SPECIAL REPORT

on Micro-miniaturization discusses concepts, approaches, problems, techniques and applications of microminiature components, circuits and systems.

Experimenting with thin-film evaporative deposition.
An Integral Part of Your Equipment
This high-vacuum pump incorporates three Variacs for the control of motor speed and voltages.

A Research Tool
Variacs control current through coils used for heating ingot of experimental semiconductor material.

Photo Courtesy of Consolidated Electrodynamics Corporation

Photo Courtesy of Bell Telephone Laboratories

Variac

the Original Continuously-Adjustable Autotransformer

featuring DURATRAK, G-R's exclusive treatment for the Variac contact surface.

*U. S. Patent No. 2,949,592

A Handy Workbench Accessory
Engineer uses a Metered Variac to check voltage range specifications of a prototype electronic instrument.

General Radio Company

Designed, Engineered, and Manufactured by

Write For Complete Information
BUSINESS

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ENGINEERING

Deposition is employed by Motorola to build film circuits. Attempts are being made to lay down active elements in thin-film form. Thus, circuits may be built by a continuous process. See p 97

Special Report On Microminiaturization. Efforts are being pushed in many areas. The extent and success of these efforts are summarized. By M. M. Perugini and N. Lindgren 77

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The important advances in environmental testing come from MB

New MB vibration unit extends range, accuracy and efficiency of accelerometer calibration

Now, for the first time, a single system enables you to accurately calibrate vibration transducers at any frequency from 5 to 10,000 cps with accelerations up to 100 g.

Complete and self-contained, the MB calibration system saves you space, time and money. This entirely new system incorporates all the necessary instrumentation required for fast, accurate calibration. Newly designed circuits simplify calibration procedure and eliminate special techniques.

Powered by an extremely low distortion amplifier, the MB Model C12 calibrator produces 150 pounds of high-fidelity linear force.

The new exciter-calibrator pictured above is another example of MB’s continuing efforts to anticipate the needs of the environmental test engineer. It is another reason why engineers everywhere recognize that the important advances in environmental testing come from MB.

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A DIVISION OF TEXTRON ELECTRONICS, INC., 1102 State Street, New Haven 11, Conn.
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Write for your copy of Bulletin GC-106C, a general catalog of all Arnold products. It contains useful data on the physical and magnetic properties of Alnico magnets. Lists stock items and standard tolerances for cast and sintered magnets—also stock sizes and pertinent data on tape cores, powder cores, C & E cut cores, etc.

Your best bet for a source of Alnico permanent magnets and assemblies is Arnold—producer of the most complete line of magnetic materials in the industry. We can supply your need for any size, shape, or type of Alnico magnet. Weights range from small sintered parts weighing less than a gram to large castings of 80 lbs. or more.

Special assemblies such as rotors, traveling wave tube and magnetron magnets, etc., may be supplied aluminum-jacketed for easy mounting and added protection of the magnet—and magnetized and stabilized as desired. Large magnet assemblies may also be supplied for mass spectrometer and other measuring applications, where a high degree of stability and uniformity of field is required.

For your convenience, we carry a wide range of the more popular sizes and types of Alnico magnets in stock for immediate shipment. Unsurpassed plant facilities assure quick delivery of all special orders.

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Find them FAST in the YELLOW PAGES

ADDRESS DEPT. E-11
November 25, 1960

CIRCLE 3 ON READER SERVICE CARD
CROSSTALK

ORGANIC SEMICONDUCTOR CONFERENCE. In the Spring of 1961 ELECTRONICS, in partnership with the Armour Research Foundation of Illinois Institute of Technology, will co-sponsor an Inter-Industry Conference on Organic Semiconductors in Chicago.

This will be a new experience for us, and we do not undertake it lightly. However, we regard the activity as a natural outgrowth of our accustomed and well-established function, which is to communicate in depth facts about significant developments in our industry.

The study of organic semiconductors is one of the most rapidly growing areas of research in the scientific world. It may also be one of the most fruitful for the electronics industry. Our interest was stimulated almost a year ago, when we received a report on Soviet investigations into the use of polyacrylonitrile for transistors (ELECTRONICS, p 26 and p 65, January 22). On digging further, we discovered that many U.S. firms were also active in organic semiconductor research.

At present, the bulk of the work has to do with measurement of the properties of organic materials. These include conductivity, carrier mobility and Hall coefficient. It is early in the game, and practical devices based on present knowledge are just in the discussion stage. But it is already apparent that here is a vast untapped reservoir of new and exciting developments whose significance may equal and possibly transcend the transistor itself.

Our aim in co-sponsoring the conference with Armour is to provide industry with a forum in which to evaluate the present state and future potential of organic semiconductors. Present plans call for a number of invited and contributed papers which will contain the latest results of research in industrial and government laboratories.

We think the conference will be a significant event for the electronics industry. Further details will be published in ELECTRONICS in the near future.

SPECIAL REPORT. Since their interpretive article on progress in solid-state technology (ELECTRONICS, p 30, March 4), Associate Editor Perugini and Assistant Editor Lindgren have been paying close attention to trends in microminiaturization. One result is the comprehensive 32-page Special Report that begins on p 77 of this issue. In addition to learning where we stand on component, circuit and function-oriented approaches, you'll find out how microminiaturization techniques are being applied to equipment and systems. You'll also find reliability figures for thin-film resistors, surface passivated diodes and microelements and micromodules.

