INTEGRATED CIRCUITS
Functional parts aid design, p 72
(Illustration below)

CRYOSAR DEVICES
Promising computer elements, p 39

JUNCTION TRANSISTORS
Chart classifies modern types, p 46
### Type Sec. Test

**Typical Miniature Audios**

**RC-25 Case**

61/64 x 1-13/32 x 1-9/16

1.5 oz.

**Typical Subminiature Audios**

**SM Case**

1/2 x 11/16 x 29/32

.8 oz.

### Type No. Application MIL Type Pri. Imp. Ohms Sec. Imp. Ohms Unbal. Response Max. level dbm

<table>
<thead>
<tr>
<th>Type No.</th>
<th>Application</th>
<th>MIL Type</th>
<th>Pri. Imp. Ohms</th>
<th>Sec. Imp. Ohms</th>
<th>Unbal. DC in Pri. MA</th>
<th>Response 2 db (Cyc.)</th>
<th>Max. level dbm</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-20</td>
<td>Single plate to 2 grids, can also be used for P.P. plates</td>
<td>TF4RX15YY</td>
<td>15,000 split</td>
<td>80,000 split</td>
<td>0</td>
<td>30-20,000</td>
<td>+12</td>
</tr>
<tr>
<td>H-21</td>
<td>Single plate to P.P. grids, DC in Pri.</td>
<td>TF4RX15YY</td>
<td>15,000</td>
<td>80,000 split</td>
<td>100-20,000</td>
<td>+23</td>
<td></td>
</tr>
<tr>
<td>H-22</td>
<td>Single plate to multiple line</td>
<td>TF4RX13YY</td>
<td>15,000</td>
<td>50</td>
<td>50-20,000</td>
<td>+23</td>
<td></td>
</tr>
<tr>
<td>H-23</td>
<td>P.P. plates to multiple line</td>
<td>TF4RX13YY</td>
<td>30,000 split</td>
<td>50</td>
<td>50-20,000</td>
<td>+19</td>
<td></td>
</tr>
<tr>
<td>H-24</td>
<td>Reactor</td>
<td>TF4RX20YY</td>
<td>450 Hys.-G DC, 250 Hys.-5 mA DC, 6000 ohms 65 Hys.-10 Ma DC, 1500 ohms</td>
<td>500 CT</td>
<td>500/125 split</td>
<td>20</td>
<td>40-10,000</td>
</tr>
</tbody>
</table>

**Typical Compact Audios**

**RC-50 Case**

1-5/8 x 1-5/8 x 2-5/16

8 oz.

**Typical Power Transformers**


**Typical Filament Transformers**

Pri: 105/115/210/220V except H-130 (115) and H-131 (115/220) 50/60 Cyc.
DIFFUSION MASKS used by Fairchild Semiconductor to make integrated-circuit components. Devices help circuit designers plan and evaluate logic system breadboards. See p 72 COVER

ELECTROMAGNETIC COMPATIBILITY Analysis Center Begins Probe of Space Tracking RFI. Center is compiling data while tackling military interference problems. Decisions reached by the center will heavily influence design, location and use of military electronics equipment

TELSTAR'S TV PROGRAMS Underline American-European Cooperation. Here's how programs are converted, to satisfy differing tv standards, and transmitted over the Atlantic. Launch of second satellite this fall will expand system

NOBLE-GAS LASERS Provide More Optical Frequencies. Researchers demonstrate that 5 gases give 14 different frequencies at wavelengths between 1.5 and 2.2 microns. Neon and helium mixture radiates coherent visible light

SYNCHRONOUS SATELLITE Program Enters Second Phase. Development of full-size Syncom begins. One of these could continuously relay voice and tv between the Americas, Europe and Africa

CRYOSAR ELEMENTS Hold Promise for Tomorrow's Computers. A recent development in cryogenics, the Cryosar, operates by impact ionization of germanium at liquid helium temperatures. It may be used for storage cells, flip-flops and other computer building blocks. Outstanding features are low cost, low power dissipation and simplicity of construction. By L. M. Lambert and J. E. McAteer Aeronutronic Division of Ford Motor Co. 39

JUNCTION TRANSISTORS: A Guide to Modern Types. New chart classifies the many varieties according to method of fabrication. Grown, alloy, electrochemical, diffusion and epitaxial transistors are described. Here is a clear and concise look at the basic differences in transistor configurations. By R. L. Pritchard, Texas Instruments Inc. 46

OVERCOMING TURN-ON EFFECTS in Silicon Controlled Rectifiers. Limited turn-on speed of silicon controlled rectifiers causes problems in applications such as high-frequency inverters and pulse modulators. Here are ways of avoiding unexpected triggering, high turn-on losses and possible device failure. By N. Mapham, General Electric Co. 50

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NOVEL ZENER DIODE Array Forms High Speed Quantizer. Zener diodes provide simultaneous voltage comparison and stable voltage reference in an analog-to-digital converter while alleviating interaction problems inherent in conventional comparators. Technique offers higher speed capability than is found in most other converters.

By J. J. Kolarcik, Radio Corporation of America 52

SELECTING TV STANDARDS. Nomographs enable design engineers to get overall view of various combinations of bandwidth, resolution, scanning rates, aspect ratios and blanking interval. This unusual design chart will be especially helpful to military and space TV designers.

By J. W. Wipson 56

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The “Two Cultures” Controversy

IS WESTERN SOCIETY being split into two mutually antagonistic cultures, the traditional and the scientific? Is the gap between them becoming so wide it imperils our future?

A controversy over these questions began in England and is now gravitating to America. Because it focuses on challenges presented by the current scientific revolution, we consider it of particular interest to electronics engineers.

THE CONTROVERSY was triggered by a recent reply by British critic F. R. Leavis to a lecture given in 1959 by author-scientist C. P. Snow. Snow was shocked that no one in a literary group could describe the second law of thermodynamics, a question “which is about the scientific equivalent of ‘Have you read a work of Shakespeare’s?’” He went on to castigate literary people in general for being insufficiently aware of and in some ways opposed to the scientific revolution.

Scientists, Snow claims, struggle to improve man’s social condition. This condition, he says, is that most humans are underfed and die before their time; it will, he thinks, be overcome by carrying out the scientific revolution, especially in the underdeveloped areas of the world. Scientists and engineers are called the people for this task, which Snow sees as the one way out through H-bomb war, over-population and the gap between rich and poor. Before they can be effectively utilized, however, it will be necessary to close the gap between the two cultures, he concludes.

THESE OPINIONS were attacked by Leavis because he was alarmed that Snow’s “The Two Cultures and the Scientific Revolution” had become so influential as to be required reading in British schools. Leavis calls Snow “portentously ignorant” and feels that his thesis presents a challenge to be dealt with vigorously.

Levis takes issue with Snow’s description of the literary culture as well as with his idea of a world in which raising the standard of living is the almost exclusive aim. He questions Snow’s emphasis of the world’s overall social condition to the exclusion of the individual condition, and calls for “something that is alien to either of Snow’s two cultures,” a third intelligence that is “strong in experience, and supremely human” to meet the challenges of the future arising out of the advance of science and technology.

This future, Leavis says, will be one of rapid changes, unprecedented tests and challenges, decisions and possible non-decisions, momentous and insidious in their consequences for mankind.

WE ARE KEENLY AWARE of the scientific revolution and of the importance of men who are in the forefront of it. Yet we disagree with much of Snow’s story. We believe his picture of a society polarized into two antagonistic cultures to be exaggerated, and think that non-scientists are not as ignorant and opposed to science as Snow makes them out.

While concurring with Snow that Western technology should help underdeveloped nations to pass peacefully through their inevitable scientific revolution, we believe Leavis’ warning that such concern is not enough to be a vital one. For the concern of man should not be solely with improving his physical standard of living. To suggest that we will be secure in a “scientific” future resulting from this concern is naive. Science and engineering will help us reach a better world, but only our humanity will enable us to realize it.

Coming In Our August 24 Issue

READING WRITING. Developers of reading equipment for data processing systems have made type and numeral readers practical and are going after handwriting readers. Next week, L. D. Harmon, of Bell Telephone Labs, describes a reader that identifies handwritten names of numerals. It makes logical decisions based on word appearance.

Other upcoming feature articles include a new approach to serial decoding, by R. M. Centner and J. R. Wilkinson, of Bendix Research Labs; a simplified curve tracer for displaying transistor beta, by J. V. McMillin, of Measurement Research Center; an r-f induction heater that simulates reentry, by B. E. Mathews and F. R. Sias, Jr., University of Florida, and a graphical method for designing digital circuits, by R. W. Hockenberger, of Avco.
COMMENT

Powers of Numbers

In the June 15 Comment (p 4) you rejected R. O. Whitaker's suggestion about his power-of-ten system on the grounds that it introduces severe printing problems.

May I point out that this same problem has been encountered in writing programs for digital computers. The solution to the problem has not only been found but is in widespread use. It is illustrated in the following table (using the example in Whitaker's letter):

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Power of Ten</th>
<th>Digital</th>
<th>System</th>
<th>System</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>137 Tc</td>
<td>137 (12)</td>
<td>137.E+12 c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64.8 nf</td>
<td>64.8 (–9)</td>
<td>64.8.E–9 f</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180 µohms</td>
<td>180 (–6)</td>
<td>180.E–6 ohms</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The letter E probably originated as an abbreviation for the word “exponent” (of ten multiplier). Note that the digital computer notation:

(1) Presents no print-setting problems. It can be (and regularly is) typed by any typist on conventional typewriters.
(2) Is already in widespread use by computer programmers.
(3) Is self-explanatory.

For further reference, you may check any of the numerous Fortran manuals distributed by I.B.M.

G. J. GALLAGHER
E. I. du Pont de Nemours & Company
Wilmington, Delaware

Those parentheses in the power-of-ten portion of the table should really be circles around the numbers, in the Whitaker system. But, as reader Gallagher notes, circles around numbers involve printing problems.

A more recent letter from reader Whitaker, amending his original letter, ends with:

The one argument in favor of the prefixes is that it is easier to say “teracycles per second” than it is to say “times ten to the twelfth cycles per second.” However, this advantage disappears if we use the word up to indicate positive powers of ten and the word down to indicate negative powers of ten. The frequency in the example above would be spoken as “137 up 12.” The capacitance would be spoken as “64.8 down 9.”

An additional advantage of the exponent system over the prefix system is that order of magnitude of an expression may be more quickly obtained. In the case of the circle system, add the numbers in the circles. In the case of the prefix system, convert the prefixes, add up the characteristics of the numerical portions, and add the result to the converted prefixes.

R. O. WHITAKER
Rowco Engineering Company
Indianapolis, Indiana

Praise From a Student

At the moment, ELECTRONICS is the only electronics magazine I subscribe to. Before I ran across it in the library at Valparaiso University, I was continually frustrated by the rather immature and nonrigorous treatment of articles in the other well-known and popular magazines intended primarily for servicemen. Along with a few engineering journals, ELECTRONICS is the only publication which answers the needs of the serious student of electronics.

So I am glad that you have fulfilled your obligation to good scientific treatment of a scientific subject. And in particular I commend you for avoiding the characteristic dryness of some of the other journals, and for having a personality of your own which is inspiring instead of dully methodical.

It is true now that I am probably not the most valuable subscriber from the standpoint of your advertisers. But I shall probably still be reading ELECTRONICS when my time comes—so I hope you do not begrudge me the (most necessary) pleasure of your magazine now.

NORMAN R. DITTMAR
Petoskey, Michigan

In the interest of providing a wide variety of the latest information to this country's engineering students, who constitute one of the most valuable assets of the nation, we make a number of subscriptions available to senior engineering students.
predictable performance over wide ambient temperatures...

it's thermoproof!

Solid state PORCELAIN CAPACITORS

* low loss
* low noise
* greater stability
* wide temperature range
* impervious to humidity

-55°C to +125°C operation
0.5 mmf to 6800 mmf
50 to 500 vdc
Conforms to MIL-C-11272B

© Vitramon, Inc. 1962

And performance is predictable! All "VY" Capacitors will retrace the curve, illustrated, within 5 ppm — an important factor in multi-stage circuits where capacitance must change in an identical manner in all stages, or where precise compensation is needed.

© Vitramon, Inc. 1962

Box 544 • Bridgeport 1, Connecticut
No leads to unsolder
Four overlapping Beta Ranges • High meter resolution
Direct reading with test circuit power off

New Sierra 219B 4-range Transistor Tester reads Beta directly in the circuit; also measures $I_{co}$, Beta out of circuit.

Less downtime and less danger of damage to transistors under test with this new Sierra instrument—battery-operated, light weight, portable, easy to use.

Maintenance, quality control, incoming inspection and production testing are just a few of the applications where you save time and money by testing transistors, even complete assemblies, without unsoldering leads. Model 219B reads Beta in the circuit, 1 to 120. $I_{co}$ is measured on a straightforward basis; collector potentials of 3, 6 or 12 Vdc may be selected. All controls are on the front panel... an instrument of convenience, speed, accuracy.

Write or phone today for information and demonstration.

SPECIFICATIONS

Test ranges
- Beta: 1-4, 3-12, 10-40, 30-120*
- $I_{co}$: 0-50, 0-500 µA

Accuracy
In circuit: ±20% for external loads over 500 ohms.
Improved accuracy above 500 ohms, usable readings below 500 ohms.

Out of circuit: ±10%

Power: Internal battery, mercury or zinc-carbon type, 600 hrs. av. life; output indicated on front-panel meter.

Operating Temperature: 32 to 149° F

Size: 9" high, 7¾" wide, 6½" deep, weight, 10½ lb., including batteries.

Price: $275.00

*Beta readings to 300 may be approximated.
Niobium Capacitor Will Make Bow at WESCON

BOSTON—Solid niobium capacitor will be unveiled next week at WESCON by Sprague Electric Co. The solid-electrolyte capacitor has electrical characteristics and applications similar to tantalum. Two advantages cited by Sprague are:

First, niobium is more abundant and is available in domestic ores. The U. S. depends on Katanga, in the Congo for tantalum, so its use in the U. S. is controlled. Second, niobium prices may be lowered in the future, although first prices will be comparable to tantalum.

Sprague reports it worked three years on development of the solid niobium capacitor and has developed a process related to but substantially different from the tantalum process. Packages are identical to tantalum packages.

The company sees interest by the military, since niobium capacitors offer relief from the tight tantalum supply situation, and by industry too, since applications will be protected against the possibility of the government shutting off the supply of tantalum for nonmilitary uses.

NBS Establishes Three New Electronics Sections

CIRCUIT STANDARDS division at National Bureau of Standards’ Boulder, Colorado, Laboratories, has created three new sections from units of the Electronic Calibration Center. The role of each of the new sections will be to continue to develop, maintain, and improve calibration services, instrument and measurement techniques. The new sections provide microwave calibration services, high-frequency calibration services and low-frequency calibration services.

Visible Light Lasers Go Onto Commercial Market

TWO COMPANIES have announced the commercial availability of c-w visible-light lasers, both helium-neon units with output in the 6,300 angstrom region. Both are priced at $7,500. One is being introduced at WESCON by Perkin-Elmer, who jointly developed it with Spectra-Physics, Inc., and the other is being introduced by Raytheon. The Raytheon unit has an estimated output of 15 µw in a single mode, higher output in multimode operation.

Field Measurements Detect Distant Nuclear Explosion

BOSTON—The recent high-altitude nuclear blast at Johnston Island was detected electromagnetically 6,000 miles away in Natick, Mass., by researchers from Space Sciences Inc. Arthur Winston, company president, says the technique involves amplifying and recording below Vlf, at frequencies of the order of 1 cps.

Nonpolarizable contacts 6 or 7 inches in diameter are imbedded in earth at five points in the Natick area, 100 feet to 1,000 feet apart. The electric field potential between two or more probes is amplified and fed into an x-y recorder which plots variations in potential against time. These marks of electric field measurements plotted against time yield a clear signature of the blast, says Winston, providing a picture of how ionospheric changes affect electric fields in the earth. The recordings are being analyzed for implications in nuclear test detection.

Japanese Form Guild For Computer Research

TOKYO—The Computer Technology Research Guild, an organization to correlate research on large computers in an attempt to compete with U. S. firms, was recently formed by Nippon Electric Co., Fuji Electric Communication Apparatus Mfg. Co. and Oki Electric Co. Plans include development and manufacture within three years of a large, high-efficiency computer comparable to the IBM 7090. NEC will develop magnetic core equipment, Fuji the punch-card system and Oki the printer. The rest of the

One Way or Another, Hong Kong Gets Transistors

TOKYO—Reports reaching Japan say the Hong Kong government has refused the offer by the Ministry of International Trade and Industry to lift the ban on exports of transistors from Japan to Hong Kong. Exports were suspended since last May. Hong Kong has reportedly made arrangements to import transistors from West Germany and other European countries.

Neither the Japanese Foreign Office nor MITI received official reports from their consulates in Hong Kong. They were puzzled by the reports reaching the industry.

A spokesman for the Japan Machinery Export Association said however, “Whether the Hong Kong Government says yes or not, it does not make much difference so far as transistor exports to Hong Kong are concerned because stocks are going anyway on business deals.”

The Japan Electronics Parts Industry Association, with a membership of 120 firms, recently said a contract will be signed with one Hong Kong firm to export monthly 50,000 kits for six-transistor radios worth $250,000. A spokesman for the association said similar deals will be signed with other Hong Kong companies.
system will be developed jointly. Total development cost will be about $2 million. The guild has received a $241,666 government subsidy for fiscal 1962.

Navy Weighs Design for TFX Plane's Missiles

WASHINGTON—Navy has accepted the technical proposal of Hughes Aircraft for an air-to-air missile system that would be used on the Navy's version of the TFX tactical fighter plane (p 14, July 13, and p 14, Dec. 29, 1961). Hughes won in competition with Bendix, Grumman and Raytheon.

The Navy stressed that Hughes' selection does not commit it to final missile development. Says the Navy: "The major objectives will be to refine further the system proposal and to define the system characteristics in conjunction with the aircraft design studies."

The qualifications in Hughes' status reflect the extension of competition between Boeing and General Dynamics (with Grumman as a partner) for a Pentagon development contract for the plane itself.

Du Pont Enters Instrument Business With Analyzer

WILMINGTON, DEL.—An on-stream photometric analyzer of liquids, gases and some solids will be the first product of Du Pont's Instrument Products division, established last January. To determine a materials' composition, the instrument measures the amount of visible or ultraviolet light of a specific wavelength that a sample absorbs. A similar principle is also used to measure the thickness of transparent and translucent films and coatings.

Army Command to Manage Electronic Activities

ARMY ELECTRONICS COMMAND, for the management of research, development, procurement and production of electronic material required by the Army, has been officially established, announced Maj. Gen. S. S. Hoff, commander. The command, located at Ft. Monmouth, N. J., will also provide contact between the Army and industry. Operating budget is expected to vary between $700 million and $1 billion.

Electronics Command is one of five middle management commands, others being Missile, Weapons, Mobility and Munitions Commands.

Space Fuel Cell Contract Awarded By Air Force

SOLID-ELECTROLYTE fuel cell, able to operate at temperatures as high as 1,850° F, will be developed for the Air Force space program by Westinghouse Research Labs. The contract calls for modification of a previously developed experimental cell (p 27, June 8), to determine its feasibility for space use and for evaluation of the cell in comparison with other space power systems.

Electrolytes will be ceramic mixtures such as zirconium and calcium oxide. Electrodes will be metals such as platinum or nickel. Fuel will be hydrogen, fed to the negative electrode, and oxygen, fed to the positive electrode. Westinghouse says its experimental version has produced current densities of more than 100 amperes a square foot and that cells operated at low current density have operated longer than two months with no noticeable deterioration.

Industry Will Receive NASA Research Results

INDUSTRIAL APPLICATION advisory committee will coordinate NASA's efforts to transfer new scientific and technological knowledge from NASA's research and development to industry. The committee will recommend methods for identifying, retrieving, evaluating and disseminating innovations having a high industrial potential. Recommendations will be implemented through NASA's Office of Applications. E. P. Stevenson, who formerly held industrial positions, will head the committee.

In Brief . . .

MARINER II will be launched by NASA, no earlier than today, in the second attempt to reach Venus.

GENERAL ELECTRIC is entering the process instrumentation field. It estimates total annual market for equipment will grow from $330 million now to $700 million in 1970.

RADIO AND TV production during the first six months of 1962 was higher than in the first six months of 1961, reports EIA. Total TV output was 3,295,501 compared to 2,801,136 last year, and radio production was 9,264,445 compared to 7,537,290.

JAPANESE electronics output input increased 20 percent during 1961 to a total of $1.4 billion, according to the U.S. Department of Commerce.

RAYTHEON reports that its Sparrow III missile, launched from an F4H fighter plane, downed a supersonic Regulus II missile. Raytheon quoted Navy as stating it was the first head-on interception of a ground-launched missile by an air-launched missile.

RADAR ALTIMETER with a range of zero to 5,000 feet is to be developed by Sperry Gyroscope for Air Force. Error below 40 feet is to be no more than 2 feet.

EIA ANNOUNCES that more than 60 microwave components manufacturers have agreed to participate in a statistical program for the industry.

CONTRACTS include $1 million to Vitro Electronics, for 500 h-f communications sets; $650,000 to Manson Labs, for r-f oscillators; $469,000 to U. S. Science Corp. for aircraft instrument testers.

GENERAL ELECTRIC is developing a monitoring and telemetry system for a Snap 10-A, 500-w nuclear space power system being developed by Atomics International for AEC. Under another AEC contract, Martin Co. is to develop a conceptual design for another 500-w nuclear power system.
Get nearly twice the capacitance of older designs in Sprague’s new high-gain etched-foil TANTALEX® Capacitors

IMPROVE FILTERING EFFICIENCY WITH NO SACRIFICE IN RELIABILITY, SIZE, OR WEIGHT!

HIGH CAPACITANCE Tubular Tantalex Capacitors with almost double the capacitance of standard etched-foil tantalum capacitors have been developed by the Sprague Electric Company to meet the needs of design engineers.

A new etching technique, the result of an intensive research program, gives considerably higher effective surface area to the capacitor electrodes without sacrifice in reliability or in any of the electrical parameters by which foil tantalum capacitors are usually judged.

Unlike other “high capacitance” foil tantalums, Sprague Tantalex Capacitors continue to maintain their rigid standards for shelf and service life under severe environmental conditions. Certain performance characteristics have actually been tightened. For example, allowable leakage current has now been halved, making the use of these capacitors possible in many new applications.

Etched-foil Tantalex Capacitors are available in two operating temperature ranges—polarized Type 112D and non-polarized Type 113D for -55 C to +85 C operation, as well as polarized Type 122D and non-polarized Type 123D for -55 C to +125 C operation.

The Foil-type Tantalex Capacitor Line also includes conventional low-gain etched-foil and plain-foil capacitors in both polarized and non-polarized construction, providing a foil tantalum capacitor for every application.

Relaxation at 500°F of DURANICKEL Alloy 301 springs, age-hardened at 900°F/6Hr. All stresses corrected for curvature; modulus corrected for temperature.

Reloaded to original length 8 day intervals.

80,000 psi.
70,000 psi.
60,000 psi.

Nickel Alloy Springs last longer in Corrosive Environments and at High Temperatures

The physical constants of DURANICKEL Alloy 301 and PERMANICKEL Alloy 300

<table>
<thead>
<tr>
<th>PHYSICAL CONSTANT</th>
<th>DURANICKEL Alloy 301</th>
<th>PERMANICKEL Alloy 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFIC GRAVITY, GM/CM</td>
<td>8.26</td>
<td>8.75</td>
</tr>
<tr>
<td>DENSITY, LB./CU. IN.</td>
<td>0.298</td>
<td>0.316</td>
</tr>
<tr>
<td>THERMAL CONDUCTIVITY AT (32°-212°F)</td>
<td>128/137**</td>
<td>400</td>
</tr>
<tr>
<td>BTU./SQ. FT./HR. °F./IN.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELECTRICAL RESISTIVITY OHMS/CIR.</td>
<td>260**</td>
<td>94.5**</td>
</tr>
<tr>
<td>MIL. FT. (68°F)</td>
<td></td>
<td>15.7**</td>
</tr>
<tr>
<td>MICROHMS/CM. (20°C)</td>
<td>43**</td>
<td></td>
</tr>
<tr>
<td>TEMP. COEF. OF RESISTIVITY PER°F.</td>
<td>0.0006</td>
<td>0.002</td>
</tr>
<tr>
<td>PER°C. (20-100°C)</td>
<td>0.001</td>
<td>0.0026</td>
</tr>
<tr>
<td>MEAN COEF. OF THERMAL EXPAN. AT (77°-212°F),</td>
<td>0.0000072</td>
<td>0.0000072</td>
</tr>
<tr>
<td>IN./IN./°F. AT (25-100°C) CM./CM.°C.</td>
<td>0.000013</td>
<td>0.000013</td>
</tr>
<tr>
<td>MAGNETIC TRANSFORMATION TEMP. F. (APPROX.)</td>
<td>200**</td>
<td>563**</td>
</tr>
</tbody>
</table>

Design Stress for age-hardened DURANICKEL Alloy 301 and PERMANICKEL Alloy 300 springs at elevated temperatures.

<table>
<thead>
<tr>
<th>Coiling Method</th>
<th>Maximum Shearing Stress for temperatures (°F) indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>Up to 400°F. 550 to 600°F.</td>
</tr>
<tr>
<td>Hot</td>
<td>70,000 psi 60,000 psi</td>
</tr>
</tbody>
</table>

Other nickel alloys recommended for electrical spring assemblies include PERMANICKEL* Alloy 300 high electrical and thermal conductivity requirements, MONEL* Alloy 400 for general applications requiring corrosion resistance in addition to toughness and strength up to temperatures of 450°F and INCONEL Alloy 600 for good strength, ductility, resistance to oxidation and good spring properties up to 750°F.

You can get the complete story on nickel alloy springs. Write for our technical bulletin T-35, “High Nickel Alloy Helical Springs.” Our corrosion and high temperature engineers will be glad to help with any specific problem you have.

INCONEL* Alloy X-750 is the outstanding choice for springs operating up to 1200°F because of its high strength stability, good oxidation and corrosion resistance, and resistance to relaxation.

DURANICKEL* Alloy 301 gives excellent service at temperatures up to 600°F. It is used for infrared bulb spring contacts, springs in sun lamps and spark plugs, electric toaster coils and numerous other applications requiring relaxation resistance at elevated temperatures.

Other nickel alloys recommended for electrical spring assemblies include — PERMANICKEL* Alloy 300 high electrical and thermal conductivity requirements, MONEL* Alloy 400 for general applications requiring corrosion resistance in addition to toughness and strength up to temperatures of 450°F and INCONEL Alloy 600 for good strength, ductility, resistance to oxidation and good spring properties up to 750°F.

You can get the complete story on nickel alloy springs. Write for our technical bulletin T-35, “High Nickel Alloy Helical Springs.” Our corrosion and high temperature engineers will be glad to help with any specific problem you have.

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NAVy IS PUSHING PLANS for a substantial ship modernization program, against the backdrop of the administration's stress on preparation for limited war.

About 75 percent of the fleet was built during World War II. Navy wants at least 518 new vessels in the next seven years, double the present shipbuilding program. The cost, about $25 billion, would be well over the Pentagon's present long-range plans for naval modernization.


STRAW IN THE SATELLITE WIND: LOWER RATES FOR U. S.

