellent as high voltage, high gain amplifiers. Circle inquiry card **Number 93.**

Want high-level color demodulation?

The 6AG10 compactron

This little G-E 6AG10 compactron gives full color fidelity . . . actually does the work of 2 miniature demodulators, or of 2 pentodes and 3 triodes. The 6AG10 puts out 3 "color-difference" signals directly to 3 cathode-ray-tube guns. Here, unquestionably, is your lowest-cost way to full-color-fidelity demodulation. And best of all, it's a COMPACTRON. Ask your G-E engineer/salesman for our new "Compactrons for Color TV" Brochure or circle **Number 94** on the magazine inquiry card.

MORE

COMPONENT CAPSULES

Solid-state light-sensitive switch controls G.E.'s meter relays

GE-Type 195 meter relay with single setpoint

Contactless pass-through control action—that's the advantage you get with these solid-state meter relays. Completely self-contained control action is initiated by a light-sensitive switch directly controlling the load relay. No troublesome pointer contacts. No external amplifiers, power supplies or load relays. No mechanical interference with meter movement. Pointer travel is unrestricted across the entire scale. You get continuous indication above and below the setpoints. And you get all this in a distinctive, easy-to-read BIG LOOK meter package. Ask for Publication GEA-8014 or circle magazine inquiry card **Number 95.**

PREDICTION: Crystal-can relays out. 150-grid relay family in.

G-E low-profile 150 Grid-space relays set the trend for things to come in relay applications. Available now in 2-pole and 4-pole arrangements (and a latching version's due this year, too) these small devices have 150-mil terminal spacing, are only 0.32" high. This growing family of new relays offers you the best in space-saving ability with all the performance required from a mil-spec relay. Circle **Number 96.**

Family will soon include new latching version

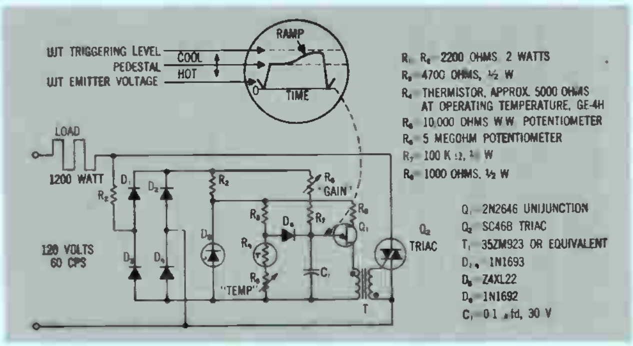
Give critical components the protection they deserve

Triggered Vacuum Gap

Divert system and component faults through a General Electric triggered vacuum gap. Nothing else will do the job as well. TVG's trigger remarkably easily, just as low pressure gas gaps do. Yet TVG's are gas-free. Their voltage holdoff capabilities won't degenerate. They are also free from adverse atmosphere damage, adaptable to any environment, and will protect against faults ranging from 10 to 100% of their rated voltage. Circle **Number 97** for more information on all 5 available models.

Try this new ramp-and-pedestal precision temperature regulator

At maximum gain setting, this low cost circuit controls load power over its entire range by a mere 3°C change in thermistor temperature. What's more its feedback control network is stabilized by the circuit's adjustable gain. How's it work? Ask your G-E engineer/salesman for Application Information Publication 671.1 and cost details. Or circle magazine inquiry card **Number 98.**



8 different case sizes now for Black Hawk capacitors

And each capacitor size has 5 different voltages to choose from—50, 100, 200, 400 or 600 VDC. Black Hawk capacitors are molded to give you a hard, moisture-resistant shell around the capacitor roll. Each one you use has strong welded leads, extended foil construction, and very precise dimensions (±0.005). Circle **Number 99** on the magazine inquiry card for all the facts.

Featuring molded encapsulation

WE MAY NOT OFFER EVERYTHING YOU WANT FROM ONE COMPONENTS SUPPLIER. BUT WE DO COME A LITTLE CLOSER THAN ANYONE ELSE.

285-12

GENERAL ELECTRIC

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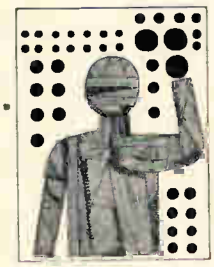
Electronics is a discipline unlike any other. For whatever name we give to these fast paced times in which we live—the Age of Space, the Age of Mass Communications, the Age of Transportation—electronics plays a vital role. Through advances in this single key technology, advances in all others are brought nearer to reality. And nowhere is this truth more evident than at Lockheed, where to all programs, electronics is essential. Research. Development. Systems. At Lockheed, those knowledgeable in the nuances of electronics help to further man's achievement upon this planet. They bring practicality to investigative ocean vehicles such as Lockheed's Deep Quest, a two-place research submarine. They permit land vehicles of the future to achieve reality. And they extend the reach of mankind heavenward through spacecraft systems such as Agena. Undersea, on land, and in space environments, Lockheed electronic systems control and guide, communicate and compute. Now, generalists and specialists, experienced and interested in a broad spectrum of electronics assignments, are invited to write Mr. K. R. Kiddoo, Professional Placement Manager, Sunnyvale, California. Lockheed is an equal opportunity employer.



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MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

We hate the numbers game

because we fall for it ourselves, sometimes. Sure, a volt is a thousand millivolts, and your gigacycle has the same thousand megacycles in it that ours has. Numbers **are** necessary, and we sell many of our instruments **simply because** our numbers are better; but **numbers alone** can't possibly describe the many reasons why one instrument design is superior to all the rest. Take our **2-Gc-Dispersion Modular Spectrum Analyzer** series, for example. When you sit down and compare the numbers, the POLARAD design wins by a tidy margin, in just about every department . . . but the numerical specifications can't tell you that **only the POLARAD design** is completely image-free . . . that **only the POLARAD design** has the foolproof harmonic-identifier push button . . . that the Model 2992-A is really a three-piece "starter set", from which, by adding only four more modules, from "open stock", you can build up **the most** complete spectrum analyzer capability ever offered... that with those seven, you can assemble 17 different spectrum analyzers! Check the features listed here—there's not a number in them, but they constitute a powerful set of reasons for **going the POLARAD route.** Call 212-EX 2-4500. One demonstration is worth 10,000 numbers.

This module alone is a complete Spectrum Analyzer with 100 Mc Dispersion.

Add Continuous Phase-Lock Frequency Stabilization with this Module . . . permits narrow-dispersion analysis of signals down to 1 Kc resolution!

Add this "Swept Front End" module for 2-Gc dispersion over 10 Mc—91 Gc.

MODEL 2992-A 2-Gc-DISPERSION SPECTRUM ANALYZER

- **TRULY QUANTITATIVE.** Built-in crystal markers. Choice of LIN-LOG-POWER display modes, all with excellent level-resolution, for optimum signal-amplitude accuracy.
- **WIDEST RESOLUTION RANGE**
- **WIDEST DISPERSION RANGE.** In calibrated steps or variable in a pair of continuous ranges.
- **ERROR-FREE.** Push-button Harmonic Identifier—foolproof, fast, positive! Image-free presentation over full rated dispersion on all bands—without exception!
- **LOWEST NOISE, HIGHEST STABILITY.** Obtainable at present state of the art . . . orders of magnitude better, due to phase-lock stabilization of front-end L.O., which eliminates spurious FM/jitter.

By the way, those rumors you hear are true. We can't give you better than about 60-day delivery, despite nearly tripled production on the 2992. We are shipping and manufacturing like mad, though, to try to catch up. (No manufacturer *enjoys* having instruments on the shelf. Backlogs are better.)

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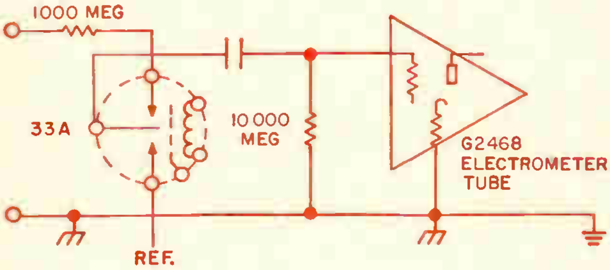
162

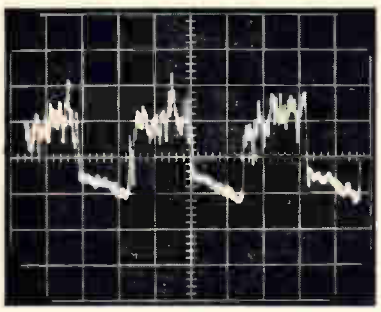
 Circle 172 on reader service card

PART 8 of a series on THE STATE OF THE CHOPPER ART

INPUT CIRCUIT IMPEDANCE ABOVE 1000 MEGOHMS



AT 1000 MEGOHMS USE A 33A . . . . .

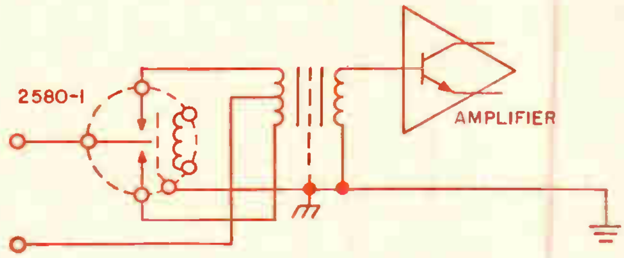


150 MICROVOLT SIGNAL, 10,000 MEGOHMS

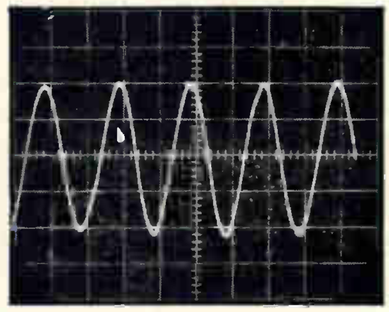
33A

We do feel awfully apologetic about using a tube. Maybe if we just kept at it we could get a MOS FET with INSULATED GATE working, and we do know how much better SOLID STATE is. But our Chief Engineer has a mighty small appreciation for creative art. He said meet the budget. So we're sorry, but a G2468 electrometer tube works at 10,000 megohms but only costs a couple bucks. Same reason we used a 33A chopper. No romance. No fun developing new circuits. It just works. Noise and offset? Down around ¼ uv.

OFFSET VALUES BELOW 10 NANOVOLTS



AT 10 NANOVOLTS USE A 2580-1 . . . . .



½ MICROVOLT SIGNAL, 10,000 OHMS

2580-1

We have been deluding our faithful readers. The Airpax choppers we have foisted off all these years were **not** completely free of noise. In fact some of them, like the 33A next door, were **loaded.** They run upwards of 200 or 300 nanovolts—0.2 of a microvolt. But perhaps we can make it up to you with the 2580-1. It doesn't seem to have any hum pickup or fixed offset or variable offset. A most rash and unscientific statement. Interpreted, means we don't know how to measure below 10 nanovolts.

Should you use the same chopper at 10,000 ohms or 10,000 megohms? You can. It might be more expensive. Mechanical choppers perform for three reasons. The open contact approaches infinite resistance. The closed contact approaches zero resistance. And the transit between zero and infinity approaches zero time. Reliability? We have photo choppers and transistor choppers to sell you, when you need not save money. Or when you need over 25,000 hours life.

AIRPAX ELECTRONICS incorporated Cambridge, Maryland (301) 228-4600

2½-D memory operates in nanoseconds

Computer memory's unusual wiring scheme permits high-speed operation at low cost

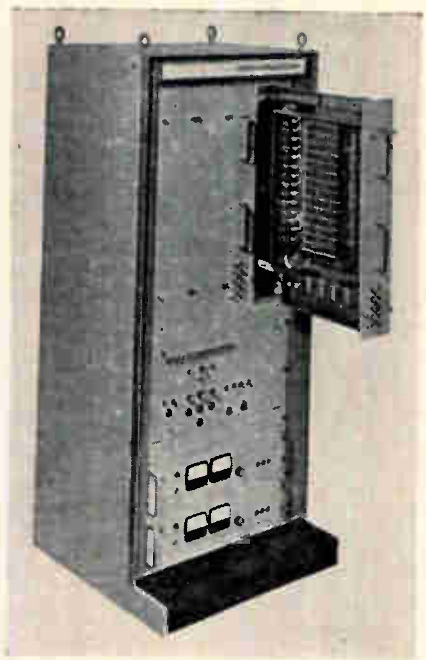
The world's fastest large-scale commercially available ferrite-core memory will make its debut at the Spring Joint Computer Conference in Boston, April 26 to 28. The Nanomemory 650, made by Electronic Memories, Inc., has a cycle time of 650 nanoseconds and an access time of 300 nanoseconds, for any of up to 16,384 words each of which may be as long as 84 bits.

This speed is attained with a 2½-dimensional organization, which combines the speed of a linear-select, or 2-D, design with the economy of a coincident-current, or 3-D, design. The cores are toroidal, similar to those in most conventional ferrite-core memories, with an outside diameter of 0.02 inch. The memory is faster than other big ferrite-core memories, and bigger than other fast memories, some of which are experimental only. [See p. 118; and Electronics, Dec. 28, 1965, p. 36, for example.]

The sketch below illustrates how the 2½-D combines the advantages of its 2-D and 3-D cousins.

A 2-D memory is organized as a single plane. It is expensive because, for high speed, a capacity of 2^n words requires decoding of n address bits.

Because a 3-D organization requires substantially less address decoding it is cheaper, but it is substantially slower. It is organized as a series of stacked planes; each plane contains one bit in each word contained in the memory.



In the 2½-D organization, the plane array resembles the 2-D; but the x-winding is doubled around to pass through two rows of cores. Current in the x-winding may pass in one direction or the other, depending on which of the two rows of cores is being addressed.

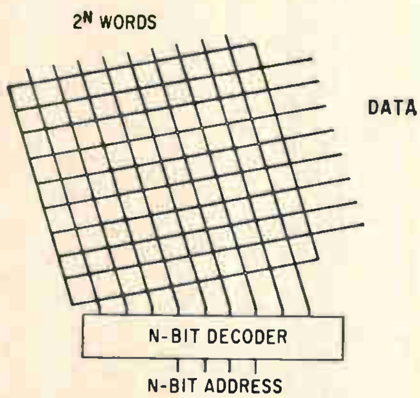
The Nanomemory 650 is complete with all electronic circuits in one package. However, only one side of the data register is available as output; if the user requires both 0 and 1 outputs, he must provide his own inverters in his own circuit package.

A price range of 6 to 8 cents per bit is quoted for the N-650. This comes to about $100,000 for the largest available size, 16,384 words by 84 bits.

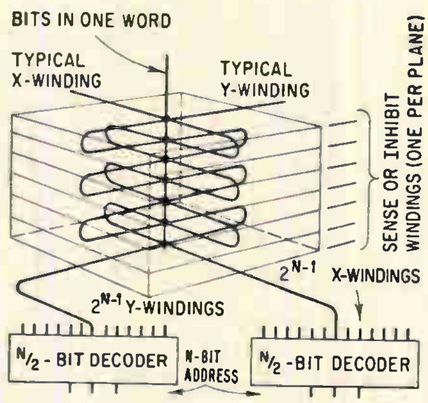
Specifications

Capacity	4,096, 8,192, or 16,384 words
Word length	8 to 84 bits
Operations	Read and restore Clear and write Read, modify and write (split cycle)
Cycle time	650 nanoseconds (read, write) 775 nanoseconds (minimum split)
Access time	300 nanoseconds
Input power	115 ±10 vac, 60 cps, single phase, 3 wire 700 watts normal, 1700 peak, typical (varies with word length)
Operating environment	+10° to +40° C., 90% relative humidity
Interface	Twisted-pair, either voltage or current. Either positive or negative voltage output (not both)
Weight	350 pounds
Delivery	4½ to 5 months

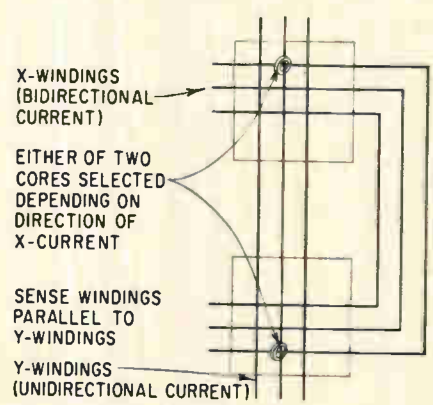
Electronic Memories, Inc., 12621 Chadron Ave., Hawthorne, Calif. 90250
Circle 350 on reader service card.



Two-dimensional organization is fast but quite expensive for large memories.

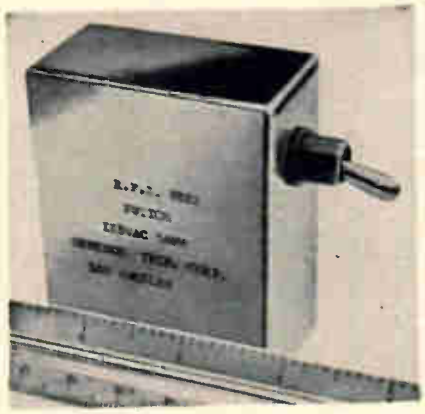


Three-dimensional organization is less expensive, but limited in speed.



Bidirectional current is part of address decoding in 2½-dimensional scheme.

Power switch without r-f interference



A switch for alternating-current power circuits, which can be opened and closed without generating excessively large interference transients, has been developed by the Genistron division of Genisco Technology Corp.

The device senses when the a-c line voltage is zero, switches the control circuit on and allows current to flow to the load thereafter. If the switch is closed at any other time in the a-c cycle, the sensing circuit waits until zero voltage is reached before it energizes the load.

When the switch is opened, the device waits until the load current is zero before turning the circuit off. This eliminates the abrupt discontinuity in voltage and current that causes high-frequency portions of conducted noise to be generated. The action of the switch also assures long life, since no damaging current surges occur. It also protects sensitive equipment, such as power semiconductors, from high-level switching transients.

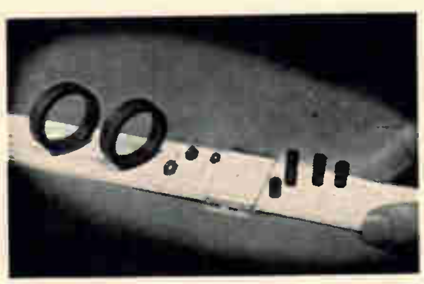
The switch is of solid state design and uses long-life, silicon semiconductor devices that are conservatively rated. The mechanical section of the switch only handles milliamperes of current at low voltage.

Specifications

Voltage	110-125 a-c, at 60 hz or 400 hz (cps)
Current	
Model no.	
RFS 115-5	5 amps
RFS 115-10	10 amps
Dimensions	1.5 x 2.8 x 2.5 in.
Weight	11 ounces
Mounting	Panel, ⅜ in. dia., hole
Noise	Meets Mil-I-26600
Delivery	4-6 weeks

Genisco Technology Corp., 6320 W. Arizona Circle, Los Angeles 45, Calif. **[351]**

Cores and toroids use soft ferrite ceramics



Safe ferrite magnetic material is available for commercial, military, and industrial electronic applications. The first shapes being produced are in the form of threaded cores and toroids.

The new materials are used in r-f coils for f-m radio and tv receiver circuits, discriminator circuits, telemetry, multiplex receivers, and i-f band circuitry. These applications require controlled permeability, Q and temperature stability.