Coming In Our December 2 Issue

LAMINAR JUNCTIONS. As brought out in this issue's Special Report, laminar junction layers mark one of the new techniques for constructing microcircuits. In our next issue, J. E. Allegretti and D. J. Shombert of Merck Sharp & Dohme Research Laboratories in Rahway, N. J., describe how silicon semiconductor devices can be formed by vapor deposition of single-crystal silicon layers on a single-crystal silicon substrate. Their informative article shows how the technique can be applied to the formation of complete circuits.
A Pair of Smoothies For Series Regulator Service

The Raytheon CK6336A and CK6528 are mechanically rugged, long-life twin power triodes. They are designed to handle large currents over a wide voltage range and at high temperatures in regulated power supplies. Zirconium coated graphite anodes, ceramic insulators, gold plated molybdenum grid wires, and hard glass envelopes are some of the advanced design features of both types.

Stringent power supply regulation requirements are no problem for these "smoothies." Get full technical data on the CK6336A and CK6528 as well as Raytheon's expanding line of high voltage rectifiers, pulse modulators, and transmitting types. Please write to: Raytheon, Industrial Components Division, 55 Chapel St., Newton 58, Mass.

For Small Order or Prototype Requirements See Your Local Franchised Raytheon Distributor.

<table>
<thead>
<tr>
<th></th>
<th>Max. Plate Voltage</th>
<th>Max. Plate Dissipation Watts</th>
<th>Max. Plate Current (per plate)</th>
<th>Amplification Factor</th>
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<td>CK6336A</td>
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<td>2 x 30</td>
<td>400 mAdc</td>
<td>2.7</td>
</tr>
<tr>
<td>CK6528</td>
<td>400</td>
<td>2 x 30</td>
<td>300 mAdc</td>
<td>9</td>
</tr>
</tbody>
</table>
**COMMENT**

Upgrading the Consumer

Regarding your comments on upgrading the consumer in Crosstalk in the Oct. 21 issue (p 4):

You neglected the improvement that could be made in tv receivers by adding components to minimize or eliminate television interference. Especially plagued by the omission of such components are the many conscientious radio amateurs who operate well designed, completely shielded, properly adjusted, adequately filtered transmitters that emit clean signals. These operators are constantly harrassed by protests of tvi from set owners who possess poorly designed built-to-a-price receivers that are notorious for poor shielding, wide-open tuners that lack sharp cutoff below channel 2, improper i-f frequencies, and other faults.

No problem faced by radio amateurs has the enormity of this problem. Despite the increase of U.S. radio amateurs to well over 200,000, tens of thousands of them are radio amateurs in name only due to the curtailment of their activity since World War II resulting from tvi. For only since World War II have millions of cheap high-frequency broadband receivers been in the hands of the public—all for tv reception.

J. S. Lee

**WESTERN ELECTRIC**

**CHICAGO**

... Among your comments regarding upgrading the consumer, you mentioned several possible improvements in circuit design but fail to mention shielding or wave-trapping to kill spurious emission from superheterodyne receivers. Granted that most consumers don't realize their sets put out a signal (except when tuning whistlers cross over their radio settings and hash up the audio), still these spurious emissions are serious. They may be fouling up our missile guidance, and they are sufficiently confusing to air-navigation devices that all airlines have banned use of portable radios, tv sets and tape recorders while aircraft are aloft.

J. A. BIBB

Hialeah, Fla.

Hams and airline spokesmen alike attest the validity of these statements. While not properly falling under the heading of Upgrading the Consumer, the shielding of spurious emissions should become a part of a general campaign for upgrading the consumer set.

**USSR in Space**

Everybody was saying that the USSR would launch a man in space while Khrushchev was at the UN. He's come and gone—so?

GENE G. MACAULAY

PHILADELPHIA

So two things. Firstly, there's a sizable body of evidence that some large space attempt was made by USSR scientists around the time Mr. Khrushchev came to the U.S. It could have been a man-into-space shot: more probably it was a Mars probe, since conditions then were optimum for such a shot. In any event, the attempt—if made—was either abortive or so successful that it's been kept under wraps.

Secondly—and possibly providing an illumination on previous Soviet experiments—Russian rocketeer F. Sergeyev remarked recently in Moscow that the USSR has the "means and conditions" for sending a man into space, but needs "practical experience ... in launching satellite space ships and effecting their safe and reliable return to earth." He added that last spring's orbiting doghouse "is in excellent state and can be used for more flights."

**Electronics Abroad**

I am writing to tell you how interesting I find your new feature Electronics Abroad. Almost daily we in the industry are made to realize how much activity is going on beyond our borders of the U.S. Your interest in this area helps readers to learn and share in this expanding field. Keep up the good work.

C. REUBER

CHICAGO
this is the actual size of the NEW, COMPACT, PROGRAMMABLE, HALF-RACK, ® REGATRAN POWER SUPPLIES...

with continuously variable current limiter...

These new Regatrans are sparing only of space . . . delivering super-regulated, virtually ripple-free d-c power with the instant start-up and very high reliability of solid-state circuitry . . . and offering a group of features hitherto unprecedented in d-c power supplies of this size.

<table>
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<tr>
<th>MODEL NUMBER</th>
<th>DC OUTPUT</th>
<th>MAX. RMS RIPPLE</th>
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<tbody>
<tr>
<td>TR212A</td>
<td>0-100</td>
<td>0-100 MA</td>
</tr>
<tr>
<td>TR018-1</td>
<td>0-18</td>
<td>0-1 AMP</td>
</tr>
<tr>
<td>TR036-0.2</td>
<td>0-36</td>
<td>0-200 MA</td>
</tr>
</tbody>
</table>

For a closer look, ask your local Electronic Measurements representative for a copy of Specification Sheet 5000 . . . or write direct.
Every breakthrough in military electronic equipment design creates new, complex and urgent problems in installation, modification, testing, maintenance and personnel training. Hallicrafters radical new "Blue Streak" project—utilizing quick-reaction techniques—offers experienced Hallicrafters support teams to assist key military personnel . . . pinpoints problems in advance . . . solves them on the spot with new levels of speed and economy.