NOTHING HAPPENED to the Communications Satellite Act during last week's hearings before the Senate Foreign Relations Committee. The committee sent the bill back to the Senate unchanged. The bill was sent to the committee in an effort to break the marathon debate begun by a group of 10 to 15 senators led by Estes Kefauver (D-Tenn.) and Wayne Morse (D-Ore.), who want government ownership of the system.

The only positive result of the week's delay in the showdown was the increased likelihood of reduced rates for government use of the satellite communications system. Support for this was voiced, although amendments putting it in writing were voted down in committee.

Top Administration officials supporting the bill, including Attorney General Robert F. Kennedy, Secretary of State Dean Rusk and FCC Chairman Newton Minow, did little to sway the dissident senators.

WHILE THE ADMINISTRATION was lobbying hard for approval of the satellite monopoly, it was being urged by David Sarnoff, RCA chairman, to unify overseas communications policy and merge all American international carriers into a single company. The proposal, made in a speech before the American Bar Association, was not received by the administration with the warmth shown for the satellite communications plan. Similar proposals have been rejected previously. The best opinions in Washington are that no immediate action will be taken on the offer.
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For complete technical data please write:
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August 17, 1962

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A SIMPLIFIED MECHANICAL DESIGN OF TERMINAL EQUIPMENT FOR INCREASING RELIABILITY AND DECREASING COST

The Problem:

Many data communications systems today are either experimental forerunners of possible major systems of the future or part of an overall experimental program which may or may not be repeated. Because of the uncertainty about the future requirement for the hardware, it is not practical to develop special equipment for each application. This leaves us with the problem of constantly redesigning equipment to fit ever-changing requirements, or having to purchase superfluous equipment to meet the requirements. If a device is needed for development of various timing signals, to be compatible with existing equipment, then the logical answer would be to purchase only a timing device — not a complete deck of equipment just to get a timing generator. There should be a solution to any requirement of this type — a solution which would provide complete functional units, each one performing one of the common functions in a data communications system. Incidentally, Rixon has the solution!

The Solution:

Rixon's solution is a new hardware approach based on simple, low-cost functional units with common mechanical features, which has eliminated the heretofore sacred mechanical design features. This naturally has resulted in a drastic reduction of manufacturing complexity, and an equally important improvement in reliability. Mechanical features, whose sole purpose was to provide quick access for mechanical service have now, through redesign, been eliminated — a cost-saving factor. Improved reliability is then achieved by eliminating potential mechanical failure points and by devoting more careful consideration to circuit and component design margins. Therefore, Rixon can furnish you with basic functional units which offer greater flexibility, increased reliability, and at lower cost.

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CIRCLE 201 ON READER SERVICE CARD
Telephone craftsman uses special pneumatic tool to flatten connector onto insulated wires. Metal tangs pierce insulation and produce a splice that is equivalent to a soldered joint.

Along the cable routes of the Bell System, wires are spliced at a rate of 250,000,000 a year. Conventionally, connections are made by "skinning" the insulation, twisting the bare wires together, and slipping on an insulating sleeve. Now, with a new connector initiated at Bell Telephone Laboratories, (diagram at lower right) splices can be made faster, yet are even more reliable.

The craftsman slips the two wire ends—with insulation intact—into the connector, then flattens the connector with a pneumatic tool. Springy phosphor bronze tangs inside the connector bite through the insulation to contact the copper wire. The stable, low-resistance splice established is maintained for many years, even under conditions of high humidity, corrosive atmospheres and vibration.

Ultrasensitive measuring techniques devised by our engineers demonstrate that the new connector provides the equivalent of a soldered connection, even with voltages as low as 25 millionths of a volt.

Working with our manufacturing partners at Western Electric, our engineers developed this connector into a design capable of being mass-produced at low cost. It is being introduced in the Bell System.
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Evaluate new design concepts with Tri-Plate modules

30 days! By breadboarding with TRI-PLATE Modules the circuit was proved practical, and Bendix gave Sanders the go-ahead to produce the design in quantity as Integrated TRI-PLATE Packages. Production models were delivered on schedule and weighed only 6 ounces! This is but one illustration of the new directions in electronics made possible by TRI-PLATE Products. There are more than 600 TRI-PLATE Modules — including over 150 TRI-PLATE Mounts for standard and advanced semiconductor devices — available to help you speed the time from design to production. And systems designed in Modules can be produced in quantity as Integrated TRI-PLATE Packages, with performance equal to or better than the modular prototype, and with great savings in size and weight.

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- MULTI-KILOWATT, high duty cycle, pulsed TWT's with PPM focusing.
- HIGHEST FREQUENCY BWO's available with permanent magnet focusing.
- CW TWT's for AIRBORNE ECM, lighter and more compact than previously available tubes.

Current programs, including 5 KW L-band TWT's for high performance phased array radars, and one watt BWO's to 75 gc, will maintain Varian's leadership in TWT technology. Varian is a superior name in TWT's, with an extensive line of available tube types. If you need superior TWT's, Varian has (or can design) the ideal tube for you. Contact Tube Division.
Analysis Center Begins Probe

ECAC compiles data base while solving military rfi problems

By SY VOGEL
Associate Editor

ANNAPOlis, MD.—Analysis of radio frequency interference (rfi) problems in a Space Detection and Tracking (Spadat) area will be undertaken by Department of Defense’s Electromagnetic Analysis Compatibility Center (ECAC). This new project involves analysis of factors involving Spadat radar, uhf radar, f-m telemetry, f-m radio relay, ground/air a-m voice radio, drone controls, missile-destruct links and television.

Work on specific projects is undertaken in addition to ECAC’s prime mission of compiling and coordinating spectrum signatures and environmental data for a data base to be used in the military’s overall battle against rfi.

PROJECTS—In addition to the Spadat project, ECAC will also analyze rfi in L-band radar in southern California, in the Montgomery, Ala., Air Defense Sector and in the Chesapeake Bay area.

Typical data of interest in the L-band radar rfi problem are signal densities, pulse amplitude distributions, operating and spurious frequencies, pulse widths and separations. ECAC’s prediction of receiver performance will include estimates of pulse-count outputs, ppi representations and Sage processor representations.

Study of the vhf-uhf interference problem in the Montgomery, Alabama, Air Defense Sector involves uhf radar, f-m telemetry, f-m radio relay and ground/air a-m voice radio. This area has thousands of emitters, many radiating c-w. The rfi problem in the Chesapeake Bay area involves several radio and communications systems.

DATA BASE—The data base will comprise the answers to any specific problems that ECAC works on, in addition to accumulated data. The accumulated data includes files of spectrum signatures of electronic equipments, describing performance characteristics, and an environmental file with information such as type of terrain near the equipment, site location, prf, hours on and off, atmosphere effects and antenna orientation.

ECAC now has data on about 65 equipments and expects to catalog about 200 additional equipments by July, 1963. Emphasis now is on getting data on equipments, particularly radar, that radiate at 100 Mc and up. Eventually, data on equipments operating below 100 Mc will be collected.

The environmental data file will eventually include hundreds of thousands of situations in the continental U. S., central Europe, striking-force operations and space operations. The enormous amount of data—perhaps 150 million 36-bit words will be needed for continental U. S. alone—is processed and reduced by the Census Bureau’s Posic system and stored on tape.

ECAC now uses a computer at the Armstrong Research Foundation. It will be replaced in November by a Univac 1107.

The data base being compiled will be used for many purposes. Results of analysis of specific problems will help the Department of Defense determine the value of such analysis, as well as solving problems.

Recommendations on operational problems could include equipment fixes (modifications made in the field), siting criteria, frequency assignments and allocations, and design requirements for new systems. Spectrum-signature restrictions may be imposed on new equipment going into an operational area.

ECAC will thus be able to use its files of data and analytical models and its predictions and analysis to tell operational commanders how to get the most out of their equipment when in a given rfi environment.

ECAC will also make information available to other organizations working on rfi problems, to aid in
TYPICAL PROBLEM. Transmitter hidden by coastal hills interferes with ship's radar (A). In analysis model (B) numbers indicate in ascending order of complexity the RFI problems to be solved.

PROBLEM ANALYSIS—To analyze a particular RFI problem, ECAC will pump data derived from its files into an analytical RFI prediction model, as diagrammed.

After the computer runs through an analysis of an RFI problem, its predictions and analysis will be verified experimentally at one or more of the following test centers: Army Electronic Proving Ground, Ft. Huachuca, Ariz., Navy Air Navigation and Electronic Projects Station, Patuxent River, Md., and USAF Rome Air Development Center (RADC), Rome, N.Y.

Test results will be checked against the computer’s analysis; if they do not coincide, the analytical model will be revised or additional input data obtained.

For example, suppose the captain of the ship shown in the drawing wants an estimate of the RFI his radar may encounter when cruising off a coastline.

The diagram represents the analytical model. The broken lines indicate the insertion of the desired-signal source in the model. The encircled numbers indicate types of information that ECAC could give to the captain. For example, (1) is an estimate of the RFI signal density at the receiver antenna. The higher the number, the more complicated the problem. In addition to items (1) to (5), ECAC might also provide advice on siting criteria.

If it is determined that a change in frequency is necessary to cope with the situation shown in the drawing, and that this change would have to be outside the band of frequencies allocated to the task force including the ship off the coastline, ECAC might recommend assignment of another band.

MODELING TECHNIQUES—Perhaps ECAC’s most difficult job is to develop analytical models that will produce accurate predictions of RFI and indicate suitable remedies. Generally, models will have to cope with multiple emitters that can cause interference.

One such difficult problem would be posed by the 20,000 emitters in a battle area—magnified by the problem of multiple propagation paths. A technique for reducing the number of possible interferers and simplifying the analysis problem uses probability distributions. Final answers or predictions to a given problem may be a statistical estimate. Such answers tell an operations officer the likelihood of interference in a given situation.
The revolutionary 12 amp ZJ218 Controlled Avalanche Rectifier protects itself and the rest of the circuit up to 3900 watts peak power dissipation in the reverse direction. You get new high reliability standards up to 1200 PRV, protection of other circuit components, simplified rectifier series operation in high voltage applications, continuous operation in avalanche breakdown region at high voltage, and built-in "zener" diode protection even well beyond 1200 volts.

This reverse impulse test will prove how the Controlled Avalanche Rectifier withstands typical transient circuit voltages as high as 5000 volts, dissipates high levels of peak power in the reverse direction. Peak reverse power for rectifiers with avalanche voltages above 800 volts is over 250 watts in this circuit. (Connect a scope between the indicated voltage and current taps and ground to view impulse voltage and current.)

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The ZJ218 Controlled Avalanche Rectifier is available in 600, 800, 1000 and 1200 PRV types. See your General Electric District Sales Manager and find out how to end your voltage transient problems with no derating. Or write Rectifier Components Department, Section 16H74, General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ontario. Export: International General Electric, 159 Madison Avenue, New York 16, New York.
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The splice is mounted on Mylar® tape, which is fed into the crimping mechanism of a special air and electric AMP machine. Stripping wheels built into the machine quickly strip the fine wire insulation. An operator then places the stripped fine wire and stranded lead wire into the splice, actuates a foot pedal, and the splice is finished. Twelve seconds... one splice. No burning, no cold solder joints, no wire damage. No heat oxides form. And the Mylar insulates one side of the splice.

If you're designing transformers, relay coils, solenoids, inductors, feed coils, or any other product that involves fine wire splices, you need the AMP-FINE-Y-R splice.

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Scientists and Engineers who thrive in an atmosphere of freedom; whose creative processes flourish through exchange of ideas; who relish exploring the unexplored—to such men we say: Lockheed has a place for you. For example: In Human Factors; Electronics Research; Thermodynamics; Guidance and Control; Stress; Servosystems; Reliability; Dynamics; Manufacturing Engineering; Astrophysics; Astrodynamics; Advanced Systems Planning; RF Equipment Engineering; Bioastronautics and Space Medicine; Weapons Effects; Aerophysics; Digital Communications; Antennas and Propagation Engineering; Tracking, Telemetry and Command Engineering; Communications Analysis. Send résumé to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1608, 2408 N. Hollywood Way, Burbank, California. An equal opportunity employer.
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WRITE FOR DATA SHEET
Launch of second satellite this fall will expand system

By PAUL CHERECWICH, JR.
Editorial Staff
LESLIE SOLOMON
Associate Editor

NEW YORK—Expectations are that there will be two Telstar satellites in orbit this fall, broadening the scope of the first private satellite communications system. NASA will reportedly launch a second Bell Telephone Laboratories satellite for AT&T in October.

With the single Telstar now in orbit, transatlantic message and television transmissions can be carried out for only limited periods. The Andover, Me., ground station sees the satellite for at most 250 minutes a day, and the maximum mutual visibility with Europe is only 102 minutes a day.

Maximum duration of visibility comes only every 190 days. Telstar is on a comparatively high orbit (apogee is 3,501.8 miles and perigee is 593.35 miles), but the visibility periods vary due to the northward precession of the apogee.

The orbit is almost exactly the one planned for the satellite. Telstar is expected to keep circling the earth for 200 years, but the electronic equipment on board will be shut off after two years. The equipment is functioning as planned (ELECTRONICS, p 7, Aug. 3), making the launch an all-around success.

Telstar has been used as a repeater for transmission of photofacsimile and high-speed data, for one-way and two-way telephone calls, and for black-and-white and color television, in addition to obtaining space environment data.

TELEVISION—Though Telstar is carrying out a number of scientific and engineering experiments, the one that has captured worldwide public—and political—interest is the transatlantic transmission of television broadcasts.

Engineering co-operation on both sides of the Atlantic is needed to get the signals to the satellite. Conversion and communications equipment of several kinds must be blended before Americans and Europeans can see each other’s tv fare (see map and table).

Scan converters were not employed directly in the first programs from France and England. The early French program was pre-converted on tape for American receivers. At Goonhilly Downs, the BBC uses a camera built to U.S. standards.

TV ROUTES—For regular transmission of Eurovision programs from Europe to the U.S., here’s the procedure:

European tv pictures are transmitted to Eurovision’s main switching center in Brussels, Belgium, at 625 lines and field frequency of 50 cps (625/50 is the western European standard). French pictures are scan converted from 819/50 to 625/50.

Pictures are then carried by coaxial cable to the English Channel, microwaved over the Channel, and sent by coaxial cable to the BBC center in London. There, they are scan converted to 405/50 for British consumption, and to 525/60 for the U.S. The 525/60 signals are sent by cable to Goonhilly Downs and by microwave to the nearby ground station for transmission to Telstar.

Telstar relays the television signals to Andover, Maine, at 525/60. The signals are carried by microwave to Portland, Me., and then
Cooperation

by coaxial cable to the AT&T long-lines building in New York City for network distribution.

Transmission from the U.S. to Europe follows the reverse procedure, with one exception. Scan conversion to French standards (819/50) is done in London, so no conversion is necessary at Brussels before transmission to France.

TRANSMISSION — The satellite receives signals—whether tv or other data—in a 50-Mc bandwidth around 6,390 Mc. Incoming signals are mixed with a crystal-controlled beat oscillator, producing 90-Mc signals (see diagram). They are amplified, mixed again to produce 4,170-Mc signals, then amplified 5,000 times by a traveling-wave tube (the only electron tube in the cascade connected beyond the converter, producing 90-Mc signals (see diagram). They are amplified, mixed again to produce 4,170-Mc signals, then amplified 5,000 times by a traveling-wave tube (the only electron tube in the satellite—other active components are semiconductor devices) for transmission back to earth.

Leaving the satellite at 21 watts, signals are received on earth at 0.31 × 10⁻¹⁹ watt to 15 × 10⁻¹⁹ watt, depending on slant range distance.

The horn antenna at Andover, primary U.S. ground installation, has performed according to expectations. The absolute noise temperature is 51 K when the antenna is pointing near the horizon and is 32 K at zenith.

The effects of an fm feedback circuit in the receiving system are particularly noticeable during television transmission and reception. The circuit acts as an automatic tuning device, rapidly tuning a narrow-band receiver to the exact frequency being transmitted at any instant, even though the signal varies over the bandwidth. The signal-to-noise ratio during television transmission is 23 db.

TRACKING—To let antennas track it, Telstar transmits a 4,080-Mc signal at 0.02 watt.

Tracking at Andover involves four steps: Orbital position is predicted from data obtained on previous satellite passes. Course tracking by a vhf command tracking system narrows Telstar's position to 1 degree out of a 20-degree field of view. A precision tracking system further narrows the satellite's position to 0.02 degree. A method known as vernier autotrack then automatically tracks Telstar with the horn antenna, which has a 0.2 degree field of view.

A comb filter spectograph, developed by Itek, is used in the precision tracker (see diagram) to divide the broadcasting spectrum into 300 channels. A crystal filter in each channel is triggered whenever the satellite signal is encountered. A voltage-controlled crystal oscillator, receiving commands from the crystal filters, tunes the receiver in the precise frequency, thus accounting for doppler effects in the 4,080-Mc signal.

After the satellite has been acquired by tracking, radio commands turn on transmitting equipment. Telstar has not responded to commands signals from some remote ground stations, such as the Holmdel, New Jersey, station. Project engineers feel this is due to distances involved and the susceptibility of the pulse signal to static.

**WORLD TELEVISION TRANSMISSION STANDARDS**

<table>
<thead>
<tr>
<th>Standards</th>
<th>Width (Mc)</th>
<th>Western Hemisphere</th>
<th>Western Europe</th>
<th>Eastern Europe</th>
<th>France</th>
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<tr>
<td>No. of lines per picture</td>
<td>405</td>
<td>525</td>
<td>625</td>
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<td>819</td>
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<td>Channel width (Mc)</td>
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<tr>
<td>Sound/video separation (Mc)</td>
<td>-3.5</td>
<td>+4.5</td>
<td>+5.5</td>
<td>+6.5</td>
<td>11.15*</td>
</tr>
<tr>
<td>Sound carrier to edge of channel (Mc)</td>
<td>+0.25</td>
<td>-0.25</td>
<td>-0.25</td>
<td>-0.25</td>
<td>0.1*</td>
</tr>
<tr>
<td>Interface</td>
<td>2:1</td>
<td>2:1</td>
<td>2:1</td>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>Line frequency (Kc)</td>
<td>10.125</td>
<td>15.750</td>
<td>15.625</td>
<td>15.625</td>
<td>20.475</td>
</tr>
<tr>
<td>Field frequency (cps)</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Picture frequency (cps)</td>
<td>25</td>
<td>30</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Video modulation</td>
<td>-4</td>
<td>-5</td>
<td>-5</td>
<td>-5</td>
<td>-5</td>
</tr>
<tr>
<td>Black level (%)</td>
<td>30</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Audio modulation (Mc)</td>
<td>a-m</td>
<td>f-m</td>
<td>f-m</td>
<td>f-m</td>
<td>a-m</td>
</tr>
</tbody>
</table>

* French standards invert video and audio frequency in certain channels

_August 17, 1962_
LASER SEISMOGRAPHS
Possibility of accuracies to 1 part in $10^{11}$ with gaseous lasers is arousing interest in their use as highly accurate seismographs.

A seismograph using two lasers might work like this: one laser would be isolated from earth tremors while another would be anchored to the earth so that any deformation would change the separation between the laser mirrors. Since the exact laser frequency is a function of the distance between the mirrors, the change in distance could be measured by observing the change in beat frequency between the two lasers. In principle this measurement could be made to 1 part in $10^{11}$ if isolation and temperature control techniques were perfected.

LASER TUBES containing the five noble gases are checked for alignment

Need a New Laser Frequency?
Single Noble Gases Give 14 More

If gases are mixed, the number of frequency possibilities is 20-plus

By MICHAEL F. WOLFF
Senior Associate Editor

NEW YORK—Prospect of optical communications at a greater number of frequencies than was heretofore thought possible is offered by the recent discovery of several new gaseous optical masers (lasers) at Bell Telephone Laboratories.

Following hard on their report of laser action in neon-oxygen and argon-oxygen (ELECTRONICS, p 62, July 6), Bell scientists last week showed:

• A helium-neon laser that can emit a c-w beam of visible red light.
• Five single-noble-gas lasers that radiate c-w at a total of 14 different frequencies at wavelengths between 1.5 and 2.2 microns (see table).

HELUM-NEON—The new helium-neon laser radiates at 6,328 angstroms, the highest coherent optical frequency yet reported. Its visibility is expected to make experimentation easier and also allow using more efficient photomissive detectors and electro-optical modulators.

The device is also significant because it embodies construction techniques that have overcome some of the early doubts that the physical sensitivity of gaseous lasers might prevent using them in practical optical communication systems. It represents recent improvements in laser construction.

The original helium-neon laser (ELECTRONICS, p 31, Feb. 17, 1961) provided a coherent output in the near infrared. It used highly reflecting parallel mirrors that had to be aligned to a few seconds of arc in metal chambers at each end of the tube. The new laser is simplified and uses confocal mirrors outside the discharge. Mirrors need alignment only to a few minutes of arc. Tube terminations are merely glass windows and are inclined at the Brewster angle that minimizes reflection losses for radiation polarized in the plane of incidence, polarizing the emitted beam. The mirrors, now more accessible, are coated with dielectric layers designed for peak efficiency of reflectivity at about 6,350 angstroms.

Another difference is the use of a d-c discharge instead of r-f to impart energy to the helium. Metal electrodes were placed inside the glass cavity without impairing the gas efficiency, resulting in a more stable and uniform discharge and more efficient use of the input power, it was claimed.

The 3-milliwatt output beam has an angular divergence of $1/4$ minute of arc. (This means if it were projected at the moon through a 12-inch telescope it would cast a spot 1 mile in diameter.)

SINGLE-GAS LASERS — Recent experiments have borne out indications that coherent oscillation could be obtained with pure noble gases as the active medium (ELECTRONICS, p 7, Feb. 23). The studies were carried out in similar tubes but using a different excitation method—electron impact excitation.

In tubes filled with neon, argon, krypton or xenon, the free electrons in an r-f discharge impart their
GAS LASERS DEVELOPED AT BELL

<table>
<thead>
<tr>
<th>Gas</th>
<th>Frequency (10^14 cps)</th>
<th>Wavelength (microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium-Neon</td>
<td>2.683</td>
<td>1.114</td>
</tr>
<tr>
<td></td>
<td>2.601</td>
<td>1.153</td>
</tr>
<tr>
<td></td>
<td>2.586</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>2.502</td>
<td>1.198</td>
</tr>
<tr>
<td></td>
<td>2.485</td>
<td>1.207</td>
</tr>
<tr>
<td></td>
<td>4.741</td>
<td>0.6328 (visible)</td>
</tr>
<tr>
<td>Neon-Oxygen, Argon-Oxygen</td>
<td>3.551</td>
<td>0.8446</td>
</tr>
<tr>
<td>Helium</td>
<td>1.456</td>
<td>2.0603</td>
</tr>
<tr>
<td>Neon</td>
<td>1.423</td>
<td>2.1019</td>
</tr>
<tr>
<td>Argon</td>
<td>1.854</td>
<td>1.618</td>
</tr>
<tr>
<td></td>
<td>1.771</td>
<td>1.694</td>
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<tr>
<td></td>
<td>1.677</td>
<td>1.793</td>
</tr>
<tr>
<td></td>
<td>1.455</td>
<td>2.0616</td>
</tr>
<tr>
<td>Krypton</td>
<td>1.775</td>
<td>1.690</td>
</tr>
<tr>
<td></td>
<td>1.771</td>
<td>1.694</td>
</tr>
<tr>
<td></td>
<td>1.681</td>
<td>1.784</td>
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<tr>
<td></td>
<td>1.644</td>
<td>1.819</td>
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<td></td>
<td>1.561</td>
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<td></td>
<td>1.418</td>
<td>2.116</td>
</tr>
<tr>
<td></td>
<td>1.371</td>
<td>2.189</td>
</tr>
<tr>
<td>Xenon</td>
<td>1.495</td>
<td>2.0261</td>
</tr>
<tr>
<td>Cesium*</td>
<td>0.4178</td>
<td>7.180</td>
</tr>
</tbody>
</table>


Kinetic energy directly to the gas atoms. These atoms are thus excited to a higher energy level from which they fall and emit coherent radiation at a characteristic wavelength.

Because of differences in its electron configuration, pure helium acts differently. Laser action here is believed to be produced by excited helium atoms in an upper energy level transferring energy by collision with atoms in the ground state.

Three of the 14 coherent emission lines seen in the new lasers have never been observed in spontaneous emission. Electron impact is seen as a general technique that may lead to other coherent oscillations at other frequencies. Details of these studies are reported by C. K. N. Patel, W. R. Bennett, Jr., W. L. Faust and R. A. McFarlane in Physical Review Letters, Aug. 1.

Gaseous lasers are still less powerful than the solid-state lasers. In some cases power output can be increased by increasing electron density. Power output of a xenon laser was raised from 5 mw to 10 mw by introducing helium into the xenon discharge.
Design of Advanced Syncom Begins

HUGHES AIRCRAFT is now working on the advanced model of its Syncom communications satellite. The new version will probably carry four repeaters, each capable of continuously relaying up to 300 two-way telephone calls or one TV channel.

The company will first develop subsystems and an engineering structural model to determine the final design for a commercial system, under a development contract from NASA's Goddard Space Flight Center. After the development contract is completed, it would take about a year to get an advanced version ready for launching.

Three, small experimental versions of Syncom are being built for launch early next year. These will provide only a single two-way voice channel. Engineering concepts for the control system, electronics and structure of these have been completed, Hughes said, and will be applied to the design of the larger version.

The satellite will be stabilized by spinning it at about 100 rpm. A 16-element phased array transmitting antenna will enable the satellite to transmit continuously to earth despite the spinning. A biconical horn antenna will be used for receiving and whip antennas for telemetry and control.

Syncom is planned as a synchronous satellite. Orbiting at an altitude of 22,300 miles, it would appear stationary to earth stations. Stations would use fixed antennas rather than tracking systems.

One such satellite, parked over the Atlantic, would provide continuous 24-hour message and TV relay service among North and South America, Europe and Africa. Three satellites would blanket almost the entire earth.

New Symbols Adopted For Military Planes

MILITARY aircraft will be identified by a new, uniform designation system. The new designations are intended to clear up any confusion resulting from the use of dissimilar designations by the services for the same aircraft.

Classes of electronic equipment carried by the planes can be inferred from the designations. The designation will be three letters, followed by a design number and letter to indicate model. The three letters will be, respectively, a status prefix symbol, a modified mission symbol and a basic mission or type symbol.

Status prefix symbols are: G, permanently grounded; J, special test, temporary; N, special test, permanent; X, experimental; Y, prototype; Z, planning. Operational aircraft will have no status prefix letter.

Modified mission symbols are: A, attack; C, cargo/transport; D, director; E, special electronic installation; H, search rescue; K, tanker; L, cold weather; M, missile carrier; Q, drone; R, reconnaissance; S, antisubmarine; T, trainer; U, utility; V, staff; W, weather.

Basic mission and type symbols are: A, attack; B, bomber; C, cargo/transport; E, special electronic installation; F, fighter; H, helicopter; K, tanker; O, observation; P, patrol; S, antisubmarine; T, trainer; U, utility; V, vtol and stol; X, research; Z, airship.
NEW G-E CERAMIC TUBES REDUCE MICROWAVE COMPONENT SIZE*
UP TO 40 TIMES

Detailed value-analysis chart shows how size, cost and performance advantages can be yours. Clip coupon, or circle reader service number, for free copy.