Two basic grades of the company's soft ferrite ceramic magnetic materials have been developed, and will also be available in three or four sub-grades.

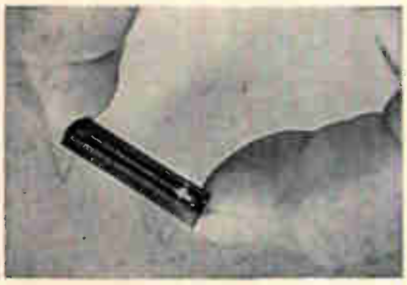
One of the two grades has an operating frequency range of approximately 1 kc to 1 Mc. The other grade operates in the megacycle frequency range.

Current production of the toroids and threaded cores is confined to several standard sizes from the manufacturer's tooling. These sizes include ¼-28 pitch and $\frac{10}{32}$ pitch threaded cores with hexagonal holes, ranging from ¼ in. to ¾ in. in length. The toroid sizes range from a ⅛ in. outside diameter to a 1.1 in. outside diameter.

Delivery from available tooling is three to four weeks. Present threaded core prices range from $15 per thousand to $25 per thousand and toroids from $50 per thousand. Custom-made parts will also be manufactured.

The Arnold Engineering Co., Box G, Marengo, Ill., 60152. [352]

Readout-out integrator with infinite memory



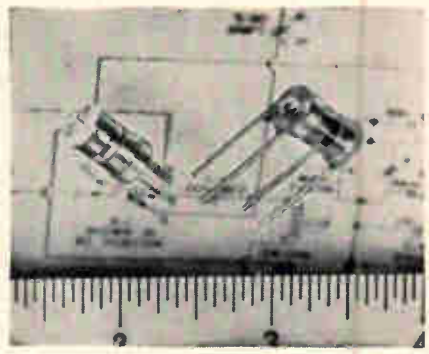
An electrochemical integrator offers both visual and electrical readouts and infinite memory capabilities. Model 304 integrator uses the manufacturer's ampere hour meter and differential capacitance read-out techniques to provide extremely accurate and symmetrically reversible long- and short-term integrations. Size, complexity, weight, power consumption and cost are substantially reduced compared to electromechanical devices performing similar integration functions.

Model 304 measures 1.1 in. long by 0.18 in. wide and may be used with any input signal between −2 ma and +2 ma. The input threshold is zero. The stored integral is retained indefinitely, regardless of power or other external factors. Total capacity is a 4-inch stored integral.

The integrating element consists of a capillary tube filled with two columns of mercury separated by a gap of aqueous electrolyte. The input signal electroplates mercury across the gap at a rate that is a direct function of the input signal's amplitude, which causes the gap to move. The outside of the capillary tube is covered by a vapor-deposited conductive sheath. The capacities between this sheath and each electrode are differentially proportional to the electrolytic gap's position and therefore to the integral of the input signal. This capacity is sensed by superimposing an a-c signal on the input signal. The amplitude of the output a-c is a direct and very linear function of the integral.

Curtis Instruments, Inc., 351 Lexington Ave., Mount Kisco, N.Y., 10549. **[353]**

Metalized-glass trimmer capacitor



A metalized-glass miniature trimmer capacitor is claimed to have capacitance ranges up to three times greater than previous models. The Mini/High Capacitance trimmer is available in four capacitance ranges, in both panel mount and printed-circuit styles.

Company engineers said the new trimmer offers smaller size for capacitance ratio than available in competitive production printed circuit styles, and comparable size in panel mount styles. Nominal lengths of the standard units are from ½ in. to 1⅛ in. Capacitance ranges in standard production sizes now available are 1 to 12, 1 to 24, 1 to 36 and 1 to 48.

The hermetically sealed construction of the metalized-glass assembly, coupled with the Mini-Trimmer mechanism, is ideal for miniaturized circuits requiring greater capacitance adjustments. The new units will meet complete test requirements of Mil-C-14409B.

Temperature coefficient of capacitance is ±50 ppm/°C. Q factor

Meet the DC voltage standard with:

STABILITY WITHIN 15 PPM

...for 7 days, 25 ppm for 6 months.
Recorded stability history available.

0.003% ACCURACY

...ensured by temperature-controlled precision Zener reference.

IMMEDIATE DELIVERY

...the COHU Model 326 is off-the-shelf...like the entire family of COHU DC voltage standards.

...and voltages from 0 to 1222.2221 in 3 ranges; steps as small as 1 μv.

Price: $2490.00 F.O.B. San Diego, additional export charge.

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SAN DIEGO CALIFORNIA

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TIME CODE GENERATOR

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Integrated-circuit logic
5 simultaneous time codes
Change code by inserting new circuit card
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Circle 181 on reader service card

New DC Scope!

... the Heathkit® IO-14

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A 5" DC scope with calibrated time base & 5X sweep magnifier. For 115/230 volt, 50-60 cycle operation.
Kit IO-14, 45 lbs. $299.00
Assembled IOW-14, 45 lbs. $399.00

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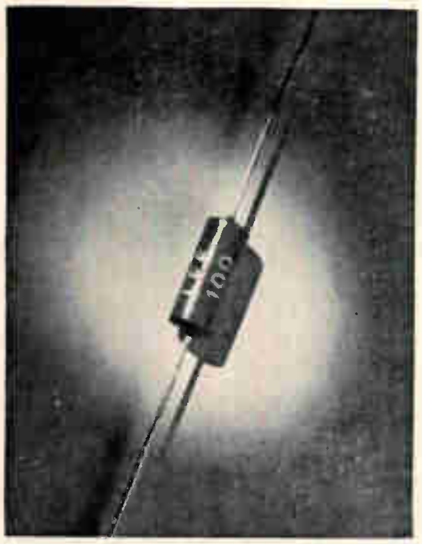
Name________
Address________
City________ State________ Zip________

Prices & specifications subject to change without notice. TE-141

Circle 438 on reader service card

is guaranteed as 500 minimum at 1 Mc. Working voltage is 1,000 v.
LRC Electronics, Inc., Horseheads, N.Y. [354]

Shielded inductors for printed circuits



The Micro-Red subminiature shielded inductors offer an inductance range of 0.10 μh to 10,000 μh in an envelope size 0.335 in. long by 0.125 in. diameter. They are specifically designed for density circuitry.

The manufacturer claims they set a new industry standard with exceptional Q values, ranging from 40 to 85 over the inductance range. These inductors are offered in 61 predesigned values for stock delivery and are designed to meet Mil-C-15305, Class 1, Grade B.
Lenox-Fugle Electronics Inc., 475 Watchung Ave., Watchung, N.J. [355]

Multiconductor cables offer size reductions

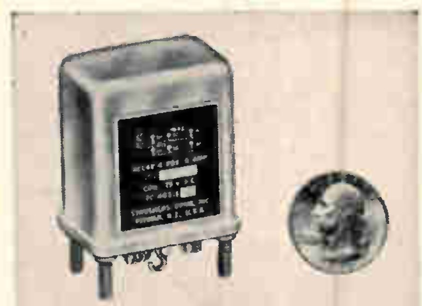
Miniaturized round multiconductor cables are now being marketed. Using MIL-ENE polyester laminate insulations, the cable shown at right offers size reductions as great as 50% over cables in which individual conductors are insulated with more conventional PVC. Only four mils of MIL-ENE insulation provide the electrical and mechanical properties of ten mils of PVC.

Combining the MIL-ENE primary insulation with jackets of polyurethane, finished cables are stronger, more flexible and substantially smaller than those previously available. A wide range of specially designed cables are available incorporating twisted triads, pairs and quads along with co-axes, shielded and unshielded leads.

Cables are produced to customer specifications with deliveries running six to eight weeks. Prices vary with constructions.

W.L. Gore & Associates, Inc., 555 Paper Mill Road, Newark, Del., 19711. [356]

Hermetically sealed aerospace relays



Hermetically sealed relays with two-pole, double-throw contacts are rated for 10-ampere resistive loads at 28 v d-c or 115 v, 400 cps. Designed to MIL-R-6106E specifications, drawing MS25273, the units are for aircraft, missile, ground support, and other aerospace applications. Bifurcated movable contacts are used on both types to insure contact reliability under extreme vibration and shock.

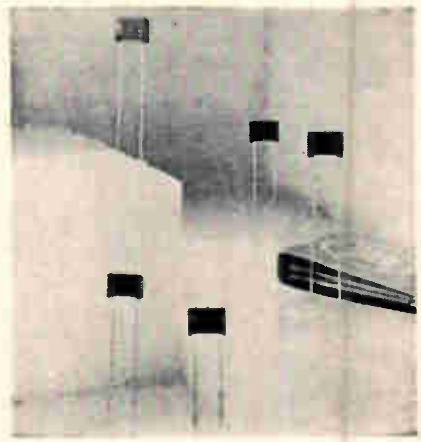
Two models with solder hook terminals are currently available. Both measure 1.531 in. wide by 1.1 in. deep by 1.781 in. above the mounting surface. Type FC-402-1 has a d-c coil nominally rated at

28 v., 0.25 amp. The FC-402-2 has a self-contained rectifier for a-c coil operation at 115 v, 400 cps, 0.07 ampere.

Both relays are available on an approximate six-week delivery basis. Prices are in the $14 range for types with d-c coils, $20 for a-c operated types.

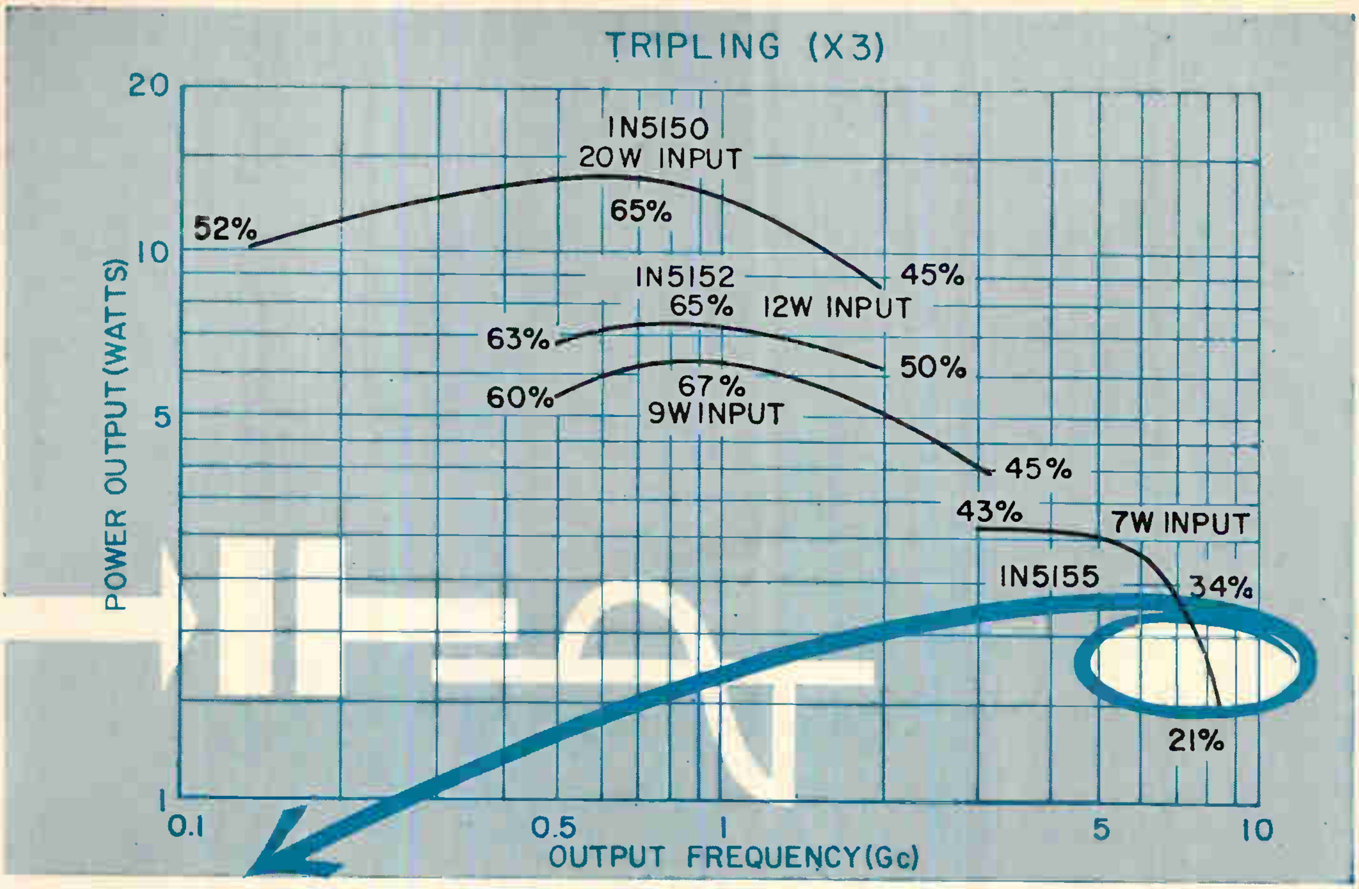
Struthers-Dunn, Inc., Pitman, N.J., 08071. [357]

Military quality glass capacitors



Low-cost glass capacitors meet or exceed all the performance requirements of military specification MIL-C-11272. Type CYW-6 capacitors are designed for tuned r-f and analog circuits; for signal generating, shaping, and handling; and for critical applications requiring exceptional stability and repeatability in addition to low drift and losses.

Capacitance range of the CYW-6 is from one through 560 pf at a voltage rating of 300 v d-c, permitting the capacitors to be used in either transistor or vacuum tube circuits. The injection-molded plastic case, which houses the same kind of glass capacitor element used in higher priced military-type CY units features tiny feet that raise the body of the case off the circuit board to effect more reliable soldering and facilitate cleaning of the board surface. The upright mounting also contributes to higher efficiency in circuit packaging. Standard lead material is gold-plated dumet, which is both solder-



1.8 WATTS at 8000 MHz

...typical microwave performance of Motorola's NEW 1N5154/5 High-Power, Step-Recovery Varactor.

If unmatched power and efficiency at microwave frequencies up to 8000 MHz is one of your specific design goals, you'll want to check the specifications on the high-powered performance of the four new Motorola large-area, step-recovery varactors shown here.

You'll find each unit an ideal frequency-multiplier for high power at microwave frequencies for transmitters, local oscillators, one-step high-order multipliers, reference frequencies, broadband circuits, parametric amplifier pumps, and other UHF and microwave applications.

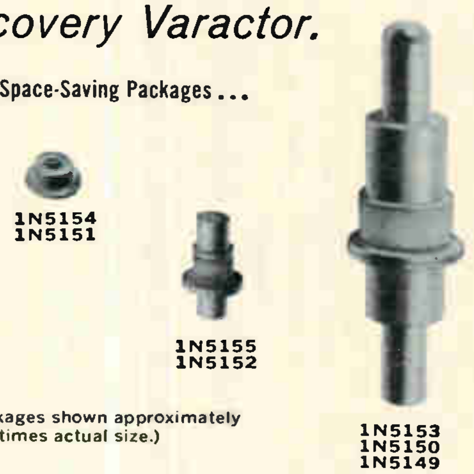
Another pleasant surprise is the price—as low as $18.00 each (100-up)!

Call your franchised Motorola distributor for immediate delivery on the types you'll want to try right now! For data sheets and application notes, write to: Dept. 031, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

*(We guarantee minimum tripler 2-watts output at 6 GHz with 40% efficiency.)

MOTOROLA Semiconductors

Three Space-Saving Packages...



(Packages shown approximately $2\frac{1}{2}$ times actual size.)

GUARANTEED TEST PERFORMANCE

	INPUT		OUTPUT			
Product Type	Frequency	Power	Frequency	Min. Power	Min. Efficiency	Price Each (100-Up)
1N5154/5	2 GHz	5 Watts	6 GHz	2 Watts	40%	$28.00
1N5151/2/3	1 GHz	12 Watts	2 GHz	6 Watts	50%	28.00
1N5150	.5 GHz	37 Watts	1 GHz	24 Watts	65%	28.00
1N5149	.5 GHz	20 Watts	1 GHz	11 Watts	55%	18.00

able and weldable.

Prices of the CYW-6 glass capacitors range from 27 cents to $1.44 each in quantities above 1,000. Delivery is from 4 to 8 weeks after receipt of order.

Westinghouse Electronic Capacitor Department, Box 130, Irwin, Pa. [358]

Low loss co-ax-relay uses reed switch

A coaxial relay using a special high-frequency, Form A contact miniature reed switch as the switching element has been developed for use in low level r-f switching for communications and instrumentation applications.

The proportions of the reed switch, and its associated insulation and shielding, have resulted in a unit whose characteristics closely match those of coaxial cable. The relay's excellent impedance match and minimal line disturbance are apparent by a vswr of 1.05 and an insertion loss of appreciably less than 0.1 db. Line isolation is 44 db at 100 Mc with switch open.

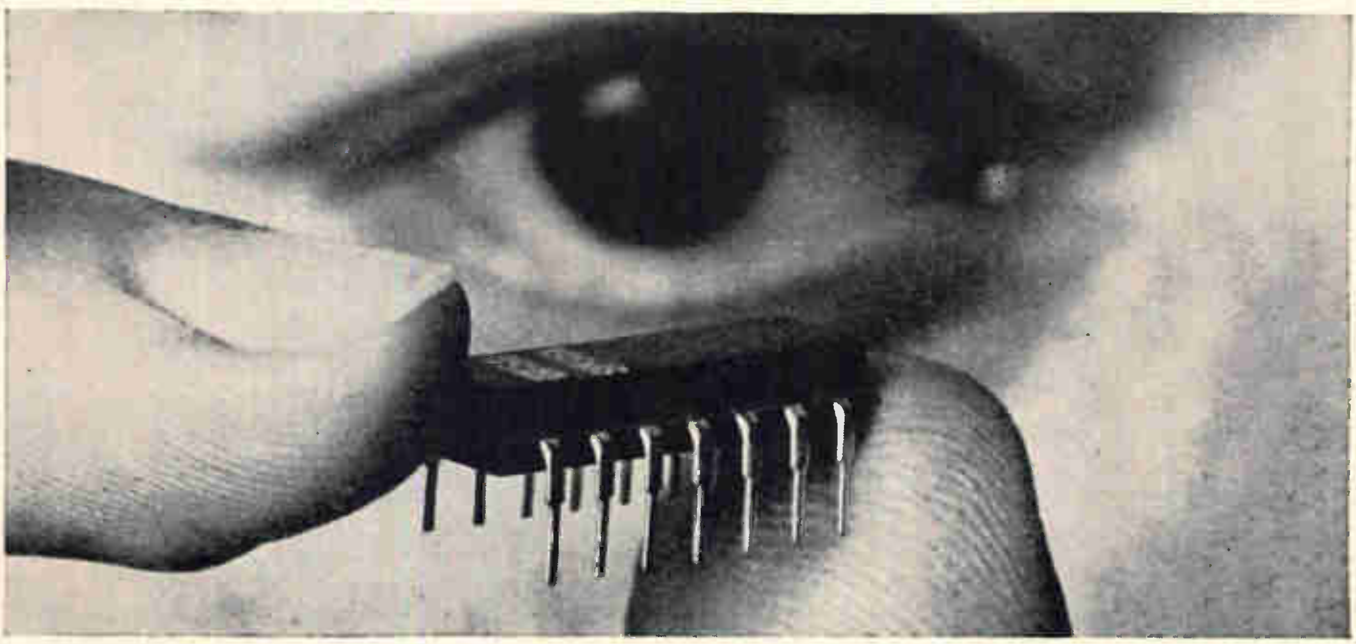
Known as the Duncoaxial relay, the unit is housed in a steel enclosure measuring approximately $1\frac{5}{16}$ in. long x $\frac{17}{32}$ in. square, less connectors. Coaxial connectors are mounted at each end. Subminiature r-f connectors of 50 ohms and 75 ohms impedance are standard.