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TEAMWORK IN MAINTENANCE: Hallicrafters mobile test vans and in-house repair of black boxes sets new standards in speed and reliability.

...a hard-hitting
TEAMS provide electronic industry technology in support of military programming groups for SAC aircraft at OCAMA and other materiel commands.

Modernization of RF transmission systems completed in 30% less time through "BLUE STREAK" team assistance to base maintenance groups.

Advanced ECM equipments are installed by "BLUE STREAK"-SAC teams with a minimum of down time. Maintenance and operational training is speeded up, too.

For further information on Hallicrafters facilities and experience in military electronics research, development and production, please write to: THE HALLICRAFTERS CO., MILITARY ELECTRONICS DIVISION, CHICAGO 24, ILLINOIS.
now! plug in the solution to your amplification problem!

Special Plug-In Units Make KIN TEL's Wideband DC Amplifier the Basic Component in a Variety of Data Acquisition Systems. Why Not in Yours?

With a 112A-A Plug-in, the amplifier provides accurate drift-free signals at any of ten fixed gains from -20 to -1000 with a stability of ±0.1% and an accuracy within ±0.5%. A Micro-Gain control sets individual fixed gains within ±0.01%, and a 2:1 vernier control adjusts gains between fixed steps. Outputs are available up to ±45 volts or ±40 ma at an impedance less than 1 ohm, linear within 0.01% at DC and within 0.1% to 2 kc. Drift is less than 2 µv for 400 hours, and noise is less than 5 µv from DC to 750 cps, less than 15 µv to 50 kc. Bandwidth is within ±0.5% to 2 kc, ±3% to 10 kc, ±3 db to beyond 40 kc.

With a 112A-B Plug-in, the amplifier gain is fixed at +1 with an accuracy, stability, and linearity within ±0.001% at DC, ±0.1% to 2 kc. Input impedance is 10,000 megohms +100µf at DC, 1,000 megohms +100 µf at 2 kc. Bandwidth extends to 100 kc. Output capabilities are the same as with the 112A-A plug-in.

With a 112A-O Plug-in, the user may install resistances for any fixed gain or for +1 operation as described above. Resistive and reactive components may be installed for use as a summing amplifier, an integrator, or for other specialized operational applications.

With a 112A-AO Plug-in, ten fixed gains are available with all the features described for the 112A-A unit, and in addition, an operational position is provided on the panel control for use with an external feedback network in specialized summer, integrator, or computer functions.

With any plug-in, the 112A may be used in a single-amplifier cabinet or in either a one- or six-amplifier module to fit a standard 19-inch rack. Write today for detailed technical literature or demonstration. Representatives in all major cities.

PRICES:

<table>
<thead>
<tr>
<th>112A amplifier alone</th>
<th>$530.00</th>
</tr>
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<tbody>
<tr>
<td>112A-A Ten-gain Plug-in</td>
<td>95.00</td>
</tr>
<tr>
<td>112A-B Plus-one Plug-in</td>
<td>85.00</td>
</tr>
<tr>
<td>112A-O Empty Plug-in</td>
<td>45.00</td>
</tr>
<tr>
<td>112A-AO Ten-gain/Operational</td>
<td>105.00</td>
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<tr>
<td>195 single-amplifier cabinet</td>
<td>125.00</td>
</tr>
<tr>
<td>191A Single-amplifier rack module</td>
<td>150.00</td>
</tr>
<tr>
<td>190 Six-amplifier rack module</td>
<td>295.00</td>
</tr>
</tbody>
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5725 Kearny Villa Road
San Diego 11, California
Phone: BRowning 7-6700
Tunneling Observed In Supercooled Thinfilms

ELECTRON TUNNELING, previously observed in various semiconductor devices, has now been demonstrated in supercooled thin film sandwiches. Researchers at General Electric have disclosed that if a sandwich formed of dissimilar metals separated by an insulating barrier about 10" in. thick, carriers in other than forbidden energy states can tunnel through the barrier. Experiments used lead and aluminum, with an aluminum-oxide layer about 10 molecular-diameters thick.

With only the lead superconductive (between 1.2 K and 7.2 K), the voltage-current curve resembles a triode characteristic. When both metals are superconductive (below 1.2 K), there is a pronounced negative-resistance "knee." Use of magnetic fields—which cancel superconductivity in metals—permits changing the negative-resistance region. At 0.2 mv applied voltage, GE reports, "we have found . . . the current through a lead-aluminum-oxide-aluminum sandwich at 1 K changes by a factor of 100,000" when the lead is switched from superconductive to normal.

Negative-resistance characteristic is independent of the current direction, unlike the same characteristic in the tunnel diode. GE figures the new device could be made to function as a switch, diode, negative-resistance diode, triode, resistor or capacitor—depending on the application of voltage and magnetic fields.

Unit has a lifetime in excess of 10,000 charge-discharge cycles, can produce peak currents of 10 kilamps per sq ft for a tenth of a millisecond. Cells are impervious to short-circuit damage. Prototype shown to ELECTRONICS is about the size of a one-pound coffee can; Hoffman says secondary power source models can be made as small as an aspirin tablet. Shelf life claimed is virtually infinite.

Company has also been pushing work on gallium-arsenide semiconductor devices for high-speed applications.

Piezoelectric Device Sparks Sparkplugs

"SPARK PUMP" and timer are used in a novel ignition system developed by Cleveland graphite bronze division of Clevite Corp. The spark pump is made of a piezoelectric ceramic capable of operating reliably up to 250 F and developing voltages up to 30 Kv. Operated at from 16 to 21 Kv, the life of the ceramic is about a hundred million cycles, or 500 hours of life at 3,600 rpm.

Ceramic and its housing are encapsulated in a 31-cu.-in. volume weighing 8 oz. Spark is squeezed out by application of pressure; 80 psi produces 16 Kv without need for an autotransformer. Mechanical timer triggers the application of mechanical pressure. Rise time is of the order of 10 nanoseconds.