In many UHF applications, up to 10 Ge (KMC), microminiature G-E ceramic tubes can replace TWT's, magnetrons, klystrons, and parametric amplifiers with no sacrifice in performance. G-E ceramic tubes are up to 40 times smaller and 20 times lighter than most UHF devices. Often, ceramic tubes can effect component cost reductions as high as $1,400.

To determine the specific reductions G-E ceramic tubes can make in your equipment, check these 6 size- and weight-saving features:

1. Microminiature size and weight range:
   Length: 0.315" to 2.75"
   Diameter: 0.325" to 1.25"
   Weight: 0.972 gram to 66.6 grams

2. High-gain, low-noise ceramic tubes eliminate components, require less complex circuitry. Useful to "C" and "X" band frequencies.

3. Ceramic tubes withstand strong spurious signals and switching transients; minimum protective circuits required.

4. Lower power requirements mean smaller, less elaborate power supplies.

5. High-temperature tolerance (400°C, max.) can eliminate cooling equipment.

6. Ceramic tubes are highly resistant to nuclear radiation; heavy shielding is eliminated. Ceramic planar structures tolerate high shock and vibration.

Most G-E ceramic tubes are on approved MIL-spec lists and are available "off-the-shelf" from your local General Electric Receiving Tube Sales Representative. Send today for your free value-analysis chart which lists all the size, cost and performance advantages that can be yours with G-E ceramic tubes.

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How Cheap is "Cheap"?

"Why should we buy from you when we can get the 'same thing' from other suppliers at a lower price?"

In selecting a supplier of lacing tape (or any component), price and compliance with specifications are not the only criteria. But too often, manufacturers ignore the other factors involved and consequently lose money.

For example, in a $15,000 piece of equipment there may be only 15 cents worth of Gudebrod lacing tape. It costs $75 to work this tape. It may be possible to buy the same amount of tape from other suppliers for 2 or 3 cents less... it "will meet the specs" according to these suppliers. But one of our customers recently pointed out why he still specifies only Gudebrod lacing tape in such cases.

"We tried buying some cheaper tape that 'met the specs.' Within a few months our production was off by 50%... boy, did the production people really scream about that tape. And our labor costs doubled... our costing people really flipped!

"Another thing, why should we risk the possible loss of thousands of dollars when the original material cost difference is only a few cents. Once you put cheaper tape on and something goes wrong after the equipment is finished... you've had it. No, thank you! We learned our lesson! We buy Gudebrod lacing tape!"

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1. Gudebrod lacing tape guarantees increased production!
2. Gudebrod lacing tape guarantees reduced labor costs!
3. Gudebrod lacing tape guarantees minimal maintenance after installation!
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Electronics Division
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New York 1, New York

MEETINGS AHEAD

Western Electronics Show and Conference, WEMA, IRE; Los Angeles, Calif., Aug. 21-24.


Information Processing, International Conference, IRE-PGEC, IFIPS, AIPPS; Munich, Germany, Aug. 29-Sept. 1.

Information on Theory International Symposium, Puit and Benelux Section of IRE; Free Univ. of Brussels, Belgium, Sept. 3-7.


Data Processing Exhibit, Assoc. for Computing Machinery; Orange County War Memorial, Syracuse, N. Y., Sept. 1-4.

Petroleum Industry Conference, AIEE and ISA; Carter Hotel, Cleveland, Ohio, Sept. 9-14.


Engineering Writing and Speech Symposium, IRE-PGEMS; Mayflower Hotel, Wash., D. C., Sept. 13-14.

Electrochemical Society Meeting; Statler-Hilton Hotel, Boston, Mass., Sept. 16-20.

Rectifiers in Industry Meeting, AIEE; Desher-Hilton Hotel, Columbus, Ohio, Sept. 18-19.

Ordnance Environmental Symposium (unclassified), R&D Div. of the Army Chief of Ordnance, Southwest Research Institute; El Tropicano Hotel, San Antonio, Texas, Sept. 18-20.

Advance Report

Quantum Electronics International Symposium, IRE, Societe Frederaine des Electroniciens et des Radioelectriciens, Office of Naval Research, et al; UNESCO House, Paris, France, Feb. 11-15, 1963. Oct. I is the deadline for final registration and for sending 3 copies of a summary to: The Third International Symposium on Quantum Electronics, 7 Rue de Madrid, Paris 8, France. Papers may be presented in either French or English. Topics include: masers; lasers; coherence; optical pumping; atomic clocks; applications to spectroscopy, magnetism and relativity. Emphasis will be on basic physical principles rather than engineering.
SIMPLIFY
YOUR PULSE-SAMPLING MEASUREMENTS
with this NEW
Tektronix Dual-Trace Oscilloscope

Here's what you can do:

... Trigger internally—observe the leading edges of both A and B traces. Matched internal delay lines in both channels assure accurate time comparisons.

... Measure pulse risetimes with 0.35 nanosecond response in both channels. Time measurement range extends to 1 millisecond.

... Display repetitive signals on 16 calibrated equivalent sweep rates from 1 nsec/cm to 100 µsec/cm, accurate within 3%. Magnifier provides sweep expansion from 2 to 100 times... time per dot remains the same for digital readout.

... Change the probes' signal source without affecting the dot transient response.

... Reduce time jitter and amplitude noise, if needed, on the more sensitive vertical ranges and faster sweep rates by means of a smoothing control.

... Measure millivolt signals in the presence of a substantial dc component by means of a dc-offset voltage monitorable at the front panel.

... Calibrate with amplitude signals available from the front panel. Calibrate with timing signals traceable to National Bureau of Standards.

... Show lissajous patterns in addition to single and dual-trace displays and signals added algebraically.

... Drive X-Y plotters or similar readout accessories.

... Drive external equipment, with fast delayed-pulse output.

... Add plug-in units as they come along.

Here's how you do it:

1. Plug in the power cord and signal source,
2. Set the controls on the vertical and timing plug-in units,
3. Take the measurements.

In one compact laboratory oscilloscope you have a complete pulse sampling system with risetime of 0.35 nanosecond. Using the 50Ω inputs, or the Tektronix passive probe or cathode-follower probe designed for use with the instrument, you can meet most of the general-purpose measurement demands in repetitive-signal applications.

Type 661 Oscilloscope (without plug-ins) $1150
Type 451 50Ω Dual-Trace Sampling Unit $1430
Type 371 Timing Unit .......................... $ 750
Probes:
Type P6026 Passive Probe... .......................... $ 140
Type P6032 Cathode-Follower Probe... .......................... $ 160

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CIRCLE 33 ON READER SERVICE CARD
Cure...
for space headaches

new ultracompact half-inch switch cuts space problems down to size!

It's become almost axiomatic in electronics that "thinking big" requires thinking small. And, of course, when circuit proportions shrink, the demand for smaller switches mounts correspondingly. Imagine how many tight places are presently crying for the advantages of this new half-inch diameter, multisection rotary switch: the very first of its kind, functionally equivalent to a regular-size rotary — physically smaller than your index finger!

Obviously rotary switches have "gone small" before; but this is far-and-away the first multisection, 12-position design able to match the versatility of its more sizable counterparts. Up to 5 sections per switch; 3 poles per section! And small size doesn't imply delicateness. Half-inch Oak rotary switches shrug-off environmental extremes . . . withstand 50-hour salt spray; feature reliable double-wiping, self-cleaning contacts.

Even if your present requirements are apart from this sort of diminutive design, Oak application engineers still offer you a vital service. Their experience ranges through all sorts of switching problems involving function, environment, space and costs. And Oak capabilities also encompass production of precision subassemblies, made to your exact specifications.

For further information, contact your Oak representative. Or, feel free to phone us direct any time that we can be of help.
Where creativity pays practical dividends

OAK rotary Power-Rated Switch — New compact design, with trim profile. Lowest-cost of all rotary power switches! Actually brings savings of one-third to one-half, compared to other alternatives. And the new Oak rotary Power-Rated Switch is just one current offspring of New Product Engineering — the department at Oak now given the full-time assignment of creating and improving product design. Rotary power switches can be had with one, two or three sections; provide up to 12 positions. UL listed for 125 vac, 6 amps; inductive rated at .75 PF; tested to 60,000 makes-and-breaks — or ten times UL requirements!

OAK space-saver slideswitch — 30% slimmer than prior designs, with seven fewer parts. Width savings so significant as to suggest literally hundreds of uses in equipment where space is at a premium! Economical too — you’ll find this trim, new slideswitch priced lower than bulkier, ordinary models. Series-200 Oak slideswitches are obtainable in 11 different switching configurations. Rated 3 amps; available with or without UL listing. Double-wiping, self-cleaning contacts. Operation thoroughly tested, proven more reliable and longer-lasting than even its popular forebears.

OAK also helps you save time! A new program now means distributors nation-wide will carry more than 130 types and sizes of Oak rotary switches, right on their shelves! You’ll find superior replacements for many common makes; plus special configurations not available from stock anywhere else. Also component parts for assembling your own style of switch, from one to four sections, two to 23 positions. Quality is fully equivalent to our custom switch runs. Call collect for the name of your nearest Oak stock-switch distributor: Area code 815; 459-5000 — request Oak operator 10.

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That's why IGC microwave ferrite is the choice for new Rantec guidance antenna. Rantec Corporation selected our General Ceramics R-1 ferrite rods for the phase shifters of a production "flat plate" electronically conically scanned slot array. Reason: Sensitivity and linearity, together with extremely low insertion losses and uniform quality. These factors resulted in the smallest unit size with reproducible characteristics. These "flat plate" antennae are applicable to aircraft, missile, satellite and ground applications. They replace the older parabolic types because of improved electrical performance, coupled with advantages in physical form factor and inherent reliability. We make four basic microwave ferrite materials — R-1, R-4, R-5, and R-6. These are available in both custom and standard sizes and shapes and offer a wide range of saturation values. For complete specification data, write for Bulletin 29 to Indiana General Corporation, Electronics Division, Keasbey, New Jersey.
You may not need capacitors as good as these

Fansteel GOLD-CAP® tantalum capacitors satisfy a very particular need for extremely high reliability. Your design may not justify their extra cost. If so, Fansteel makes and stocks twelve other types of tantalum capacitors that will surely fill the bill. Gold-Caps are produced under Fansteel Spec. No. 6CA-101 which exceeds the requirements of any Mil. Spec. The stability of each and every unit is tested at temperature extremes for Capacitance, D-C Leakage, E S R, and Impedance. Altogether, 7,891 readings, calculations, examinations, and comparisons are made for every 100 units by Fansteel's tough Reliability Center with the aid of modern computers. When a capacitor is given a GOLD-CAP tag, individually serialized, and provided with certified test results, it has earned it. No, we can't be positive that these are the best tantalum capacitors in the world, but we have no reason to think that they aren't. Send for GOLD-CAP Spec. No. 6CA-101 and see what we mean. Rectifier-Capacitor Division, Fansteel Metallurgical Corporation, North Chicago, Ill.

This is what you get—certified test data, such as illustrated, is furnished with each and every GOLD-CAP capacitor. Further inspecting or testing is unnecessary.

<table>
<thead>
<tr>
<th>CAPACITOR NO.</th>
<th>TEST NO.</th>
<th>TEMP. °C</th>
<th>DF%</th>
<th>D.C. R. %</th>
<th>INITIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>23650-0012</td>
<td>1</td>
<td>+25</td>
<td>4.8</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>23650-0012</td>
<td>2</td>
<td>+55</td>
<td>47.0</td>
<td>.20</td>
<td>87.0</td>
</tr>
<tr>
<td>23650-0012</td>
<td>3</td>
<td>+25</td>
<td>4.8</td>
<td>.80</td>
<td>100.0</td>
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<td>23650-0012</td>
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<td>108.7</td>
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<td>23650-0012</td>
<td>5</td>
<td>+25</td>
<td>53.3</td>
<td>.80</td>
<td>98.7</td>
</tr>
</tbody>
</table>

August 17, 1962
This newly expanded line of Bendix® Power Transistors is especially valuable for use in DC-DC converter and DC-AC inverter circuits and for switching up to 400 watts as drivers for relays, relay replacements, solenoids, magnetic clutches and other high current applications. Characteristics of typical types are listed in the table below. Included in the expanded line are power transistors which offer unusually flat beta curves for less amplifier distortion, increased current gain (up to 200 at 3 Ade), and increased power ratings. Each power transistor is 'Dynamically Tested,' an exclusive Bendix quality control process that tests each unit to assure uniformity and maximum reliability. For data on the complete line of Bendix Power Transistors and Power Rectifiers, write to Holmdel, N. J.

<table>
<thead>
<tr>
<th>Type Number</th>
<th>VCES Vdc</th>
<th>IC Adc</th>
<th>PC W</th>
<th>hFE</th>
<th>IC Adc</th>
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<tr>
<td>2N456A-8A</td>
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<td>7</td>
<td>90</td>
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*Also available per MIL-S-19500/36A & MIL-T-19500/67
The Cryosar: Promising Element For Tomorrow’s Computers

A recent cryogenic development, the cryosar operates by the impact ionization of germanium at liquid helium temperatures. Its outstanding features are low element cost, low power dissipation and simplicity of construction.

By L. M. LAMBERT and J. E. McATEER, Research Laboratories, Aeronutronic Division of Ford Motor Company, Newport Beach, California

DATA PROCESSING is becoming more important as experimental knowledge of the physical world increases, as industrial and military facilities increase productivity and efficiency, and as the ever-expanding volume of the written word accumulates almost geometrically. To cope with these problems, increased effort has been expended toward systems that are faster, that are smaller in physical size, that have larger capacities and that have better input-output facilities. The cryosar has been investigated.
to evaluate its potential as a new device for faster, smaller, and larger-capacity digital systems.

Cryogenic systems of any type must compete with standard systems operating at essentially room temperature. To be practical, the cryogenic system must have something to offer that the standard systems do not. Present systems fail to provide:

(1) Adequate device characteristics to permit low-power (for example, one-microwatt) and high-speed (such as 100 Mc) operation, so that high-density packaging techniques can be fully utilized.

(2) Simple automatic or semi-automatic means of assembling high-component-count circuits. Even in principle, the solution to this problem is difficult to visualize because of the critical constructions involved in the various devices used.

(3) High enough reliability in the active devices; however, significant gains in this area are now being made through surface passivation techniques.

(4) Low enough cost in all phases so that it is economical to throw away faulty circuits or even subsystems.

(5) Means of engineering large systems, since high-component-count systems utilizing even moderately high-density packaging techniques and operating in the low megacycle region are difficult to assemble because of circuit noise coupling and ground potential gradients.

It would be instructive to see whether the cryosar is able to make contributions to the solution of some of the present problems in these five areas. The categories may be examined in order for ease of comparison:

(1) The nature of the device phenomena often places bounds on the power capabilities of a device. By proper design, the breakdown current of the cryosar can be smaller than one microampere, with the corresponding sustaining voltage as low as a few tenths of a volt. One microwatt operating power is not a lower bound, but appears to be a reasonable value of power dissipation. The speed of switching at these low powers will probably be less than 100 Mc, but nevertheless should be in the megacycle region.

(2) Because of the simplicity of construction of the cryosar (essentially two contacts on a germanium wafer) important innovations in circuit assembly would be possible. The wafer itself could form the substrate for circuit construction. Multilayer interconnections may be possible using present evaporation technology.

(3) Since the impact ionization phenomenon used in the cryosar is a bulk phenomenon, the device is extremely reliable. Surface passivation and other precautions are not required, because surface properties are not that important.

(4) The cost of the unassembled cryosar device is essentially the cost of single-crystal germanium. It is difficult to visualize cheaper devices, since no individual yield problems are involved. In addition, if modern evaporation and masking techniques are employed, the cryosar circuitry would still be extremely cheap, and replacement would appear more feasible than repair of subsystems. The film deposition is noncritical; it is just a convenient way to put on ohmic contacts. If the films are thicker than about 3,000 A, they are suitable for ohmic contacts. Unlike the cryotron, the films serve no function other than for contacts and therefore impurities, structure and other parameters have no meaning, whereas they are important to cryotron fabrication.

(5) It seems reasonable that if ground planes of lead (which is superconducting at liquid helium temperatures) are used in cryosar systems, perfect shielding and ideal ground planes can at last be realized.

In addition, since the cryosar is a majority carrier device, radiation damage should be less than with other existing semiconductor devices. For space exploration or high-radiation environment systems, this may well be an important factor.

Other cryogenic devices, such as the cryotron, also offer some
advantages in these categories. However, the cryotron is critically dependent on temperature for its operation (typically ±0.1 K). Since localized heating is inevitable in a practical digital system, this presents a grave problem and possibly a limitation in the speed of the device since the thermal conductivity of liquid helium is about that of air at room temperature.

Temperature is not a critical control parameter with cryosars: ±2 deg K is satisfactory for most applications, for which operational temperature is about 4.2 deg K.

**IMPACT IONIZATION** — Impact ionization of germanium at liquid helium temperatures has been investigated as a physical phenomenon by many workers. The negative resistance process and device possibilities were first investigated by Rediker and McWhorter who assigned to the device the name cryosar. Cryo pertains to the low-temperature environment involved in the device's operation. Sar is made up of the initial letters s for the switching, a for the avalanche, and r for the recombination processes. In short, the device switches on by avalanche or ionization, and switches off by recombination of the free carriers. The avalanche process is an impact-ionization process whereby electrons, for example, in an n-type material, are accelerated to high enough energies by the applied electric field so that when they collide with an un-ionized impurity atom, the impurity atom is then ionized, and its carrier is released to be accelerated and to ionize even more impurity atoms. The low-temperature environment of the cryosar is necessary to ensure that un-ionized impurity atoms exist in the semiconductor. The low temperature also permits the ionization to occur at lower electric fields because of the lower losses to the lattice. Electric fields of about a volt per centimeter are sufficient to ionize germanium at helium temperature. In a sense, the semiconductor crystal lattice at this temperature is a lossless waveguide for the propagating electron wave, except for the neutral and ionized impurity atoms and to a lesser extent, except for the dislocation and imperfections in the crystal lattice. This latter scattering mechanism has been estimated by Dexter and Seitz and is generally regarded as negligible in high-quality single crystals of silicon and germanium.

The impact ionization of single-crystal germanium containing a single-impurity type has been investigated by several workers since Hung and Gieseman published their findings of low temperature anomalies in Hall coefficient and resistivities in 1950. A typical plot of field versus log current is as shown in Fig. 1. The sudden change in conductivity is due to the generation of a large number of free carriers by impact ionization of un-ionized impurity atoms. The finite conductance prior to breakdown is of interest, and for moderate concentrations of a single impurity type (for example, donor or acceptor atoms less than 10¹⁰ atoms per cubic centimeter) it appears to be due, at least in part, to the mobility of thermally generated electrons or holes. The pre-breakdown mobility is governed by the scattering of the free carriers by the neutral and thermally ionized impurity atoms. (Intrinsic generation of carriers is of course completely negligible.) A formula for the mobility due to scattering by ionized impurity atoms has been proposed by Conwell and Weisskopf and appears to be approximated to a reasonable degree by considering only the Rutherford scattering due to the coulomb interaction of the carrier and the impurity center and also by considering the scattering potential caused by strains in the crystal lattice because of the presence of the charged impurity atom in a substitutional site. This latter scattering mechanism is essentially a discontinuity in the wave transmission properties of the periodic crystal structure.

Erginsoy has approximated the effect of the neutral impurity atom by analogy with the scattering of slow electrons by hydrogen atoms.

The cryosar of most interest, from the standpoint of device possibilities is the two-impurity or the heavily compensated cryosar. The presence of compensating impurity atoms cause the voltage versus log current characteristics to appear as shown in Fig. 1. The considerations concerning neutral and ionized impurity scattering are still valid in this case. However, the ionized impurities are now the entire population of compensation atoms, plus those majority atoms which gave up their electrons (for example, in n-type material) to the acceptors, plus those donors which
provide thermally activated electrons for the conduction band. The remaining neutral-impurity atoms are those donor atoms which have not participated in either of the above donor-ionization processes. Because of the presence of the compensating atom, however, another pre-breakdown conduction process is in evidence. This conduction mechanism appears to be due to the finite probability of a carrier tunneling from an occupied or un-ionized impurity atom to an equivalent unoccupied or ionized impurity atom. This conduction process differs from the normal conduction process of thermally generated carriers in that it does not occur in the conduction or valence bands as is normal for \( n \) or \( p \) semiconductors, respectively. A compensating impurity is necessary to this phenomenon in order to empty the donor atom of its electron and thereby ionize it. The electron of the un-ionized donor then has a vacant site to which it can tunnel. The probability of charge transfer within the impurity level increases rapidly with impurity concentration. At higher doping, concentrations greater than \( 10^{11} \) atoms per cubic centimeter in germanium, a different impurity conduction process occurs which does not require compensation. At very high impurity densities, the overlap of the wave functions of adjacent impurities is so strong that the carriers are no longer localized, and an impurity band is formed in which conduction can readily occur in a manner comparable to a metal. This second mechanism is not of present interest.

As the applied field is increased, the generation of carriers by impact ionization occurs; however, the breakdown field and the sustaining field no longer coincide in the heavily compensated case, the sustaining field being decidedly smaller. Such a situation can be recognized as negative resistance. The origin of this negative resistance as suggested by McWhorter and investigated by Callaway and Cummings appears to be due to a loss mechanism analogous to scattering from an ionized hydrogen molecule, \( H^+ \). Suppose, for example, that a pair of donor atoms in an \( n \)-type material are located adjacent to each other as well as in the vicinity of an acceptor impurity atom. Since the acceptor will certainly be ionized by capturing one of the two electrons associated with the two donor atoms, this leaves two donor atoms with one electron in addition to the newly ionized acceptor atom. Now if the donor atoms are properly spaced in their substantial lattice sites, the energy situation will be similar to that of an ionized hydrogen molecule, \( H^+ \). This atomic configuration presents itself to conduction carriers as an additional inelastic scattering mechanism which absorbs energy, as do the
phonons, by being excited from the symmetric to antisymmetric state. The calculations of this loss mechanism agree favorably with experiment. It is necessary therefore that a larger electric field be provided to accelerate the conduction carrier to high enough energies to overcome this additional loss mechanism and to ionize the un-ionized impurity atoms by collision. Once the breakdown occurs, and therefore essentially all impurity atoms are ionized, the H⁺ ion disappears and becomes just two ionized donor atoms. The field necessary to sustain this breakdown should be essentially the same as that required in an uncompensated material, where the proper consideration is given to the fact that the total number of ionized impurity scatterers is now the sum of the two impurity types.

CRYOSAR CIRCUITS—The very low operating currents and voltages of the cryosar element offer very intriguing possibilities for low power, large capacity storage systems.

Because the cryosar is a two-terminal device and has such a low resistance in the ON condition, the problem of coupling to the element on a system basis becomes quite severe. Johnston's approach to the solution of this problem was to fabricate a "compound" cryosar which essentially is a compensated and uncompensated cryosar in series. This gave rise to a two-terminal device having a double break and provided some isolation from element to element on a system basis.

Capacitive and electromagnetic coupling schemes were investigated and found unattractive for various reasons. The storage cell to be described, while somewhat similar to Johnston's, has several important differences.

The basic cell is shown in Fig. 2A. Component $K_1$ is a compensated cryosar while $K_2$ is an uncompensated cryosar. If the cell contains a one, $K_1$ is in the ON condition and $K_2$ is in the OFF, or high-impedance state. The ON current that flows through $K_1$ produces a voltage across $R_s$, which is slightly less than the breakdown voltage of $K_1$. To read the information, a positive pulse is applied to the $W/I$ (Write/Interrogate) terminal. Since $K_1$ is in the ON condition, the voltage will appear across $R_s$, causing $K_2$ to break down, and an output to appear across $R_a$. The amplitude of the voltage is a function of the dynamic resistance of $K_1$ and $K_2$, and the bias point of $K_1$ with $K_2$ in the ON state. The signal which appears on the output is a positive pulse; therefore, all other $K_2$ cryosars in the bit direction have the voltage across them reduced if the cell is in the one state. If the other cells are in the zero state, the output is not large enough to break down $K_1$; therefore, all $K_2$ elements in the bit direction will remain in their high-impedance (several megohms) state, and good isolation is achieved.

In the zero state, $K_1$ is OFF and the interrogate pulse is insufficient to break it down, therefore no output will appear across $R_a$.

Writing is accomplished by a two-pulse write cycle that consists of a negative pulse on the $W/I$ line which clears all cells to zero. The ones are then written in by a positive pulse on the $W/I$ line (equal to the interrogate pulse) and a negative pulse on the $W$ line. The amplitude of the negative pulse is such that when it is in coincidence with the positive write pulse, both $K_1$ and $K_2$ are in their low-impedance state. When the pulses are removed, $K_1$ remains ON (low-impedance) while $K_2$ returns to its high-impedance (OFF) state.

Resistor $R_s$ is small enough so that the voltage drop across it is negligible though not small enough to unduly load the $W/I$ driver.

Figures 2B through 2E show the wave shapes obtained with an experimental double-cryosar storage cell. The cryosars had the following characteristics: For $K_1$, $V_s = 1.35$ v, $I_s = 1.2$ µa. For $K_2$, $V_s = 0.52$ v, $I_s = 0.8$ µa, and $R_{off} = 2$ megohms.

The cryosars were those used for obtaining characteristics and had large contact areas, and hence fairly large capacities; they do not represent the optimum design. From the waveshape it can be seen that with an interrogate signal of 350 mv that the one output is approximately 150 mv and the signal-to-noise ratio is about 5. Most of the noise is attributed to capacitive feedthrough and pickup in the lines into the helium bath. It should be possible to improve this ratio with smaller contact size and good packaging techniques.

The storage cell described is, as mentioned, not optimum. The following design is based upon planar cryosars which appear to be obtainable and have the following characteristics:

For $K_1$: $V_s = 0.3$ v, $V_a = 0.15$ v, $I_s < 0.5$ µa, $I_a < 1$ µa, and $R_{on} = 0$.

For $K_2$: $V_s = 0.1$ v, $I_s < 0.1$ µa, $R_{off} > 2$ megohms, and $R_{on} = 0$.

Should it prove unfeasible to use planar cryosars, then the bulk-type cryosar would be used. The only difference in the system would be that the voltages used would be higher. Therefore, more power would be consumed.

Using the above parameters and referring to Fig. 2A, assume $I_s = 2$ µa. Let $V_s = 0.09$ v when $K_1$ is on. Therefore, $R_s = V_s/I_s = 0.09 v/2 = 45,000$ ohms.

If it is assumed that $R_s$ is small so that the voltage drop across it is negligible, then $V_s = V_a + V_s = 0.09 + 0.15 = 0.24$ v. Then the interrogate signal is given by $V_{int} = V_s - V_a = 0.06$ v. Let $V_{int} = 50$ mv.

If it is assumed that the output current through $R_s$ is to be limited to 2 µa then $R_s = V_{out}/I_s$.

The output voltage will be given by $V_{out} = V_{int} - circuit losses$, which in the idealized case is given by $V_{out} = V_{int} - (V_s - V_s)$, so that $V_{out} = 0.04$ v, and therefore, $R_s = 20,000$ ohms.

Because both cryosars are in their high-impedance region when the cell is in the zero state, the noise signal will be determined by the capacity of the cryosars. If a S/N ratio of ten is desired, the capacitance allowable per element is found to be 0.05 ± 0.05 pf, where ± is the rise time of the interrogate pulse in nanoseconds. Even for fast rise times it is easy to achieve capacities well below the allowable.