Coil power requirement is approximately 0.4 w with nominal voltages of 6, 12, and 24 v d-c. Contacts are rated for continuous currents of 10 ma or less and open

Should you buy Signetics new SP600 series dual in-line plug-in packages just because they're low-priced?

No, there are better reasons.

They contain multi-function DTL circuits, for one.



For another, the SP600 package is monolithic. A solid epoxy block encapsulates both the circuit chip and the leads connecting it to the external plug-in pins. Result: mechanical ruggedness and built-in vapor barrier protection for the circuit. The new SP600 series package has been tested and stressed to levels far in excess of those required by MIL-S-19500D and MIL-STD-750, even though it is intended for commercial applications. Handling and insertion ease are guaranteed by 100 mil center-to-center pin spacing and 300 mils between rows conforming to widely accepted circuit board drill patterns. Mechanical or hand insertion and high-volume flow soldering techniques can be used on all Signetics SP600 series circuits. For the other umpteen reasons, write for your free copy of our SP600A brochure.

SIGNETICS INTEGRATED CIRCUITS
A subsidiary of Corning Glass Works,
811 East Arques Avenue, Sunnyvale, California
Tel.: (408) 739-7700 TWX: (910) 737-9965

Signetics SP600 series includes a J-K flip-flop, three multiple DTL gate packages (dual, triple and quadruple NAND/NOR), a quadruple gate-input expander, and a dual DTL line driver/buffer element.

Circle 187 on reader service card

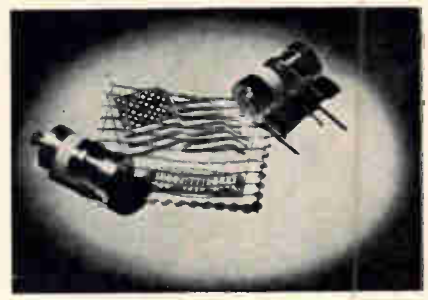
New Components

circuit voltages of 10 v d-c or less.

The relay is priced in the $20 to $40 range, depending upon quantity. Delivery is approximately six weeks.

Struthers-Dunn, Inc., Pitman, N.J., 08071. [359]

Miniature capacitors are air-variable

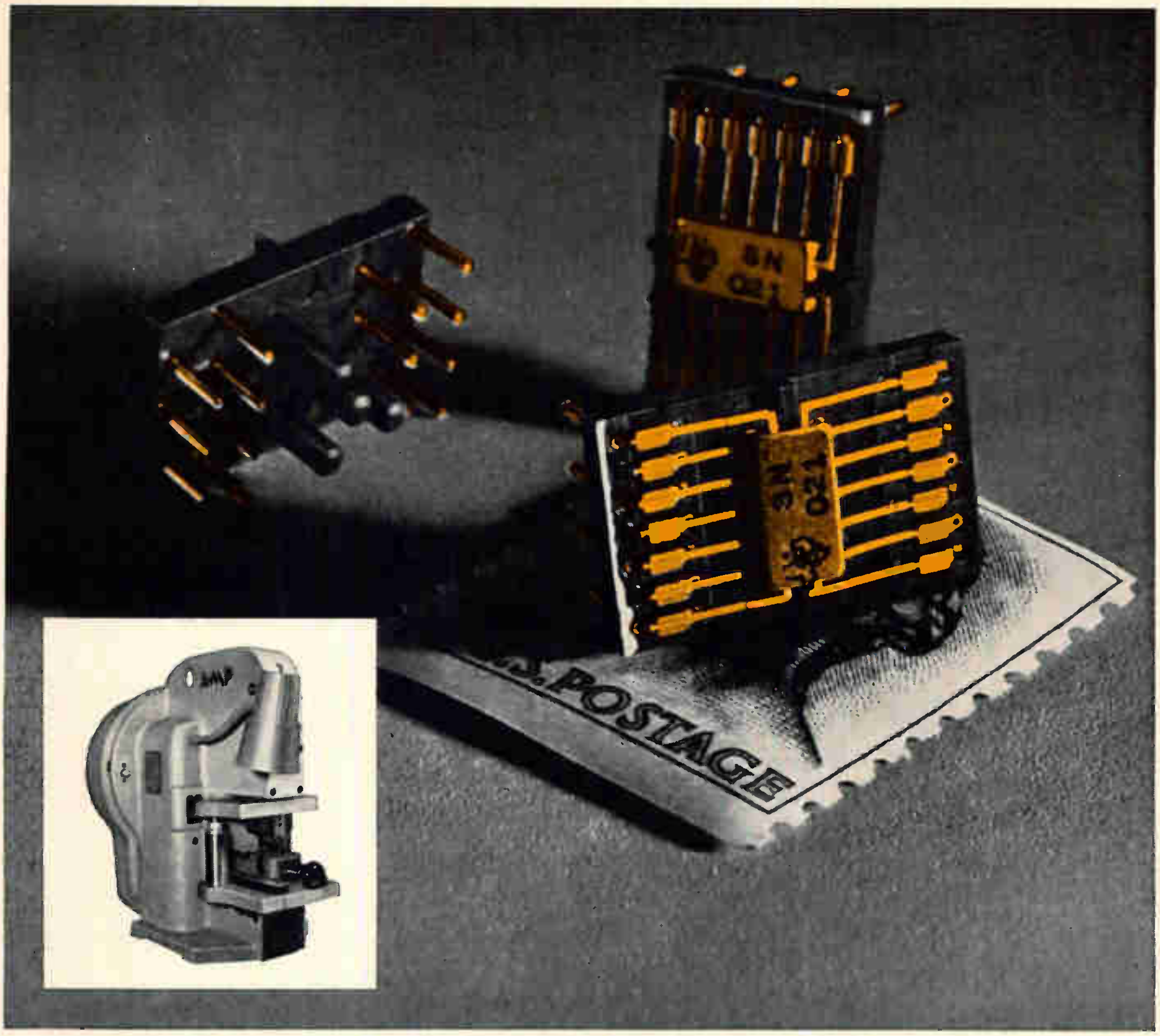


Extremely high Q and greater capacitance values are featured in the VAM series miniature air-variable capacitors. The small, rugged units have a Q factor of greater than 2,000, measured at 100 Mc and 10 pf. They offer very low losses at higher frequencies. Capacitance range is from 0.8 to 10.0 pf measured at 1 Mc. Designated VAM 010 and VAM 101W, they are designed for panel mounting or printed circuit use, respectively.

Insulation resistance is 10^4 megohms at 100 v d-c and 25°C. Units are gold plated to prevent corrosion damage and for high surface conductivity. A high-density insulator between rotor and stator provides excellent structural strength as well as electrical characteristics. Rubber-gasketed threaded end caps effectively seal the units against contamination after tuning.

The new capacitors measure approximately ½ in. long and $\frac{11}{64}$ in. in diameter. They have a working voltage of 250 v d-c and a test voltage of 500 v d-c. Measured through an operating temperature range of −55° to +125°C, their temperature coefficient of capacitance is 0 ± 20 ppm/°C.

JFD Electronics Corp., 15th Ave. at 62nd St., Brooklyn, N.Y., 11219. [360]



GANG CRIMPING

A new breakthrough in integrated circuits

All 14 ribbon leads of the flat pack above were crimped simultaneously to pins on our new AMP-CRIMPAC* Header . . . a feat of engineering that only a leader in crimping techniques would attempt.

Frankly, it wasn't easy—even for us.

For one thing, we had to use plastic as the anvil for the crimping dies. Nobody had ever done that before. Then, we had to make the pack's .050″ mounting centers compatible with existing wiring techniques. And, to top it off, the whole system had to be completely trouble-free and uniformly reliable.

Here's how we did it. We made the AMP-CRIMPAC Header of sturdy phenolic and molded in 14 pins, staggered so that they come through on .100″ centers. We designed a precision automatic machine to gang crimp all 14 of the pack's leads at once. After encapsulation, the pack assembly is as rugged as a transistor can or other plug-in component. It can either be plugged and soldered directly onto printed circuit boards, or plugged into an AMP-CRIMPAC Receptacle.

The receptacle attaches to the system panel and is provided with posts that accept AMP's TERMI-POINT* clips for automatic or manual back-panel wiring. Both the header and its mating receptacle are color-coded, polarized, and keyed for optimum control during production and in field maintenance.

Why go to crimping in integrated circuits? Consider the evidence:

- Reliability is controllable and repeatable
- No heat damage to the circuit function
- No need for bending or pre-forming pack leads
- Exceptionally fast assembly
- Less capital outlay for equipment
- Available for all 1/4″ x 1/4″ or 1/4″ x 1/8″ flat pack applications

Now you can enjoy system maintainability right down to the single flat pack circuit. Write for more information on AMP-CRIMPAC Headers and Receptacles today.

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AMP
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Harrisburg, Pennsylvania

INDUSTRIAL SALES DIVISION

A-MP★ products and engineering assistance available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

Circle 189 on reader service card

D-c dvm measures a-c within 0.02%

A plug-in a-c to d-c converter now makes it possible to measure a-c voltages with an integrating type digital voltmeter and achieve an accuracy within 0.02% of full scale. The DT-1404 plug-in, developed by the Data Technology Corp., can be used with the company's six-digit d-c voltmeter and also provides common-mode noise rejection of 140 decibels at 60 cycles per second.

The plug-in is essentially a rectifier and filter that convert the a-c input signal to a d-c signal proportional to the rms value of the a-c input. This signal is accurately measured and displayed by the d-c dvm. Although conceptually simple, the converter is a complex device, which the company claims overcomes many problems of a-c measurement with a digital voltmeter.

The a-c input, which can range from 1 volt to 1,000 volts, is applied to an attenuator circuit. The attenuator output is summed at the junction of a high-gain operational amplifier with feedback from diodes at the amplifier's output. Two feedback paths are needed so that both the positive and negative half cycles of the rectified output appear at the summing junction. The rectifier output is also applied to the filter which smoothes the half-wave rectified signal before it is applied to the digital voltmeter.

To compensate for the effects of stray capacitance, the resistors in the attenuator are paralleled with trimmer capacitors. Glass dielectric capacitors are used throughout the DT-1404 to minimize any nonuniform capacitance changes that may occur over the instrument's operating frequency range from 50 cps to 10 kc.

Leakage resistance in the attenuator as high as 10^{10} ohms causes a 0.01% error in an instrument of this type, so engineers at Data Technology mounted the attenuator resistors on terminals over a grounded plate. This established the leakage path from the terminal to ground, rather than across the resistor itself.

All the measuring circuits are contained in an isolated guard shield, which is the third wire of the input circuit. This provides the instrument with high common-mode noise rejection. A multiple-pole output filter provides sufficient ripple attenuation for stable readings.

Although the plug-in is packaged to fit the company's DVX-315 digital voltmeter, it can be used separately wherever a a-c to d-c conversion is required because it contains its own power supply and shielding.

Specifications

Input impedance	Greater than one megohm shunted by less than 20 picofarads
Input voltage range	1 v rms full scale to 1,000 v rms full scale in four ranges
Input frequency	50 cps to 10 kc
Linearity	±0.01% of reading ±0.01% of full scale relative to best zero-based straight line
Overall accuracy	±0.02% of full scale
Output	Push-pull, d-c output proportional to full wave average value of pure sine wave input, calibrated to indicate rms
Power	115 v, 60 cps, less than 5 va

Data Technology Corp., 2370 Charleston Rd., Mountain View, Calif. 94040 [361]

Coulometer presents data in digital form

An electronic measuring instrument has been developed that displays directly in coulombs. (A coulomb is one ampere-second.) The instrument is a refinement of an ampere-hour recorder and process controller made by the company for several years for the electroplating industry.

The coulometer (or coulomb meter) is a semiconductor device that integrates the voltage developed across a current shunt with time for presentation in digital form to an accuracy of better than 1% ± one digit. A front panel switch selects internal shunts for full-scale ranges of 0.01, 0.1, 1.0 and 10.0 amperes. Decimal point position to the digital presentation is directly identified by each switch position.

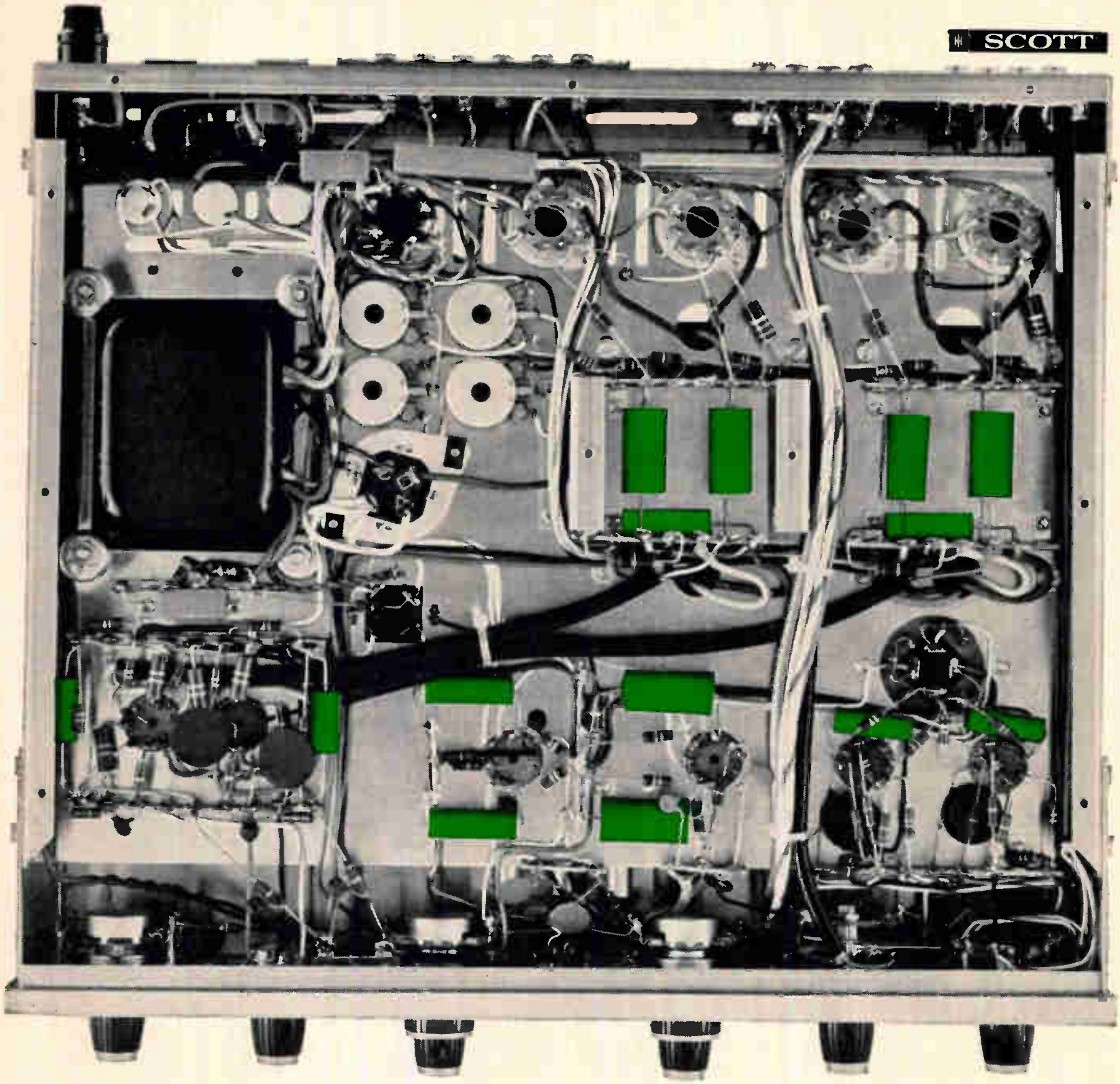
The electromechanical counter is equipped with a manual reset. Electrical connections are provided on the rear of the instrument to connect the pulse output to external equipment for automatic printout, data accumulation, separate count accumulation or special process control. The instrument operates from 115 v 60 cps single phase.

The instrument is expected to have many applications in research and quality control. Special variations of the unit for time integration with voltage, current or temperature will be furnished on special order. Model VT-1176 coulometer is available from stock at $350.

Vari-Tech Co., 546 W. Leonard, Grand Rapids, Mich. [362]

Temperature recorders are 0.02% accurate

Expanded scale recording of temperature and absolute accuracy of 0.02% are features of a new line of temperature recorders. The CR-207 series recorders do away with the necessity of cold junction compensation or ice bath reference junctions in temperature measurement. Temperature sensing is by means of wire resistance thermometers. Any platinum, nickel iron, or nickel unit in patch type, tubular type, air sensing type, immersion



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 Du Pont Co., Room 3370A, Wilmington, Delaware 19898. (In Canada, write Du Pont of Canada Ltd., P.O. Box 660, Montreal 3, Quebec.)

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style, etc., may be used. The instrument uses a precision Wheatstone bridge with high sensitivity magnetic amplifier null detector to determine the resistance of the sensor, and hence its temperature. Readout is on a front panel digital dial. Absolute accuracy is to 0.02%.

The temperature indicator and recorder of the CR-207 are of the expanded scale type which is capable of monitoring extremely small deviations in temperature. With typical resistance sensors, a span of as low as 0.3°C can be spread across the full scale of the indicator and recorder making 0.01°C easily observable. Larger spans may, of course, also be selected by adjustment of the front panel span switch, which has seven pre-calibrated positions.

The recorder on the CR-207 is synchronously driven, so chart times are exact. The total time may be changed by a gear change lever to 1, 7, or 30 hours for one model, or 1, 7, or 30 days for the second. The recording is inkless and is done from behind the chart, so no part of the trace is obstructed from view. Any desired notation may be made on the chart paper in either ink or pencil.

Harrel, Inc., 16 Fitch St., E. Norwalk, Conn., 06855. **[363]**

Wave analyzer with digital display

Model 301A wave analyzer permits the user to examine fundamental frequencies, harmonics, and other components of any signal in the range of 20 cps to 100 kc. Frequency resolution is specified as ±(1% + 10 cps) from 20 cps to 10 kc, and ±100 cps for 10 kc to 100 kc.

The instrument contains a digital frequency display that is direct-reading in kilocycles. The five-digit display provides numerical values in 10-cps increments, with 2-cps interpolation marks. A tuner motor drives the instrument across the full range of 20 cps to 100 kc in approximately 35 seconds.

The 301A also contains provisions for operation as a tracking signal generator or as a selective voltmeter with restored signal output. In the signal generator mode, the frequency of the output is the same as that to which the voltmeter is tuned.

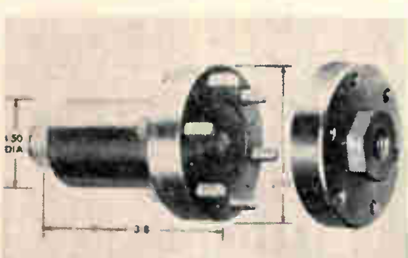
Frequency-response measurements can be made by turning only one knob. Both voltmeter and signal generator are automatically tuned to the same frequency. The output level of the generator is held constant within ±0.5 db across the full frequency range.