Soviet "Discover" Ionospheric Scatter

SOVIET NEWS AGENCY Tass reports that Nikolai Kabanov has been awarded a diploma for his 14-year study of a phenomenon, to be known as Kabanov's Effect, by which radio energy when reflected by the ionosphere is partially scattered, a certain portion back-scattering to the radiation source.

Kabanov postulates that the backscatter from the earth's surface can be used to get radar coverage of areas thousands of miles away, admits that any returned energy would also include a picture of intermediate hop-points.

Tass adds that the main significance of the discovery is expected to lie in helping select favorable frequencies for long-distance communications, and in observing and exploring the ionosphere. "It also should enhance the reliability of radio communications, making it possible to transmit from low-power stations with simpler antennas and less interference."

Long-Life Fuel Cell Uses Sodium, Bromine

FUEL CELL designed to provide electrical power in an unmanned space vehicle has been developed by Hoffman Electronics. The cell uses sodium and bromine as mutually reactive fuel elements, mercury as a carrier for the sodium. Oxidation of the sodium by the bromine produces a power output of 2.8 v per cell; input from solar cells electrolyzes the sodium bromide into its constituents for recycling.

Australia to Receive Mills Cross Radiotelescope

GIANT RADIOTELESCOPE of the Mills cross design will be erected in the homeland of B. Y. Mills, of Sydney, Australia, after whom the design is named.

The telescope will be built on an as-yet unselected site in New South Wales, will be 20 times as powerful as the Jodrell Bank paraboloid in England. Estimated cost is $750,000. University of Sydney's Radioastronomy Center is sponsoring the project, hopes to have one section operating by year-end 1962. Australia will also help the Organization for European Economic Cooperation build the cruciform instrument now being considered for the Benelux high country near Luxembourg (ELECTRONICS Newsletter, p 11, Sept. 16).

The New South Wales design will include two arms forming a cross oriented east-west and north-south. Each arm will be a mile long and forty feet wide, consisting of a mesh of reflectors focused on an antenna running down the center of the arm.

Mills cross systems are not steerable, but can be tilted. Tilting of one arm and electronic phasing of the other will permit viewing all the southern sky. The Benelux unit will provide complementary data on the northern heavens.

Minneapolis Sales To Top $600 Million

NORTHEASTERN NATIONAL Bank of Minneapolis, which has helped foster the rapid growth of electronics in the Land O' Lakes, reports that the industry in Minnesota will rack up more than $600 million in sales for 1960. Estimate was included in
a plant location study.

The report points out that there are 117 electronics and related-sci-
ence companies operating in Minne-
sota. Of the total, 105 are in the Twin Cities area. Sixty are classed
as manufacturers of electronic
equipment and devices, 32 as ele-
tronic component manufacturers,
nine as engineering and research
service companies. Sixteen com-
panies are specialty and custom
manufacturers for electronics and
related sciences. The companies em-
ploy 40,000 people, with an annual
payroll running about $200 million.

Japanese Designers
On Miniaturization Binge

INDUSTRIAL DESIGNERS in Japan are
trying their traditional skills at
handling small objects, tying into
the postwar progress in optics and
electronics which has sparked
Japan's business boom.

At last week's new products
show in Tokyo, sponsored by Min-
istry of International Trade & In-
dustry, tiny versions of earlier
designs took the limelight. Several
companies showed miniature tape
recorders; one, built by Eiwa, fits
into the palm of your hand. Others
showed even smaller transistor
radios, including one by Sony with
a watch movement that turns it
into an alarm-clock radio. Mini-
ture "fish-finder" sonar, less than
$8 x 6 x 3 inches and weighing less
than six pounds, was on display; it
operates on a dry battery, can run
continuously for 13 hrs.

Navy Needs Practical,
Reliable Gear: Bennett

PRACTICAL CONSIDERATIONS of elec-
tronic equipment design were
stressed last week by Rear Ad-
miral Rawson Bennett, Chief of
Naval Research. Speaking to en-
gineers at the New England Re-
sarch & Engineering Meeting in
Boston, Bennett warned that the
day is fast passing when the cost
of military equipment is not a
factor.

"In our pride of technical ac-
complishment, we are in danger of
developing things that are too
small to be economically practi-
cal," the admiral said. "We do
need equipment to win wars, but
all the services are going to be
forced to determine what is good
enough. Our opposition is doing
so. Our overseas rivals are pretty
good at making things just good
enough to do the job."

In reliability, Adm. Bennett
said, we take two steps backward
for every step forward. Compo-
ment reliability has improved sig-
nificantly, but we are building
complexity into systems at a faster
rate than our improvement in re-
liability.

Ultrasonics Sorts Beef
For International Exposition

ULTRASONIC DEVICE will judge prize
steers during a ten-day interna-
tional exposition opening this
week in the Chicago stockyards
amphitheatre.

A search unit operating at 20
Kc will be passed along the ani-
mal's back to determine the depth
of backfat covering the loins and
ribs, and to measure the size of
the loin-eye, lean-meat source of
filets. The measuring unit was de-
volved by J. R. Stouffer, animal
husbandry expert from Cornell
University.

Emerging signals are recorded
on 60-second film, will help judges
evaluate proportion, size and
quantity of lean-meat-to-fat dis-
tribution throughout entire ani-
mal. Later comparison with
dressed carcasses will give officials
opportunity to check accuracy of
soundings.

New era of cattle judging is ex-
pected to result from this ultra-
sonic circuit and others under de-
velopment at Michigan State and
Beltsville, Md., and in Europe.
Measurement technique could also
become very important to stock
raisers in selecting breeding stock
to produce more high-quality lean
meat with less fat.