Figure 3A shows the connection in more detail. The cryosar on the $W$ line serves as an isolator. The amplitude of the $W$ pulse necessary for writing a one can easily be calculated and is found to be 0.21 v if the isolator cryosar has the same characteristics as the previous uncompensated cryosar.

It can be seen from Fig. 3A that uninterrogated storage cells on the bit line present a high impedance to the output signal on the bit line,
since the uncompensated cryosar is always in its high impedance state unless interrogated. However, any current which is caused to flow because of the capacitance of the element is in such a direction as to decrease the current through the compensated cryosar in the one (ON) state, and hence would tend to turn it off. This then is another restriction on the amount of capacitance an element may have. As mentioned previously, the ON current is taken as 2 µa while the sustaining current is assumed to be less than 1 µa; therefore \( C < 0.025 \Delta t \) pf, and as mentioned previously, this is not difficult to achieve.

The value of \( R_i \) should be fairly low for the reasons mentioned previously. A reasonable value would be 50 ohms, so that the voltage drop would be negligible for a reasonable number of elements. When all cells common to a word line are in the one state, the impedance seen by the \( W/I \) driver during interrogate is

\[
Z_{W/I} = R_i \parallel \frac{R_e \parallel R_2}{n}
\]

where the vertical lines denote that the resistors are in parallel and \( n \) is the number of bits in the word. In the present case, if \( n = 64 \), \( Z_{W/I} = 42 \) ohms. Thus, the \( W/I \) driver does not see a widely varying impedance.

The power consumption of the cell in the ON state is 0.48 µw. If a fairly large system were built with a three-watt refrigerator, there would be considerable cooling power left for any circuits that might be put into the bath with the array.

It is worth noting that all the necessary pulse voltages are readily obtainable with tunnel diode circuitry. Tunnel diodes work quite well at liquid helium temperatures although no long-time storage data are available. It may be possible to construct a fairly large storage system where only a small number of connections to the outside environment are necessary.

CRYOSAR LOGIC—With the possibility of very small element capacities and extremely large OFF resistances, performing logic functions with fairly complex structures may be possible.

Johnston has described a decoder* which could be used with the storage cell described previously. Figure 3B shows this decoder which is made up of uncompensated cryosars. If, for the sake of illustration, it is assumed that the uncompensated cryosars have a breakdown voltage of one volt and that the true state is denoted by an input of one volt, the operation is as follows:

During read, the normal of the address is applied to the decoder input lines and a positive clock signal is applied at the clock terminal as indicated. A positive pulse will then appear on the output of the true line. No output will appear on the other lines because of the clamping action of the cryosars which return to the false (negative input) input lines.

For writing into the memory, the complement of the address is applied to the decoder input lines and a negative clock pulse (clear operation) is applied to the clock input. A negative pulse will appear on the output that clears the word to zero. No negative pulse appears on the other lines because of the clamping action of the cryosars which return to the positive inputs. The address is then returned to normal and followed by a positive clock pulse, and the decoder operates as for the read operation. This positive pulse on the word line in coincidence with the information signal (negative pulse) on the bit line selectively writes ones into the proper bit location.

The decoder described above is, of course, a logical AND gate. Used by itself, this gate has a level shift between input and output. It is possible to restore the original levels and perform an OR function by adding a second level of logic. This configuration is shown in Fig. 3C.

If it is assumed that the logic levels are +1 volt (true) and 0 volt (false) and the cryosars have a one-volt breakdown, then the output of the AND portion of the gate will be at +2 volts only if \( A \) and \( B \) are both at +1 volt. If either one or both of the inputs are at the lower voltage, then the output is at +1 volt. Thus, the first stage performs the logical function \( AB \) with the true output being represented by +2 volts. The output of the OR section will be +1 volt if either of the inputs are at +2 volts (true) so that a logical OR is performed. The configuration thus accomplishes the AND-OR function with the input and output levels corresponding.

Because of the low-loss nature of the elements in the ON state it may prove possible to perform many levels of logic before regeneration is necessary. Regeneration and inversion could possibly be accomplished with compensated cryosars or tuned diodes. The fan-in, fan-out capabilities should also be quite good because of the large resistances in the OFF state and small

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* Cryosar decoder

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**Footnotes:**

1. The power consumption of the cell in the ON state is 0.48 µw.
2. If a three-watt refrigerator is used, considerable cooling power is left for other circuits.
3. The value of \( R_i \) should be fairly low for the reasons mentioned previously.
4. The number of elements is limited by the breakdown voltage of the cryosars.

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**Diagrams:**

- CRYOSAR LOGIC
- PULSE GENERATOR
- Waveforms illustrating pulse generator waveshapes.
capacities of the elements.

Another possible logic configuration is shown in Fig. 3D. This is essentially a current summing type of logic. The uncompensated cryosar \( K_1 \) is biased to point \( a \) of Fig. 3E and has a breakdown voltage equal to the sustaining voltage of the compensated cryosars \( K_n \) which provide the logical inputs. If all the \( K_n \) cryosars inputs to one gate are in their low voltage state, then \( K_1 \) remains at point \( a \). When the unit is clocked with a negative pulse, the current through \( K_1 \) is reduced and a negative pulse output produced. If any of the \( K_n \) units are in their high voltage state, the \( K_1 \) unit has more current flowing through it and will be at point \( b \) for one input, point \( c \) for two inputs, etc. No output results when the negative clock is applied.

The output of this unit could turn off a \( K_1 \) cryosar of a succeeding stage, which had been turned on by a reset pulse, thus storing the information. This type of system would use a multiphase clock.

The fan-out capabilities of the \( K_1 \) unit are potentially excellent, being determined by the values of the voltage and resistors chosen for the circuit.

**PULSE GENERATOR** — Figure 4A shows a pulse generator circuit which has several different modes of operation, depending on the supply voltage. If the supply voltage is less than the cryosar peak voltage, a positive pulse triggers the device to the on state and the output voltage remains at \( V_r \) providing

\[
\frac{V - V_r}{R_1 + R_2} \geq I_s
\]

where \( I_s \) is the sustaining current. The device may be returned to the high voltage state by a negative pulse at the input or by momentarily decreasing the supply voltage so that the current falls below \( I_s \).

If the supply voltage is larger than \( V_r \) and

\[
\frac{V - V_p}{R_1 + R_2} > I_p
\]

where \( I_p \) is the peak current then the cryosar is on in the quiescent state. The application of a negative pulse at the input will turn the cryosar off and the output voltage will begin rising to \( +V \) with a time constant essentially determined by \( R \) and \( C \). When the voltage reaches \( V_p \), the device will break down and return to the on condition. Wave-shapes of a circuit operating in this mode are shown in Fig. 4B and 4C. The input was a negative pulse of about 150 mv amplitude and the circuit values were \( R_1 = 1,600 \) ohms, \( R_2 = 100 \) ohms, \( C = 0.0047 \) uF, and \( V = +2 \) volts. Resistor \( R_1 \) is included in the circuit to prevent the signal source from being short-circuited by the cryosar in its on state.

This general type of circuit could be useful as a sense amplifier for the memory described and for storing of logical information. Its speed is primarily limited by the RC time constant as the voltage goes toward \( V_r \) (for the circuit tested), it should prove possible to make the circuit much faster than that presented.

Pulse generators capable of giving larger outputs, without increasing the inputs, should be possible using cryosars placed in series as shown in Fig. 4D. In this circuit each cryosar would have a voltage across it less than its peak voltage. The third cryosar is turned on by a positive pulse and goes to its low-voltage state, thus applying more voltage across the first two cryosars which are then turned on.

Figure 5 shows a cryosar flip-flop circuit together with the wave-shapes obtained at the two outputs. The circuit works in the following manner.

The values of resistors are chosen so that in the quiescent state only one cryosar is in the on condition. This is accomplished by assuring that if both cryosars attempt to be in the on state, the sustaining current that must flow through each cryosar will result in a voltage drop across \( R_1 + R_2 \) and \( R_3 \) that the voltage across the cryosar must be less than the sustaining voltage and thus one must be in the off state.

The flip-flop is triggered by a positive pulse input which turns the on cryosar off. The two capacitors, \( C_n \), serve as ‘memory’ by virtue of the different voltages which are across them, assuring that the cryosar which was off turns on and \( C_m \) aids in regeneration. The manner of triggering shown in Fig. 5 provides isolation between input and output.

The main disadvantage of this cryosar flip-flop circuit is that the design depends on an accurate knowledge of the value of sustaining current, \( I_s \). At this time the sustaining current appears to be the least desirable parameter of the cryosar and is sometimes even difficult to determine as it appears to vary over a given wafer.

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GUIDE TO MODERN JUNCTION

New classification of the many varieties of transistors according to the

JUNCTION TRANSISTORS, until recently, were made by one of two classical methods: the grown-junction, or the alloy-junction, technique. However, a number of new types of transistors made by the diffusion technique have become available, and more recently the epitaxial transistor has been introduced. This article classifies the various presently available transistors into five major categories and describes briefly their methods of fabrication.

The first junction transistors, in 1951, were of the grown-junction type. This type comprises a rectangular bar, as shown in Fig. 1A, cut from a germanium crystal grown from a melt to which suitable impurities have been added. Emitter and collector contacts then are made to the base region, generally located approximately midway between the two ends. Shortly after the grown-junction technique, the alloy technique was developed, in which small dots of indium were fused, or alloyed, into opposite sides of a germanium wafer of suitable conductivity, as illustrated in Fig. 1B. Emitter and collector contacts then are made to each of the dots, and the base contact is made to the wafer. Silicon transistors also can be made by each of these two techniques.

Attempts to reduce the dimensions of alloy transistors for high-frequency use subsequently led to the introduction of the electro-chemical etching and plating technique, which led to the development of the surface-barrier transistor. The construction of this type of transistor is similar to that of the alloy transistor, except that depressions are etched into the wafer before the collector and emitter dots are added, and the latter are generally of much smaller size than in the conventional alloy transistor.

In each of these three classical methods of fabrication the three regions of the transistor—emitter, base and collector—generally are of uniform resistivity.

DIFFUSION TECHNIQUE—The introduction of solid-state diffusion techniques has provided an additional method, with a high degree of control, of making p-n junctions and, hence, of fabricating transistors. Moreover, the use of diffusion techniques makes it possible to provide nonuniform emitter, base and collector regions so as to provide better transistor characteristics than are obtainable from the classical designs of uniform-resistivity regions.

Diffusion of impurities can take place from within the crystal, or through the surface from an external source; the latter is termed gaseous diffusion. It is possible also to combine diffusion techniques with one of the classical techniques described above: for example, a nonuniform base region can be obtained by diffusion, while the emitter and collector junctions can be made by the alloy technique. Alternatively, one p-n junction can be formed by diffusion while the other is formed by one of the classical techniques, or the entire transistor—that is, the two p-n junctions—also can be formed by diffusion.

As a result of this flexibility, transistors made by diffusion may assume one of several different physical appearances. For example, some diffused transistors are indistinguishable in appearance from corresponding classical structures. On the other hand, some types of diffusion transistors are of the mesa construction, illustrated by Fig. 2A, in which the semiconductor wafer is etched down in steps so that the base and emitter regions appear as plateaus above the collector region. Both rectangular and circular cross sections have been employed, as illustrated by Fig. 2B and 2C, respectively.

EPITAXIAL TECHNIQUE—More recently, a new technique—that of epitaxial deposition—has been applied to commercial devices. In the epitaxial technique, a film of single-crystal semiconductor material is deposited on a single-crystal substrate. Most of the work on epitaxial films to date has consisted of depositing a layer of a semiconductor material on a substrate of the same material—that is, germanium on germanium or silicon on silicon. However, the deposited epitaxial film may be a different material from that of the substrate.

Thus far, the epitaxial technique has been used only to develop transistors in which a thin, high-resistivity collector region is deposited on a low-resistivity substrate of the same conductivity type—that is, a thin p-type collector region is de-

GROWN-JUNCTION type of transistor, (A); alloy-junction type, (B) 
—Fig. 1
TRANSISTOR TYPES

methods of fabrication

posited on a p+ substrate for germanium pnp transistors, or a thin n-type collector region is deposited on an n+ substrate for npn silicon transistors. This leads to a family of transistors which will be termed here epitaxial-collector, known by a variety of names, such as diffused-base epitaxial mesa transistor. The chief advantage of this type is lower saturation resistance and lower collector storage time relative to a comparable, nonepitaxial device.

However, the epitaxial technique is considerably more general, and it is possible to deposit multiple layers of different conductivity type, that is, it is possible to form epitaxial junctions. For example, an n-type epitaxial collector can be deposited on an n+ substrate followed by a p-type epitaxial-base-layer deposition. The emitter region then may be made by conventional diffusion technique or by the alloying technique. This form of device (not yet commercially available) is termed here the epitaxial-base transistor. Finally, it should be possible to extend the epitaxial technique further to make a complete all-epitaxial transistor by epitaxially depositing collector, base, and emitter layers.

PLANAR TECHNIQUE — The planar technique, mentioned often in commercial literature, is an auxiliary technique for making junctions by standard diffusion techniques. Strictly speaking, the term planar refers to a device in which each of the junctions—emitter-base and collector-base in a transistor, as shown in Fig. 3—is brought to a common plane surface," as distinguished from the mesa structure in which one or more of the p-n junctions are brought to the surface at the edge of a cylinder comprising the mesa, as shown in Fig. 2A. However, the real significance of the planar structure is not that it is planar, but that as a result of the technique of diffusion through an oxide mask used in making a planar structure, the junctions are formed beneath a protective oxide layer. Hence, many of the surface problems associated with other types of transistors having junctions exposed at the surface are avoided. As a result, this type of transistor has generally lower reverse currents and improved d-c current gain at low currents.

However, an equivalent structure could be fabricated in which the junctions were formed beneath a protective oxide coating but which were not actually planar.

CLASSIFICATION SCHEME — The transistor types are here classified according to five major categories—grown, alloy, electrochemical, diffusion, and epitaxial. The method of classification is somewhat arbitrary—for example, a grown-diffused transistor could be classified either as a grown transistor or as a diffused transistor. Accordingly, a cross-referencing scheme is necessary, provided here by the chart of Fig. 4, illustrating the interrelations among the various techniques in producing different types of transistor structures.

GROWN-JUNCTION TRANSISTORS—

(1) **Double-doped transistor:** the original grown-junction transistor, formed by growing a crystal and successively adding p- and n-type impurities to the melt during the course of growing the crystal.

(2) **Rate-grown or graded-junction transistor:** a variation of the double-doped type, in which n- and p-type impurities are added to the melt from which the crystal is grown. The growth rate then is varied in a periodic manner while the crystal is drawn from the melt. During one stage of the growth cycle, the crystal contains a predominance of p-type impurities, whereas during the other stage of the cycle n-type impurities dominate, resulting in a crystal from which npn transistors can be cut.

(3) **Melt-back transistor:** a variation of the rate-grown transistor in which the rate growing is performed on a very small physical scale. This results in a lower thermal time constant for the crystal growing system, thinner base regions and, hence, higher-frequency transistors.

(4) **Melt-quench transistor:** similar to melt-back transistor.

(5) **Grown-diffused transistor:** a transistor made by combining diffusion techniques and the double-doped process. In this case, n- and p-type impurities are added simultaneously to the melt in the course of growing the crystal. Subsequently, the base region is formed by diffusion during the continued growth of the crystal.

(6) **Melt-back diffused transistor:** a transistor made by combining diffusion techniques and the melt-back process, analogous to the...
combination of the grown and diffusion techniques described above leading to grown-diffused transis-
tors. In this case, however, the impurities are added to the transistor bar by the melt-back process, and
the base region subsequently is formed by diffusion by baking the transistor bar.

**ALLOY-JUNCTION TRANSISTORS—**

(1) *Alloy* transistor (previously known also as *fused* transistor): comprises a wafer of semiconductor material of *n*- or *p*-type conductivity with two dots containing *p*- or *n*-type impurities, respectively, fused or alloyed into the wafer on opposite sides of the wafer to pro-
vide emitter and base junctions, while the base region comprises the original semiconductor wafer.

(2) *Drift* transistor: (a) In scientific literature, a *drift* transistor refers to a type of transistor having a nonuniform, or graded, base region so that high-frequency re-
response is improved relative to a similar uniform-base structure.
(b) *Drift* transistor, commercial: A trade name for a *diffused-alloy* transistor.

(3) *Diffused-alloy* transistor: a transistor made by combining diffusion and alloy techniques. The semiconductor wafer is first sub-
jected to a gaseous diffusion to produce the nonuniform base region, and then alloy junctions are formed in exactly the same manner as in a conventional alloy transistor. An intrinsic region transistor, for example, a *pnip* unit, can be made by this technique by starting with a semiconductor wafer of essen-
tially intrinsic conductivity.

(4) *Alloy-diffused* transistor, or post-alloy-diffused transistor: another type of transistor made by combining diffusion and alloy tech-
niques. The alloy dot material contains both *n*- and *p*-type impurities.
Then the emitter-base junction is formed by the conventional alloy process, while the base region is formed by diffusion from within the crystal. This is the distinction between the diffused-alloy transistor and the post-alloy-diffusion tech-
nique. The collector region comprises the original semiconductor wafer. Alternatively, if the original wafer is of the same conductivity type as the base region, then the emitter-base junction and the base region can be formed as described above, while the collector junction can be formed as in a conventional alloy transistor. In this case, as in the case of the diffused-alloy transis-
tor, an intrinsic region can be included between base and collector.

**ELECTROCHEMICALLY ETCHED AND PLATED TRANSISTORS—**

(1) *Surface-barrier* transistor (SBT): comprises a wafer of semiconduc-
tor material into which depressions have been etched on opposite sides of the wafer by electrochemical techniques. The emitter and collector base junctions, or metal-semiconductor contacts, are then formed by electroplating a suitable metal on the semiconduc-
tor in the depression areas on opposite sides of the wafer, while the original wafer constitutes the base region.

(2) *Micro-alloy* transistor (MAT): a variation of the surface-barrier transistor described above in which suitable *n*- or *p*-type impurities are first plated in the etched depressions and then alloyed into the *p*- or *n*-type semiconductor wafer.

(3) *Micro-alloy Diffused* transistor (MADT): a transistor made by incorporating diffusion techniques with the micro-alloy transistor construction described above. In this case, the semiconductor wafer is first subjected to gaseous diffusion to provide a nonuniform base re-
gion prior to the electrochemical plating process.

(4) *Electro-chemical Diffused Collector* (ECDC) transistor: a transistor made by combining diffusion and electrochemical tech-
niques. A nonuniform base region and the collector-base junction are obtained by gaseous diffusion into a semiconductor wafer that consti-
tutes the collector region. Then the emitter-base junction is ob-
tained by the electrochemical etch and plating technique, as in the MAT. The electrochemical tech-
nique also is used to place the collector contact close to the collector-
base junction.

**DIFFUSION TRANSISTORS—**

(1) *Diffused-base* transistor: comprises another type of transistor made by combining diffusion and alloy techniques. In this case, a non-uniform base region and the collector-base junction are formed by gaseous diffusion into a semi-
conductor wafer that constitutes the collector region. Then the emitter-
based junction is formed by a conventional alloy junction on the base side of the diffused wafer for example, by evaporation of a metallic stripe, while the remaining portion of the original wafer constitutes the collector region.

(2) *Diffused-emitter* and *base or double-diffused mesa* transistor: a semiconductor wafer which has been subjected to gaseous diffusion of both *n*- and *p*-type impurities to form two *p-n* junctions in the original semiconductor material. The active area of the transistor, that is, the area of the collector-base junction then is defined by etching away the undesired portions of the emitter and base regions to expose a mesa. An intrinsic-region transistor, such as *pnip*, also can be made by a variation of this process.

(3) *Triple-diffused* transistor: a variation of the double-diffused transistor in which the semiconductor wafer first is subjected to a deep diffusion to effectively lower the resistivity of the collector region—for example, to form an *nn* + structure for an *npn* transistor. The *nn* + wafer then is sub-
jected to gaseous diffusion of both *p*- and *n*-type impurities to form emitter-base and collector-base junctions leading to an *npnn* + structure. Alternatively, this may be considered as an intrinsic-region transistor, such as *npin*, if the origi-
inal semiconductor wafer has high resistivity.

(4) **Planar transistor**: comprises a semi-conductor wafer which has been subjected to gaseous diffusion of both $p$- and $n$-type impurities to form two $p$-$n$ junctions in the original semiconductor material, as in the case of the diffused-emitter and base transistor. However, the active area of the device—that is, the area of the collector-base junction, is defined by oxide masking of the base diffusion, rather than by mesa etching (see Fig. 3).

EPITAXIAL TRANSISTORS—

1. **Diffused-base epitaxial mesa transistor**: one of the epitaxial-collector transistor family. Made by combining diffusion, alloy and epitaxial techniques. First, a thin collector region is epitaxially deposited on a low-resistivity substrate. Then a nonuniform base region and the collector-base junction are formed by gaseous diffusion into the epitaxial collector region. The emitter-base junction is obtained from a conventional alloy junction on the base side of the diffused wafer.

2. **Double-diffused epitaxial mesa transistor**: another of the epitaxial-collector transistor family. A thin collector region is epitaxially deposited on a low-resistivity substrate. Then base and emitter regions are formed as in the case of the ordinary double-diffused mesa transistor, and the collector-base junction area is defined by etching a mesa.

3. **Planar epitaxial transistor**: another of the epitaxial-collector transistor family. A thin collector region is epitaxially deposited on a low-resistivity substrate. Then base and emitter regions are formed as in the conventional planar transistor.

4. **Epitaxial base transistor**: a transistor made by epitaxially depositing a base region of one conductivity type on a collector region of the opposite conductivity type. The emitter region then can be formed either by alloying or by diffusing, leading, respectively, to an alloy-emitter epitaxial base transistor, or a diffused-emitter epitaxial base transistor.

5. **All-Epitaxial transistor**: All three regions of the transistor are obtained by epitaxial deposition.

The material presented here obviously does not describe original work. A number of authors have categorized transistors in similar schemes. Several authors have also written excellent survey papers—e.g. R. N. Hall—describing methods of fabrication. The concept of the chart shown in Fig. 4 originated with H. L. Owens.

This article is based on material prepared for a book “Transistor Circuit Design” written by the engineering staff of Texas Instruments, Transistor Products Division, and shortly to be published by McGraw-Hill Book Co.

BIBLIOGRAPHY

Overcoming Turn-on Effects in Silicon Controlled Rectifiers

Limited turn-on speed of silicon controlled rectifiers causes problems in some applications. Here are ways of avoiding unexpected triggering, high turn-on losses and possible device failure.

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UNPREDICTABLE EFFECTS
during switching of silicon-controlled rectifiers have been noticed by designers of high-frequency inverters and pulse modulators, where high values of di/dt occur. Such effects are due to a turn-on phenomenon: the junctions of the scr are turned on at first, only over a small area near the gate lead, and the turn-on process then spreads until whole junction has been turned on.

The turn-on velocity has been measured to a first approximation with a two-gated scr. This velocity was used to predict the turn-on performance of two types of scr’s, and the calculated results compared with measurements.

When the scr is turned on, the anode-to-cathode voltage does not drop immediately; instead, the voltage appears to drop exponentially. This effect is most prominent with high values of di/dt. To explain this effect, assume that the scr is turned on as in Fig. 1A. At 5 µsec after turn-on the voltage drop is much greater than at 25 µsec, because the current density at 5 µsec is much higher due to the restricted area. As the current density increases, the voltage drop increases.

The high initial current density and high voltage drop generate considerable power within a small area, thus raising the temperature of the junctions. When this temperature exceeds 125°C there is a temporary falling off of the characteristics; this is especially noticeable in forward breakover voltage, turnoff time and dv/dt. In inverters, this effect appears as unexpected triggering of the scr’s, resulting in both scr’s being on simultaneously. If the heat becomes excessive it can permanently damage the scr’s characteristics or destroy the device. Such scr failure shows as a small hole in the pellet from anode to cathode near the gate lead.

An unexpectedly high stud temperature also indicates turn-on losses due to slow spreading.

During the turn-on period, protection of the scr by fuses can be inadequate. Fuse ratings are based on the I²t rating of the scr, derived from data taken with the whole junction turned on; the fuses, therefore, do not protect the scr against small-area heating.

MEASUREMENTS OF SPREAD —To measure the velocity of turn-on spreading, several type-C80 235-a mpere scr’s were equipped with a second gate, placed diametrically opposite the normal gate. The normal gate was triggered with a short pulse, and the voltages across the two gates observed. It was assumed that when these two voltages become equal, the entire junction is
turned on; the velocity of spreading would then be the distance between gates divided by time taken to equalize the voltages.

Figure 1B shows a typical oscilloscope using a sine wave pulse. Velocity increases as the current waveform peak increases. The relationship between velocity and pulse peak value is a second-order effect. The velocity may be taken as 0.1 mm per μsec.

From physical measurements of the scr's junctions, it is possible to calculate the current density and voltage drop as turn-on propagates across the junction area. Using an assumed turn-on velocity, a turn-on curve can be calculated and then compared against a measured one. This has been done in Fig. 2A for a type-C35 25-ampere scr.

CORRECTIVE ACTION—Knowing that the spreading velocity is of the order of 0.1 mm per μsec, the designer can take corrective action. When the current rises rapidly, care must be taken to check for local heating. Local heating is liable to occur in any scr with a single gate lead when di/dt exceeds several amperes per μsec immediately after triggering. Knowing the junction diameter and the location of the gate lead, the current density at any time can be determined; at present the safe value for current density has not been established.

High local values of current density can be satisfactorily decreased by placing a saturating reactor in series with the scr; this limits the current for several microseconds to a low value, until the reactor saturates. During the delay period the turned-on area has time to increase so that the current density is reasonably low when the bulk current flows.

Figure 2B shows a comparison of current density with and without a saturating reactor in a 110-ampere type-C50 scr; a 10-to-1 improvement is apparent. The reactor consisted of a 1-inch diameter core with a winding of a few turns.

Figure 3 shows the predicted and measured curves of voltage drop across a type-C50 scr carrying a 325-ampere sinusoidal pulse, 12 microseconds long; the delay period was 4 μsec with an 8-ampere current during the delay period. Divergence during the first 2 μsec is due to the inaccuracy of assuming that the gate is a point on the periphery; actually it is a small area near the periphery.

In practice, no significant improvement in the turn-on speed of a junction can be achieved by centrally locating the gate. However, a great improvement is achieved when a distributed gate is used.

Figure 2C shows measured voltage drop with a 160-ampere 8-μsec pulse and compares a single gate with a laboratory model of an scr having a distributed gate.
SOLID-STATE analog-to-digital converter uses zener diodes for quantizing—Fig. 1

Versatile Zener Diode Array

Zener diodes provide simultaneous voltage comparison and stable voltage reference while alleviating interaction problems found in conventional comparators

By JOHN J. KOLARCIC
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AN ANALOG/DIGITAL converter, built to fulfill a particular signal processing requirement for an experimental character detection communication system, employs a simple conversion technique applicable in many other areas. Using solid-state components for active circuit elements, quantization or voltage selection of the signal sample is obtained through an array of zener diodes. The converter periodically samples an analog voltage to obtain a pulse stream of 0 to 8 pulses depending on the amplitude of the sampled voltage. The polarity of the quantized signal is also determined in this sampling process, thus producing rapid conversion.

The technique of simultaneous voltage comparison in the quantizer by an array of zener diodes appears to be a new one, offering a higher speed capability than found in most other converters because of the inherently faster response of zener diodes over standard diodes. The problems of interaction found in other converters using resistor-diode networks are greatly reduced by the zener diodes, which also offer stable voltage reference in each comparator.