As a voltmeter with restored signal at the output (identical in frequency with the input signal), the 301A provides a filter effect to isolate one signal out of a group, or a signal partly masked by noise, and amplifies it for greater resolution and measurement accuracy.

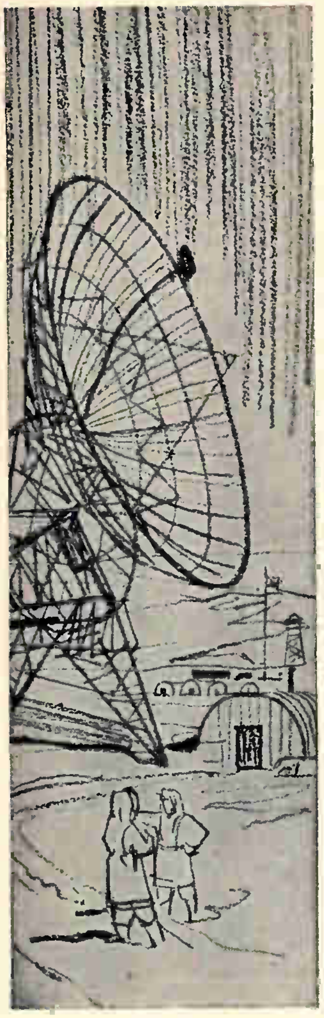
Full-scale voltage ranges cover from 30 μv to 300 v. The instrument also reads dbm directly on 600-ohm circuits at full-scale levels from +50 to −90 dbm, with ±0.5-db accuracy. Price is $1,995.

Sierra/Philco, 3885 Bohannon Drive, Menlo Park, Calif., 94025. **[364]**

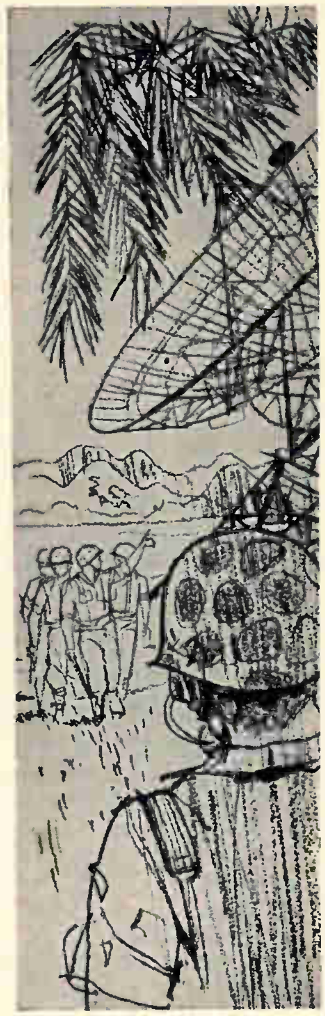
Pressure transducers rated to 3,000 psi



A series of pressure transducers consists of five units with capabilities of 15, 100, 300, 1000 and 3000 psi. The 1281 series is designed for use in industries such as aerospace, petroleum, chemical, hydraulics and others. The pressure sensors operate on a variable inductance



ACTUAL SIZE



bridge principle in conjunction with carrier amplifiers and are for use with such recording systems as Sanborn models 31, 321, 350 series, 7700 series, and 950 series.

Contact material is 17-4 stainless steel and the transducer housing is of nickel plated steel. The temperature range of —40°F to 250°F allows accurate operation with a thermal zero shift of 0.01% per degree. The 1281 series pressure transducers exhibit a 0.5% linearity, and 8 mv per volt of excitation sensitivity, and have high overload protection. The units measure 2.50 in. in diameter by 3.8 in. high, and weigh 24 oz. They can be flush-mounted or with threaded adapters.
Sanborn Division, Hewlett-Packard Co., 175 Wyman St., Waltham, Mass., 02154. [365]

Portable bridge spans wide values

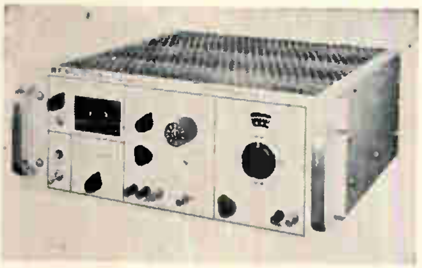
A versatile, portable bridge (model 4959) provides accurate, sensitive and convenient measurements over wide spans of conductance and resistance values. When used with appropriate conductivity cells, it is ideally suited for measuring electrolytic conductivity or resistivity of grounded or ungrounded solutions extending from ultrapure demineralized water to strong acids, bases or salts.

A dual range permits operation from 0.5 to 105,000 microhms or 9.5 to 2 million ohms, based on the use of a 1.0 cm^{-1} cell. An adjustable dial permits compensation for a wide range of cell constants and solution temperatures.

When properly adjusted using the compensation-factor calculator supplied with the bridge, the instrument reads out directly in specific conductance and specific resistance.

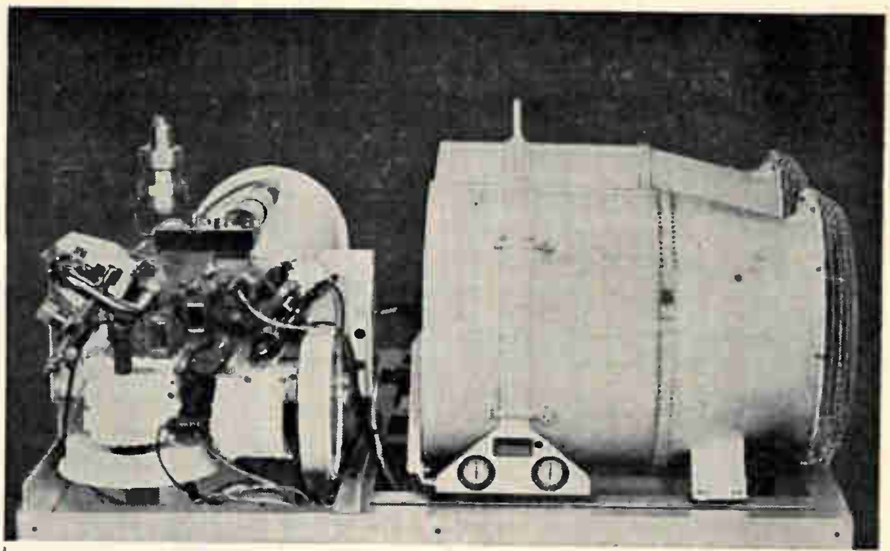
Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. [366]

Modular, solid state servo analyzer



A general-purpose servo analyzer, model 910 Servodyne finds broad application in servo system testing and transfer function analysis. The unit incorporates a precision electronic function generator and high-accuracy variable phase reference. The function generator provides sine, triangle, square and ± peak reference output signals (unmodulated or modulated) whose amplitude is accurately presettable. These signals serve as the drive, or forcing function, to the servo or network under test.

A signal from any desired point in the test unit is compared via an external oscilloscope (not supplied) with the drive signal to obtain a measure of amplitude ratio between drive and test signal. A separate variable-phase signal from the Servodyne enables the operator to determine phase of the test signal. Frequency of the forcing function is preset, in three decades, from 0.01 to 99 cps using panel-mounted thumbwheel switches. Frequency is accurate to ±2% of setting. Amplitude is continuously adjustable over three ranges: 0 to 100 mv, 0 to 1.0 v, and 0 to 10.0 v; and may be preset to an accuracy of ±2% of setting, ±5 mv (±0.5 mv on the lowest range). The variable-phase reference is continuously adjustable from 0 to ±180° and can be

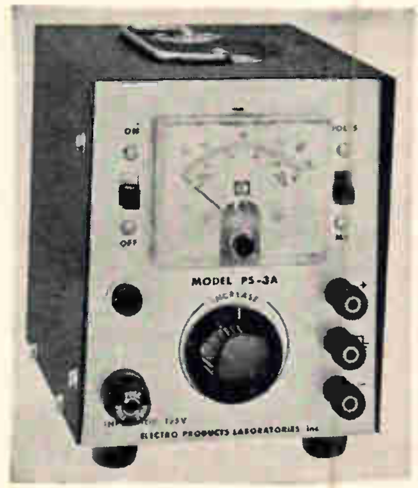


set with ±1° accuracy.

All input and output signal returns are electrically isolated from chassis. Instrument construction is modular solid state with all circuits packaged as plug-in printed circuit boards.

Canoga Electronics Corp., 1805 Colorado Ave., Santa Monica, Calif. **[367]**

Power supply offers 0.02% regulation



Model PS-3A d-c power supply offers 0 to 25 v d-c at 0 to 200 ma; and 0.02% line or load regulation. Maximum ripple is 0.5 mv. The unit also offers a 12-to-1 ratio for output voltage adjustment.

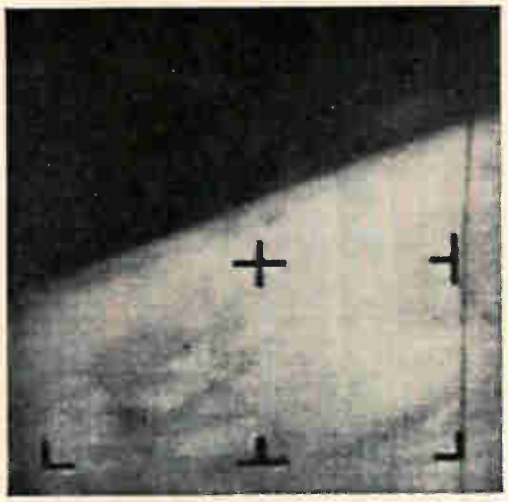
The supply provides dependable performance for designing transistor circuits, and for development, testing and equipment-operation applications. It also serves as a bias supply for vacuum-tube circuitry.

D-c voltages remain constant regardless of load, within ratings, at any output voltage; and regardless of a-c input supply voltage fluctuations between 105 and 125 v a-c, 60 cps.

Other features include: special internal reference and stabilization circuitry, floating output terminals with separate chassis ground terminal, and 2% accuracy D'Arsonval meter for monitoring voltage and current. Size is 6¼ in. high x 5 in. wide x 6 in. deep. Weight is 3½ lbs. Price is $99.95.

Electro Products Laboratories, 6123 W. Howard St., Chicago, Ill., 60648. **[368]**

If you want to capture signals from way way out,



record them on the tape with total recall

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PRECISION MAGNETIC TAPE

VISIT BOOTHS 420 & 430
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When you put a reel of Memorex instrumentation tape on your transport, you can expect the most reliable performance, 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 instrumentation tape specification data and a bibliography of technical information available without obligation from the Memorex library of reprints.

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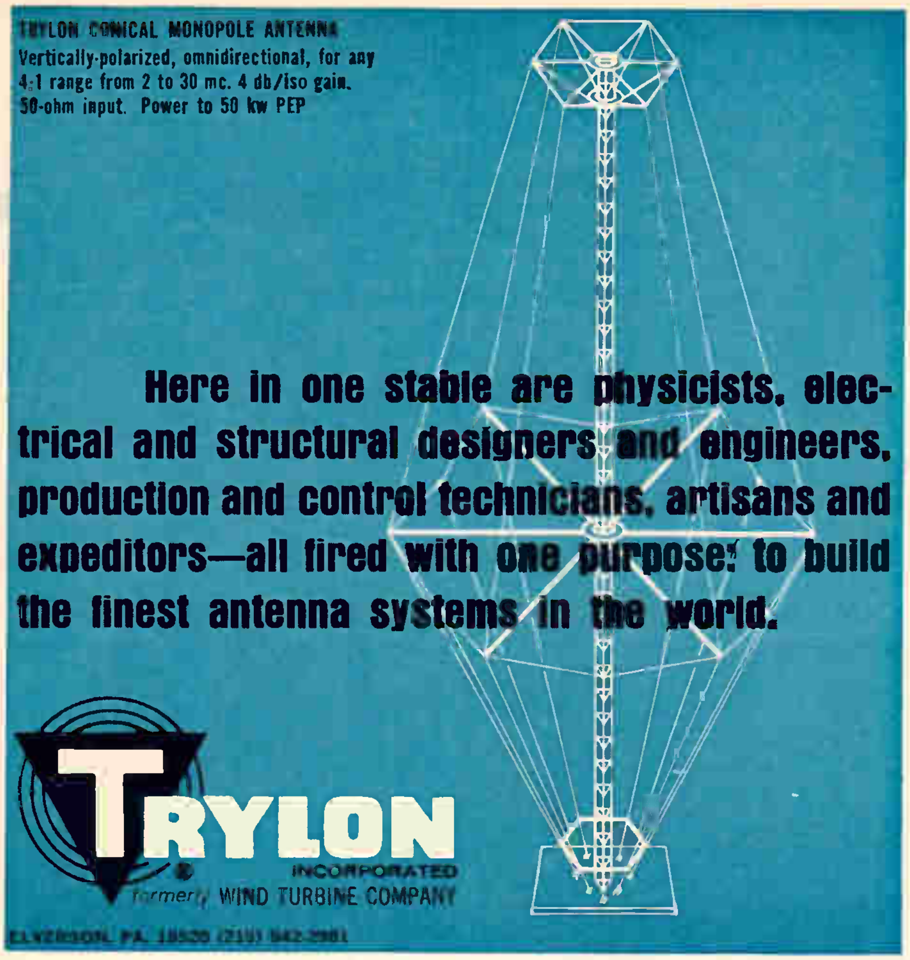
Circle 199 on reader service card



New Semiconductors

Power transistors have 50-Mc response

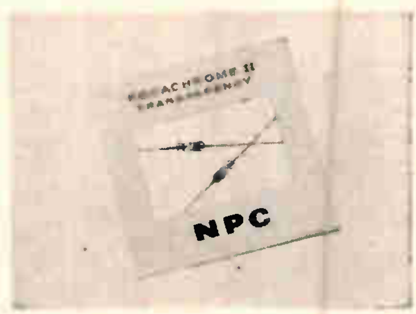
A line of high voltage silicon power transistors is announced. These 10 amp planar n-p-n units feature collector to emitter breakdown voltages from 200 v to 325 v. They are offered in the TO-3 package and have a frequency response of 50 Mc and a base capacitance of 150 pf.

The transistors are suited for use in high voltage inverters and switching regulators, tv deflection circuits, as well as all line voltage switching and amplifier applications.

The series is MHT 7201 through MHT 7205; prices in 100 quantity are from $52 to $100.

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. [371]

High reliability silicon diodes



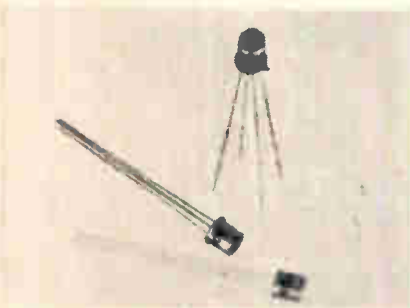
A line of high reliability, silicon planar epitaxial diodes is designed for high speed switching and computer applications. Types 1N914, 1N914A, 1N916, 1N916A and 1N3064 miniature glass silicon diodes are packaged in a standard DO-7 case. Application of advanced epitaxial technology provides greater reliability, increased yield, and reduced cost. It offers extremely low forward voltage drop at higher forward current.

The chip, prior to final hermetic seal, receives a surface passivation which provides a hermetic seal in itself, eliminates photo effects and improves stability. Operating over a temperature range of −65° to +175°C, these high performance diodes have a peak reverse voltage of −100 v for types 1N914 through 1N916A, and −75 v for type 1N3064.

Maximum reverse current is −50 μa for types 1N914 through 1N916A at a reverse voltage of −20 v and ambient temperature of 150°C, and −100 μa for type 1N3064 at a reverse voltage of −50 v and ambient temperature of 150°C. Maximum reverse recovery time is 4 nsec at 25°C.

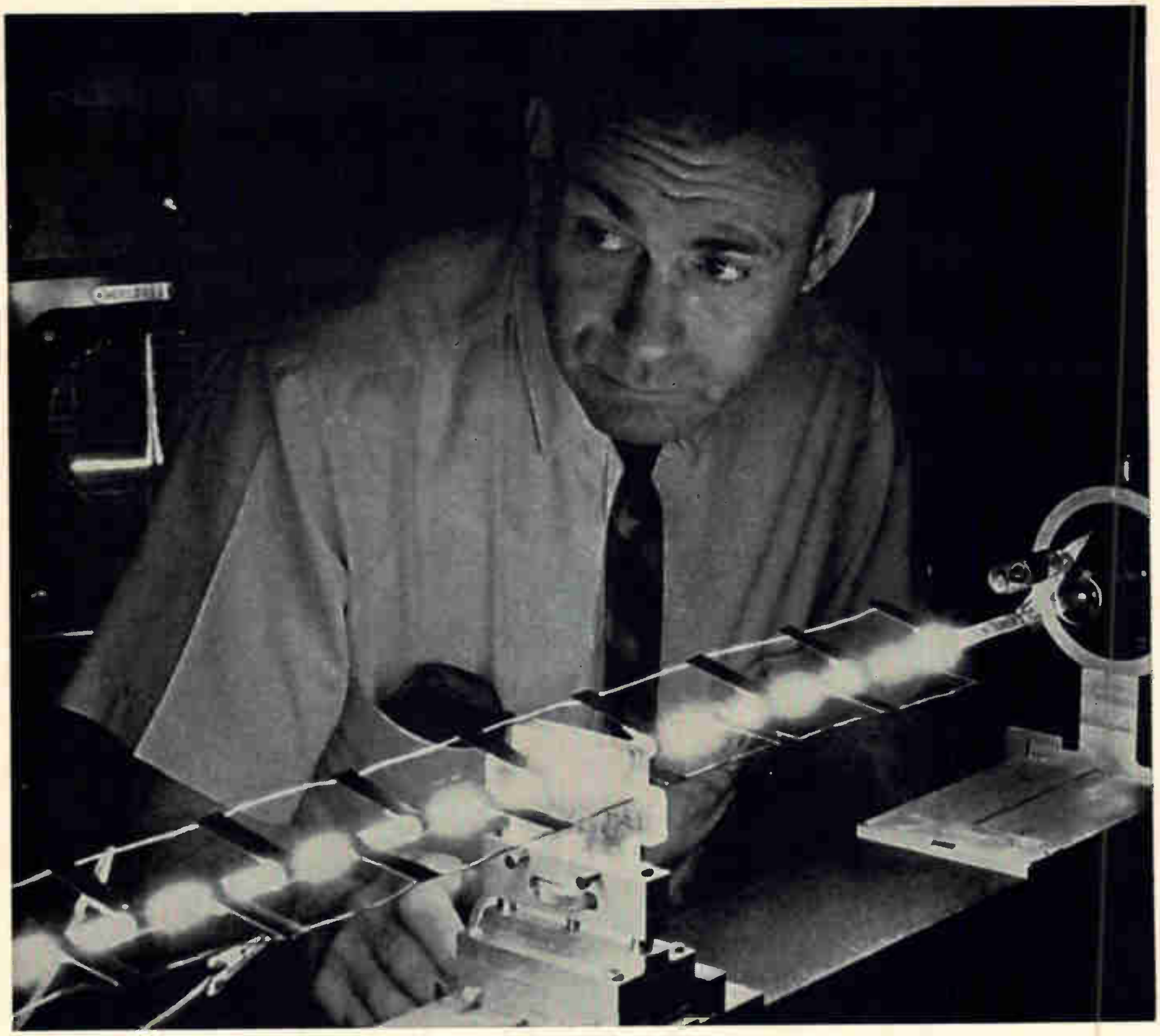
Nucleonic Products Co., Inc., 3133 E. 12th St., Los Angeles, Calif., 90023. [372]

Solid state isolator is photon-coupled



Model 4310 is a solid state photon-coupled isolator with an injection luminescent photon source and an improved silicon p-i-n diode photodetector. The photon source is an improved gallium arsenide diode. The isolator, packaged in a 4-lead JEDEC TO-18 hermetically sealed case, can be used on printed circuit boards as a conventional semiconductor component. The anode of the input diode is connected to the case.