"Voice" Awards Contract
For Greenville, N. C., Site

U. S. INFORMATION AGENCY has
awarded the contract for the big
transmitter Voice of America is
building near Greenville, N. C.
Low-bidding team — Alpha of
Texas and Continental Electronics,
both Texas-based companies—will
put up the facility for $12.2 mil-
ion, a little less than half the
total cost of the installation.

Project is expected to be in op-
eration by the end of 1962, will com-
prise six 500-Kw, six 250-Kw and
dix 50-Kw transmitters.

Soviets Display
Two New Missiles

TWO MISSILES not previously ob-
served in the USSR's armaments
were displayed in the rocket-
 rattling show of strength that
formed the climax of the Soviet
Union's annual Nov. 7 celebration.

The parade commemorating the
43rd anniversary of the Bolshevik
revolution showed off massed bat-
talions of motorized infantry, para-
troopers, artillery and mis-
siles. Among the latter was a
surface-to-air missile resembling
the Nike-Ajax which appeared to be
a heatseeker and may be an
improved version of a rocket
weapon long in use in Soviet
forces. The missile is probably
one that downed the U-2.

A surface-to-surface missile
bigger and longer than anything
previously observed in the Soviet
arsenal also showed up in the
parade. It had a larger exhaust
opening indicating longer range,
probably in the ICBM class.

Air Agency to Try Tropo
For Transatlantic Commo

RESEARCH & DEVELOPMENT Bureau
of the Federal Aviation Agency
has ordered a special antenna sys-
tem and high-power amplifier gear
to test forward-scatter vhf trans-
mision for possible use on the
long transatlantic reaches. Pan
American Airlines has been oper-
ating a vhf link with a 400-mi
range out of Shannon Airport.
FAA is hoping to build on Pan
Am's experience to replace present
h-f communications—highly sus-
ceptible to atmospheric distur-
bances and fading—with a vhf
system.

FAA will build two transmitters
on the North American end of the
transatlantic airway, then build
others in Europe if the tropo-
scatter system works out.
QUADRUPLED POWER IN THE SAME CUBE
THE CAPITRON RADAR PULSE MODULATOR

To see through peapod fog or moonless night, the Navy F8U2N Jet interceptor required a quadruple-power radar modulator that would fit in the same volume as the original power units.

The problem was a natural for AMP’s Capitron personnel and facilities. New transformer design standards were developed, new high temperature insulations tested, new components created. The unit was packaged and tested in record time. Capitron is now in volume production of this unit . . . the AMP #855053.

Specifications: delivers 600 KW of pulse power to transmitter . . . 22,000 volts . . . requires only three inputs—DC voltage, system triggers, and AC for filaments . . . internal temperature range from −70°C to +150°C . . . conforms to mil specs.

Complete specifications available. Send for them today.

CAPITRON DIVISION
AMP INCORPORATED
Elizabethtown, Pennsylvania

Capitron products and engineering assistance are available in Canada through Aircraft-Marine Products of Canada, Ltd., Toronto, Canada

November 25, 1960
WASHINGTON OUTLOOK

SHAKEUP in the organization of the nation's space operations seems to be definitely among the plans of the new administration. The separation of the program into military and civilian space applications is considered impractical and unwieldy by many influential advisors to the President-designate.

These observers think the split has delayed important policy decisions, fostered duplication of effort and wasteful rivalries, and stymied effective formulation of long-range plans. Lyndon Johnson, who headed the Senate's space committee in the late 86th Congress, is known to have a special interest in reorganizing the space program.

National Aeronautics & Space Administration and the Pentagon are both, for instance, competing for funds to develop active communications satellites and super-power rocket boosters. Advanced Research Projects Agency has turned over the responsibility for communications satellites to the Army Signal Corps, but NASA still retains an interest. Contractors gripe because they don't know where to submit project proposals. And Congressional leaders are peeved because the space programs lack central direction.

It's still too early to see exactly how drastically the space operations will be overhauled. But it is clear that any reshuffling of bureaus and responsibilities will aim at meshing the military and civilian sides of the program under more centralized administration.

NASA AND THE DEFENSE DEPARTMENT are studying a joint proposal from Aerojet-General and Todd Shipbuilding for construction of rocket-launching complexes at sea. The two companies seek funds to support detailed engineering studies of the project and to compare costs of ocean-launch systems with conventional land installations.

The companies say that ocean-launch facilities are "feasible and inevitable." They claim that ocean-launching sites would minimize critical problems of design, water supply and safety in super-power chemical rockets of the million-pound-thrust class, and nuclear-powered rockets now under development.

They propose several ocean-launch concepts: coastal cliff sites, offshore pier sites, missile drydocks and modified Texas towers. The most ambitious plan in the Aerojet-Todd package would build a "planetary rocket ocean platform" (PROP), envisaged as a huge buoyant seabase for use in fabricating, assembling, static-testing and launching large missiles and space vehicles.

IN THE WAKE of the Presidential election, you can expect a renewed drive to cut defense procurement costs. Funds for individual projects will be hiked (the talk here is of a $2 billion or more rise in overall defense spending next year), but there will be more emphasis on holding down costs so that the increase in money will buy even more defense.

Kennedy believes, for example, that a billion dollars or so can eventually be saved through "efficiency improvements." Much of this would be based on Pentagon reorganization.

Some defense experts argue that additional money can be saved if contracting practices are overhauled. This philosophy will be demonstrated by a Congressional push to consolidate procurement as much as possible, to get rid of incentive-type contracts, to stress advertised bidding, and to increase competition for negotiated contracts.

AIR FORCE SECRETARY Dudley C. Sharp has ordered a series of plant inspections to "survey management practices" of major Air Force contractors. Martin's Titan ICBM project will be the first program scrutinized. The surveys are the latest step in the Air Force's efforts to screw down the lid on costs and to prod contractors into buying more efficiently and exercising tighter control over production.
Now offers you high quality, moderately priced precision Frequency Meters covering eight important microwave bands.