Design principles are easily adapted to other communication and telemetry applications.

OPERATION—In the first stage of the converter (Fig. 1), the signal is amplified to a level suitable for quantization. In this stage, it is also converted from a bipolar signal to two unipolar signals on two channels. In the second stage, the two unipolar channels are fed to their respective sampling circuits. With an input signal applied to the first stage of the converter, either unipolar channel obtains an output at any instant, resulting in an output obtained from only one sampler at each sampling time. The outputs of the sampling circuits are combined so that the signal of either sampler circuit can drive a linear pulse power amplifier. The linear pulse amplifier feeds the zener diode array of the quantizer, where the sample is quantized into any of 8 discrete quantum levels. The polarity of the signal is also determined in this stage, where a polarity sensing trigger circuit senses the pulse polarity by determining which channel has an input at sampling time. The polarity information is stored in a binary register.

In the third stage, the pulses from the fired zener diodes in the quantizer are fed to their respective pulse standardization circuit, which is a Schmitt trigger. Each pulse standardization circuit is connected to a precision trigger circuit. The time interval of each precision trigger circuit is made an integral multiple of the period of the clock frequency.

In the fourth stage, the precision trigger outputs are combined in logic circuits so that the output of the trigger corresponding to the longest time period, after a sampling, excludes all shorter periods. This exclusive period is mixed with clock pulses, using the logic circuits, to obtain a pulse stream of 0 to 8 pulses. The number of pulses obtained at the output is an indication of the magnitude of the signal input to the analog/digital converter. These pulses and the polarity information obtained in stage 2 provide sufficient information to be fed to digital data processing equipment.

ANALOG SIGNAL PROCESSING—The analog signal is brought into the proper voltage amplitude range, 0 v to 8 v, by transistor operational amplifiers to facilitate processing by the quantizer, Fig. 2. The attenuator pad was used to set the gain of the amplifier system to the proper level to adjust for the various input signal levels used in test runs of the associated system. To allow using the quantizer for both the negative and positive voltage excursions of the analog signal,
Forms High-Speed Quantizer

diode rectifiers separate the bipolar input signal into two unipolar signal paths. The two unipolar signals feed two linear power amplifiers to provide the low impedance drive required by the sampling circuits. The linear amplifier connected to the space sampler output is arranged to obtain a noninverted output. Thus both the mark and the space channel outputs obtain a 0 V to -8 V output swing capability, enabling the use of a common quantizer for both channels.

SAMPLING CIRCUITS—The second stage of the converter consists of sampling circuits, a polarity determining circuit, quantizing circuits, and a voltage clamped linear power amplifier circuit (Fig. 3A). Two identical sampling circuits are used, each using an emitter follower circuit whose collector voltage is supplied by an additional emitter follower called a sampler driver. The sampler drivers are individually driven by gates which are connected to a one-shot delay trigger. The trigger has a pulse width of 50 µsec and is actuated by a synchronous timing pulse command from the system using the converter. Two outputs of the sampling circuits, M and S, determine amplitude of the signal sample, and two, M₂ and S₂, determine the polarity of the sample. The former drive the pulse power driver from their respective mark and space channel inputs. The latter, also driven by the mark and space channel inputs, drive two Schmitt triggers. The sampler having the larger input at the sampling time energizes the trigger of that channel. The Schmitt triggers connect to the alternate inputs of a polarity register bistable circuit to store the polarity data, during sampling intervals, for digital processing.

The two amplitude outputs M and S are combined to obtain a common drive to the linear pulse power driver. At the input of the power driver, the pulse signals are clamped to a 2-V d-c level to obtain a linear response from the quantizer circuits. The linear pulse power driver provides the low impedance, high current source required by the quantizing circuits.

QUANTIZATION—The quantization of the sample pulse signal (Fig. 4) from the pulse power driver is performed in a zener diode array. The zener diodes provide the quantizer with stable reference voltages of low output impedance. The array consists of eight zener diodes having zener voltage breakdown from 2 V to 9 V in 1-V increments for the successive diodes. The 2-V zener diodes were used to accommodate the lowest quantum level since zener diodes of less than 2 V are not commercially available. The sample pulse signal amplitude input has a range of 0 V to -8 V. To obtain a linear response a d-c clamp of 2 V is required. This permits a -0.5 V input pulse level to fire the -2 V zener, quantum level 1, at -2.5 V. Quantum level 2 permits a -1.5 V
QUANTIZER (A) DETECTS signal polarity and stabilizes signal. Trigger circuits (B) select appropriate signals. Output NOR circuits (C) select signal of longest time period—Fig. 3

level to fire the −3 volt zener at −3.5 v. The quantum levels 3 to 8 are similarly obtained where the highest quantum level, 8, permits a −7.5 v level to fire the −9 v zener at −9.5 v. The 0.5 v excess over the zener breakdown voltage allows a uniform voltage to be developed at each zener diode load resistor, providing uniform triggering voltage for the pulse standardizing trigger circuits.

TRIGGER CIRCUITS—The third stage comprises 8 pulse standardizing and 8 precision trigger circuits (Fig. 3B). Each of the zener diodes activates a pulse standardizing trigger circuit which, in turn, activates its respective precision trigger circuit. The standardizing trigger circuits, which obtain their uniform standard voltage swing when triggered, provide a sufficient level to fire the precision trigger. Depending on the level of the sampled input signal, 0 to 8 precision triggers are fired at each sampling time. The pulse duration of each precision trigger is made an integral multiple of the pulse repetition period of the system clock.

OUTPUT LOGIC—Outputs of the precision triggers are combined in NOR logic circuits (Fig. 3C) so that the trigger corresponding to the longest time period, after a sampling, excludes all shorter periods. This exclusive output signal is mixed with clock pulses, using the NOR logic circuits, to obtain a pulse stream of 0 to 8 pulses. The number of pulses obtained at the output is an indication of the magnitude of the signal input to the converter.

The pulse stream of 0 to 8 pulses together with the polarity signal provided the required information, in digital form, for the digital data processing equipment used. The converter operated successfully when tested for several weeks with an experimental character detection communication system.

Modification of the converter for other applications includes changing the number of quantum levels and selecting zener diodes to provide a specified nonlinear characteristic. The serial output presentation could be converted to a simultaneous coded or noncoded form.

Other applications include a method for digitization of voice and facsimile signals. Uses may be found in reduction of large stores of analog data to digital form, to more readily enable statistical evaluation.
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Charts enable design engineers to get overall view of various combinations of bandwidth, resolution, scanning rates, aspect ratios and blanking interval.

By J. WARREN WIPSON
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WITH the increase of military television, ground-based and space-borne, a number of television system standards have come into use. While the conventional broadcast standard is most commonly used, the gamut runs from wide bandwidth high-resolution to narrow bandwidth slow-scan space systems. Resolution for any particular application may range from 100 or 200 tv lines to well over 1,000 lines with corresponding video bandwidths spanning from a few Kc to over 20 Mc. With this wide choice, the job of specifying and evaluating tv systems can be overwhelming. With the charts in this article, the systems engineer can obtain an overall view of various combinations of bandwidth, resolution, scanning rates, aspect ratios and horizontal blanking intervals.

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August 17, 1962
the formula \( H_H = 2 \left[ \frac{1 - B}{f_s} \right] \) \((BW/A)\) relating horizontal resolution to the scanning frequency, horizontal blanking time, video bandwidth and aspect ratio.

Here \( H_H \) is the horizontal resolution in tv lines, \( B \) is the percent horizontal blanking, \( f_s \) is the scanning frequency in cps, \( BW \) is the bandwidth in cps, \( 2 \) is the number of changes per cycle (for black and white resolution lines) and \( A \) is the aspect ratio \((w/h)\).

Assume that an f-m transmission link is to be used having an r-f bandwidth of \( \pm 10 \) Kc with a 2:1 deviation ratio as calculated from the signal-path noise characteristic. Since only 5 Kc of video bandwidth is allowable, the designer must critically examine the subject of information to be transmitted. Surveillance of instruments and gages which indicate comparatively slowly may require fairly good resolution but yet the information rate or the number of pictures transmitted per second can be low. On the other hand, rapidly changing events may require moderate resolution (350 tv lines) at a more rapid framing rate \((\sim fps)\). The problem of arresting subject motion when using slow framing rates is a separate consideration that can be accommodated by electrical or mechanical shuttering when natural lighting is available or by strobe lighting the subject.

**TYPICAL SOLUTIONS—Given**

the 5-Kc video bandwidth with a subject of cloud formations the designer may choose a frame rate of one picture every 10 seconds. Since the subject orientation and physical makeup may best fit a square format \((1:1 \text{ aspect ratio})\), approximately equal horizontal and vertical resolution will be selected. Using the chart, a trial solution will be tested with the three previously determined parameters (bandwidth, frame rate and aspect ratio).

For instance, from chart C: select 300 lines per frame at a frame rate of 10 sec and read 30 cps horizontal frequency. Using a 10-percent blanking factor (admittedly on the low side) as a first approximation, proceed to the 1:1-aspect ratio diagonal. Moving from this point to the interception with the 5-Kc bandwidth trace, the chart indicates 300 lines resolution proving that the initial selection was reasonable.

The chart is useful to approximate the system parameters within the confines imposed by the transmission link and the subject to be viewed.

As another example, determine the system parameters for minimum bandwidth when the
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desired horizontal resolution is 500 lines and the framing rate is 4 sec/frame. Inspection of chart B shows that the bandwidth will have to be greater than 15 Kc to have a vertical resolution of at least 200 lines. Assuming that the vertical resolution is to be close to that of the horizontal, the other conditions for minimum bandwidth are: aspect ratio should be a minimum (although usually not less than 1:1 unless the outline of the subject warrants); and blanking time should be a minimum. While this is governed by circuit design, practical percentages will fall in the same range regardless of the scan rate.

Using a minimum of 12-percent blanking (the circuit designer will probably want more), and an aspect ratio of 1:1, trial plots can be made starting from 500 lines resolution in an attempt to arrive at a desirable horizontal scanning frequency. For instance, for about 35-Kc bandwidth, read 125 cps horizontal and 500 lines per frame. For less bandwidth, a compromise might be made at the expense of vertical resolution. For 400 lines per frame and 100 cps horizontal, the bandwidth is about 28 Kc.

While this article touches superficially on the study of resolution, more comprehensive treatments are to be found in the many references following.

REFERENCES
7. O. H. Shade, Image Gradation, Graininess and Sharpness in Television and Motion Picture Systems, Journ...
FLAT FACE DISPLAY TUBES
Rauland's flat face tubes (16", 22", 24") minimize parallax error. Resolution capability of 1000 TV lines at 100 foot-lamberts light output. Suit your specific requirements with any type of radar display tube in any size with any type phosphor or gun.

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- Erase Capability of less than 2 seconds
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Two stock types are:
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Many other combinations are possible—and available. Your inquiries are invited.

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A subsidiary of

Radio Corporation, Chicago, Illinois
NEW Openings for EEs & MEs in Product Design and Development

Delco Radio's continuous search for new and improved electronic products provides challenging opportunities—in several areas—for capable engineers; specifically:

MOBILE COMMUNICATIONS (Automobile Radiotelephone) EQUIPMENT—
EEs—3-5 yrs. Exper—for design of and production assistance with 150 and 450 mc receiver transmitters; transistorization, packaging, duplex operation and dial mobile. Desire experience or interest in mobile communications equipment, private system or telephone link.

Project Engineers—work includes supervising type tests and FCC qualification testing of automotive radiotelephone equipment. Must audit designs for field reliability.

SUBMINIATURE MILITARY COMMUNICATIONS EQUIPMENT—
EE or ME—for assignment to development group designing all-transistor portable transmitters and receivers, operating in 2-100 mc range. FM-AM-FSK-CW-SSB modulation.

AUTOMOTIVE RADIO DESIGN AND DEVELOPMENT—
EE—to work with Senior Engineer on advanced development of auto radios and other entertainment devices, including FM-AM, miniaturized circuitry and components.
ME—for design of small electronic mechanisms, including FM-AM, Signal Seeking and push-button tuners, and components modules.
EE or ME—for packaging of auto radios and associated tuners, solenoids, etc. Required to make some engineering contacts with automobile manufacturers.

DIGITAL CIRCUITS AND SYSTEMS—
includes card, module and digital systems design, and production liaison involving components and special purpose systems operating from 200 kc to 10 mc.

Project Engineer—to direct efforts of design engineers and technicians in designing

and releasing digital circuits for production. Supervisory experience highly desirable.

EEs—for design and development testing and packaging of transistorized digital switching circuits from 200 kc to 10 mc.

RELIABILITY ASSURANCE—
Project Engineer—to handle tests and evaluations of transistorized systems and components, both power and small signal type. Must evaluate results and associated statistical data. Also includes failure analysis work with suppliers and production.

EE—for design and development work on test equipment for semiconductors and special products, such as radiotelephone.

AUTOMOTIVE ELECTRONICS—non-entertainment automotive electronic development including radio control for Garage Door Operators; other transistor applications in automobile, usually involving electromechanical transducers—
ME—for advanced development work in electromechanical systems used in automotive field.

EE—for design and development of transistorized automobile equipment.

EE or ME—with electromechanical interests for development of electronic equipment for the automotive service market.

If your interests and experience fall in the above areas and if you're looking for an opportunity to fully exercise your personal competence... among men of like talent... in unmatched facilities... then let's talk. Send your resume today to the attention of Mr. Carl Longshore, Supervisor Salaried Employment.

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Kokomo, Indiana
HOW TO BE SURE OF QUALITY IN ELECTRONIC COMPONENTS

One way to be sure of the quality of electronic components is to manufacture them yourself under rigid quality control for use in your own systems. This is exactly how Fuji Tsushinki started manufacturing electronic components. Fuji is one of Japan’s leading manufacturers in the field of telecommunications, computers and automatic controls. For over 25 years Fuji has devoted a large part of its research and production to the development of better components for its own equipment and systems. Now these precise, reliable components are available to other manufacturers who want top performance at economical prices. Fuji components include capacitors, resistors, semiconductors, relays, switches, filters, oscillators and other specialized items. All Fuji components are rigidly quality controlled during manufacture and subjected to rigorous testing, to match the quality and reliability of the finest electronic systems. Before you make a major decision in components buying, check the quality and prices of our products. Detailed specifications and application data are available from our representatives shown below.

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(Fuji Communication Apparatus Mfg. Co., Ltd.)
Tokyo, Japan

Represented by: * The Nissho American Corporation: New York 5, 80 Pine St., WH 3-7840. Chicago 8, 140 S. Dearborn St., CE 6-1950
* The Nissho Pacific Corporation: San Francisco 4, 120 Montgomery St., YU-2-2701. Los Angeles 14, 649 S. Olive St., MA 7-7691
Thermoelectric Chamber Stabilizes P-C Boards

Thermal environments can now be controlled on a systems level

By DAVID J. BEAUBIEN, Pres.
Cambridge Systems Inc.
Newton, Mass.

THERMALLY STABLE environments can be provided for conventional printed-circuit boards by a recently developed thermoelectric chamber. Constant improvements in thermoelectric materials with accompanying price reductions have made more extensive use of thermoelectric devices feasible. Thermoelectric temperature control on a systems level is now considered practical if careful design practices are followed.

Designing temperature-stable circuits becomes increasingly difficult as other requirements are increased, so that even the most complex stabilizing techniques may not be sufficient to permit use of a circuit in a system. The thermal environment of circuits like oscillators, video-amplifier strips or timing circuits can often be stabilized above ambient temperature, as is done by the crystal oven. However, this approach is not always desirable if the circuit must operate reliably for extended periods at the higher temperature or if abrupt changes in ambient temperature are anticipated.

Under conditions where circuit design or ovens are not adequate for dealing with temperature problems, thermoelectric modules can sometimes provide a solution. The thermoelectric chamber in the photograph was designed for such situations. It maintains temperature of conventional printed circuit boards at 25 ±1 degree C with variations in ambient temperature from -55 to 55 degrees changing at a rate of 1 degree C per minute.

CHAMBER DESIGN—A key feature in the design is the aluminum I beam shown in Fig. 1, which provides a path of high thermal conductivity to the thermoelectric modules mounted at the ends of the beam. The printed circuit boards are encapsulated in epoxy resin, and the surfaces are finished to provide low thermal resistance between the boards and the I beam. This configuration has been found to have low response time, since heat provided to or removed from the board is not limited by the usual air space. Heat removed from the chamber is dissipated by fins on the modules.

Ducts permit a stream of air to be circulated past the lower modules, through the fan at the rear of the chamber and across the fins of the upper modules as it is discharged. This thermal design makes efficient use of the pumping capabilities of the modules. Total temperature gradient along the I beam during maximum heat rejection is less than 1 degree C.

Selecting a thermoelectric module for a particular application is a primary factor in achieving a successful design. A wide variety of thermoelectric modules is available having figures of merit from $1.8 \times 10^{-4}$ to $3.2 \times 10^{-4}$ and operating currents from 1 to 40 amperes. Other characteristics that vary widely include mechanical strength, uniformity, intraelement thermal insulation, and electrical insulation.

Generally, a thermoelectric element is chosen that provides the highest figure of merit consistent with cost. Power requirements must also be considered, since low-cost, high-current modules may use power inefficiently and require a bulky power supply. However, modules having higher impedance with small cross-sectional element area may not be uniform mechanically. If additional effort is required to mate them to flat heat sinks and chamber members, costs are increased. At the present state of development in the thermoelectric industry, it is desirable to work with the module manufacturer to obtain a compatible design. Off-the-shelf modules are seldom ideally suited to a particular application.

CONTROL CIRCUIT—The control system for the thermoelectric chamber is shown in Fig. 2. Deviations in temperature from 25 degrees C
Now you can design microwave circuits for highest frequencies at lowest noise with the new GaAs Pill Varactor Diode from Texas Instruments. These new subminiature devices offer you minimum cutoff frequency of 90 GHz to 150 GHz at -2 volts with low junction capacitance — $C_J@0$ bias from 0.15 to 0.75 pF. Your production line requirements for identical plug-in units are met through tight control of junction and package characteristics. These features offer you the lowest package capacitance and inductance in industry today — backed up with TI varactor manufacturing capacity to meet your tightest production schedules.

**TI GaAs Pill Varactor Diodes are particularly applicable to:**
- Low Noise Parametric Amplifiers
- Harmonic Generators
- Microwave Switches
- Sub-harmonic Oscillators
- Phase Shifters
- Parametric Limiters

TI also offers GaAs Varactor Diodes in the double-ended microwave cartridge.

### Electrical Characteristics at 25°C Ambient Temperature (unless otherwise noted)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>A-610</th>
<th>A-611</th>
<th>A-612</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BV_R$ Reverse Breakdown Voltage</td>
<td>$I_R = 10µA$</td>
<td>min</td>
<td>max</td>
<td>min</td>
</tr>
<tr>
<td>$C_T$ Total Capacitance (See Notes 1, 2, 3)</td>
<td>$f = 1mc, V_R = 0$</td>
<td>0.45</td>
<td>1.0</td>
<td>0.45</td>
</tr>
<tr>
<td>$Q$ Quality Factor (See Notes 4, and 5)</td>
<td>$f = 3Gc, V_R = -2V$</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

**Notes:**
1. Case capacitance is typically 0.27 pF.
2. Varactor series resonance typically occurs at 14 GHz.
3. Selection can be made to customer $C_J$ specification ±0.05 pF.
4. Quality factor measurement method available on request.
5. Cutoff frequency is defined as the measurement frequency (3 GHz) times the quality factor.
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DIGITAL CONVERTER

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ACCURACY: .05% TO ABSOLUTE
DELIVERY: 30 DAYS

Format: Binary, 10 bits plus sign.
Conversion Rate: 10,000 complete conversions per second (9.1 microseconds per bit plus 9.1 microseconds.)
Input Range: ±10.23 volts; lower or higher ranges available.
Input Impedance: 5,000 ohms; high impedance amplifier optional.

Other models start from $2,775. Both Binary and Binary-Coded-Decimal formats are available. Options include Sample and Hold, Multiplexing, and Over-Range Indication. For more information, write to NAVIGATION COMPUTER CORPORATION, Valley Forge Industrial Park, Norristown, Pennsylvania.

Gravity-Wave Generator Is Being Built

THEORETICAL and experimental research is being carried out on the detection and generation of gravity waves. The existence of gravity waves has been predicted from the General Theory of Relativity proposed by Einstein in 1916. The oscillations in a gravitational field are analogous to electromagnetic waves in an electromagnetic field. The theory indicates that a gravitating mass such as a double star or spinning rod one meter long radiates about $10^{-20}$ ergs per second when rotated rapidly about a transverse axis.

The research is being conducted under grants from the Air Force Office of Scientific Research and the National Science Foundation by Prof. J. Weber of the University of Maryland. He is building a detector to search for gravity waves from interstellar space. He is also constructing a generator and expects shortly to demonstrate that gravity waves can be produced and detected in the laboratory, according to a report in the AFOSR Research Review by Lt. Col. J. E. Duval, Nuclear Physics Div.

The detector is a 11-ton aluminum cylinder housed in a vacuum chamber, which is expected to vibrate because of gravitational radiation incident on it. Displacements of the end faces of the cylinder are converted into electrical signals by...
Transient Voltages...Cause and Cure

A transient voltage can be generated whenever a magnetic component is energized, or de-energized. The peak amplitude of the spike can be many times the normal steady state peak inverse voltage, and is dependent on the amount of magnetic energy stored in the circuit and the rate of change of the collapse of the resultant flux field.

The amount of magnetic energy stored in various circuit reactances can be approximated by \( L \frac{dI}{dt} \), and this energy, when current is interrupted can produce a voltage equal to \( L \frac{dI}{dt} \). It is apparent, therefore, that under severe load or overload conditions, a high level transient voltage with substantial energy can be generated.

In actual applications, transients are generated mainly through interruption of current by switching, although circuit characteristics and phenomena can contribute to the problem. Full advantages to be gained from silicon rectifiers have low inverse voltage capabilities and thermal capacity, so any overvoltage condition, even for a few microseconds, can destroy the junction. The circuits illustrated are typical of those where problems have been found.

In addition to the three most common causes, less obvious circuits and phenomena can generate transients. Among these are minority carrier recovery, switching magnetic amplifiers, lightning or random line conditions and motor regeneration.

The problem of computing C or RC filters is complicated because of the possibility of changing circuit parameters or causing oscillation.

Tarzian’s recently developed line of “klipvolt” selenium transient voltage suppressors, therefore, offers a relatively low cost, simply applied method of positive protection. In many applications, a “klipvolt” suppressor will reduce overall circuit cost and increase reliability. The accompanying table covers the important design factors of voltage and current that govern typical application of suppressors; however, special designs and ratings are available on request. There are two basic types of suppressors, the non-polarized for use primarily across AC components, and the polarized for use in DC load circuits. In some instances, however, it may be preferable to use non-polarized suppressors in output circuits for more positive clamping or non-interference with circuit timing or operation.

Switching in Primary—Transients are caused by interruption of “magnetic” current, or by energizing the primary and causing oscillation between inductance and distributed capacity.

Switching Load—When the load is switched, the magnetic energy stored in the input circuit generates a voltage across the rectifiers and switch.

Magnetic Components on Common Line—Other magnetic components like motors, solenoids, relays or breakers can generate a transient peak when input is interrupted. The generated voltage will appear across the rectifier.

TYPICAL—klipvolt—SUPPRESSORS—SINGLE PHASE

<table>
<thead>
<tr>
<th>DC LOAD CURRENT</th>
<th>0-35</th>
<th>36-55</th>
<th>56-100</th>
<th>101-110</th>
<th>110-200</th>
<th>201-350</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIV</td>
<td>RMS VOLTS</td>
<td>AMPS</td>
<td>AMPS</td>
<td>AMPS</td>
<td>AMPS</td>
<td>AMPS</td>
</tr>
<tr>
<td>50</td>
<td>35</td>
<td>S-487</td>
<td>S-487A</td>
<td>S-487B</td>
<td>S-487C</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>70</td>
<td>S-488</td>
<td>S-488A</td>
<td>S-488B</td>
<td>S-488C</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>140</td>
<td>S-490</td>
<td>S-490A</td>
<td>S-490B</td>
<td>S-490C</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>210</td>
<td>S-492</td>
<td>S-492A</td>
<td>S-492B</td>
<td>S-492C</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>S-493</td>
<td>S-493A</td>
<td>S-493B</td>
<td>S-493C</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>350</td>
<td>S-494</td>
<td>S-494A</td>
<td>S-494B</td>
<td>S-494C</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>420</td>
<td>S-495</td>
<td>S-495A</td>
<td>S-495B</td>
<td>S-495C</td>
<td></td>
</tr>
</tbody>
</table>

TYPICAL THREE PHASE SUPPRESSORS

<table>
<thead>
<tr>
<th>DC LOAD CURRENT</th>
<th>0-60a</th>
<th>61-115a</th>
<th>116-200a</th>
<th>201-450a</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>35</td>
<td>S-539</td>
<td>S-539</td>
<td>S-539A</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
<td>S-540</td>
<td>S-540A</td>
<td>S-540B</td>
</tr>
<tr>
<td>200</td>
<td>140</td>
<td>S-542</td>
<td>S-542A</td>
<td>S-542B</td>
</tr>
<tr>
<td>300</td>
<td>210</td>
<td>S-544</td>
<td>S-544A</td>
<td>S-544B</td>
</tr>
</tbody>
</table>

Note: All types without suffix letter use plates 1" square; with “A”=11/4", with “B”=1.6"; and with “C”=2" square. Length depends on voltage rating and varies from 11/4” to 41/4”.

Write for complete “klipvolt” application information.

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August 17, 1962

CIRCLE 67 ON READER SERVICE CARD 67
I am the seeker incessant,
Endless avenues I roam, ravelling
Slender threads toward logical conclusions,
Splintering the thrum of inaudibility
To halt the hereafter with heartbeats,
Combing the static deep for denizens
Of stingered steel and polarized petards,
Slicing through quake and classic crust
To wrench the secrets of antiquity
From the very bowels of earth, so man,
Perhaps, can stir a step nearer heaven
To sing the song of truth and amity
Its message. My mission this, my task eternal—I am sound.

TO HALT THE HEREAFTER WITH HEARTBEATS

The very low frequency phenomena of heartbeats, like those of underwater sounds, speech, structural or geological shock and vibrations, no longer defy real time, high resolution analysis. Focussing broad scientific background and intensive research talents on the problem, General Applied Science Laboratories, Inc. has developed the SA-12 Spectrum Analyzer — capable of 1 second analysis time for 500 line resolution in frequency ranges from 0-250,000 cps.

A major component of GASL's MASSDAR (Modular Analysis, Speedup, Sampling and Data Reduction) System, the SA-12 is compatible with GASL Probability Distribution Analyzer ND-501 and Spectral Density Analyzer DI-11.

Other outstanding characteristics include:

- Six scales (Frequency ranges in cps):
  0-5  0-250  0-5000
  0-62.5  0-1000  0-250,000

- Analysis of both real and recorded inputs
- Analysis of periodic, random and transient data
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THE INSIDE STORY OF UNIPLANAR* VS. MULTI-PART CONSTRUCTION

UNIPLANAR* construction boosts silicon diode reliability

Uniplanar* one-piece construction, produced at Raytheon/Mountain View (formerly Rheem Semiconductor), brings a major improvement to silicon planar diode reliability. This is demonstrated by a 300°C storage capability, unequaled shock and vibration resistance, and more uniform electrical characteristics.