The non-photon coupling between the input and output is 2 pf and 10^{11} ohms. The working voltage rating between input/output is 200 v peak maximum; and the photon-coupled current transfer ratio is on the order of 0.001 from



d-c to the cutoff frequency of 10 Mc.

The 4310 is for circuits requiring economical input/output common mode isolation of moderate levels. The 10-Mc bandwidth makes possible isolation of video bandwidth signals; pulse rise time capability is typically 50 nsec.

One important application is the interruption of common ground currents in various digital and analog circuits. The 4310 isolator is also useful in transferring signals through floated and guarded interfaces. Price in quantities from 1 to 99 is $55.

HP Associates, 620 Page Mill Road, Palo Alto, Calif., 94304. [373]

Stud-base rectifiers operate at 6 amps

A series of 6-ampere, stud-base silicon rectifiers have peak inverse voltage ratings from 15 to 1,200 v. At room temperature the series withstands an 8-msec nonrecurrent surge of 300 amps; maximum reverse current is 25 μa; maximum d-c forward drop at 6 v is 1.2 v. The rectifiers may be operated at 6 amps to a temperature of 50°C when mounted to a suitable heat sink. They then derate linearly to 0 at 175°C.

The hermetically sealed devices meet or exceed all MIL-S-19500 environmental specifications. They are direct replacements for the manufacturer's SOD stud base series, and are available in high voltage stacks to customer's specifications. Price is 35 cents to $8.40 each, depending on type and quantity. Availability is stock to 2 weeks.

Solitron Devices, Inc., 256 Oak Tree Road, Tappan, N.Y., 10983. [374]

System power supplies with fixed output

A series of fixed-output, d-c system power supplies, called Systematics, feature Mil-Spec construction, a completely field-repairable design, and integrated heat exchangers that eliminate the need for additional external heat sinks.

Open, easy-access design is based on all-silicon solid state circuitry, with 90% of the components incorporated on one plug-in printed-circuit board that can be easily and quickly removed and replaced by an identical unit in the event of damage to the power supply. This feature permits field repair, eliminating high cost of complete replacement required when sealed or encapsulated units are damaged and must be discarded.

Completely self-contained and self-cooled, Systematics do not require additional, space-consuming external heat sinks that add costs and labor to installation and often result in an inefficient thermal path that limits the life and efficiency of a sealed unit. All heat-sensitive components are mounted directly on high-efficiency heat sinks in the power supply for optimum heat transfer.

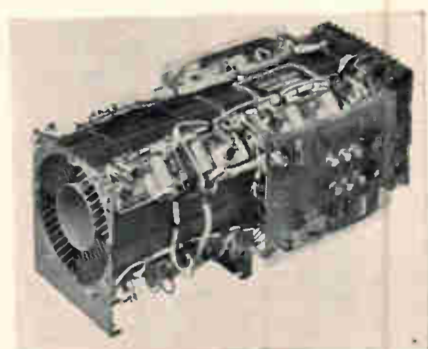
Systematics are available in 84 standard off-the-shelf models with fixed outputs spanning the output voltage range of 1 to 100 v at current ratings from 0.3 to 12 amps. All-silicon, transistor-regulated circuitry maintains regulation at 0.025%, holds ripple and noise to 1 mv rms maximum. Class F high-reliability, epoxy - encapsulated, low-loss transformers with electrostatic shields are included in the circuitry which has been conservatively designed for optimum reliability without resorting to critically matched or selected semiconductors.

All models feature special control circuits to permit finite voltage adjustment within ±10% of the rated fixed output by means of locking type potentiometers accessible from the outside for screwdriver adjustment. Each model includes remote sensing capability and automatic electronic current limiting for protection against overloads and short circuits. Cover enclosures that permit removal of the power supply without demounting the enclosure from its installed position are optional.

Prices start at $89.50. Delivery is from stock.

Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif. [380]

Deflection amplifier in modular package



Model DA 105 deflection amplifier is an all silicon, solid state modular package featuring high deflection performance characteristics at low cost. It is designed for application in any crt or storage tube display system employing magnetic deflection.

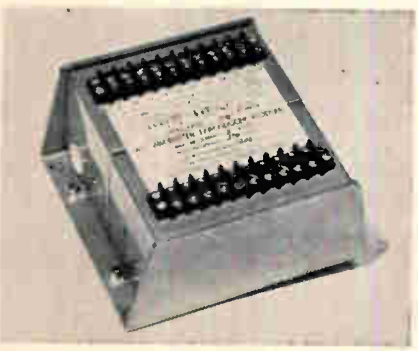
The amplifier is capable of supplying up to 12 amps of deflection current to a directly-coupled deflection coil. The module comprises two identical channels of power amplification, one for X deflection and one for Y deflection.

The new unit is a d-c coupled operational-type difference amplifier. It features excellent linearity, wide bandwidth and stable operation. Since the amplifier is d-c coupled throughout, it may be utilized in random point plotting or alphanumeric deflection applications as well as for raster or other periodic scan formats. Centering, off-set, geometry correcting and other inputs may be introduced with ease at the summing point of the difference amplifier stage.

The input of the model DA105 deflection amplifier is designed to be compatibly coupled to the output of the model SG415 sawtooth generator. The amplifier is also fully compatible with all other modular display systems components manufactured by the company.

Beta Instrument Corp., 377 Elliot St., Newton Upper Falls, Mass., 02164. [381]

Transducer modules work with wattmeters



Prepackaged modules have been developed that enable panel meters or meter-relays to function as indicating or controlling wattmeters. The new wattmeter transducer modules are available in three basic types: single-phase; three-phase, three-wire; and three-phase, four-wire.

The manufacturer furnishes special panel meters and optical meter-relays for operation with the transducer modules. Meters and transducers are calibrated together. Meter movements are rated at 50 to 100 mv d-c.

Standard ranges for 60-cycle measurement begin with 0 to 500-w full scale for single-phase transducers, with a top range of 0 to 4,000 w. For three-phase, three-wire transducers, ranges go from

New Subassemblies

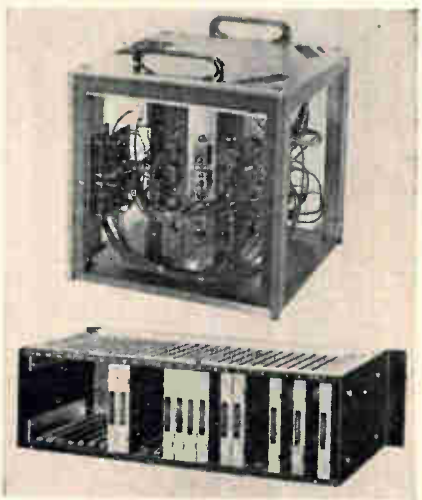
0 to 1,000 w to 0 to 6,000 w. For three-phase, four-wire transducers, ranges are 0 to 1,000 to 0 to 3,000 w. Standard inputs are 5 to 10 amps and 150 to 500 v a-c.

Single-phase transducers measure approximately 6 in. wide, 3 in. deep and 3⅓ in. high. Three-phase transducers are approximately 6 in. square and 3⅓ in. high.

List price for standard ranges are $115 for single-phase transducers; $240 for three-phase, three-wire; and $250 for three-phase, four-wire.

API Instruments Co., Chesterland, Ohio. [382]

Drum memory system at moderate cost

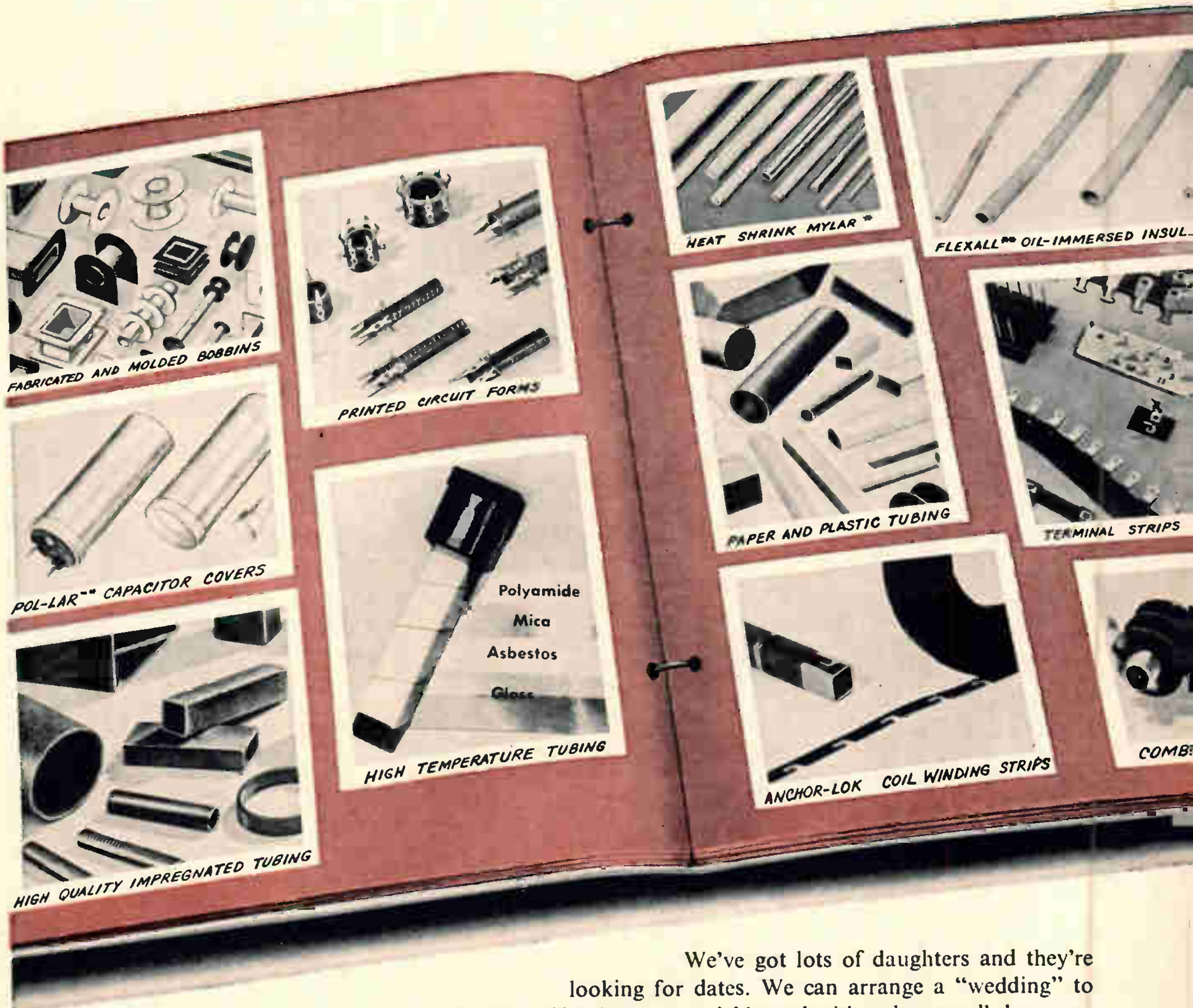


Priced below $5,000 — complete with clocking, read-write and address decoding electronics—model 52 drum memory system combines economical 80-track storage capacity of 10,000 to 200,000 bits with random access capability, data rate of 200 kc and performance-proven reliability.

Normal operation of the drum is from a 120-v. 60-cps, single-phase source, providing speeds of either 1,800 or 3,600 rpm, with maximum access time of 34 or 17 msec. Higher speeds may be obtained with a 400-cycle power source.

Use of Manchester non-return-to-zero (phase modulation) recording produces playback voltages which are either fully positive (a one) or fully negative (a zero) at

Take a look at our family...



We've got lots of daughters and they're looking for dates. We can arrange a "wedding" to your specifications . . . quickly and with only a small dowry on your part. If you see a member of our family you'd like to know better . . . call one of our "kinfolk" in your neighborhood (see column at right) or get in touch with our "home" in Wheeling (Ill.).

*Registered trademark—DuPont Co.
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Precision
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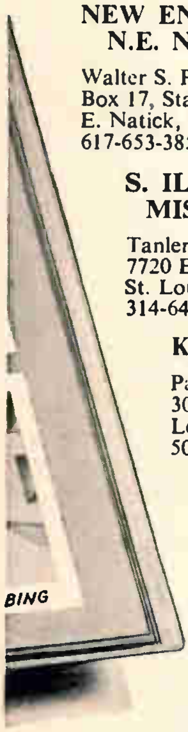
Divisions: Resinite • Buckeye Bobbin • Automation Devices

1033 S. Noel Ave., Wheeling, Ill. Phones: Chicago: 631-1445 • Long Distance: 312-537-4250, TWX: 312-537-5202

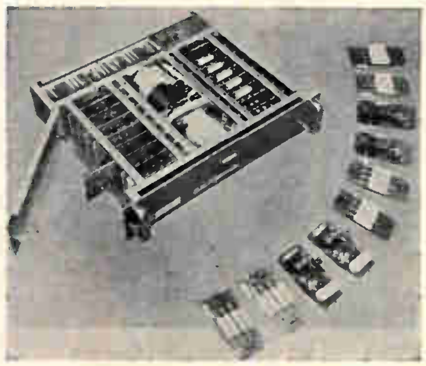


strobe time. Therefore, effective playback signal is twice the amplitude of that produced by other recording methods.

The model 52 system comprises two separate items: the magnetic drum, measuring 11 x 11 x 15 in., and mounted on four shock mounts; and associated circuits, mounted on a standard module chassis.

Vermont Research Corp., Precision Park, North Springfield, Vt., 05150. [383]

Digitally programed d-c power supply

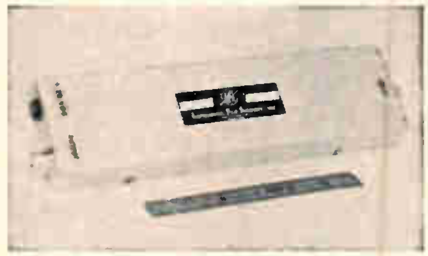


The DCP 800 is a high performance, solid state d-c power supply with exceptional versatility. It is a digitally programed unit suitable for automatic test equipment. It provides automatic changeover from regulated voltage to regulated current. Power supply and load may be spaced widely apart. Ranges are from 0.001 v to 100 v d-c in 1-mv increments, and current from 1 μa to 1 amp in 1-μa steps. Individual plug-in cards are available for reference supplies, amplifiers and voltage and current decades. Standard input is a 1-2-4-8 binary code for both current and voltage.

Flexibility of the design permits making the DCP800 a constant current/constant voltage unit, or altering it to be a constant voltage with current limiting or a constant current with voltage limiting supply. A multifunction power supply, the DCP800 can be programed in any number of voltage current combinations and is adaptable to other configurations of current or voltage limiting. Down time, maintenance time and obsolete power requirements are cut to a minimum—all being corrected by the simple, easy plug-in boards.

The Rowan Controller Co., Eatontown, N.J., 07724. [384]

Silicon solid state power amplifiers



A series of low-noise, silicon solid state, wideband power amplifiers provide a minimum of 1 watt c-w into 50 ohms over 10 kc to 100 Mc without tuning. Power gain of the model 2100 is 50 db minimum. Frequency response is ±1 db at full power output. Input impedance is 50 ohms nominal.

Variations in the model 2100 series allow for higher power output, power gain to 60 db and input impedances to 1 megohm. Price of the basic model 2100 is approximately $1,500; availability, 45 days.

Instruments for Industry, Inc., 101 New South Road, Hicksville, N.Y. [385]

Electromechanical time code generators

Two series of low-cost electromechanical time code generators have been announced. Both are of modular construction and fit in a standard 19-in. rack and panel mount. The K42601 series supplies time information in straight decinal switch patterns, and the K42602 series provides binary coded decimal.

These units can supply digital time inputs to data handling systems, digital computers, illuminated time displays, telemetering systems, tape punchout devices, checkout equipment, and direct printout devices.

Seven standard models with various combinations of readouts in seconds, minutes, hours, and days are available in either series. Visual display is obtained from counters with $\frac{3}{16}$-in. white characters on a black background. Settings are made by wheels with knurled o-d's for easy rotation.

All units operate from a standard 115-v, 60-cps supply. Time base is an integral, synchronous motor-driven repeat cycle timer. Up to 50-ma loads can be handled. Minimum life is one year at rated load.

Units can be modified to provide special code outputs, if required.
The A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn., 06720. [386]

Pulsed laser system is solid state

Model 1401 is a complete pulsed-gallium-arsenide-laser system, including power supply. The laser operates at room temperature and radiates at least one watt peak power when pulsed between 0.1 and 1.0 kc.

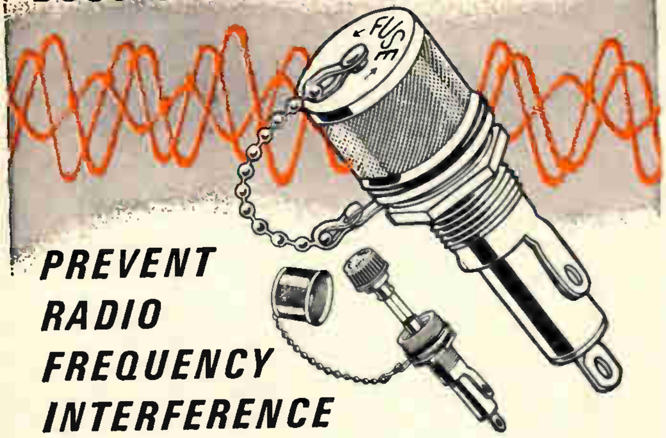
All solid state electronics for pulsing the diode is self-contained. Current pulses of 100 amps for 100 nsec are generated.

Output light is at a wavelength of approximately 9,000 angstroms and the bandwidth is approximately 150 angstroms. The beam is collimated (or may be focused) by means of a lens at the end of the package. A standard $\frac{3}{8}$-in. rod is provided for optical bench mounting. Price of the model 1401 is $750.
Austin Electronics Corp., P.O. Box 9312, Austin, Texas, 78756. [387]

Precision frequency power supply

Model 6B precision frequency power supply is ruggedly built, and

BUSS SHIELDED FUSEHOLDERS



PREVENT RADIO FREQUENCY INTERFERENCE

For use where fuse and fuseholder could pick up radio frequency radiation which interferes with circuit containing fuseholder —or other nearby circuits.

Fuseholder accomplishes both shielding and grounding.

Available to take two sizes of fuses—¼ x 1¼″ and ¼ x 1″ fuses.

Meet all requirements of both MIL-I-6181D and MIL-F-19207A.