Frequency is read directly in KMC on the large, precisely calibrated spiral scale. No charts or interpolation are required. Accuracy is high—up to 0.06% including 0 to 100% relative humidity change, 20° C temperature variation and dial accuracy (See Specifications).

Model 532 Frequency Meters comprise a special waveguide section mounting a high Q resonant cavity tuned by a choke plunger. A 1 db or greater dip in output indicates resonance. There are no spurious modes or resonances. Tuning is by a precision lead screw, spring loaded to eliminate backlash. Minimum calibration spacing is 1/32" to provide good resolution.

### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Overall Accuracy (%)</th>
<th>Frequency Range KMC</th>
<th>Dial Calib Accuracy (%)</th>
<th>Calibration Increment (MC)</th>
<th>Max. Temp. Coefficient % per °C</th>
<th>Price</th>
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<tbody>
<tr>
<td>GS32A</td>
<td>0.065</td>
<td>3.95 - 5.85</td>
<td>0.033</td>
<td>1</td>
<td>0.0012</td>
<td>525.00</td>
</tr>
<tr>
<td>J532A</td>
<td>0.065</td>
<td>5.30 - 8.20*</td>
<td>0.033</td>
<td>2</td>
<td>0.0012</td>
<td>300.00</td>
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<tr>
<td>HS32A</td>
<td>0.075</td>
<td>7.00 - 10.0</td>
<td>0.040</td>
<td>2</td>
<td>0.0015</td>
<td>195.00</td>
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<tr>
<td>X532B</td>
<td>0.080</td>
<td>8.20 - 12.4</td>
<td>0.050</td>
<td>5</td>
<td>0.0010</td>
<td>150.00</td>
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<tr>
<td>MS32A</td>
<td>0.085</td>
<td>10.0 - 15.0</td>
<td>0.053</td>
<td>5</td>
<td>0.0012</td>
<td>275.00</td>
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<td>PS32A</td>
<td>0.100</td>
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<td>0.068</td>
<td>5</td>
<td>0.0012</td>
<td>210.00</td>
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<tr>
<td>KS32A</td>
<td>0.110</td>
<td>18.0 - 26.5</td>
<td>0.077</td>
<td>10</td>
<td>0.0033</td>
<td>230.00</td>
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<tr>
<td>RS32A</td>
<td>0.120</td>
<td>26.5 - 40.0</td>
<td>0.083</td>
<td>10</td>
<td>0.0017</td>
<td>250.00</td>
</tr>
</tbody>
</table>

K and R band models available with circular flange adapters; specify K532AC and R532AC respectively.

*When used between 5.3 to 7.5 KMC, or 5.7 to 8.2 KMC, single mode resonance is achieved.

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

For complete details, call your HP representative or write direct

HEWLETT-PACKARD COMPANY
1052A Page Mill Road
Palo Alto, California, U.S.A.
Davenport 6-7000
Sales representatives in all principal areas

HEWLETT-PACKARD S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland
Cable "HEWPACK-SA"
Tel. No. (022) 26. 43. 36

circle 15 on reader service card 15
"Essentially, this corporation will be people—people of the highest quality. The United States Air Force recognizes that men of great scientific and technical competence can perform at their best only when they can exercise their initiative to the full under leadership which creates the climate for creativity. We expect Aerospace Corporation to provide that kind of environment."

SECRETARY OF THE AIR FORCE

Among those providing their leadership to this new non-profit public service corporation are: Dr. Ivan A. Getting, president; Allen F. Donovan, senior vice president, technical; Jack H. Irving, vice president and general manager, systems research and planning; Edward J. Barlow, vice president and general manager, engineering division; and Dr. Chalmers W. Sherwin, vice president and general manager, laboratories division.

These scientist/administrators are now selecting the scientists and engineers who will achieve the mission of Aerospace Corporation: concentrating the full resources of modern science and technology on rapidly achieving those advances in missile/space systems indispensable to the national security.

The functions of Aerospace Corporation include responsibility for: advanced systems analysis; research and experimentation; initial systems engineering; and general technical supervision of new systems through their critical phases, on behalf of the United States Air Force.

Aerospace Corporation is already engaged in a wide variety of specific systems projects and research programs—offering scientists and engineers the opportunity to exercise their full capabilities, on assignments of unusual scope, within a stimulating environment.

Immediate opportunities exist for:

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- **Space Vehicle Specialists:** Senior Power Systems Engineer Sr. Flight Performance Analyst Re-entry Aerodynamicist

Those capable of contributing in these and other areas are invited to direct their resumes to:

Mr. James M. Benning, Room 110 P.O. Box 95081, Los Angeles 45, Calif.
ELECTRON TUBE NEWS
...from SYLVANIA

specifically for "on-off" and control applications...

SYLVANIA
GOLD BRAND TUBES feature...

- REMARKABLE RELIABILITY
- EXCEPTIONAL STABILITY
- LONG LIFE EXPECTANCY
- HIGH UNIFORMITY

More than a decade ago, Sylvania developed the first vacuum tube specifically for computer-type applications... the reliable 7AK7. Today, there is a large family of field-proven Sylvania types specifically designed for "on-off" control applications, including eleven premium-quality Gold Brand Tube types.

Sylvania Gold Brand Tubes for computer applications exhibit highly stable electrical characteristics even under long periods of operation at cutoff conditions — offer high uniformity of characteristics from tube to tube — feature long life and reliability. This is the direct result of stringent material and process controls to assure minimal cathode interface formation, low cathode sublimation, improved plate dissipation capabilities and low interelement leakage.
NEW! SYLVANIA-7738, -7803

...feature high electrical stability, high reliability in short continuous service under difficult environmental conditions.