The result of Raytheon/Rheem Uniplanar* construction is a one-piece unit that can’t shake loose or become misaligned. The entire chip assembly, including ohmic contact, is formed by a single process. This technique permits positive surface passivation of the entire junction area. A high level of uniformity is achieved, since ohmic contacts are chemically formed thousands at a time.

300°C storage is obtained because, for the first time, it is possible to exclude the latent contaminants introduced by multi-part assembly techniques.

Uniplanar* construction is available at no extra cost in such types as 1N914, 1N916, IN3064, and 1N251. For further information, please contact the nearest Raytheon Field Office.

* Exclusive one-piece planar construction from Raytheon/Mountain View (formerly Rheem Semiconductor).

August 17, 1962
Product design engineering at Sage is highly specialized. We concentrate solely in the area of bridging that gap between precision and stability on the one hand and power rating on the other.

Now, for flat card assembly as well as for other component cluster approaches to circuit squeezing, SAGE offers industry's smallest grouping of 1, 2, and 3 watt resistors.

<table>
<thead>
<tr>
<th>Actual Size</th>
<th>Style</th>
<th>Rated Watts at 25°C</th>
<th>Nominal, inches</th>
<th>Range, Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SA1W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SA2W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Performance features of MIL-R-26C are easily met. SA2W is in fact RW59, presently the smallest unit detailed in MIL-R-26C.

Sage Impervohm silicone resin provides moisture and voltage protection, and may be safely operated at temperatures to 350°C.

Above styles available in non-inductive windings, also with weldable leads on special order.

Test samples available on request.

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**Equipment Design** • high performance solid state receivers, transmitters, frequency synthesizers and data handling equipment for radar and communications systems, oceanographic instrumentation systems and display complexes.

**Familiarity with State-of-the-Art** • statistical communications theory, advanced signal processing techniques, ultra-reliability through application of low-level redundancy, advanced structural and thermal designs for severe environments.

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EVALUATING

Integrated-Circuit Performance

By PETER SCHINK, Fairchild Semiconductor, Mountain View, California

Plan functional circuits with available parts, save time and money

INTEGRATED circuits, or circuits existing in a single substrate, offer possibilities of remarkable increase in reliability at circuit cost approaching that of a single transistor.

Integrated-circuit parts are now available to facilitate breadboarding a custom circuit and determine its adequacy. Offered by Fairchild Semiconductor, these functional parts provide circuit designers with a degree of freedom in obtaining a custom-designed integrated circuit without undergoing unnecessary and expensive tooling costs.

Cover photograph shows integrated parts offered initially to custom designers. Two 15K resistors are shown top right and left center. A 6K resistor is shown at bottom left; two medium geometry transistors, top center and right center; a small geometry transistor, bottom right; a large geometry transistor, right center; a common anode diode array, bottom center; and a common cathode diode array, top left. These parts represent an initial offering to fill particular needs. Future parts will include field-effect transistors, large-valued resistors, and capacitors.

The objective will be to provide further versatility in using integrated circuits, to obtain electronic functions with the ultimate in reliability at minimal cost.

TYPICAL CHARACTERISTICS

A high speed npn switching transistor is available with these typical parameters: \( L_{CBO} = 10 \text{ v}, C_{cb} = 5 \text{ pf at } V_{CB} = 5 \text{ v}, f_t = 400 \text{ Mc} \) at \( I_C = 3 \text{ ma} \), \( V_{CE} \text{ (sat) } = 0.25 \text{ v at } IC = 3 \text{ ma and } \tau_B = 20 \text{ nsec at } I_C = I_B = I_S = 10 \text{ ma. The total power of a circuit incorporating this transistor should not exceed 500 mw.} \)

The diffused p-type 6K resistor is available with taps at 100, 200, 500 ohms, 1K, 2K, and 6K. Resistor breakdown voltage = 20 v at 10 \( \mu \)a, and temperature coefficient from +25 C to +125 C is +2,000 ppm per deg C.

Three high speed silicon diodes are available in the common-anode configuration, with these typical characteristics: \( BV = 30 \text{ v at } 10 \text{ ma}, V_f = 0.8 \text{ v at } 3 \text{ ma, } C_r = 4.0 \text{ pf at } V_f = 0, \text{ and } \Delta V_f \text{ (voltage match between diodes) } = 15 \text{ mv max. at } 3.0 \text{ ma.} \)

These integrated parts, packaged in standard 70-5 cans, provide a breadboard circuit with characteristics similar to those of the final single-substrate circuit. Each device encounters a p-type diffusion to isolate it from the substrate, and therefore has the inherent capacitances and leakage currents of the eventual device. Geometry of diffused areas of the elements remain constant when integrated into the circuit, so parameters will not vary between breadboard and final circuit. Temperature coefficients of resistors in an integrated circuit are taken into account by providing diffused resistors.

DESIGN ADVANTAGES—Reliability of integrated circuits is enhanced by the fact that both passive and active elements are in effect placed in the circuit, using proven, silicon planar transistor diffusion techniques. These elements are then connected into a circuit by evaporating interconnecting metal in a single step.

As in the case of transistors, integrated circuits are manufactured in large numbers on silicon wafers which, following diffusions and evaporative metal interconnections, are scribed into individual circuits and packaged. The cost of circuits per wafer is inversely proportional to yield, and can approach transistor costs, because manufacturing techniques are similar to those used on transistors, and the number of circuits per wafer can approach the number of transistors per wafer.

As an additional cost factor, the circuit must meet necessary black-box conditions, regardless of the numerous device parameters required of a single transistor in the circuit. It therefore becomes meaningless to subject various transistors to individual parameter requirements which do not influence circuit operation. Circuit yields per wafer thus can be theoretically better than transistors per wafer.

DESIGN DRAWBACKS—An apparent, but possibly surmountable, drawback of integrated circuits is lack of flexibility in circuit configuration. Microelectronic approach doesn’t adapt itself to last-minute circuit change, because of the relatively expensive and time-consuming art of making high resolution and accurately-registered masks for each diffusion step in the process. An answer to this problem is simply a thorough, exact worst-case design, using rules of design pertinent to integrated circuits.

To make a valid worst-case design, however, certain peculiarities of integrated circuits must be taken into account. To obtain elec-
FOR PRODUCTION ECONOMY

CONSIDER TUNG-SOL PRESS-FIT SILICON RECTIFIER ASSEMBLIES

For applications requiring 3 amps to 75 amps, Tung-Sol production techniques can deliver attractively economical, production-ready rectifier assemblies employing press-fit diodes. Availability of rectifiers in both polarities makes it possible to mount more than one diode on a single heat sink, resulting in assemblies that are the lightest weight available for any given power capacity. They lend themselves to compact designs, as the shortest dimension can be mounted in any of three planes. Minimal operating temperatures in the 1-15 amp range, plus surge ratings to 400 amps and PRV ratings to 600V assure maximum circuit protection.

Tung-Sol press-fit diodes have proved highly reliable in a wide variety of applications. They are hermetically sealed, with welded cases and ceramic-to-metal seals. All have protective finishes to withstand moisture and the corrosive conditions present in normal industrial environments.

For more information about Tung-Sol rectifier assemblies, or press-fit diodes for use with your own heat sinks, contact the Tung-Sol regional office nearest you, or write for Bulletin CT-17. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX: NK193.

TYPICAL CONFIGURATIONS

SINGLE PHASE CENTER TAP

SINGLE PHASE BRIDGE

THREE PHASE BRIDGE

Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Melrose Park, Ill.; Newark, N. J.; Seattle, Wash. CANADA: Montreal, Que.; Abbey Electronics, Toronto, Ont.; Prairie Pacific Distributors, Ltd., Edmonton, Alta.
For your products ranging from home instruments to military electronics, you can find any electrolytic capacitor you need in the Mallory line... unbeatable for quality, variety and performance. 85° ratings, MIL types, subminiatures, wax tubulars. Name it and you can get it... from stock at factory prices from Mallory Distributors. Write for latest catalog.

Distributor Division
P. O. Box 1558, Indianapolis 6, Indiana

Mallory Aluminum Electrolytic Capacitors

For your products ranging from home instruments to military electronics, you can find any electrolytic capacitor you need in the Mallory line... unbeatable for quality, variety and performance. 85° ratings, MIL types, subminiatures, wax tubulars. Name it and you can get it... from stock at factory prices from Mallory Distributors. Write for latest catalog.

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Mallory Aluminum Electrolytic Capacitors

Electrical isolation between adjacent active devices in the substrate, an isolation diffusion is required to form compartments of n-type or collector material in the substrate. The isolation diffusion is p-type, forming a wall around and a floor under the n-type starting material. By virtue of a back-biased pn junction, isolation between collector regions is obtained. Associated with the p isolation region is the parasitic junction capacitance and leakage current associated with a junction area of this size.

Diffused resistors are normally made during the p-type base diffusion of the transistors, and they have temperature coefficients of approximately ±2,000 ppm/deg. C. Since a diffused resistor uses the bulk resistivity of a p region floating on n material, a distributed capacitance is associated with the resistor in an amount determined by the voltage gradient along the resistor.

These factors discourage worst-case design, unless they may be taken into account with a breadboard that accurately simulates operation as it would be in the final integrated circuit. It is obvious that a valid simulation of the leakages, temperature coefficients and capacitances would be difficult when using standard individual components.

USE OF KIT—This is the way the integrated parts enable manufacture of a custom integrated circuit:
Designer is provided with integrated parts, data sheets, circuit boards, and an application handbook.
Designer develops his circuits, using the data sheets and breadboards, designates parts of the circuits he wants integrated. Breadboard is returned to the maker, accompanied with black box parameters.

The maker lays out the masks necessary to make the circuit, and constructs test equipment to insure circuit performance within specifications. These are the expensive steps in the process which will be minimized by this approach.

Circuits are then diffused, packaged, and tested to specification as they come off the production line. Some of the design rules that have to be followed in using the integrated units are described below:

A point-count system is used to determine area consumption of the final circuit. Each device is assigned a point-count value, and the total for the circuit should not exceed a prescribed figure. This correlates with the maximum possible amount of circuitry permitted per chip, before yield becomes markedly affected.

The isolation diffusion region should always be committed in the circuit. This reduces undesirable collector-to-collector capacitive coupling effects, and facilitates layout of the evaporative metal interconnections over the silicon dioxide on the top surface of the substrate.

Resistors designed into the circuit may be expected to vary ±20 percent from the desired absolute value, but if absolute values can be discarded as a criterion, like resistors in the same substrate will be matched within ±1 percent.

Noise Levels Measured For Various Resistors

CURRENT NOISE levels for metal film resistors have been compared to precision wire wound resistors, as well as other types (see chart).

According to tests conducted against U. S. Bureau of Standards measurement criteria, the best measurement of current noise is in the area of −35 to −40 db. Below this point there is no observable difference between test set noise and resistor noise. It was at this level that Daven conducted tests on their own metal film resistors.

Current noise is measured in microvolts per volt per frequency decade. The measurement is in deci-
SERVOSCOPE® SERVO SYSTEM ANALYZER*: 

the constant factor in servo system analysis

From missile design to industrial equipment, wherever servo systems must be tested and evaluated quickly, accurately, and dependably, the SERVOSCOPE® servo system analyzer is still the standard (shown: Model F ... frequency range 0.005 — 100 cps).

When Servo engineers introduced this remarkable self-calibrating "servo system analyzer" twelve years ago, industry was quick to recognize an important advance. Why? From the simplest to the most complex electronic, electrohydraulic, electromechanical, and electropneumatic servo system, SERVOSCOPE provided reliable answers in a hurry. Here, at last, was an accurate, useful standard—a well thought out, well designed test instrument made for servo engineers by servo engineers.

Today, twelve years, and thousands of instruments later, wherever you look you see SERVOSCOPE. To the engineer working with missiles, weapons systems, airborne gear, ground support equipment, instrumentation, navigation equipment, communications, computers, industrial feedback loops, controls ... SERVOSCOPE is an accepted fact, an accepted part of the program. SERVOSCOPE is still the standard.

If your lab is still without a SERVOSCOPE, see what it can do... ask for a demonstration. Call the Servo office or representative in your area today. A free set of SERVOSCOPE WORKSHEETS or Servo conversion factors, as well as technical literature, will be sent you on request.

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*A SERVOMATION® PRODUCT
the Model 310-AB!

Look at all the features Krohn-Hite packs into one low-cost filter! Krohn-Hite's Model 310-AB variable band-pass filter covers the range from 20 cps to 200 kc. It features continuous independent adjustment of the high and low cut-off frequencies, so that the center frequency and band width are both adjustable.

Slope is 24 db per octave. Dials are direct-reading for quick and accurate measurement. Cut-off frequency accuracy is ±10%, with ±5% available.

A big advantage of the Model 310-AB is its high input impedance. It can be bridged across sensitive circuits without disturbing them. Its low output impedance is another advantage, and the output doesn't require terminating in a specific load.

Low noise is another feature of the 310-AB. Its hum and noise spec is that of other much more expensive filters (less than 0.25 millivolt rms), allowing the filter to work at low signal levels.

How does Krohn-Hite put so many features into a $350 filter? Easy — Krohn-Hite are filter specialists — the first to introduce many filtering techniques now in widespread use. So, for the most for the money, ask for a demonstration of the 310-AB. Check it out, and then check the price tag! Write for full specifications.

Silicone Coat Protects Microwave Components

GENERAL PURPOSE protectant, developed to prevent tarnish of metals finds application in microwave guides, where surface corrosion of aluminum inhibits electrical characteristic of guide.

New silicone compound can be sprayed, wiped or dipped to any metal, UCAR 101 Silicone provides a thin coat having long-lasting finish. In the waveguide application, the uniformly thin film of silicone does not change critical dimensions.

Bond strength formed with a metal surface falls between a mechanical bond and a true chemical bond. Bonding mechanism is a form of chemisorption or hydrogen bonding. Union Carbide's coat is highly resistant to attack by oxides, sulphides or other gaseous materials that attack metal. Thermal stability is good. Short time tests have been performed on copper. Coating withstands 3 to 5 minutes on copper exposed to 1,200 deg F.

Lowering Temperature Of Induction Coil

CZECH RESEARCHERS claim that the temperature factor of an induction coil can be diminished by winding the coil on a supporting body with a low coefficient of expansion. Czech monthly Slaboproudy Obzor reports that further reduction is achieved with auxiliary compensation members. Coil can be divided into two parts connected outside of the supporting body with metal column. Both parts of such a coil are connected with a member from non-conducting material located inside the coil body. Invention was developed by Jaroslav Endrst and Vlastimir Rehacek on their patent 99,209.
a comprehensive guide to current information on every branch of Science and Technology

...a practical new way to bridge the gap between your specialty and other fields into which your work leads you

If you find yourself among the growing number of science and engineering specialists unable to keep up with the explosive pace of developments today, you will see a valuable solution at the top of this page.
Look to the Linen Thread Company for the most complete line and latest types of lacing tapes and cords for electronics—including X-Type Nylon Cords, which meet Specification Mil-T-713A, cost far less, give superior performance in indicated applications.

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(A Div. of Indian Head Mills, Inc.)
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CIRCLE 204 ON READER SERVICE CARD

Eisler
A NAME TO REMEMBER IN MACHINERY FOR ELECTRONICS

At left: No. 105-BST1 Single position Button Stem and Wafer making machine—Fully automatic. Designed for small production runs on special tube parts or for laboratory use. Produces button stems up to 1/2" diameter. Machine can be supplied with up to 24 positions.

Illustrated below: An Eisler precision Vertical Spot Welder designed exclusively for welding of electronic components. Available in sizes from 1/2 to 7 1/2 KVA.

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CIRCLE 205 ON READER SERVICE CARD

Fairmount

10MC FREQUENCY COUNTER/STANDARD
A NEW CONCEPT IN PRECISION MEASURING

The Model 14-20C 10MC Frequency Counter/Standard combines features of a precision counter and a high stability frequency standard into an advanced design unit.

- Simultaneous and independent use of both frequency standard and counter.
- Stability of 1x10⁶ per day and 5x10⁶ per week.
- Nine standard decade output frequency from 0.1 cps. Gate time from 1 millisecond to 100 seconds.
- Counts any one of nine decade frequencies from 0.1cps to 10MC for period and time interval measurements.
- Self checks counting and gate circuits at any of these frequencies in all combinations of available gate times.
- Operates within -20° C to +55° C.
- Operates from an external 100KC or 1MC reference frequency.

$2,200

WESCON BOOTH #3245

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Finish the moon shot
Jules Verne began
72 years ago!

Science fiction pioneer Jules Verne foresaw problems in hitting the moon. His fictional moonship missed its mark, after nearly colliding with a meteor.* Now, 72 years later, Hughes offers you the opportunity to be part of a real moon project.

Help us soft-land the SURVEYOR on the moon with a package of delicate test instruments. Or work with us on other sophisticated projects: SYNCOM (synchronous-orbit communications satellite); VATE (versatile automatic test equipment; Anti-ballistic Missile Defense Systems (boost-intercept, mid-course, terminal) and many others. Positions are open for senior and junior control engineers, circuit designers, electronic weapon systems analysts, mechanical engineers and infrared specialists, with degrees from an accredited university.

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Culver City 23, California

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HUGHES

*In Verne's 1890 novel, "From the Earth to the Moon," his spaceship, "Columbiad," was launched from Tampa, Florida—just 120 miles from Cape Canaveral! After missing the moon, the craft returned to earth at 115,200 miles an hour. It plunged into the sea, popped to the surface—and the three men inside were found "playing at dominoes."

Bettman Archive
Making Bulbs for Double-Ended Tubes

Electrode support buttons are precisely located in bulbs for storage tubes

HIGH Precision is required in the glass bulbs used in new dual gun storage tubes. Especially critical are electrode support locations on the envelopes, since these determine the relation of collector and storage screens to the read and write guns. Physical specifications and seal contours for the envelopes are also stringent.

To solve the problems, engineers of Raytheon, the tube manufacturer, and Corning Glass Works, the bulb manufacturer, first had to state the requirements in terms understood by personnel at both companies, since such stringent specs had not previously been required of production line bulbs. Then complementary methods were developed to locate the electrode support buttons during envelope manufacture and to position interior parts during tube manufacture.

The function of the finished CK-7702 tube is to store electronic signals for comparison and to create a bright display. A current use of the tube is in the U. S. Coast Guard's experimental RATAN (Radar and Television Aid to Navigation) system. The radar image of marine traffic and fixed objects is converted into a television image, and, since the signals are stored, moving objects leave trails on the tv screen. Display brightness is high enough for viewing in ordinary light.

BULB MANUFACTURE—First step in making the bulbs is to form the envelope bodies and flared necks from glass tubing. Next, using a special jig, one neck is sealed to the body, with a deviation in concentricity of no more than 0.020-inch of the center axes of both neck and body along their entire lengths.

A standard gauge is used to mark the body for the reference button, one of four buttons around the body of the bulb that will support the assembly of four collector and storage screens. The other anode button locations also are spotted longitudinally on the body at the same time with this gauge.

The special jig shown in the sketch is then used to fix the square-
AIRTRONICS

electronic products for the telephone industry...

Portable Test Hybrid
Simplifies cable acceptance tests and return loss measurements.

Far End Terminating Set
Provides precision network termination during cable testing.

Pulse Meter
Furnishes a convenient method of measuring dial speed and percent make.

Program Equalizer
Corrects Attenuation Distortion easily, quickly. In use by many AM and FM Broadcast Stations.

PRECISION NETWORKS
WE 115 TYPE
BUILD OUT AND TERMINATING SET
PROGRAM EQUALIZERS
TRANSMISSION MEASURING SET

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AUTOMATIC SALES CORPORATION / A subsidiary of General Telephone & Electronics or Write direct...

This Portable Unit brings 8 Miles of Transmission Lines into Your Lab

Eliminates the Need for Leased Lines

Wherever you have a requirement for transmitting information, data, and intelligence this portable equipment will simulate transmission lines right in your lab.

The standard unit simulates 8 miles of transmission line, but it can be modified for any line length required. Plug-in modular construction. Seven plug-in modules each simulate 6,000 ft. of standard telephone cable with loading coil.

The Airtronics Artificial Line meets field engineering requirements. Some time-saving, money-saving laboratory uses are for testing data transmission (offers loaded or unloaded test facility); for testing amplifier operation over telephone lines (permits actual frequency response measurement to be observed over a simulated line); for checking system gain requirements for a pre-determined frequency range; for simulating complex values of AC impedance and DC resistance as incorporated in telemetry circuit transmission; for training purposes (used exclusively by every major telephone company).

The Airtronics Artificial Line is available in 19, 22, 24 and 26 gauge.

FOR FURTHER INFORMATION CONTACT:
AUTOMATIC SALES CORPORATION / A subsidiary of General Telephone & Electronics or Write direct...

August 17, 1962
Acoustical Components of Superior Quality

JAPAN PIEZO supplies 80% of Japan's crystal product requirements.

PHONOGRAPH MOTOR — DC
PM — 31-1
9V, 2,500RPM: No-load current, 35 mA; load current, 80 mA.
Starting torque, 13 g-cm; load torque, 5 g-m. Size: 2.4 cm × 4.6 cm. Weight: 100 gm.
Write for detailed catalog on our complete line of acoustical products including pickups, cartridges, microphones, record players and many associated products.

STORAGE TUBE is used to convert radar information into TV display in marine navigation aid.

ness and the radial and longitudinal position of the four buttons that will hold the screen assembly. The jig fits inside the bulb body.

A reference button is the first to be sealed. A hole is opened in the bulb body with a hand torch and the button is seated against the end of the reference arm of the jig. A pin is passed through the hole in the button into the hole in the arm of the jig, holding it in place. While the glass is still soft, the button is withdrawn enough so that it is outside the inside diameter of the bulb body. Then the button is adjusted with a hand gage for correct distance from the center axis of the bulb and for proper tilt in relation to envelope wall.

After the seal is annealed, the pin is withdrawn and the jig is used for the other three screen buttons. After sealing, the center of the four-button system must be within 0.02-inch of the bulb axis.

Positioning of the remaining three anode buttons is not as critical and is done by eye at previously marked places.

TUBE MANUFACTURE—In tube manufacture, the screen assembly is also positioned by pins; the screen assembly is placed on pedestal, the bulb body is slipped over it, and the pins are inserted through the holes in the buttons into the holes in the assembly.

Tube manufacture is completed by installing the remainder of the

Tv Images of X-Ray Views

DIRECT tv viewing of x-ray views of various types of components has been made possible by recent development of high resolution tv cameras. Quality checks of small components are speeded and substantial economies are realized by eliminating x-ray film processing equipment, film stock and by reducing inspection time.

The television system, developed by American Microwave and Television Corp., has high resolution due to the small spot size, 18 Mc video amplifier bandwidth and 945 scanning lines. Equivalent optical resolution would be 700 lines horizontal and 650 lines vertical.

Further work is going on to provide greater magnification within the ½ × ½ inch viewing rectangle of the x-ray pick-up tube.
THAT'S ABOUT THE SIZE OF IT

Slap 10,000 pf of stable capacitance in just .176 of a square inch of your circuit board with this new Corning TY capacitor. It's the TY09, the biggest of a small but stable bunch.

All our TY's give you ultrastable capacitive elements of fused glass and foil. The new case and potting compound eliminate inter-component, wire, or chassis short circuits.

You'll find TY's mount easily because we space the parallel leads uniformly on .100" grids and they're symmetrical with the case. Welding or soldering is easier, too, with the gold-flashed Dumet leads. We焊 them to the conductive plates to give you greater strength.

Check this table for the TY sizes and ratings you need. All of them perform at 300 volts from -55°C to +125°C with no derating.

<table>
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<th>Capacitance Range pf</th>
<th>Min.</th>
<th>Max.</th>
<th>L ± .005&quot;</th>
<th>W ± .010&quot;</th>
<th>T ± .005&quot;</th>
<th>S ± .020&quot;</th>
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Get more information fast from Corning Glass Works, 3901 Electronics Drive, Raleigh, North Carolina.
electronics, sealing the other neck to the body and evacuating the tube. The method for locating buttons and positioning the screens (patent pending by Raytheon) has permitted rapid production of the tubes.

APPLICATIONS — The storage tube has many application possibilities. Characteristics such as simultaneous write and read, variable automatic prime, fast erase, and magnetic deflection of both read and write beams make possible the design of advanced systems.

Resolution of 1,200 tv lines per diameter at 50 percent modulation is obtained through magnetic focus with dynamic correction. The tube meets requirements of FAA-R-1213b, and is designated for use in other military equipment specifications.

One advanced system that uses modified version of the tube is a radar bright display equipment, being developed for the Federal Aviation Agency. Principal elements of the transistorized equipment are a scan converter that accepts radar, beacon, map and range-ring video signals, stores these signals within the storage tube, then sends out the information in a form suitable for presentation on high-resolution television displays.

Hungarians Electroplating Powder Metal Parts

NOVEL METHOD of electroplating metal parts produced by powder metallurgy, pressed to size and sintered, combines vapor heat treatment and electroplating. Development was undertaken at General Machine Planning Institute of Budapest, Hungary.

An oxidizing process is substituted for the traditional treatment preceding electroplating, so that components produced by powder metallurgy are provided with an oxide coating. The oxide is then plated with a nickel film. The oxide layer seals the otherwise porous material, thereby preventing penetration of melted nickel which would otherwise produce internal corrosion.
LUNAR SURFACE RESEARCH

...one of more than 500 R&D programs under way at Douglas

This Douglas study seeks to increase man’s understanding of the character of the moon’s surface and how it will react to space-exploring machines and men.

Theoretical investigations are being supplemented by experiments in the Douglas Space Physics Laboratory. Here the effects of high vacuum on simulated properties of the surface of the moon are being studied to deduce the best model for the lunar surface that satisfies existing data. Moon crater formation is also under study to determine whether volcanic processes are in action.

Of career interest to engineers and scientists

Douglas has entered into a period of greatly expanded activities in a number of programs (like the above) which relate to tomorrow’s technology. Outstanding positions are now open in a wide variety of fields.

We urge you to contact us regarding current openings if you have a background in any of the engineering or scientific areas related to missile and space systems or space exploration.

Send us your resume or fill out and mail the coupon. Within 15 days from the receipt of your letter, we will send you specific information on opportunities in your field at Douglas.

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DESIGN AND APPLICATION

Sweep Generator For Millimeter Frequencies

*BWO* is swept between 26.5 and 40 Ge with 1-percent linearity

ANNOUNCED by Wave Particle Division of Paradynamics, Inc., Huntington Station, L. I., New York, is the model V850A swept signal source for *K* band. Typical power output is 10 mw between 26.5 and 40 Ge. The oscillator is a permanent magnet focused backward wave oscillator whose output changes linearly with time by the application of a time varying voltage to the helix. Shaper networks produce 1-percent frequency linearity over the band. Internal sawtooth sweeps between 0.1 and 100 cps are provided or external sweeps can be applied. Sweep width goes from single frequency output to entire range of instrument. Frequency is indicated within 1 percent on a front panel meter. Five presettable narrow-band swept frequencies are available. Residual r.m is held below 0.002 percent over entire instrument range.