Write for BUSS Bulletin SFH-12

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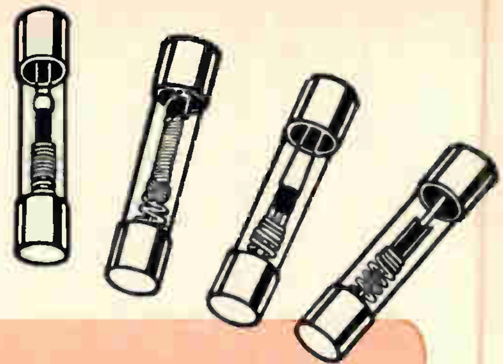
BUSSMANN MFG. DIVISION, McGraw-Edison Co., **ST. LOUIS, MO. 63107**



FUSETRON

dual-element Fuses

slow blowing

Write for BUSS Bulletin SFB

"Slow blowing" fuses prevent needless outages by not opening on harmless overloads—yet provide safe, protection against short-circuits or dangerous overloads.

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Circle 212 on reader service card

Circle 212 on reader service card

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(Patented)

PORTABLE COOLING UNITS

Compact, convenient, efficient method of obtaining cooled liquids at exact temperature for direct testing or recirculation to auxiliary equipment. New patented principle permits rapid cycling . . . control to within ±0.15°C. Compressor runs constantly . . . lasts longer. Exclusive no-load starting avoids overload stopping and manual reset. Four models . . . two capacities.

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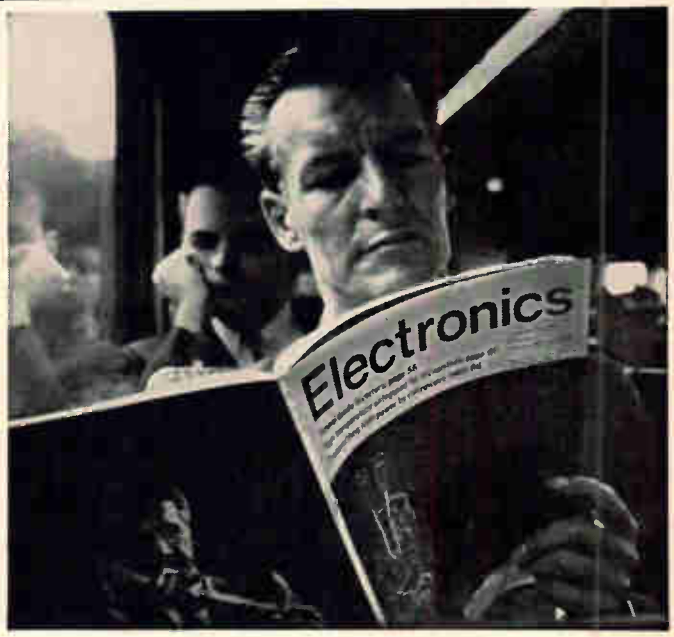

Great editorial is something he takes to work

(What a climate for selling!)

Electronics
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330 West 42nd Street, New York, N.Y. 10036

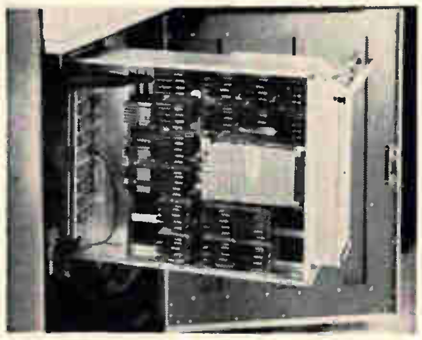
New Subassemblies

can provide tens of thousands of hours of trouble-free, dependable 115 v a-c power at 60 cps. It can be used to power many 115 v a-c devices, up to 250 w, where the frequency of the power is critical and requires extremely accurate regulation. Its rugged design plus modern techniques in use of solid state regenerative divider chains along with the precision built crystal control oscillator, maintain a frequency accuracy of 1 part in 10^{-9} per day.

One of the prime functions of the 6B is to provide and maintain an accurate a-c power source to power the manufacturer's time-of-day announcement equipment. The 6B is equipped with an output frequency correction feature so that minor adjustments in time can be easily made. With this unit, it is no longer necessary to rely on local station or utility power for operation of the time-of-day equipment.

The Audichron Co., 721 Miami Circle, N.E., Atlanta, Ga., 30324. [388]

IC core memory offers easy cabinet access



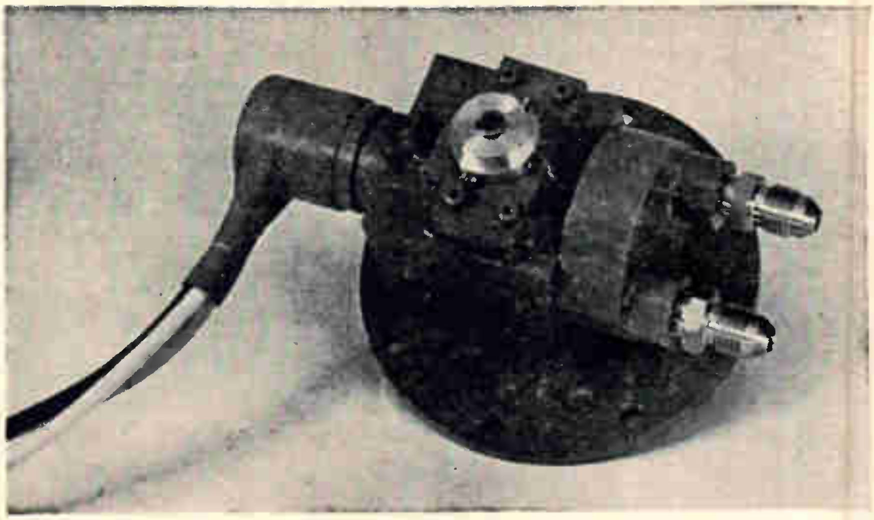
One-μsec cycle time, 500-μsec access time, plus availability in capacities from 4,096 x 6 bits to 16,384 x 84 bits are some of the features of the ICM-40 core memory. The 5¼ in. high ICM-40, originally designed to mount horizontally, is now available with new hardware for vertical mounting in a standard 24 in. deep x 19 in. wide cabinet. In the vertical configuration, the memory module swings out, tilts and locks for easy access to the module side or the wire wrap side for testing, module replacement or inspection.

Because of its 5¼-in. dimension, the ICM-40, which provides ¼ million bits of storage, can be interleaved with other vertical modules for more efficient packaging density without sacrificing accessibility at the front of the cabinet. For example, three vertical mounted ICM-40 units provide 4K x 84, 8K x 84 or 16K x 42 bit size memory capacity and at the same 1-μsec cycle time as the horizontal unit.

Computer Control Co., Inc., Old Connecticut Path, Framingham, Mass., 01702. [389]

New Microwave

Single knob tunes low-noise klystron



Low noise, single-knob tuning and high power output are features of a family of two-cavity klystron oscillators introduced by Varian Associates of Palo Alto, Calif. Varian claims that its VA-521 series has the lowest noise output of any klystrons in this power range —2 to 10 watts. Designed for doppler radar applications, the tubes have the added advantage of simple tuning. They operate in C band at center frequencies of 5.5 to 7.0 gigacycles per second.

In doppler radar systems, for example a side-looking radar for ground mapping, tube noise modulates the frequency of the oscillators, thus reducing the resolution capabilities and sensitivity of the system.

To generate a signal without frequency modulation, the VA-521 is designed to minimize sources of noise within the tube. A low-current electron beam is used to reduce shot noise. In some klystrons, grids are used in the gaps of the cavities to increase the coupling between the beam and the cavity. The VA-521 series operates without these grids, eliminating the noise caused by the interception of electrons by the grid. Ion traps, which are required to prevent a space charge around the grid, are also eliminated, avoiding another source of noise.

The noise output of the VA-521 is equivalent to a frequency deviation of 0.3 cps. By comparison, a gridded two-cavity oscillator has a noise output equivalent to a 1 to 2 cps deviation. These noise measurements are equivalent to the root mean square voltage measured in a 1-kilocycle bandwidth at the output of a frequency discriminator. The measurement is made at a frequency separated 30 kc from the carrier.

A single knob controls a diaphragm that simultaneously tunes both cavities over a ±50 Mc minimum range. Strongly overcoupled cavities prevent small errors in the tracking of the resonant frequency of each cavity from appreciably affecting the r-f output. In tubes with critically or weakly coupled cavities a tracking error between cavities can cause the tube to drop out of oscillation.

Although low-noise tubes generally have low power outputs, the VA-521 series can provide at least 2 watts and as much as 10 watts of stable radio-frequency power. This relatively high power output requires that the klystrons be liquid cooled. A typical tube, the VA-521A, operates at 5.5 Gc and delivers 2 watts output at 4 kilovolts d-c beam voltage and 33 milliamperes d-c beam current.

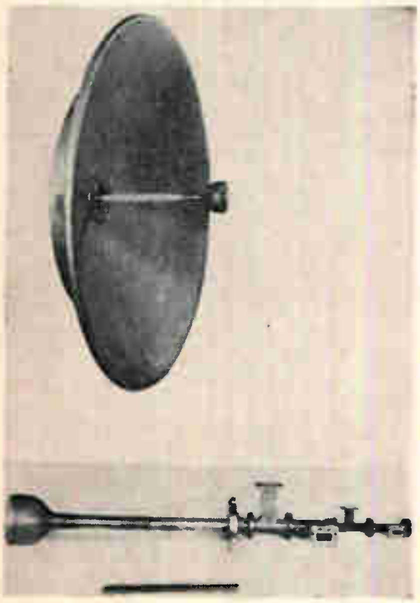
Each VA-521 is warranted for a life of 1,000 hours. Standard models can be delivered in 60 to 90 days.

Specifications

Series	VA-521
Frequency range	5.5-7.0 Gc
Tuning range	±50 Mc
Power output	
Minimum	2 watts
Maximum	10 watts
Tuning	Mechanical

Varian Associates, 611 Hansen Way, Palo Alto, Calif. 94303 [391]

Dual-frequency microwave antenna



A four-port rear-fed microwave antenna is available with mechanical features and electrical characteristics as good or better than the manufacturer's front-fed design. The dual-frequency antenna allows simultaneous dual polarized operation in both the 6 Gc and 11 Gc bands with the use of a single parabola.

The antenna consists of a slender cylindrical feed equipped with a small fiberglass cap to protect the feed aperture and splash plate. An external full radome enclosure is not required in direct radiator applications. The feed is easily insertable from the rear of the antenna dish. It will meet all wind-loading and environmental specifications required of ordinary front fed commercial and public utility antennas.

While vswr at both bands is

consistently being measured at 1.13, the manufacturer expects production units to run in the order of 1.15.

Gabriel Electronics, division Maremont Corp., North St., Saco, Me. [392]

Uhf circulators cover broad band

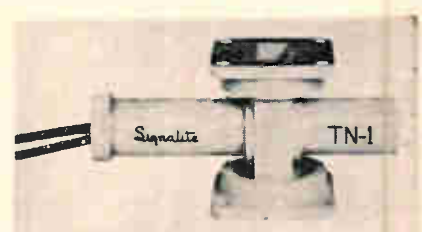
Uhf coaxial circulators cover a two-octave range from 250 Mc to 1 Gc with four units. The units provide excellent electrical characteristics over a minimum bandwidth of 33⅓%.

Typically, the model V25T has isolation of 17 db minimum, insertion loss of 0.6 db maximum, and vswr of 1.30 maximum over the frequency range of 250 to 350 Mc.

Price is available on request; delivery, 30 days after receipt of order.

E & M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. [393]

Transmission-type noise generator



A miniature transmission-type, 90° E-plane noise generator, type TN-1, is designed for use from 8.5 to 9.6 Gc in systems where space and weight are at a premium. With low non-operating insertion loss and vswr, it is intended for system use directly in the receiver line of X-band systems.

The unit is especially suitable for airborne and shipborne systems that have limitations on available drive power and which require rugged components with long operating life. The thermionic, but still single-ended, cathode in the tube permits a two-lead construction for the complete noise generator while simultaneously providing a low tube drop with subsequent low operating power requirements.

Typical specifications include 900-v starting spike, nominal operating voltage of 55 v at 100 ma current, excess noise ratio of 14.5 ±0.5 db with an operating vswr of 2.1 max, and a cold vswr of 1.25 max. Length along the waveguide axis is less than 2 in. and height of the tube holder section, perpendicular to the waveguide axis, is 4 in. The entire unit weighs only 4 oz.

Signalite Inc., 1933 Heck Ave., Neptune, N.J. [394]

Pump tubes available for masers, paramps

Reflex klystron oscillators, designated the VA-254 series, serve as pump tubes for masers and parametric amplifiers. Well-suited for airborne use, this durable reflex klystron delivers at least 150 mw into a matched load over its entire 1,000-Mc tuning range. Tubes are available for any specific center frequency between 18 and 26.5 Gc. Tuning is mechanical.

Hermetically sealed, the VA-254 oscillator not only operates at high altitude without pressurization, but it can also be cooled by liquid im-

New Microwave

mersion, conduction, or forced air. Weighing only 3.5 oz, it mounts in any position.

Varian Associates, 611 Hansen Way, Palo Alto, Calif., 94303. [395]

Crystal controlled local oscillator

Model MA-8730 is a solid state, crystal controlled local oscillator that features high frequency, stability, compactness, and light weight. This 1.5-pound source operates in the 14 to 16 Gc frequency range, giving 4 mw power output with low input power drain on a single 28-v d-c supply.

Short term frequency stability is $\pm 5 \times 10^{-9}$ per 100 msec and spurious response is —30 db. The device is designed for applications in high resolution mapping radars, data link, doppler navigators, and landing navigation systems.

Microwave Associates, Inc., Burlington, Mass. [396]

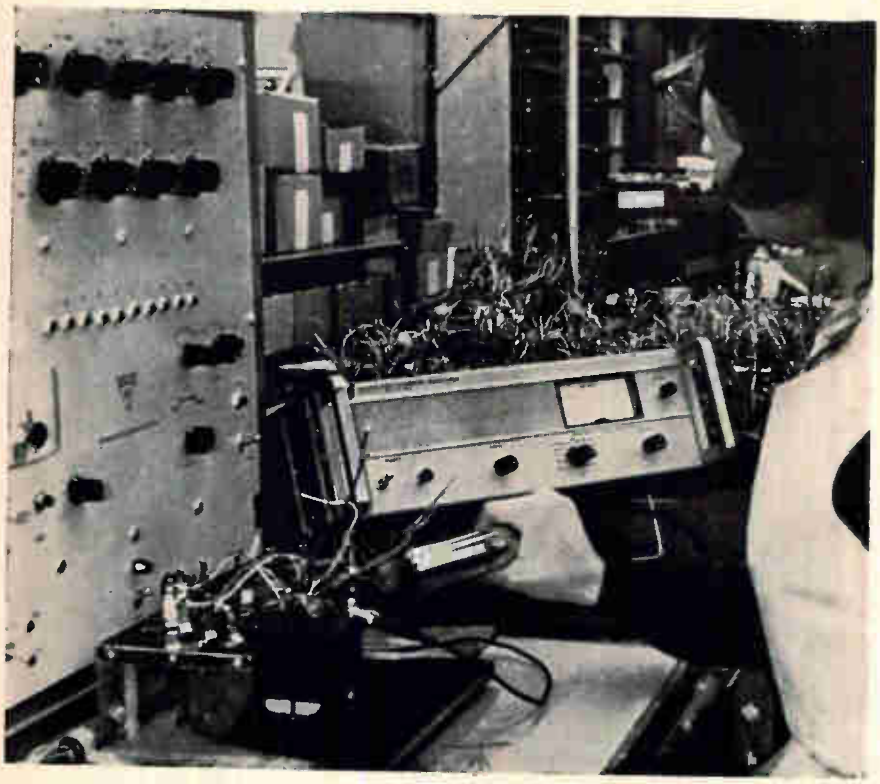
Reflex klystrons feature long life

Every model in a new series of eight reflex klystrons (types YK-1070-YK1077) has a guaranteed life expectancy of 5,000 hours. All are designed for use in the output stages of microwave communications links and are mechanically and electrically similar to the international VA222 series, for which they are suitable alternatives.

They cover a frequency range of 5.925 to 8.1 Gc. Each type has a power output of 1 watt, and tuning is by screw adjustment of the external cavity. The klystrons are contact-cooled, eliminating the need for a blower and thus reducing the cost and improving the reliability of a microwave communications link. Output connections are in WR137 waveguide (British size 14).

Mullard Overseas Ltd., Torrington Pl., London, W.C1, England. [397]

Noisy components? Reject them



A good ear is no longer needed to tell whether an electronic component has passed the ultrasonic noise test. An improved ultrasonic detector can be set up on the production line to inspect the components and automatically accept and reject them.

Designated the Delcon 4950A Ultrasonic Translator, the tester is an outgrowth of the battery-powered detectors which the Delcon division of the Hewlett-Packard Co. makes for such applications as field-testing for leaks in pressurized telephone cables. Those detectors give an audible indication of noise intensity, requiring the operator to make a qualitative judgment of whether a fault exists.

The go-no-go tester can, for example, test the transformers of television receivers. It listens for the noise that is produced by corona discharge and high-voltage breakdown. In the photograph above, the instrument is making a corona test on a filament high-voltage transformer during a breakdown test at 3.5 kilovolts. The mid-point on the meter indicates the rejection noise level.

The instrument will also announce detection of a fault with an indicator light, display the noise on an oscilloscope, feed the results to a recorder, or trigger relays that actuate rejection mechanisms on automatic inspection lines. It can make measurements as rapidly as 150 a minute. Also, it can be set up to ignore spurious signals resulting from harmonics of, for example, a sweep transformer's 15.75-kilocycles-per-second frequency.

Although the new model makes operator judgments unnecessary in routine use, it does have a loudspeaker for personnel training, noise identification and test setup. It is also the first Delcon model to operate on alternating current.

Two methods can be used to set up the instrument for go-no-go tests. A noise level above the ambient factory and system noise can be selected arbitrarily. This method is recommended for detecting electrical noise in transformers, capacitors and insulators, and for finding leaks in pressurized or vacuum components. The other method, determining the unacceptable noise level by preliminary sample testing, is preferred for such tests as detecting excessive friction in bearings and other moving parts.

Specifications

Frequency range	36 to 44 kilocycles
Noise intensity	Zero to 90 decibels
Test probe	22° directional microphone
Sampling intervals	0.1, 0.3, 1 and 3 seconds
Recorder output	1 volt d-c full scale
Oscilloscope output	1 volt a-c full scale
Power input	115 or 230 volts, 50 or 60 cps
Price	$1,475, immediate delivery

Delcon division of the Hewlett-Packard Co., 943 Industrial Avenue, Palo Alto, Calif. **[401]**

Laser welding unit for high production

A production laser welder, model 355, is announced for use in microelectronics and other high production microwelding applications. A prototype of the first generation has logged 2 million operations over the past 13 months. Model 355's repetition rate is beyond the 1 pulse per second range.

Closed cycle, liquid medium cooling of the laser cavity allows for close control of the ruby rod temperature to produce consistent laser power and flash tube life expectancy as high as 100,000 flashes. Stereo microscope or projection optics are available and an output laser beam power meter is standard. Pulse forming networks allow pulse variation over a 1 to 4 millisecond range.