Originally designed for service in expendable sonobuoy equipment dropped by aircraft, these two types are typical of Sylvania capabilities in the design, development and manufacture of tubes for specialized industrial-military applications. If your design requirements demand specialized industrial-military type tubes, draw on the creative engineering and production capabilities of Sylvania. Your Sylvania Sales Engineer is ready to work with you.

SYLVANIA-7738 ...a miniature high-mu triode, 7738 utilizes silver-plated pins and high grid-wire T.P.I. for excellent VHF performance. Lead inductance is optimized by the use of shielding. It is capable of withstanding 450g shock.

SYLVANIA-7803 ...a miniature double-triode, it offers high g_m of 12,500 μmhos per unit and low capacitance. 7803 uses the Sylvania-developed, rugged strip frame grid—enabling use of fine grid wire, high T.P.I.

For further information, contact the Sylvania Field Office nearest you. Or for data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. K., 1100 Main Street, Buffalo 9, N. Y.
These Litton TWT twins are PPM focussed X-band traveling wave tubes. They are not prototypes. They are metal and ceramic tubes in field application now.

Designed to cover X-band with minimum saturated CW power of 20 milliwatts (L-3266) and 2 watts (L-3236), they may be operated in cascade to amplify signals as small as —50 dbm to the 2 watt level. Their performance, far exceeding the conservative specifications, is evident in the accompanying graphs.

Small size (less than 12" in length), light weight (under 4 pounds each), and extreme environmental capability (temperature compensated —54°C to 86°C) make these tubes the ideal choice for military applications. A typical airborne equipment, designed and manufactured by Granger Associates of Palo Alto, California, incorporates the L-3266 and L-3236 and occupies only 0.75 cubic feet, including all necessary power supplies, modulating circuitry, cooling, etc. This equipment is now in field operation.

If your work involves ECM repeaters, radar target enhancement, frequency diversity radar or any application requiring broadband microwave amplifiers, appraise these new tubes. In production quantities their price is the lowest in the field. Ask for catalog sheets on the L-3266 and L-3236.

Address: Litton Industries Electron Tube Division, 960 Industrial Road, San Carlos, California.
Some small talk...

From my past comments in this column, some may suspect that I disapprove of small, local shops. The truth is—we both need them. They serve United by keeping our plant free from the clutter of non-profitable, low volume orders. Also, they force us to keep our toes in the water when competing for jobs we both can handle profitably.

These same shops provide you with single graphite parts, customized for you, at a reasonable price. Delivery and service are good.

How we both serve you—each in our own way—is illustrated best by newspapers. In Bay City we like our local daily—The Bay City Times. But, with its plant and editorial staff, we know it couldn’t handle the job of putting out the New York Times.

And, if the New York Times plant and staff had to be supported by Bay City, papers would cost a dollar or more apiece.

That’s why it is wise for management in considering sources for vital graphite parts to review their own market potential.

United has the experience, staff, plant and financial strength to help you achieve a profitable volume. That’s our objective.

FINANCIAL ROUNDUP

Reports Cite Earnings Dips

Electronics companies with strong lines of consumer products though often accustomed to steady or rising gains, are beginning to show some fluctuations according to reports coming in this quarter. Here are some examples:

Hallicrafters, Chicago, manufacturer of ham radio gear, electronic organs, shortwave radios and military electronics equipment, reports a gain of 15½ percent in net sales and a 30-percent rise in earnings after taxes for the year ended Aug. 31. Net sales figures, up this year, were $29,374,490 as compared with 1959’s $25,417,364. Earnings after taxes this year were $907,777 as against $689,037 last year. Sales backlog in commercial products at the end of this year was $10 million as compared with last year’s $5 million.

Motorola reports third quarter sales this year were up by a slight margin over previous third quarter records, although profits compared to the similar period last year were lower by about 9 percent. Net sales for the quarter were $77,201,664 as against $77,145,487 last year. Profits were $3,276,633 as against $3,598,653. R. W. Galvin, company president, commenting on the dip, said volume was held down by reduced demand for tv receivers and certain other consumer products, as well as reduced volumes in the company’s military division. Also mentioned as factors were increased general costs, temporary startup costs on new transistors and the company’s decision to expand new-product investigation and engineering.

Magnavox Co., Ft. Wayne, Ind., announces company earnings show a continuation of the trend to higher earnings levels established last year with a 50-percent increase in profits. Net profits for the nine months ending Sept. 30 were $5,534,000, compared with $2,384,000 last year, equal this year to $1.50 a share compared with $1.01 for 1959. Company president Frank Freimann says the “disproportionate increase in earnings is the result of a greater profit margin on the government and industrial operations of the company, and a more favorable mix in consumer products, as well as an improvement in operating efficiency.” September quarter sales for the firm, however, were off by 10 percent in television and stereo hi-fi products, due in part, according to company officials, to delayed shipments and industry-wide sales declines during the period. Sales in October are reportedly up and the fourth quarter, said to be historically the most profitable, looks favorable.

Admiral Corp.’s president Ross Siragusa says his company’s sales and profits on tv and radio receivers were higher during the first three quarters of this year, but adds that appliance sales slipped sharply during the period. “The severe industry-wide slump in appliances and the subsequent operation of our Galesburg, Ill., appliance manufacturing facility at below capacity were responsible entirely for the lower profits this year,” he said. Consolidated sales for this year’s first nine months were $144,976,-988, compared with $145,849,148 in 1959. Profits were $1,207,764, compared with $4,906,253 last year, before taxes.

After-tax figures were $497,072 or 21 cents a share this year as against $2,371,376 or 99 cents a share last year.