**Circle 301, Reader Service Card**

Precise Ratio Transformer Is Phase Reversible

RECENTLY announced by Magnetic Amplifiers Div., 632 Tinton Ave., N. Y. 55, New York, the Decatran ratio transformer is a compact panel component that is phase reversible, has better than 0.02-percent accuracy and a resolution of 1 part on 1,000. A multiposition switch produces preset ratios of 0.000 to 1.099 and 0-and 180-degree phase. Frequency range is 30 to 1,000 cps. Applications include a-c potentiometers, transformer checking, servos, instrument calibration and potentiometer testing. Structurally, it consists of a single toroidal core upon which an input (primary winding) and three tapped output (secondary) windings are placed. The secondary windings are arranged so as to be selectively added together to yield a three decade output. Selection is by a three decade thumbwheel switch, with a fourth switch section for changing the phase of the input. The sketch shows a typical application.

**Solid State Load Cell Uses Piezoelectric Effect**

MANUFACTURED by Semtran Instruments Inc., Rt 73 Industrial Center, Maple Shade, New Jersey, the model 3200 load cells feature an output of 100 mv per volt input at 75 F with outputs of 1 v at rated load with 10 v input and up to 30 v optional input. Excitation can be either a-c or d-c. Load ranges are between 0 to 10 and 0 to 200,000 lb with up to 500,000 lb optional. They are available in compression, tension and universal series. Natural frequency is over 1 Kc and linearity is better than 1 percent with continuous resolution. Hysteresis is less than 0.08 percent rated load output and creep is less than 0.1 percent after 30 seconds. Overloads of 150 percent (300-percent optional) cause no change in zero or calibration. The cell uses the piezoresistive effect of a silicon element. A mechanical strain produces a change in electrical resistance of the element in a precision bridge circuit. Large and accurate voltage changes are developed and split resistors are used for internal temperature compensation.

**High-Vacuum Tetrode Features Reliability**

UNITED ELECTRONICS CO., 42 Spring St., Newark 4, N. J. The 4PR60B...
MB Hydraulic Shakers cut vibration-testing costs for large payloads

Vibration or shock testing of very large payloads—such as missile sections, or complete missiles—usually requires extremely high forces at moderate velocities and frequencies. It is not unusual for force levels to be in the order of 100,000 lbs.

In this force range, MB's electro-hydraulic shakers may cost as low as 1/5th the price of comparable electro-dynamic units. What's more the electro-hydraulic shaker is much smaller and more compact. For example, a hydraulic actuator with a 100,000 lb. force rating is only 18'' square by 13'' high!

MB's hydraulic shakers complement our line of electro-dynamic exciters and extend the limits of vibration, shock and fatigue testing. The electro-dynamic exciter fills the need for testing at high frequencies and relatively low forces and amplitudes, whereas hydraulic shakers are most advantageous for tests requiring extremely high vibratory forces and long strokes in the low to intermediate frequency range.

Some applications for hydraulic shakers:
- fatigue testing of heavy structures and members
- brute force testing of large, high pressure pipe, massive weldments
- vibrating heavy mass loads directly-supported on the shaker
- simulating transportation specifications
- applying static and dynamic loads simultaneously
- pulse testing and combined tests in environmental chambers
- simulating vibratory loading transmitted through more than one support

An MB hydraulic shaker system can add extensively to your testing capabilities; available in 27 standard models with forces of 1,000 to 100,000 lbs. and strokes to 18''. These shaker systems can also be custom designed to meet your specific requirements.

For detailed information write to MB Electronics; 781 Whalley Ave., New Haven 8, Conn.
No. 1 OF A SERIES . . .
The Difference Between Digital Voltmeters:

Franklin Electronics Makes Every Kind of Digital Voltmeter

HERE IS THE

MODEL 650

CIRCUIT: All-electronic.
METHOD: Voltage-to-time conversion, electronic ramp.

The all-electronic voltage-to-time conversion, ramp-type digital voltmeter (such as the Franklin Model 650 shown here) is preferred where (1) higher speed readings are desired; (2) the measured voltage may be unstable or noisy and; (3) printer operation is desired.

The Model 650, in addition to the inherent qualities of ramp-type digital voltmeters, has other important features too . . . a practically infinite input impedance . . . automatic polarity indication . . . optional automatic range switching . . . internal calibration cell . . . and a host of other advantages fully described in DATA SHEET 2027.

Coax Circulators Rated 10 W Average Power
CASCADe RESEARCH, a div. of Lewis and Kaufman Electronics Corp., 5245 San Fernando Road West, Los Angeles 39, Calif., announces a line of subminiature coaxial circulators and isolators in all frequency ranges from 500 to 11,000 Mc. A typical unit pictured operates from 2,200 to 2,500 Mc and provides isolation of at least 20 db; insertion loss, 0.3 db; power 10 w average, 5 Kw peak; vswr, 1.20; operates from -20 C to +75 C. (305)

Toggle Switch Designed for Dry Circuits
CUTLER-HAMMER, 315 N. 12th St., Milwauk ee 1, Wisc., offers an a-c, d-c toggle switch equipped with silver or gold flash current contact carrying members for dry circuit and low energy applications. Rated 3 amp at 250 v and 5 amp at 125 v, a-c, d-c, the device has 0.110-in. tab type quick connect terminals which are also suitable for use as solder lugs. (306)

Ferrite Circulators
MOTOROLA, INC., P.O. Box 5409, Phoenix, Ariz., has available a wide range of compact, 3- and 4-port ferrite circulators covering the frequencies from uhf to 9.6 Ge. (307)

Modular Delay Line Suited for P-C Boards
ALLEN AVIONICS, INC., 255 E. Second St., Mineola, L. I., N. Y. Series A measures 8 in. by 8 in. by 0.450 in. high and is a complete delay line in itself. Delays range from 0.1 to 1 µsec with a time delay to rise time ratio of better than 3. By combining units this ratio can be increased to about 70 with time delays up to 250 µsec. Completely encapsulated, modules have a temperature coefficient of 50 ppm per deg C. Normal dcwv is 300. Quantity price is $6.75 each. (308)

Decade Counter Operates to 1 Mc
ROBOTOMICS, INC., 4624 E. Garfield St., Phoenix 8, Ariz. Model F1702D operates to 1 Mc and features plug-in transistors and plug-in display lamps. Miniature contact springs are gold plated, bifurcated, with four separate contact points for max reliability. Display is bright 1 in. in-plane display with optional decimal point, or optional + and - sign. Decade operates from a single +12 v supply at less than 2 w. Modular boards can be quickly interchanged to provide minimum down time and fast field servicing. (309)

Filament Supplies
ALFRED ELECTRONICS, 3176 Porter Drive, Palo Alto, Calif. Four new filament supplies providing 0 to 15 v at 0 to 5 amp are designed for fail-safe operation to prevent accidental heater damage of micro-
wave tubes. Voltage and current are metered. (310)

Running Time Meter

INDUSTRIAL TIMER CORP., Highway 287, Parsippany, N. J. Series C-8 compact and rugged d-c running time meter provides digital readout of operating time from 1/10th of an hour to 9999.9 hours. (311)

Semiconductor Cooler Uses Teflon Washers

WAKEFIELD ENGINEERING, INC., Wakefield, Mass. Radial fin semiconductor cooler for rectifier or stud mounting transistor applications is adaptable to stack arrangements. Uses standard Teflon insulating washers. Accommodates press fitted and stud mounted (up to 1/4 in. hex case) rectifiers and transistors. Semiconductor mounting surface and one foot is not anodized. (312)

Small Torque Motor Offers Constant Tension

BEAU ELECTRONICS, INC., Waterbury, Conn., announces a small torque motor, designed to operate at a constant tension without vibration, shimmy, and cogging, and producing a uniform pull on tapes.

That's the performance record of this new, solid-front .025" jack. And the unique construction of the caged beryllium copper spring in a housing with a blind hole permits dip soldering or encapsulation. What's more, after 68,000 cycles, there was no significant increase in contact resistance . . . and no physical deterioration.

In addition to this new jack, there are 35 other basic types of CAMBION Miniature Plugs and Jacks — and a wide choice of finishes and insulation, too — to meet your individual requirements for both conventional and printed circuits. They're carefully processed from the highest quality materials to meet all applicable MIL specifications. And like all CAMBION electronic components — the broad line includes more than 10,000 different items — they are unconditionally guaranteed in any quantity.

Wherever good contact is essential, insist on CAMBION plugs and jacks. For information on deliveries and prices, and a copy of PLUG AND JACK CATALOG No. 70, write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts.
Gamewell made this special completely from scratch.

Every part of this rotary switch was newly designed by Your Engineered Specials service to meet a customer’s special requirements. The unit provides bi-directional operation at 160 rpm max. It is rated at 28 VDC, 60 ma... has high vibration and shock resistance... and -55° to +150°C. temperature range. Although this design called for only six poles and 11 switching segments, many more could have been provided.

Gamewell’s YES service has developed answers to hundreds of special “pot” problems. Interested? Write for the full story.

Servo Amplifier Features Reliability

M. TEN BOSCH, INC., Pleasantville, N.Y., has developed a 400-cycle servo amplifier capable of yielding 6 w over a temperature range of -55 to +125 C. The transistorized, hermetically sealed unit has a wide range of applications where reliability is required. Power gain at 2 w output with a 20 Kw input impedance is 2400. Phase shift is adjusted internally to 0 deg. A supply voltage of 28 v d-c at 350 ma is required. For orders of 10 to 99 unit price of the model 1800-4700 is $272. (314)

Operations Recorder Needs No Decoding

ROCHESTER INSTRUMENT SYSTEMS, INC., 275 N. Union St., Rochester 5, N.Y. Model RA-150 direct reading Recording Annunciator is designed to maintain a continuous surveillance of a number of stations and automatically print out alarms... threads, fine wire, film, or yarn. With an efficiency factor of 2.1 w per oz-in., the type 4001 offers 12 oz-in. of torque with a power input of 25 w max. The six-pole unit has an overall diameter of 3 in. and operates within a temperature range of from -65 to ±165 F.

CIRCLE 313, READER SERVICE CARD

Accurate time totalizing meter

Hermetically sealed 21 jewel watch movement and spring coupled D.C. (20-35 v) torque motor gives accuracy within 1% even under most critical operating conditions. Determine reliability, prevent failures, and facilitate maintenance procedures of aircraft or missile electronic equipment and systems. 1,000 and 10,000 hour readings. Parabam’s sub-miniature meter meets all requirements of MIL-M-26550.

CIRCLE 207 ON READER SERVICE CARD

- SCAN CONVERSION
- FLICKERLESS DISPLAY STORE
- VIDEO STORAGE

RECORDING STORAGE TUBE SYSTEMS

Single-gun, dual-gun, multi-tube systems to convert scan for radar, sonar, television, and to perform analog processing, data analysis, contract or expand time scale, auto correlation.

- SLOWED TELEVISION TRANSMISSION

by telephone line or other narrow-band systems.

- IMAGE ENGINEERING

OPTICAL CHART READERS, FLYING SPOT SCANNERS, LOW-LIGHT-LEVEL CAMERAS, and IMAGE RECTIFICATION. Automatic inspection and recognition of size, shape, color, and texture.

Write or call for complete information:

CIRCLE 208 ON READER SERVICE CARD
along with the time in the exact sequence and in a dependable, permanent record. The RA-150 basically consists of four units: an encoder; a storage and converter unit; a control unit; and a digital printer. Depending on options, a 100-point RA-150 is priced at about $5,000.

Sweeping Oscillator Gives Rapid Alignment

KAY ELECTRIC CO., 14 Maple Ave., Pine Brook, N. J. The Rada-Sweep BX-800, a sweeping oscillator designed for rapid precise alignment of aircraft Nav/Com equipment, incorporates a fixed band sweep and markers with one knob control and 11 center frequencies plus one spare. It also features 28 pulse-type crystal control markers which are accurate to ± 0.05 percent. It has a 70 ohm output impedance with 0.5 v rms, r-f output at 70 ohms flat to ± 0.5 db over widest sweep width.

Magnetic Amplifiers Provide High Stability

MILITARY & COMPUTER ELECTRONICS CORP., 900 N.E. 13th St., Ft. Lauderdale, Fla. Series 20 Ultamag magnetic amplifiers deliver 2 v across 10,000 ohms with only 1 × 10^-8 w control, a power gain of 46 db with stability in the order of 1 percent. Temperatures (operating)
FINEST FAMILY OF MINIATURE ACCELEROMETERS

This family of versatile accelerometers offers standard models for virtually any acceleration-measurement requirement... in 10 standard ranges from ±1g to ±500g. For tri-axis measurement, see opposite page. Outstanding features include: small size, light weight, precision construction for long life and superior performance. You can depend on the calibration figures that accompany each instrument. More than 15 major checks are used to prove performance. All CEC accelerometers are compatible with a wide range of associated CEC instrumentation. For complete specifications, write for CEC Bulletin 4202-X21, or call your CEC sales and service office.

Leak & Friction Detector Aids Quality Control
DELCOR LTD., 49 Industrial Road, Palo Alto, Calif., announces an instrument for inspecting fabricated pressure and vacuum vessels or systems by instantaneously detecting ultrasonic sound energy from leaks as minute as 0.003 in. in diameter. The transistorized Ultrasonic Translator is operable for one year on three mercury cells. (318)

High Speed Multiplexers Operate to 100 C
SCIENTIFIC DATA SYSTEMS, INC., 1542 Fifteenth St., Santa Monica, Calif. The MU-series analog switches are designed for data gathering and other switching applications. They settle to 0.01 percent in less than 15 µsec, and have over-all accuracies of 0.015 percent. Control facilities permit channels to be selected either at random or sequentially. Price for a typical 64-channel solid state system is $5,300 including control registers. (319)

Coax Crystal Mixers
MICROLAB, Livingston, N. J. The XR series of lightweight, coaxial crystal mixers cover the 225 to 600 Mc region in seven overlapping
ranges, are fixed tuned, and require no r-f adjustment. (320)

Triode Power Amplifier
Tunes 350 to 2,000 Mc
ANTRON CORP., 17 Felton St., Waltham 54, Mass. Model 125 increases the power level of uhf and L band signal generators and low power oscillators, and may be used as a frequency multiplier as well. Up to 17 db of gain and up to 3 w of output power are available over most of the tuning range. An output coupling control permits gain and bandwidth to be adjusted. (321)

Microwave Clamps
Come in Sizes W, A, B
DEMORNAY-BONARDI CORP., 780 So. Arroyo Parkway, Pasadena, Calif. Clamps permit rapid assembly and disassembly of waveguide instruments and components without the time consuming inconvenience of assembly with screws. Perfect alignment of the flanges and strong mechanical connection is assured. Currently the clamps are available in DeMornay-Bonardi sizes W, A, and B. This covers the frequency range of 50 to 140 Gc. (322)

Polyester Resin
DUREZ PLASTICS DIVISION, Hooker Chemical Corp., North Tonawanda.

A new instrument, CEC's Type 4-204 Tri-Axis Strain Gage Accelerometer is the smallest and lightest of its type - measures three axes of acceleration on a single mounting surface. Range of each axis (±5g to ±500g) is factory selectable. Provision is made inside the transducer case for electrical temperature compensation. Performance characteristics are outstanding. Cross axis response: less than 0.01g/g. Linearity and hysteresis combined: not more than ±0.75%. Operable temperature range: -70°F to +300°F. For complete data, call your nearest CEC sales and service office or write for Bulletin CEC 4204-X1. When you think of transducers, think of CEC.
Only one way to clean it. Ultrasonically.

Complete cleanliness is a must in the production of precision gyroscope parts. A grain of dust, a microscopic fiber, even a fingerprint could spoil its performance. Manufacturers of these tiny components and assemblies have found only ultrasonic cleaning can do the job properly... and high-powered Westinghouse ultrasonic equipment does the job best.

Solid state ultrasonic generators are trouble-free. All-metal Magnapak transducers cannot be overdriven, and deliver more cleaning power per watt than any others.

Westinghouse offers standard equipments in tank sizes from 1½ to 600 gallons, and powers up to 25,000 watts, or cleaning installations engineered to your production problem.

For more information or a demonstration, contact Westinghouse Industrial Electronics Division, 2519 Wilkens Avenue, Baltimore 3, Md. You can be sure... if it’s Westinghouse.

Westinghouse® Ultrasonics

CIRCLE 209 ON READER SERVICE CARD

For Production Line Testing...

EICO SCOPES

give you:
• professional performance
• reliability
• ruggedness
• versatility
... at moderate cost

EICO's high quality standards and low initial cost add up to true economy: EICO units outperform scopes selling for two or three times EICO's prices.

With kits, the initial cost is even lower. And the experience each operator gains in building his own, increases his efficiency, and enables him to keep his scope in better condition, with less "down" time.

<table>
<thead>
<tr>
<th>Kit</th>
<th>Wired Frequency (sinusoidal)</th>
<th>Sensitivity (rms)</th>
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<tr>
<td>5&quot; Push-Pull Scope #477</td>
<td>$69.95 $109.95</td>
<td>DC-500 2 CPS T6 10mV</td>
</tr>
<tr>
<td>5&quot; DC-4.5 MC Scope #460</td>
<td>79.95 129.95</td>
<td>DC-4.5 1 CPS to 400 kC flat</td>
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See the 41 additional EICO test instruments helpful for your lab and production work. Write for free Catalog & name of neighborhood Distributor.

3300 NORTHERN BOULEVARD, Dept. 98, L. I. C., 1, N. Y.

CIRCLE 96 ON READER SERVICE CARD

Monitors Scope Displays ECG, EEG

MEDTRONIC, INC., 3055 Highway 8, Minneapolis 18, Minn. Using a wide variety of plug-in adapters, conventional ECG, EEG, and fetal ECG are easily displayed on the monitor scope. Adapters allow inputs to be connected to the unit either directly, through the a-c power lines, or by means of wireless radio telemetry. An output on the monitor scope makes possible the simultaneous recording on a direct writer, any waveform that is monitored by the scope. (324)

Coax Relay Operates From -55 to +85 C

GENERAL COMMUNICATIONS CO., 677 Beacon St., Boston 15, Mass. Two-position r-f switch model 2TN-55-A has a life expectancy of one million cycles. Frequency range is 0 to 5 Ge. Vswr is 1.2:1 max up to 4 Ge. Crosstalk is—40 db max up
to 3.5 Gc. Standard connectors are type TNC and BNC. Typical shock and vibration specifications are 100 g for 11 millisec and 10 g per MIL-STD-202. (325)

Subminiature Relay
Withstands 50 G Shock

STRUTHERS-DUNN, INC., Pitman, N. J. Measuring 1½ in. in diameter by 1½ in. above mounting surface, type FC-410 handles 10 amp loads at either 28 v d-c or 115 v a-c. It has a rotary armature and four Form C (4 pdt) contacts designed for a minimum of 100,000 operations under rated loads and over an ambient temperature range of -65 to 125 C. Meets MIL-R-5757D specs. Withstands 50 g shock and 20 g vibration to 2,000 cps. (326)

S-Band Attenuator
Saves Panel Space

ANTENNA AND RADOME RESEARCH ASSOCIATES, 27 Bond St., Westbury, N. Y. Continuously variable attenuator is designed for front panel control installations. Connectors are mounted on the rear of its 3½ in. diameter to reduce panel space. Frequency range is 4.0-4.5 Gc; attenuation range, 0-50 db min; max vswr, 1.5; max insertion loss, 0.5 db; power, 10 w average and 5 Kw peak. (327)

Event Recorder

TECHNI-RITE ELECTRONICS, INC., 65 Centerville Road, Warwick, R. I. The TR-120 rack mounting inkless event recorder will monitor up to 20 on-off events simultaneously on a single heat sensitive chart. (385)
Switch quality

...YOU CAN FEEL in the smooth yet positive movement usually associated only with costly switches—indicative of a mechanical action that permits 10 ampere U.L.I. ratings in even the smallest Stackpole slide switches.

...YOU CAN SEE in the molded nylon bases and built-in terminal barriers of quick-connect terminal types in the nickel plated cases and colorful triggers ...in space-saving opportunities even for complex circuit switching.

...YOU CAN PROFIT FROM in terms of modern product styling, greater product dependability, faster production. Best of all Stackpole slide switch prices start at only $0.039. Over 15 basic types cover every circuit and rating need.

Learn more! Write for new Bulletin 78-101 on the world's largest slide switch line to:


STACKPOLE

PRODUCT BRIEFS

MINIATURE GEARHEADS and speed reducers. Available in all Bureau of Ordnance sizes from 5 to 18. Siamco, Div. of Tech-Ohm Electronics, Inc., 36-11 33rd St., Long Island City, N. Y. (328)

AUTOMATIC D-C DIGITAL VOLTMETER for use with analog computers for pot setting and readout. Auto Data, 945 Turquoise, San Diego, Calif. (329)

HIGH SPEED MEMORY uses terminal switching technique. It operates through clear/write and read/restore cycles in better than 1.5 µsec. Indiana General Corp., Electronics Div., Reasbey, N. J. (330)

SIZE 15 STEPPE MOTOR is mechanically detented. It provides an analog output from a digital input. Kearfott Division, General Precision, Inc., 1150 McBride Ave., Little Falls, N. J. (331)

POWER RHEOSTAT is vitreous enameled, wire wound. Standard units available in 22 resistance values from 1 to 2,500 ohms. Tru-Ohm Products, 3426 W. Diversey Ave., Chicago 47. Ill. (332)

UPPER SIDEBAND FILTER in compact size. It is designed for use in ssb military communications equipment. Systems Inc., 2400 Diversified Way, Orlando, Fla. (333)

FREQUENCY STANDARD is completely transistorized. Unit has a mean-time-between-failure rate of better than 10,000 hr. FXR, 33 E. Franklin St., Danbury, Conn. (334)

SOLID STATE CHOPPER for microvolt p-c use. Unit uses photosensitive light actuated element. James Electronics Inc., 4050 N. Rockwell St., Chicago, Ill. (335)

NEUTRON BEAM MONITOR, parallel geometry. It has a background count of less than 1 count per hr. Amperex Electronic Corp., Duffy Ave., Hicksville, N. Y. (336)

D-A CONVERTER has an accuracy of ± 0.03 percent of full scale. It operates at clock rates up to 200 Kc. Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa. (337)

SUBCARRIER OSCILLATOR SYSTEM for telemetry or f-m magnetic tape recording. It offers flexibility in selection of operating modes. Vidar Corp., 2296 Mora Drive, Mountain View, Calif. (338)

DIGITAL VOLTMETER is reed relay type. It has 3 automatically selected ranges up to ±999.99 v. Non-Linear Systems, Inc., Del Mar, Calif. (339)

PHOTO LAYOUT KITS for producing printed circuit artwork. Two types are available. Keil Engineering Products, Inc., 6839 Manchester, St. Louis 10, Mo. (340)

CRYSTAL OSCILLATOR is voltage controlled. Unit generates 4 mw at 76
Mc with ± 50 Kc deviation. Itek Electro-Products Co., 75 Cambridge Parkway, Cambridge, Mass. (341)

PRINTED CIRCUIT BOARD for curved applications. It is made of laminated, flame-resistant epoxy glass. RG Circuits Co., 15216 Mansel Ave., Lawndale, Calif. (342)

PLASTIC SLEEVES for wire identification and insulation. Furnished in 10 sizes, No. 16 through 2 in. diameter, W. M. Brady Co., 727 Glendale Ave., Milwaukee 9, Wise. (349)

PNP GERMANIUM POWER TRANSISTORS in 5 and 15 amp styles. All are stabilized at 125°C for 100 hr. Clevite Transistor, 200 Smith St., Waltham 54, Mass. (344)

D-C/D-C STATIC INVERTERS, power klystrons, magnetrons and crt's. Miniature unit weighs 20 oz. Abbott Transistor Laboratories, Inc., 3055 Buckingham Road, Los Angeles 16, Calif. (345)

RECTILINEAR INK PEN can be adapted to most recorders. Max excursion possible using the device is 5 cm. Invengineering, Inc., P. O. Box 360, Belmar, N. J. (346)

R-F ATTENUATOR with 50 ohms impedance. It can be set to any value from 1 to 102 db in 1 db increments. Telonic Industries, Inc., 60 North First St., Beech Grove, Ind. (347)

P-C BOARDS made of high alumina ceramic. They are available in a wide range of sizes and thicknesses. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wisc. (348)

WAVEGUIDE WATER LOAD handles 50 Kw peak, 25 Kw average Frequency range is 7.1 to 8.6 Gc. Airtron, a division of Litton Industries, 200 East Hanover Ave., Morris Plains, N. J. (349)


KLYSTRON TUBE MOUNTING BOXES for the millimeter bands. A rugged waveguide clamping bracket is provided. TRG, Inc., 400 Border St., East Boston, Mass. (351)

REFLEX KLYSTRON OSCILLATOR delivers 80 mw min power output. Tube operates at 23-24.5 Gc. Sperry Electronic Tube Division, Sperry Rand Corp., Gainesville, Fla. (352)

GENERATOR triggers delayed shutters. Time delay per channel is 1-10,000 usec, continuously adjustable. Abtronics, Inc., 64 South P St., Livermore, Calif. (353)

SHIELDED WIRE TERMINATOR is 1,000 percent faster than manual method. It meets MIL standards. Sorensen Industrial Electronic Co., Route 10, Dover, N. J. (354)

SOLID STATE A-D CONVERTERS feature high speed. Units have accuracies to ±0.01 percent. Scientific Data Systems, Inc., 1542 Fifteenth St., Santa Monica, Calif. (355)
FERRITE APPROACHES SINGLE-CRYSTAL STRUCTURE
UNIFORMITY, DENSITY GIVE HIGH PERMEABILITY

Kearfott’s MN-60 Ferrite is specially formulated for optimum performance in recording heads and other applications. Uniform crystal structure, sharp crystal boundaries, and careful control of voids produce its excellent characteristics. Initial minimum permeability is 5000, with an average of 6000 in production quantities. It is easily machined into small shapes with typical tolerances of 0.0001 inch. Surfaces are finished by machining to 16 microinches and by lapping to 8 microinches.

OTHER FEATURES OF MN-60
Negligible Eddy Current Losses Low-Core Loss Characteristics
High DC Resistivity Low Electrical Losses
High Curie Temperature Highest Uniform Quality

Typical Kearfott head configurations (actual size).

TYPICAL CHARACTERISTICS OF MN-60
Initial Permeability (at 21°C, 800 cps) 5000 minimum
Maximum Permeability Range (at 3000 gauss) 9000-10,000 gauss
Flux Density (Bmax) (at 2 oersteds) 4800 gauss
Loss Factors (at 10 kc) 3 x 10⁻⁴
(at 50 kc) 4.5 x 10⁻⁴
(at 200 kc) 45 x 10⁻⁴
Curie Temperature 190°C
DC Resistivity 300 ohm-cm

For complete data write Kearfott Division, General Precision, Inc., Little Falls, New Jersey.