Electro Powerpacs, Inc., 253 Norfolk St., Cambridge, Mass., 02139. **[402]**

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New Books

Communications

Basic Theory of Space Communications
Frederick J. Tischer
D. Van Nostrand Co., 463 pp., $11.75

Four disciplines make up the field of space communications: antennas and electromagnetics, plasma dynamics, wave propagation, and communication techniques. The book is divided into these disciplines.

The author sets out to present the basic theory of each of the disciplines with special emphasis on high-frequency relationships. His discussion and analysis of the theory concerned with each discipline is generally clear. And yet the book has many failings.

In each of the four parts, entirely too much space is devoted to elementary material which is readily available in previously published books. Many books have been written on antennas, electromagnetic theory, plasmas, propagation and communication theory that cover the subjects more extensively than Tischer does. Tischer's book would have been a much more valuable contribution if it had picked up where these texts left off.

In each part, only the last one or two chapters truly concerns the field of space communications. The rest is foundation material. Nevertheless the book does cover some important new areas in its discussion of space vehicle antennas (for example, low-noise antennas) and reentry communications.

One serious fault is the lack of simplified practical problems and their solutions. A book of this nature would be considerably more useful if it included design examples. For example, the author might have presented the performance goals for a particular spacecraft antenna, discussed the various problems, patterns, impedance considerations, etc., and then illustrated the design procedure with a step-by-step solution. A few problems, without solutions, are at the end of each chapter.

The book is poorly edited and has some errors in equations that are serious enough to raise questions concerning the accuracy of many of the mathematical expressions. Some of the notation used is not standard; in some cases it is apt to cause confusion.

The author's reasoning in portions of the discussion, such as the treatment of charged particle motion in a nonuniform magnetic field, is not easy to follow. This is because many steps are left out in derivations of formulas although the results are correct. The discussion on equivalent black body radio noise is incomplete in that the very important aspects of the polarization are not included.

The book could serve as a quick reference for some of the mathematical expressions. It could also be useful to someone with knowledge of one of the disciplines who wants to know something about the analytical bases of the other disciplines.

Stanley H. Gross
Airborne Instruments Laboratory
Deer Park, N. Y.

Recently published

European Miniature Electronic Components and Assemblies Data, Part II: France, Netherlands, Scandinavia and Switzerland 1965-66, edited by G.W.A. Dummer, J. MacKenzie Robertson, Pergamon Press, 1,123 pp., $35

American Ultraminiature Component Parts Data 1965-66, edited by G.W.A. Dummer, J. MacKenzie Robertson, Pergamon Press, 486 pp., $21.50

Fluidics, edited by E.F. Humphrey, D.H. Tarumoto, Fluid Amplifier Associates, Inc., 268 pp., $28

On-Line Computation and Simulation, Martin Greenberger, M.M. Jones, J.H. Morris, Jr., D.N. Ness, the Massachusetts Institute of Technology Press, 126 pp., $4.95

Transistors: Principles and Applications, R.G. Hibberd, Hart Publishing Co., 304 pp., $5.95

Digest of the International Solid State Circuits Conference, edited by J.A.A. Raper, Institute of Electrical and Electronics Engineers, Inc., copies available from H.G. Sparks, the Moore School of Electrical Engineering, University of Pennsylvania, 132 pp., $6

Crystals: Perfect and Imperfect, Allan Bennett, Robert Miller, Donald Hamilton, Joseph Murphy, Alexei Maradudin, Westinghouse Research Laboratories, and Walker and Company, 237 pp., $5.95

David Sarnoff, a biography by Eugene Lyons, Harper & Row Publishers, Inc., 372 pp., $6.95

Fields and Waves in Communication Electronics, Simon Ramo, J.R. Whinnery, Theodore VanDuzer, John Wiley & Sons, Inc., 754 pp., $13.50

Pulsed Neutron Research, Proceedings of the Symposium on Pulsed Neutron Research, Karlsruhe, Germany, May 10-14, 1965, Vol. 1, International Atomic Energy Agency, 698 pp., $14; Vol. 2, 917 pp., $18

Technical Abstracts

Complex integrated circuits

A systematic engineering approach to complex arrays

L. Vadasz, R. Nevala, W. Sander, R. Seeds
Fairchild Semiconductor division, Fairchild Camera & Instrument Corp. Palo Alto, Calif.

The evaluation of silicon digital integrated circuits has been more rapid than expected. Semiconductor-device manufacturers have already started to develop very complex logic arrays. These arrays will be the equivalent of hundreds of logic gates.

By putting hundreds of gates on a single monolithic silicon chip reliability is greatly improved, making complex logic arrays highly attractive to the military. However, to interest commercial and industrial users of integrated circuits, the semiconductor-device manufacturer must add other inducements. Two potential advantages are reduced engineering time and low cost.

A metal - oxide - semiconductor chip having groups of a particular component pattern known as cells can provide both advantages. With the chip, a variety of complex logic circuits, such as memory systems, can be obtained by using various cell connection schemes.

A few different combinations could probably be used to form a cell. One such cell family which has been investigated includes six sections. These are a quad nand gate, a quad nor gate, a dual gated latch, a master slave flip flop, a dual exclusive-nor gate and a quad output driver.

To minimize the over-all system-design time the user should study the manufacturer's specifications for the integrated circuit and then supply the manufacturer with the logic specification for the subsystem in accordance with the manufacturer's design limits. The manufacturer will then design the masks and build, test and deliver the circuits. The work of the user is kept to a minimum and the over-all engineering time is reduced because of the manufacturer's familiarity with the integrated circuit.

Presented at the 1966 International Solid State Circuits Conference, Philadelphia, Feb. 9 to 11.

Fixed memory with E cores

Development of an E-core read-only memory

P.S. Sidhu
Ampex Corp., Culver City, Calif.

A read-only memory to hold control information in a computer can be built of E cores. Inexpensive to build, fast and reliable, the memory's manufacture can be easily automated and the design appears to impose no limit on its size.

An E core is a piece of ferrite material with three legs perpendicular to its main body, making it resemble the letter "E". If two E cores are placed leg to leg, the result is a two-aperture ferrite core. A wire passing through one of the apertures permanently stores a 0; a wire through the other stores a 1. The sense wire is wound around the center leg of the E-core, two-aperture structure.

The E-core memory operates in the linear range of the ferrite material, so that no magnetic switching takes place. Between the drive wires (word lines) and the sense winding is an a-c coupling; stored 0's and 1's produce negative and positive pulses, respectively, in the sense wire.

An experimental E-core read-only memory was assembled containing 1,024 words of 24 bits each; the core array was in the form of two rows of 48 cores, with 256 wires threaded through each row. A current pulse on one wire then read out the contents of two words, one of which was placed in the output register. The addressing logic selected the drive wire and one of the two output words. Linear selection was used for reliability and low cost; other techniques of addressing, such as series-parallel or coincident-current, could be used on larger arrays. Because the output pulses are bipolar, the sense amplifier circuits can be simple. But the output pulses must be strobed to distinguish between a pulse and the overshoot, or ringing, that may follow it. Cycle time of the experimental memory is 250 nanoseconds; access time is 150 nanoseconds.

The outlook for further development of an E-core memory is good. In production, for instance, the cores could be wired on a board, as they were in this experimental memory, and then transferred to one or more printed-circuit cards for pluggable insertion in a computer. The assembly is easily automated. Loose or pre-formed wires, or printed circuit wires, can be dropped into the openings in the single E-core, and the wired array capped with another set of E-cores to produce the two-aperture array. The drive and sense circuits can easily be made of integrated circuits, although they were not in this model. Faster operation can be obtained with high-frequency ferrite materials, particularly since there is no magnetic switching.

Presented at the Fall Joint Computer Conference, Las Vegas, Nev., Nov. 30 to Dec. 2, 1965.

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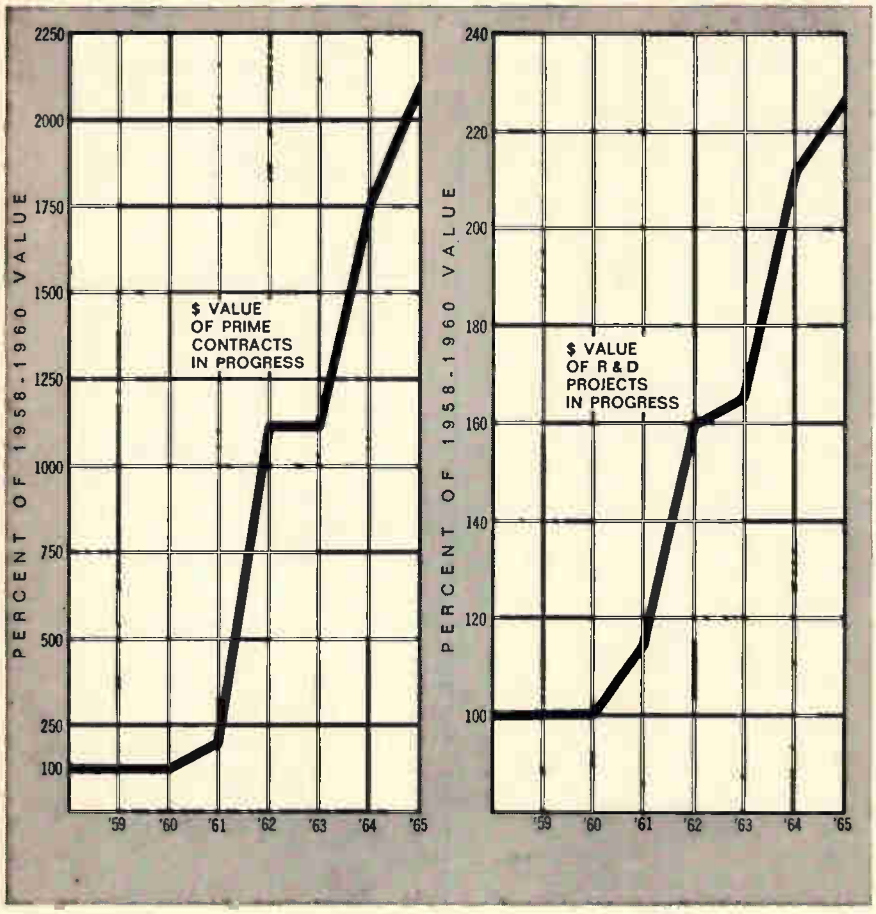

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TS-608/U (Borg-Warner, Byron-Jackson, Rollin Model 30-(*): Very similar to above except output designed for a 50 ohm load, and freq. range 41 to 400 mc. We read outputs (at high-level CW only) of 7 to 10 watts on a 50 ohm wattmeter used as a load. On AM/CW Low output use, puts out 10 v across 50 ohms. Step and variable attenuators down to 0.1 uv. With book, fob Los Angeles $1295.00
(Note: Last factory price was $14,750.00!)

SLRD (Rhode & Schawarz: 275 to 2,750 mc in 2 overlapping bands calibrated on long scale with readability of 1 part in 10,000 and accuracy of 2%. Max. power output into external 50 ohm load is more than 10 w from 275-500 mc; more than 20 w from 500-1700 mc; more than 5 w from 1700-2400 mc; more than 1 w from 2400-2750 mc. Output continuously adjustable down to about 10 to the minus 10th w. CW or AM pulse at 1 kc 100% modulated. Overhauled and certified by the factory branch, with book. Regular price is over $4000.00.
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New Literature

Resistance thermometer elements. Electric Thermometers, Inc., 615 Schuyler Ave., Kearny, N.J., 07032. Bulletin 120 is a six-page brochure describing platinum resistance thermometer elements for industrial and laboratory use between −250° and +850° C.
Circle **420** on reader service card.

Switching module. James Electronics, Inc., 4050 N. Rockwell St., Chicago, Ill., 60618. A two-page data sheet provides specifications for the Microscanner relay/p-c board module for high-speed, low to medium level signal switching. **[421]**

Ultrasonic cleaner. Multisonic Corp., 1100 Shames Drive, Westbury, N.Y. Bulletin 300 offers a description and specifications of a bench model ultrasonic cleaner, model 66. **[422]**

Microsheet glass for substrates. Electronic Products Division of Corning Glass Works, Raleigh, N.C. Properties for Code 0211 microsheet glass for substrates are tabulated in Reference File CE-10.10, a one-page data sheet. **[423]**

Digital voltmeter. Dana Laboratories, Inc., Irvine, Calif., 92664, has published an eight-page catalog describing its function-expandable 4-digit model 5400 digital voltmeter for millisecond measurements. **[424]**

Vacuum contactors. Jennings Radio Mfg. Corp., P.O. Box 1278, San Jose, Calif., 95108, presents a catalog on vacuum contactors that are designed for controlling d-c, r-f, and 50, 60, and 400 cycle circuits at all voltage levels. **[425]**

Relay assemblies. Chicago Dynamic Industries, Inc., 1725 Diversey Blvd., Chicago, Ill., 60614, has published a catalog page on the series 271-2500 fast-acting, electrical trip latch switch assemblies that can accommodate 2 to 20 slide switches with a maximum of 8 spdt contacts available per slide switch. **[426]**

Programable power modules. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N.J., 07009. Fully programable, all-silicon Transpac d-c power modules are described in catalog supplement No. 136. **[427]**

Oscillographs. Midwestern Instruments Inc., division of Telex Corp., 41st & Sheridan Road, Tulsa, Okla. Brochures describing models 621 and 1200 oscillographs contain specifications, features, operating principles and applications for the new instruments. **[428]**

Accelerometer. B&K Instruments, Inc., 5111 W. 164th St., Cleveland, Ohio, 44142, announces a specification sheet on the model 4333 low-cost measurement standard accelerometer. **[429]**

Compactrons. General Electric Co., Schenectady, N.Y., 12305. A condensed 20-page "Catalog of Compactrons" is now available for use by designers of tv and audio communications products. **[430]**

Rfi filters. The Gudeman Co., 340 W. Huron St., Chicago, Ill., 60610, offers a six-page brochure describing a wide range of tubular and bathtub style rfi filters. **[431]**

Coil forms. J.W. Miller Co., 5917 S. Main St., Los Angeles, Calif., 90003, has released a 32-page catalog describing ceramic, resinite and Velvetork coil forms. **[432]**

Custom circuit modules. Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Clara, Calif., 92702, has published a four-page illustrated brochure on its facilities and capabilities in resistance welding, dip soldering, and reflow soldering of all types of circuit modules. **[433]**

Programed current pulse generator. Computer Test Corp., 12 Fellowship Road, Cherry Hill, N.J. A technical brochure describes the model 1700 programed current pulse generator for analysis of fast switching magnetic memory devices. **[434]**

Frequency and time standards. Hewlett-Packard, 1501 Page Mill Road, Palo Alto, Calif., 94304. Application Note No. 52 is a 108-page booklet not only covering the fundamentals of frequency and timekeeping, but also containing the latest schedules on U.S. and international time signal broadcasts. **[435]**

Heat sinks. Astrodyne, Inc., 207 Cambridge St., Burlington, Mass., 01803. A complete series of natural convection heat sinks (2500 Series) is described in a four-page catalog. **[436]**

Coaxial circulators. Raytheon Co., 130 Second Ave., Waltham, Mass., 02154, has available a catalog presenting a wide selection of high-power coaxial circulators in all frequency ranges from uhf to X-band. **[437]**

Relay and timing devices. Allied Control Co., Inc., 2 East End Ave., New York, N.Y., 10021. A 64-page manual describes full operating characteristics, electrical characteristics and mounting information for over 40 different types of relays and timing devices. Copies may be obtained by letterhead inquiry.

Noise rejection. Dana Laboratories, Inc., Irvine, Calif., 92664. A 24-page technical paper, DL-521, is entitled "Techniques to Analyze and Optimize Noise Rejection Ratio of Low Level Differential Data Systems". **[438]**

Power supplies. Deltron, Inc., Wissahickon Ave., North Wales, Pa., 19454. Bulletin 203A describes a series of power supplies that features ultrafast programing speed in either voltage or current mode with instantaneous crossover to either mode. **[439]**

Printed circuit connectors. Continental Connector Corp., 34-63 56th St., Woodside, N.Y., 11377. Form RTA-1065 is a 14-page technical catalog covering an expanded group of right-angle plug and socket connectors for printed circuit applications. **[440]**

Magnetic components. Pulse Engineering Inc., 560 Robert Ave., Santa Clara, Calif. The 1966 magnetic component catalog is said to contain the most complete listing of pulse and high-frequency transformers ever offered. Copies are available by request on company letterhead.

Voltage tunable magnetrons. General Electric Co., Schenectady, N.Y. Voltage tunable magnetron brochure ETD-4374 outlines recent breakthroughs in protecting the devices against radio-frequency interference and in magnetic shielding. **[441]**

Numerical control. The Bendix Corp., Industrial Controls division, 8880 Hubbell Ave., Detroit, Mich., 48228. A 12-page, 2-color brochure (BICD-267) describes the new DirectaPath numerical control system. **[442]**

Miniature terminal block. Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N.J., offers a four-page brochure outlining the benefits and applications of its new miniature terminal block, the 300V, which allows 48 circuits per foot and ends the need for lugging. **[443]**

Toroidal cores. MicroMetals, 72 E. Montecito Ave., Sierra Madre, Calif., 91024, has available new data sheets describing a wide variety of iron powder toroidal cores, primarily for high-frequency applications. Information on Q vs frequency for typical inductances is included. **[444]**

Frequency converters. Brooks Instrument division, Emerson Electric Co., Hatfield, Pa., has issued a technical bulletin on series 4300 and 4700 frequency converters, which convert a variable frequency input into a precisely proportional d-c voltage or current. **[445]**

Diode reliability report. Unitrode Corp., 580 Pleasant St., Watertown, Mass. A 60-page report summarizes 15,700,000 diode hours of 100°C life test at rated conditions. The tests discussed were conducted over a period of three years, during which 7,885 units were life-tested without a failure. **[446]**

April 4, 1966

Electronics Abroad

Volume 39
Number 7

The Netherlands

Spot check

Toward the end of the year, Hollanders with especially acute hearing will notice, off and on, that strange, barely perceptible sounds are coming from their television and radio sets.

At that time, the government-run broadcasting stations will begin to air advertising spots. When a spot is broadcast, stations will identify it during the first five seconds with code signals—at the low end of the audio frequency range—mixed with the regular sound of the spot. Recorded on tape in a sample of receivers that matches the makeup of the Dutch population, these code signals will provide the basic data for a rating system that will tell advertisers whose message is getting through to the most listeners.

Electrologica NV, a small computer manufacturer based in The Hague, developed the system for a Dutch market research organization called Intomart. Intomart plans to install the recorders, dubbed Intometers, in a 1,000-household sample before yearend.

Coded. The system is designed so that the recorder attached to a receiver runs only during periods when the tuned-in station broadcasts a code signal. The code begins with a half-second pulse of three audio frequencies that starts the tape drive. This is followed by a half-second blank interval as a safety margin. Then come five half-second periods with single-frequency pulses or blanks; the combination identifies the spot being broadcast. Finally, there is a half-second pulse destined to identify the beginning of a block of data when the tape is run backwards to feed its contents into a computer.

For the prototype versions, Electrologica used frequencies of 70 and 90 cycles per second for the code signals. The production Intometers, however, will use frequencies of 57, 75 and 93 cycles per second.

Tape cartridge removed from Intometer recorder later is run through high-speed reader that feeds data from tape directly into a computer.