Literature of the Week

TRANSISTORIZED POWER SUPPLIES Aco­pian Technical Co., 927 Spruce St., Easton, Pa. Three bulletins cover 45 plug-in-power supplies. (356)


DELAY LINES Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J. Single-page bulletin describes type T10 series ultra-fast time delay lines. (358)

P-C BOARD ETCHING FMC Corp., 161 E. 42nd St., New York 17, N. Y. Bulletin 119 contains information useful in setting up continuous etching of p-c boards. (359)

TRANSISTOR TYPES General Electric Co., Syracuse, N. Y., has published a 16-page transistor interchangeability brochure. (360)

MEASURING INSTRUMENTS Sensitive Research Instrument Corp., 310 Main St., New Rochelle, N. Y. Vol. 29 No. 6 of a house organ covers a 10-ln. vernier d-c Poly-ranger and a fluxmeter calibrator. (361)

QUARTZ CRYSTAL OSCILLATORS Bulova Watch Co., Inc., 40-10 61st St., Woodside, N. Y. Catalog sheet describes high-precision oscillators in the 8 Kc to 100 Mc range. (362)

FREQUENCY CONVERTER Lincoln Instrument Co., Inc., Box 1194, Santa Ana, Calif. Bulletin 20323 discusses a multiple channel frequency converter for flow control systems. (363)

PANEL METER Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. has published a data sheet on Style 32 (3¼ in. square) panel meter. (364)

SERVO ASSEMBLIES Kearfott Division, General Precision, Inc., Little Falls, N. J. A catalog sheet describes a line of miniature integrated servo assemblies. (365)

RELAY CIRCUITS Automatic Electric Co., 400 North Wolf Road, Northlake, III., has published "Relay Magic", a 40-page booklet that contains 31 time-tested circuits. (366)

IR INSTRUMENTATION Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. Bulletin 14-009 is a collection of articles describing the infrared instrumentation used in weather satellites. (367)

PARTICLE-MONITOR RECORDER Royco Instruments Inc., 440 Olive St., Palo Alto, Calif. Leaflet 120-262 covers a digital-printing auxiliary for airborne- or liquidborne-particle monitor application. (368)

MAGIC TEE Microwave Development Laboratories, Inc., 15 Strathmore Road, Natick Industrial Centre, Natick, Mass. Data sheet illustrates

100 CIRCLE 100 ON READER SERVICE CARD
and describes the WR187 magic tee for 5.4-5.9 Gc. (369)

CRT MAGNETIC SHIELDS Magnetic Shield Division Perfection Mica Co., 1322 No. Elston Ave., Chicago 22, Ill. Data sheet 160 deals with sophisticated design CRT Netic and Co-Netic magnetic shields. (370)

ALL PURPOSE RELAY Artisan Electronics Corp., 171 Ridgedale Ave., Morris- town, N. J., offers a bulletin describing the model RH all purpose economy relay. (371)

TAPE READER AND SPOOLER Potter Instrument Co., Inc., 151 Sunnyvale Blvd., Plainview, N. Y., offers a brochure on the PTR-500 perforated tape reader and PTR-500 perforated tape spooler. (372)

ULTRASENSITIVE TRANSDUCERS Senson- ics, Inc., 3831 Plyers Mill Road, Kensing ton, Md. A series of ultrasonic, noise-free Bariducers are illustrated and described in a four-page bulletin. A price list is available. (373)

ROTATING COMPONENTS Daystrom, Inc., Transicoil Div., Worcester, Pa., has a four-page bulletin on the digital en- dicator for converting analog voltages to digital information in adverse environments. (374)

C-C TV MONITORS Cohu Electronics, Inc., Kin Tel Div., 5725 Kearny Villa Rd., San Diego 12, Calif. Data sheet 0-256 describes 12 c-c tv monitors from 14 in. to 21 in. (375)

POWER SUPPLIES Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. Short form cat. No. 120B covers over 400 types of transistorized power supplies. (376)

POTENTIOMETRIC VOLTMETER Smith- Florence, Inc., Overlake Industrial Park, Redmond, Wash. A catalog sheet covers the model 951, a 0.01 percent standard potentiometric voltmeter. (377)

ELECTRONIC PRINTER Hull Instruments, 726 Mission St., So. Pasadena, Calif. A 4-page brochure describes an ultra high speed printer which, through the use of fiber optics, is capable of printing 6,000 characters per sec. (378)


COMPACT DIGITAL ENCODER Gulton Indus- tries, Inc., 212 Durham Ave., Metuchen, N. J., has issued an illustrated bulletin on the digital en- coder for converting analog voltages to digital information in adverse environments. (380)

FUEL CELL ELECTRODES Yardney Electric Corp., 40-50 Leonard St., New York 13, N. Y., has available a pa- per describing the development and use of a new concept in fuel cell electrode design. (381)


Ballantine Laboratories, Inc.
Boonton, New Jersey

GIVES YOU
1% ACCURACY OVER ENTIRE METER SCALE
1 mV-250 V, 20 cps-20 kc

Ballantine's hand-calibrated logarithmic voltage scale makes it possible to read voltages to the same high accuracy at the bottom as at the top of the scale. You use the full 5 inches of mirror-backed scale. This instrument incorporates the best of the features de- veloped in 25 years experience designing and building laboratory-quality vtvm's. Conserva- tive operation of long-life instrument tubes and high multiple path feedback over the frequency range result in a unit which is insensitive to tube deterioration or tube changes. There is less than 0.5% change in indicated voltage for a change in power supply voltage of 115 ±10%.

Every Model 300G is given a 50-hour "aging" at full power line voltage during a period of several days prior to its calibration. After calibration, each instrument is "aged" again for 3 to 4 hours and then cross-checked by a second operator at a second test console before final acceptance. This is not an occasional test but applies to every Ballantine Instrument. Of course components such as indicating meters receive extensive testing prior to assembly into a vtvm.

You can be assured of more than 3000 hours use within specifications, without servicing or recalibration. The 300G is an excellent instrument for use as a reference standard in any electronics laboratory.

Frequency Range: 10 cps to 250 kc
Accuracy in % of reading anywhere on the scale: 1%, 1 mV to 250 V, 20 cps to 20 kc; 2%, 1 mV to 1000 V, 10 cps to 250 kc

Available in 19 inch relay rack version as Model 3006-S/2 at $320

Write for brochure

CIRCLE 101 ON READER SERVICE CARD
General Atronics’ Growth Continues

AS PART of a long-range expansion plan, General Atronics Corporation soon will break ground for a 29,000-square-foot addition to its main building in Wyndmoor, Pa. The building presently houses the firm’s corporate offices and its Electronic Tube, Instrument and Products divisions.

David E. Sunstein, president, said additional office space and research and development laboratory facilities will be included in the brick two-story and basement annex which will adjoin the front of the building.

The new wing will give the firm 55,000 square feet at Wyndmoor. Its Military Electronics division is located in West Conshohocken in a new 9,000 square-foot air-conditioned building in the Industrial Center. Current expansion also included the opening of a new research and development center at Arlington, Mass., on August 1, according to Sunstein.

Malcolm M. Hubbard, of M. M. Hubbard Associates, and formerly president of Hermes Electronics and vice president of Itek Corporation, will manage the new facility for General Atronics.

Hubbard, who helped organize the MIT Lincoln Laboratory for the Department of Defense and became its assistant director under Albert G. Hill, said present plans for the Arlington plant call for specialization in theoretical studies for the communication field and signal handling for radar.

He will coordinate his R&D activities, Hubbard said, with the firm’s West Conshohocken division and work closely with Hill, professor of physics at MIT and a director of General Atronics Corp.

Fink Named IEEE General Manager

PRESIDENTS of two major engineering societies, slated for merger early next year, have announced the appointment of Donald G. Fink as general manager of the newly formed Institute of Electrical and Electronic Engineers (IEEE). Fink is now director of the Philco Scientific Laboratory and will remain in that post until his successor is appointed.

Warren H. Chase, head of the AIEE, and Patrick E. Haggerty, president of the IRE, stated that Fink was the unanimous choice of a 14-man Merger Committee appointed by the Boards of the two societies.

As general manager, Fink will be the chief staff officer responsible for the day-to-day operation of the world’s largest engineering society, with an estimated membership of 160,000. Among his responsibilities will be the supervision of the publication of technical periodicals which, for AIEE and IRE, now total forty.

Fink has combined notable careers in technical publishing, government service and industrial research. After graduation from MIT and a year on its research staff, he joined the editorial staff of ELECTRONICS in 1934 and became its chief editor in 1946.

During and after World War II, while on leave of absence from his editorial duties, he served as advisor and consultant to various branches of the government.

In 1952 he joined Philco, where he is now director of the Philco Scientific Laboratory.

Fink has been a Fellow of the IRE since 1947 and of the AIEE since 1951.

Rakonitz Joins E-H Research Labs

GEORGE RAKONITZ has joined E-H Research Laboratories, Inc., Oakland, Calif., test instruments manufacturer, as manager of microwave products.

Rakonitz was formerly vice president in charge of sales and engineering at Coopertronix, Palo Alto.

George Sauer Forms Rep Organization

GEORGE SAUER, formerly manager of the components department, Electronics division, Curtiss-Wright
DYNAMICS INSTRUMENTATION AMPLIFIERS

- designed for system flexibility and highest quality operation — where the ultimate in performance is essential

Model 6050 — differential dc amplifier. Designed specifically to meet the system engineer's requirements, unit incorporates the following features:

- Wide bandwidth: 20 to 10 kc.
- Dual outputs (simultaneous): ±10 v at 100 ma and ±10 v at 10 ma.
- High common-mode rejection with 1000-ohm input line unbalance: Withstands 117 vac common mode voltage between input and output ground.
- Isolation: input and output are completely isolated from each other — from rack cabinet, and power line.
- Small size: 2½" W x 5½" H x 16½" D.

Dynamics manufactures many types of instrumentation amplifiers — guarded, insulated, and isolated. Write for literature on the Model 6050, or the entire line.

DYNAMICS INSTRUMENTATION COMPANY
583 Monterey Pass Road, Monterey Park, Calif.
Phone: Cumberland 3-7773

CIRCLE 210 ON READER SERVICE CARD

DIRECT-READING PHASE SHIFTER

Model X1646A is a direct-reading versatile instrument offering full 360° of phase shift over the entire waveguide frequency range. Constant insertion loss (2db max.), is combined with an accuracy of 2° from 8.0 to 10.0 Gc/s and 3° from 10.1 to 12.4 Gc/s to assure outstanding performance. Useful for power levels up to 10 watts. Features includes full rf shielding and a mechanical locking device to allow zero dial adjustment. Resitability is 25°.

Model X1646A
Available from stock

CIRCLE 211 ON READER SERVICE CARD

POWERTRAN DUAL OUTPUT D.C.

POWER SUPPLIES

Smallest Available! Short-Circuit Protected

Two independent D. C. output voltages: not grounded to case; supply two positive or two negative voltages, or a positive and a negative voltage.

Input: 115 volts, 60 to 2000 cycles; tubeless 10,000 hour guaranteed life; temperature —40° C. to 85° C.

Model Voltage Current % % Reg. Ripple Price
MA7 7, 7 V 60 ma. 1.5 .3 55
MA10 10, 10 V 60 ma. 1.5 .15 55
MA12 12, 12 V 60 ma. 1.5 .15 55
MA15 15, 15 V 50 ma. 1.5 .30 55
MA20 20, 20 V 50 ma. 1.5 .40 60
MA24 24, 24 V 40 ma. 2.0 .40 60
MA28 28, 28 V 40 ma. 2.0 .40 60
MA35 5, 15 V 50 ma. 1.5 .30 60
MA712 7, 12 V 50 ma. 1.5 .25 60
MA122 12, 24 V 40 ma. 1.5 .40 65

Intermediate voltage values or combinations available at no extra cost. PUB COMPLETE LINE SEE IEM, Pk. 632.

FERROTRAN ELECTRONICS CO.
693 BROADWAY • N. Y. 12, N. Y. • AL 8-5810

CIRCLE 212 ON READER SERVICE CARD

LOW COST HIGH PERFORMANCE
SPECTRUM ANALYZER

10 mc - 43 kmc

WITH ONE TUNING HEAD

PANORAMIC MODEL SPA-10

Model SPA-10 provides sensitive broadband spectrum analysis through Ka band in a single, low cost, compact unit. With such outstanding features as high sensitivity, wide dispersion range, and adjustable selectivity the easy to use SPA-10 complements Panoramic's unmatched array of widely accepted exceptionally reliable RF and microwave analyzers. Many SPA-10 modular sections are derived from the highly regarded, ultra sensitive model SPA-40.

CHECK THESE FEATURES

High sensitivity (see table below). • Dispersion adjustable to 80 kc. • Selectivity adjustable 1-80 kc. • Calibrated dispersion marker with modulation provision to measure narrow band dispersions accurately. • Bright, easy read 5° CRT display with calibrated linear 40 db log and power amplitude scales. • Single knob tuning control with illuminated slide rule scale, accurate within ± 1%, or ± 1 mc whichever is greater. • Crystal controlled ±0.1% markers (optional) check signal frequency calibrations over entire SPA-10 range. Single tuning head includes coaxial and waveguide input mixers, plus noise-free non-contacting klystron cavity shorts. • Adjustable smoothing filter simplifies noise analysis.

FREQUENCY MIN. DISCERNIBLE LEVEL
10 — 600 MC —95* to —105 dbm
360 — 2360 MC —85* to —95 dbm
2.20 — 6.04 KMC —90* to —100 dbm
4.64 — 12.24 KMC —80* to —95 dbm
12.0 — 18.0 KMC —70* to —85 dbm
16.0 — 26.5 KMC —60 dbm (nominal)
45.0 — 43.5 KMC —50 dbm (nominal)

*Guaranteed minimum sensitivity throughout band.

For detailed information on models SPA-10 as well as SPA-40, write — wire — phone

Panoramic electronics inc.
530 South Fulton Ave. • Mt. Vernon, N. Y.
(914) OWens 9-4600. • TWX IN-W-9-5239
Cables: Panoramic, Mt. Vernon, N. Y. State

Be sure to see us at WESCON:
Booth #3354-5.

CIRCLE 103 ON READER SERVICE CARD
As engineers know, first designs of any transistorized equipment can be tricky... uncertain. In the case of digital voltmeters, El met these problems back in 1957 when we pioneered solid state D. V. M's. By 1959, our second-generation instruments had increased reliability, fewer parts, and better "specs." Today's THIRD-GENERATION, ALL-ELECTRONIC series have even fewer parts, simplified circuitry, improved packaging, and a lower price. Display is quicker than the human eye. Precision and accuracy are unmatched. Available models measure any or all electrical parameters and contain all provisions for systems use. In the past 8 years, over 10,000 El digital voltmeters have been shipped! There is no short cut to this kind of experience. We invite you to set your standards to El.

Electro Instruments, Inc.
8611 BALBOA AVENUE, SAN DIEGO 12, CALIFORNIA

For complete information, see us at WESCON Booth 2021-2022, call the EI office nearest you, or write direct.

B.R. Eichbaum Joins Philco Corporation

BURLANE R. EICHBAM, formerly with the Aeronutronic division of the Ford Motor Co., has joined the staff of the Philco Scientific Laboratory at Blue Bell, Pa., Donald G. Fink, laboratory director, has announced.

As his first assignment Eichbaum will undertake responsibility for planning Philco's program in computer research, and in that connection he will be chairman of the Memory Task Force of the Scientific Laboratory, Fink said.

ITT Kellogg Plant To Be Expanded

ALCORN COUNTY, Miss., voters recently approved a $200,000 bond election which, added to $303,000...
remaining from last year's bond issue, will be used to finance a 60,-
000 sq ft addition to the Kellogg International Telephone and Tele­
graph Company of Chicago sub­sid i ary plant there.

The estimated $509,000 expansion to the recently completed $947,-
000 Corinth plant will bring total plant space to 142,000 sq ft and will
add about 200 more employees, according to W. G. Cregeen, plant
manager.

PEOPLE IN BRIEF


SPACE ERA ELECTRONICS

are "HOMING IN" to

Atlanta's

DE KALB!

An exciting new Electronics-Scientific Center is taking root in Greater Atlanta's DeKalb County.

Here, just 15 minutes from downtown Atlanta, such leaders in space age electronics as

LITTON INDUSTRIES • THETA ELECTRONICS • SCIENTIFIC ATLANTA • ELECTRONIC WIRE & CONNECTORS, INC. • ARMOUR CHEMICAL—ELECTRONICS LABORATORY

are establishing a new base of operations. These companies were represented in and are making increasingly valuable contribu­tions to every space try.

Among their reasons for choosing DeKalb are these:

1. Proximity of Emory University and Georgia Tech with their famous electronics training and research pro­grams and equipment
2. Communications, transportation facilities
3. Room for company to grow, unusual living advantages for personnel.

OTHER INDUSTRIES, TOO, are choosing DeKalb — now more than 300 new ones — among them such leaders as GENERAL MOTORS, RIEGEL PAPER, GENERAL ELECTRIC, KRAFT FOODS.

INVESTIGATE DE KALB!

Send TODAY for new color brochure and also for Electronics Study prepared by Georgia Tech.

INQUIRIES CONFIDENTIAL
COLOR BROCHURE
GA. TECH ELECTRONICS STUDY

Write, Wire or Phone
F. WM. BROOME, Industrial Manager
DeKalb Industrial Committee of 100
P. O. Drawer 759, Atlanta 22, Ga.
Telephone 378-3691
OR
C. O. EMMERICH, Chairman
DeKalb County Commission
Decatur, Ga., Telephone 375-5731

Name
Title
Company
Address
City & State

CIRCLE 105 ON READER SERVICE CARD 105
ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. Please print clearly.

emannics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ___________________________ HOME ADDRESS ___________________________
CITY ___________________ ZONE _______ STATE ____________
HOME TELEPHONE ___________________________ DATE(S) _______________________

FIELDS OF EXPERIENCE (Please Check)

☐ Aerospace ☐ Antennas ☐ ASW ☐ Circuits ☐ Communications ☐ Components ☐ Computers ☐ ECM ☐ Electron Tubes ☐ Engineering Writing
☐ Fire Control ☐ Human Factors ☐ Infrared ☐ Instrumentation ☐ Medicine ☐ Microwave ☐ Navigation ☐ Operations Research ☐ Optics ☐ Packaging
☐ Radar ☐ Radio-TV ☐ Simulators ☐ Solid State ☐ Telemetry ☐ Transformers ☐ Other ☐ ☐

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

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

EDUCATION

PROFESSIONAL DEGREE(S) _____________________________
MAJOR(S) _____________________________
UNIVERSITY _____________________________
DATE(S) _____________________________

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

RESEARCH (pure, fundamental, basic) ....... ....... .......
RESEARCH (Applied) ....... ....... .......
SYSTEMS (New Concepts) ....... ....... .......
DEVELOPMENT (Model) ....... ....... .......
DESIGN (Product) ....... ....... .......
MANUFACTURING (Product) ....... ....... .......
FIELD (Service) ....... ....... .......
SALES (Proposals & Products) ....... ....... .......

TECHNICAL EXPERIENCE (MONTHS)

SUPERVISORY EXPERIENCE (MONTHS)

106
Stimulating career opportunities for Reconnaissance Systems Engineers at Sylvania on the San Francisco Peninsula

SYLVANIA ELECTRONIC SYSTEMS—WEST offers a broad spectrum of challenging problems involved in Reconnaissance Systems Engineering including: Feasibility Studies, Operational Analysis, System Synthesis and Performance Analysis, Application and Development of Advanced Techniques, Specification of Constituent Subsystems, Human Factors Engineering and Operations Research. Typical areas in which openings currently exist include the following:

DATA ANALYSIS and SIGNAL PROCESSING. Carry out studies, the objectives of which are the design of new, or the refinement of existing data collection systems. Studies range from the analysis required to develop and define operating requirements compatible with economic and state-of-the-art considerations, through systems conceptual design in block diagram form and including specification of hardware design approach.

STATISTICAL ANALYSIS. Perform various statistical analyses at various levels of sophistication, set up mathematical models of stochastic processes. Fields of particular interest include experimental design, theory of queues, theory of mixtures, allocation of resources, search theory, and general operations research.

INTERCEPT AND DETECTION. Direct or perform reconnaissance systems operational and technical requirements studies; electronic signal environment studies; synthesis of electronic intercept systems from conception to hardware specification and system block diagram; analysis of system performance and of data related to telemetry, communications, radar and others. Direct or prepare reports and proposals and maintain technical contact with customer representatives.

ANTENNA AND PROPAGATION. Perform analyses of electromagnetic propagation aspects of reconnaissance and other systems; analyze direction finding problems and develop direction finding techniques; determine antenna requirements and configuration during synthesis of reconnaissance systems. Activities include report writing, and customer contacts.

These openings exist at all experience levels. Advanced degrees in EE, physics, or mathematics desirable.

Complete information may be obtained by writing, in confidence to

Roger Harlan

SYLVANIA ELECTRONIC SYSTEMS • WEST
P. O. Box 188 • Mountain View, California
An Equal Opportunity Employer
EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc. Look in the forward section of the magazine for additional Employment Opportunities advertising.

Position Vacant
Civil Service Opportunities
Selling Opportunities Wanted
Part Time Work

DISPLAYED

The advertising rate is $4.01 per inch for all advertising appearing in this section. Contract rates quoted on request.

$2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.
Box Numbers—counts as 1 line.

Discount of 10% if full payment is made in advance for a consecutive insertions.

Not subject to Agency Commission.

Send NEW ADS to CLASSIFIED ADV. DIV. of ELECTRONICS, P.O. Box 12, N. Y. 36, N. Y.

ELECTRONIC CIRCUIT DESIGNERS

Excellent opportunity in New Products Department of rapidly growing company making recorders and laboratory test instruments. Requirements are a degree in electrical engineering from a leading college or university and three or more years experience in instrument circuit design employing both vacuum tubes and transistors. All development work would be on proprietary instruments.

Write in confidence to:
Technical Director
HOUSTON INSTRUMENT CORPORATION
4950-4951 Terminal Avenue
Belloire 101, Texas.

Electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

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Oak Ridge, Tennessee

VAPOR CORPORATION 192* 24
Chicago, Illinois

* These advertisements appeared in the 8/10/62 issue.

FOR RESEARCH—DEVELOPMENT & EXPERIMENTAL WORK

Over 10,000 different electronic parts: waveguide, radar components and parts, test sets, meters, antennas, pulse units, amplifiers, IF and RF amplifiers, oscillators, etc. Equipment is advertised at a fraction of original cost. CIRCLE 951 on reader service card.

FOR SALE ADVERTISEMENTS

Advertising is quoted on request. Box Numbers—counts as one line additional in undisplayed ads. DISCOUNT OF 10% if full payment is made in advance for a consecutive insertion of undisplayed ads (not including proposals).

FOR RESEARCH—DEVELOPMENT & EXPERIMENTAL WORK

Over 10,000 different electronic parts: waveguide, radar components and parts, test sets, meters, antennas, pulse units, amplifiers, IF and RF amplifiers, oscillators, etc. Equipment is advertised at a fraction of original cost. CIRCLE 951 on reader service card.

UNIVERSAL RELAY CORP.

Send for Catalog S5

42 WHITE ST., N. Y. 13, N. Y. • VALHALLA 8-6900

CIRCLE 951 ON READER SERVICE CARD

A Your Best Source of Supply for—

HIGH PURITY METALS
SEMICONDUCTORS

GROMA METAL CORP.

50 Broad St., New York 4, N. Y.

Plant, Houston, Pa.

CIRCLE 952 ON READER SERVICE CARD

Your Inquiries to Advertisers Will Have Special Value . . .

—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publisher to secure more advertisers and—more advertisers mean more information on more products or better service—more value—to YOU.
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- See advertisement in the July 25, 1962 issue of Electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but electronics assumes no responsibilities for errors or omissions.

---

Specialists in...

**PERIPHERAL DATA PROCESSING**

systems, equipment, and components

**DATA LOGGERS**

* Using IBM's new Selectric (golf-ball) typewriter with printing speed of 15 characters/sec, featuring INVCOR Corporation's photoelectric techniques, special clock attachment for data logging available.

**PAPER TAPE PUNCHES & READERS**

* Model TP-200 TYPEWRITER-TRANSMITTER/RECEIVER

20 characters per sec, solenoid actuated, extremely compact.

**PHOTOELECTRIC ENCODED KEYBOARDS**

* Model PK-144 KEYBOARD

Features: photoelectric design, no metallic switches or contacts. Encoding matrices are eliminated.

Technical bulletin available on request...
For Better Service
That You Mail Early
In The Day!
2N996
SILICON PLANAR
EPITAXIAL PNP for
HIGH SPEED,
HIGH CURRENT LOGIC

- 60 mA High Current Operation
- 15 nSec Typical Propagation Delay
- 200°C Maximum Junction Temperature
- Direct Replacement for Many Germanium Transistors

The advantages of the Silicon Planar construction are now available in a wide variety of direct replacements for germanium. In addition, the diode gate now is available in a single package TO-5 type can (special product FSP-463) for miniaturized packaging.

FD-6002a

Vf @ If = 100 mA
VR @ VR = 25 V
trr @ If = If recover to 10% of If for all If from 10 mA to 200 mA

1 V Max.
100 μA Max.
4 nSec Max.

BVCEO @ IC = 10 μA
hfe @ f = 100 mc, IC = 10 mA
VCE(sat) @ IC = 60 mA, IB = 2 mA

2N996a

VCE = 12 Vols ±3%

OFF-THE-SHELF FROM DISTRIBUTORS

WESCON BOOTHS
2129-2131

FAIRCHILD SEMICONDUCTOR
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A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CIRCLE 901 READERS SERVICE CARD
RCA L and S BAND VARACTOR-TUNED INTEGRAL-CAVITY "PACKAGED" MICROWAVE DEVICES MORE VERSATILE AND EFFICIENT THAN KLYSTRONS

RCA’s new varactor-tuned integral-cavity pencil tube, A15314, operating at 1880 Mc, makes possible electronic frequency control in applications such as radar beacons, proximity devices, area surveillance equipment and telemetering devices, as well as in local oscillators and signal sources.

The cavity can be mechanically tuned between 1865 Mc and 1895 Mc and electronically tuned ± 10 Mc from any preset frequency within this range. Tuning sensitivity is approximately 1 Mc/volt. Power output over the tuning range is 200 mw minimum.

The integral packaging of the varactor with the cavity makes possible either electronic frequency control or frequency-modulated output. As such, the device has many advantages over klystrons including: better frequency stability in an FM system under conditions of varying heater and plate voltages and ambient temperature changes. Further advantages are lower input power, higher efficiency, longer life, and lower cost.

For additional information see chart at right. Detailed specifications and application information are available by writing: Manager, Microwave Marketing, RCA Electron Tube Division, Harrison, N. J.

**General Data—RCA-A15314**

<table>
<thead>
<tr>
<th><strong>Electrical</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Voltage</td>
<td>6.0 ± 5%</td>
<td>volts</td>
</tr>
<tr>
<td>Heater Current</td>
<td>160</td>
<td>ma</td>
</tr>
<tr>
<td>Maximum DC Plate Voltage</td>
<td>150</td>
<td>volts</td>
</tr>
<tr>
<td>Maximum DC Plate Current</td>
<td>35</td>
<td>ma</td>
</tr>
<tr>
<td>Minimum Varactor Voltage</td>
<td>0</td>
<td>volts</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Typical Operation—Frequency Modulated Oscillator</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>DC Plate Voltage</td>
<td>125</td>
<td>volts</td>
</tr>
<tr>
<td>DC Plate Current</td>
<td>35</td>
<td>ma</td>
</tr>
<tr>
<td>Varactor Bias</td>
<td>–10</td>
<td>volts</td>
</tr>
<tr>
<td>Peak-to-Peak Modulating Voltage</td>
<td>20</td>
<td>volts</td>
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<tr>
<td>Center Frequency</td>
<td>1880</td>
<td>Mc</td>
</tr>
<tr>
<td>Peak Frequency Modulation</td>
<td>±10</td>
<td>Mc</td>
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<tr>
<td>Minimum Power Output</td>
<td>200</td>
<td>mw</td>
</tr>
</tbody>
</table>

**INDUSTRIAL TUBE PRODUCTS FIELD OFFICES—OEM Sales:**
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