Selective. Input to the recorder is picked off the loudspeaker leads of the receiver. The audio signal first passes through a diode clipper (see block diagram). The clipper is followed by an automatic gain control amplifier so that a signal with a fairly constant amplitude is applied to the selective amplifiers, each of which is tuned to one of the code frequencies. These are two-stage amplifiers with feedback over a twin-T filter and an emitter follower.

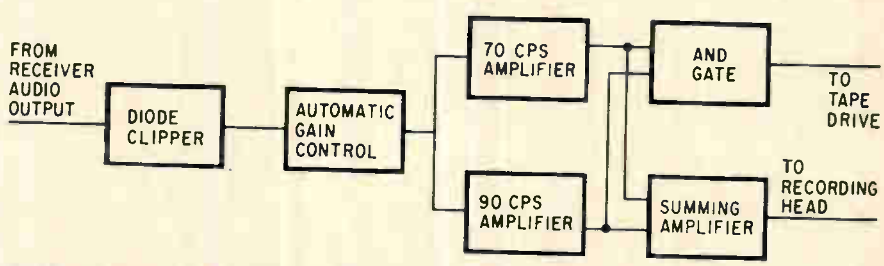
Output of the tuned amplifiers passes to both an AND gate and a summing amplifier. When a start pulse is received, the code frequencies appear simultaneously at the AND gate. This triggers a monovibrator circuit that powers the tape drive motor for five seconds. As the motor runs, the tape records the identification pulses fed to the recording head through the summing amplifier. Circuitry throughout is transistorized. The prototype version has two code-frequency channels; production models will have three.

Different. Operating as it does, the Intometer differs in many ways from the Audimeter used by the A.C. Neilson Co. to gather and store data for program ratings in the United States.

For one thing, the Audimeter runs 24 hours a day. The Intometer turns itself on for five-second recording sessions only when code signals are broadcast to identify advertising spots.

For another, data on the tape cartridges of the Dutch device can be transferred on-line into a computer. Electrologica has developed a high-speed reader that transcribes the tape data into computer language and passes it directly into a working memory of the computer. By contrast, the basic store in the Nielsen unit is a photographic film. It takes several time-consuming steps to convert the optical data on the film into magnetic pulses on a computer tape.

Nielsen has under development an Audimeter using magnetic tape that will be tried out in the Los



Dutch tape recorder runs for five seconds after frequencies from both selective amplifiers appear simultaneously at AND gate to trigger monovibrator circuit that powers tape drive motor. Prototype version shown above has two channels; production model will have three.

Angeles area about 18 months from now. Both the Audimeter and Intometer systems process the basic data on high-speed computers.

The Intometer hooks up to a receiving set simply by connecting it across the loudspeaker leads, something any technician can do in a few minutes, but the Audimeter has to be wired into the channel selector switch by a specially trained technician and it takes about an hour to do the job.

Finally, the Intometer is much the smaller of the two, about the size of a paperback book. In a household installation, this is no particular advantage since both the U.S. and Dutch units can be located off the set, down in the basement if need be. But the Intometer's small size gives it an added potential application — marketing data on use of audio radios. Philips Gloeilampenfabrieken NV, which has a 40% shareholding in Electrologica, may use the Intometer for that purpose.

West Germany

X-rays on tape

Doctors get immediate playback of X-ray images recorded on television tape.

Waiting time for results on extensive X-ray examinations has been slashed to practically nothing in some German medical centers where doctors are testing recording equipment that puts X-ray images on television tape.

Until now, physicians or researchers concerned with body functions in the chest, heart, digestive tract and the like relied on a cinematic recording of fluoroscope or serial X-ray images. But it meant waiting for the films to be developed before any detailed analysis could be made.

With the video tape equipment, however, the recording can be played back immediately. Although doctors can get instant viewing on a fluoroscope, the television tape equipment has an important advantage. The tape can be replayed over and over so doctors can spot anomalies visible only for a brief moment that might be missed in a flouroscope examination.

The recorder also is a valuable aid for teaching over closed-circuit tv systems in university hospitals and may well become standard equipment in many hospitals.

West Germany's Siemens-Reiniger-Werke AG developed the equipment, which is called the Siemens VR 1550. Basically, video signals derived from a tv pick-up unit coupled to the X-ray stereoscope are fed to the tape recorder and stored on 2-inch magnetic tape.

Whirling heads. Helical scanning techniques are used to record the X-ray images for television. The tape travels around a stationary scanning assembly. Inside it, a pair of recording heads whirls at 1,550 revolutions per minute. Because the tape describes a helix as it runs around the scanner, the recorded tracks slope across the tape. In the first half-revolution of the head drum, one head records a single field—312.5 lines of 625-line frame. In the second half-revolution the other head records the second 312.5-line field for the frame on the following track with interlacing.

The tape travels at about 4 inches per second around the scanning assembly; scanning speed of the rotating heads is 60 feet per second. At this speed the equipment can record video frequencies up to 5 megacycles.

Slow motion, too. For playback, a control system makes sure that each track on the tape stays synchronized with the head that recorded it. The system also provides for varying the tape speed to get slow-motion effects as in conventional motion pictures.

In addition to the video signals, the equipment can record audio signals from 90 cycles per second to 8 kilocycles in two independent channels. This allows doctors to record at the same time body sounds on one channel and their diagnoses or other data pertaining to the examination on the other channel. The audio tracks can be erased if a second playback without sound is desired.

Scandinavia

Down with defects

A third-harmonic testing technique pioneered in Scandinavia promises sweet music to engineers who want to speed up reliability checks on batches of linear components like resistors and capacitors.

The third-harmonic technique measures nonlinearity in components at rates up to 20 per second. This compares to integration times of as much as half a second per component when resistors are tested in the conventional way using wide-band noise sources.

Swedish idea. L.M. Ericsson Telephone Co. of Stockholm first hit upon the technique. Like manufacturers of telephone exchange equipment everywhere, Ericsson runs stringent reliability tests on the components it uses. Looking for something faster than wide-band noise testing, the company found that there's a close correlation between the noise in a linear component and the harmonic distortion the component causes when a pure sine wave is applied.

In resistors, defects like poor connections between loads and caps, bad spots in the carbon film, traces of carbon in grooves or poor contact between the cap and film show up as harmonic distortions in the test. So do small movements caused by electrostatic forces in capacitors and faulty contacts on capacitors. High-reliability equipment makers can't put components with faults like these into their gear.

Danish machine. Ericsson has been testing components with the third-harmonic technique for some years using made-in-the-house instrumentation. Now Radiometer A/S of Copenhagen has put on the market a tester based on Ericsson's experience. The Radiometer instrument soon will be introduced in the United States.

The instrument measures the third harmonic generated in components under test when a pure sinusoidal 10-kilocycle wave is applied. Although the concept is simple, some tricky circuitry is necessary to make the idea work since the third harmonic must be measured 160 decibels below the level of the 10-kc test signal. To achieve this, Radiometer developed special air core matching transformers, filter circuits, and highly stable automatic gain controls.

The third-harmonic output is displayed on a meter with sensitivity of 1 microvolt and an accuracy of 5%. For testing in production quantities, a logarithmic amplifier is switched in to prevent overload. This allows a dynamic output variation of 60 decibels, a range that can easily be encountered in production testing when components are faulty.

A component sorting device can be coupled directly to Radiometer's tester. When this is done, over-all reliability of a batch of components can be increased by sorting out components whose nonlinearity exceeds the average range for the batch.

France

Competition for Comsat?

Charles de Gaulle's determination to free France—and for that matter all Western Europe—from dependence on the United States may give the Communications Satellite Corp. some competition.

De Gaulle wants his communications satellite to link France with a dozen countries in Africa and the Mideast. A decision on the $50-million dollar project may come soon. With top-ranking space and communications officials scheduled to confer with de Gaulle and his cabinet late this month or early in May, the go-ahead could come then.

Charles de Gaulle's insistence on a French communications satellite has produced plans for the $50-million Safran project. Safran is the acronym for satellite francais.

By the dozen. Safran is the name the French have given their communications satellite project. The 400-pound satellite would have 144 telephone channels assigned a dozen each to a dozen ground stations. The main transmission station would be at Pleumeur-Bodou in Finistere, the existing French facility for space communications.

Preliminary estimates peg the cost for building the satellite, the launch vehicle, and the 12 ground stations at about $35 million. A launching pad for Safran at the French Guiana space complex [Electronics, Nov. 1, 1965, p. 159] would cost another $14 million. The tentative launch date is 1970.

For their outlay, the French would get only a part-time system. Plans are for a single satellite in an equatorial orbit. That means the satellite would be in range of the ground stations only six hours a day. For round-the-clock service, six satellites would be needed. The price presumably would be more than the French are willing to pay.

With the system they plan, it's obvious that the French don't intend to drop out of Comsat. But from de Gaulle on down, French officials refuse to consider space communications satellites as the exclusive preserve of the United States and Russia.

Side effect. De Gaulle's projected communications satellite may be a tonic for the ailing European Launcher Development Organization. Great Britain, which makes the biggest contribution to the seven-nation joint rocket effort, wants to pull out of ELDO or at least have her share of costs reduced. Cost of the three-stage ELDO-A rocket has doubled to $400 million from the $200 million originally estimated and the first one still hasn't been launched.

To launch Safran, the French are considering a modified ELDO-A rocket with an added fourth stage to boost the payload to slightly over 400 pounds. So there's a good chance France would agree to ease the British burden. The ELDO countries will meet next month to hash over future plans.

If ELDO fizzles, the French have in reserve a project to boost the lifting power of their own Diamant satellite launcher [Electronics, March 7, 1966, p. 302].

Great Britain

Uncoiled

For the upcoming generation of receivers built around integrated circuits, set makers want to do away with bulky coils, Gullivers in the Lilliputian world of thin films and silicon chips.

Researchers at Standard Telecommunications Laboratories Ltd. of Harlow, England, have come up with a thin-film IC filter design that points to the demise of coils in frequency-selective circuits for intermediate frequency amplifiers. Already they've pushed their filters to frequencies as high as 10 megacycles and obtained response factors (Q) of 20.

H. T. Roettgers and P. Lemke, who spearheaded the research work at STL, admit the Q is still too low for consumer receivers. But the pair thinks further design refinements would make their thin-film filter a practical component for receivers. First applications, though, will most likely come in professional equipment to back up mechanical filters and selective stages of noise suppression circuits.

Old hat. Filters without coils are old hat at audio frequencies. The most commonly used circuit is the twin-T, six lumped resistance and capacitance components arranged in a bridge network. Above audio frequencies, however, twin-T filters start having troubles. Their response factors are not predictable. In feedback networks, the center frequency of the filter-amplifier combination shifts away from the center frequency of the filter itself, cutting down its effectiveness. Roettgers and Lemke say their thin-film three-component filter with distributed resistance and capacity overcomes these drawbacks.

Actually, the theory of tapered distributed filters is not new. Researchers at several American companies have demonstrated the possibility. But so far there's been little success at translating the theory into a device. The theory was verified by simulating distributed resistance with impregnated paper paired with foil for the capacitive elements. Diffused R-C networks were tried but they failed because values of the diffused components couldn't be controlled closely enough.

Bell Telephone Laboratories, however, has a process—sputtered tantalum—that shows promise for high-frequency distributed filters. Already Bell Labs has designed a sputtered tantalum network for the audio-frequency notch filter in a telephone data set.

Armed. The thin-film filter developed by STL has a series arm and a parallel arm. To make it, STL first deposits a distributed series-arm resistance and the parallel-arm resistance on a glass substrate. Then follows a silicon monoxide layer to form the dielectric for the capacitor. Finally, a tapered metal top plate for the capacitor is deposited along with a connection between the plate and the parallel-arm resistor.

In a network like this, output voltage is a combination of the voltages across the two arms. Voltage across the series arm varies with frequency. At the center frequency, real and imaginary components of the voltage vector in each arm are equal and opposite; this attenuates the center frequency.

For the filters, STL has plotted standard design curves to calculate the values of resistances and capacitance needed to obtain the required center frequency. It is inversely proportional to the product of the RC values; the component tolerances determine the center-frequency accuracy.

The amount of taper on the series-arm resistance controls the Q of the filter. Theoretically, infinite Q is possible but the maximum value obtained so far is about 20. Over-all Q value of the filter-amplifier combination also depends on the gain of the amplifier. To hold Q within 5%, for example, an amplifier with a gain of 35 decibels would have to be stabilized to plus or minus one decibel.

Around the world

Japan. A laser radar—Japan's first—has been built at the Institute of Industrial Science of the University of Tokyo. Scientists there think it could be the forerunner of collision-preventing equipment for high-speed trains and aircraft. Effective range of the laser is six miles and its beam width less than 1 milliradian. The ruby laser develops an output of 20 megawatts at a one-second repetition rate.

Denmark. Storno, a Copenhagen-based maker of mobile communications equipment, plans to tackle the United States market with a taxi-alarm system. The equipment automatically transmits five tones in sequence when the driver pushes an "emergency" button. The tone sequence rings an alarm at the base station and displays the taxi's identification number on a panel.

Switzerland. Wild-Heerbrugg, Ltd., has teamed up with the Raytheon Co. to produce an automatic mapping system that scans a pair of stereo photographs and extracts profiles, contours and digital data. The equipment may find its way into applications for numerically controlled machine tool. It could translate the shape of an industrial model into digital data for NC milling machines.

Kuwait. The Marconi Co. of Great Britain has won a $2.8-million contract to build one of the world's most powerful broadcasting stations for the Kuwait government. The station will have three 750-kilowatt transmitters and cover the entire Middle East.

Electronics advertisers

April 4, 1966

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F. J. Eberle, Business Mgr.

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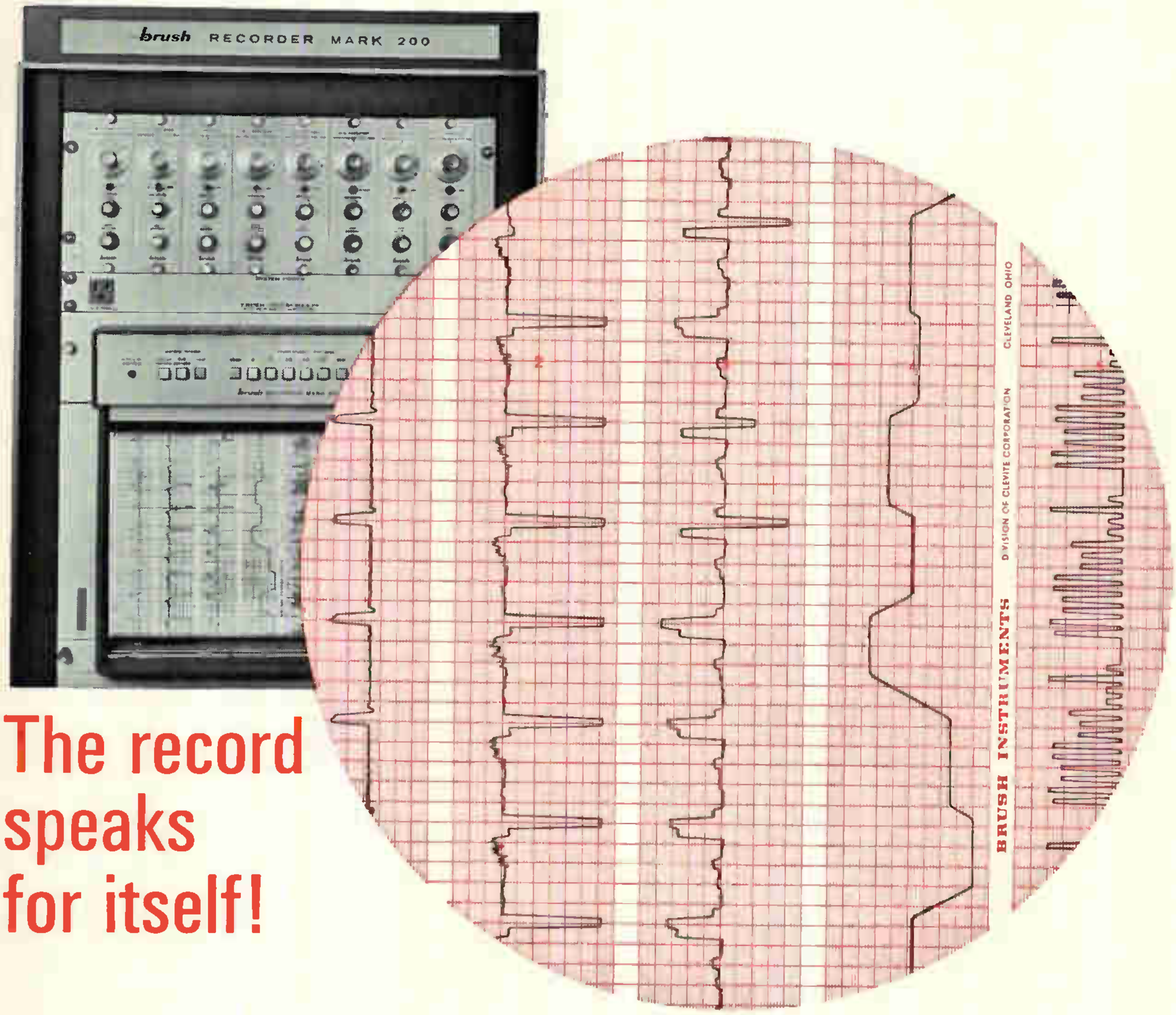

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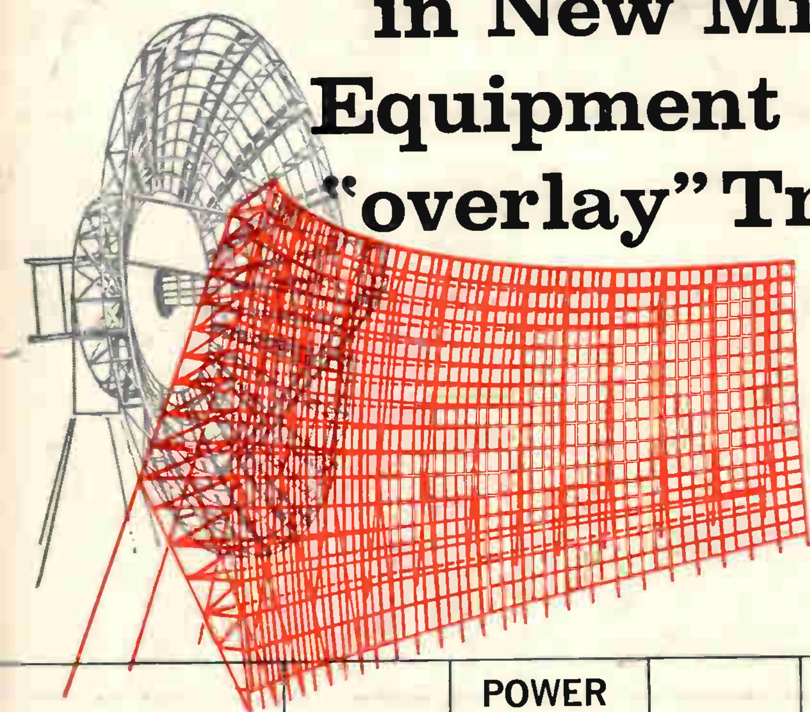

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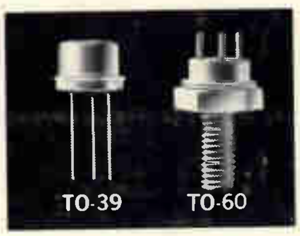

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