Zenith Radio reports a drop in consolidated net earnings which slid from $9,319,021 for the first nine months of 1959 to $8,577,752 for the same period this year, a drop of $742,169. A company statement says although consolidated sales for the nine month period were up 4½ percent over last year, to a figure of $183,952,012, profits in the period were affected by “a continuation of unrealistic pricing
and liquidations on the part of several principle competitors which placed continued pressure on the company's profits."

Consolidated sales for this year's third quarter were reported at $65,688,191, as compared with $69,127,297 last year.

Borg Warner, which manufactures a variety of electronic items through its B-W Controls division, Pesco Products division and its recently established Olivertronics division in Philadelphia says, "The current down-drift in economic conditions" adversely affected sales and earnings during the third quarter of this year. Roy C. Ingersoll, company chairman, says that despite increased selling costs, selling prices of appliances and air conditioning equipment are below those of a year ago. B-W sales during the first nine months of this year were $451,458,928, compared with $484,194,024 for 1959, a decrease of six percent.

Earnings after taxes for this period were $17,839,366 or $1.96 a share as against $25,566,788 or $2.83 a share in 1959, a decline of 30.2 percent.

25 MOST ACTIVE STOCKS
WEEK ENDING NOVEMBER 11, 1960
SHARES
IN 100'S | HIGH | LOW | CLOSE
--- | --- | --- | ---
Lockheed Aircraft | 1,317 | 29½ | 25½ | 27
Gen Tel & Elec | 1,330 | 26½ | 25½ | 27½
Avco Corp | 842 | 14½ | 13½ | 14½
Gen Electric | 816 | 80½ | 75½ | 78½
RCA | 747 | 54½ | 51½ | 54½
Westinghouse | 621 | 50½ | 47½ | 49½
Sperry Rand | 511 | 19½ | 18½ | 19½
Int'l Tel & Tel | 545 | 40½ | 38½ | 40½
Litton Ind | 512 | 81½ | 74½ | 80½
Gen Inst | 509 | 39½ | 37½ | 38
Texas Inst | 498 | 188½ | 169½ | 185
Gen Dynamics | 438 | 40½ | 37½ | 39½
Martin Co | 429 | 55½ | 52½ | 54½
Philo | 406 | 20½ | 18½ | 19½
Varian | 364 | 46½ | 41½ | 45½
Univ Controls | 363 | 13½ | 14½ | 15½
Fairchild Cam & Inst | 340 | 162 | 145 | 158½
Raytheon | 288 | 35½ | 32 | 35½
Elec & Mus Ind | 284 | 6½ | 6 | 6
Polarad | 283 | 20½ | 17½ | 20½
Zenith | 274 | 102½ | 96½ | 101½
Standard Kollsman | 271 | 20½ | 18½ | 20½
Leer Inc | 269 | 18 | 15½ | 17½
Cubic Corp | 264 | 51½ | 42½ | 49
Calliope Radio | 262 | 48 | 42½ | 47½

The above figures represent sales of electronic stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for Electronics by Ira Hays & Co., investment bankers.

November 25, 1960

FREQUENCY RANGE
0.05 cps to 30 KC, down to 0.01 cps with corrections

VOLTAGE RANGE
0.02 to 200 volts Peak-to-Peak

ACCURACY
3% throughout all ranges and for any point on meter scale.

INPUT IMPEDANCE
10 megohms with average capacitance of 30 μuf.

RESPONSE
Peak-to-Peak.

FEATURES:
- Minimum pointer "Flutter" down to 0.05 cps.
- Reset switch for rapid measurements.
- Only one period of wave required for stable reading.
- Single logarithmic voltage scale and linear decibel scale.

Write for catalog for complete information

BALLANTINE LABORATORIES INC.
Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR LABORATORY AC VACUUM TUBE VOLTMETERS, REGARDLESS OF YOUR REQUIREMENTS FOR AMPLITUDE, FREQUENCY, OR WAVEFORM. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR, ALSO AC DC AND DC-DC INVERTERS, CALIBRATORS, CALIBRATED WIDE BAND RF AMPLIFIER, DIRECT-READING CAPACITANCE METER, OTHER ACCESSORIES.

CIRCLE 21 ON READER SERVICE CARD 21
The Important Difference In Digital Voltmeters...

Check the design and construction features pictured here. These are the subtle marks of quality that exemplify the engineering leadership of NLS... the important difference between NLS digital voltmeters and those of other manufacturers. These are the engineering innovations that assure accuracy and rugged reliability... that minimize maintenance and downtime... that add to the long-term efficiency and usefulness of NLS instruments. Yes, there's more to a digital voltmeter than meets the eye... so look behind the front panel and beyond the specification sheet before you buy! Call on your NLS representative to demonstrate the instrument of your choice... to show what engineering leadership means to you in digital voltmeter performance and usefulness. Write today for the NLS catalog that describes the world's most complete line of digital voltmeters... by purpose, by price!

Originator of the Digital Voltmeter

**non-linear systems, inc.**

DELMAR, CALIFORNIA

**1** PLUG-IN MODULAR CONSTRUCTION simplifies servicing, drastically reduces maintenance costs, keeps instruments on the job. More than 99% of the components of the NLS V44, Series 20 and Series 30 instruments are mounted on plug-in modules.

**2** SNAP-OUT READOUT, exclusive on all NLS digital instruments, permits 20-second bulb replacement through front panel without tools. Precisely engraved readout numerals can be read all day from close up or far away without eye fatigue.
COMPACT DESIGN — illustrated by the 5 1/4"-high NLS 484 DVM, complete with recording controls — is one of the more obvious clues to superior engineering. Even the lowest cost NLS instruments are more compact with fewer cables and connections. Result: greater reliability.

FULLY AUTOMATIC OPERATION, pioneered by NLS, includes automatic selection and indication of range and polarity. Human error is virtually eliminated.

"NO-NEEDLESS-NINES" LOGIC in Series 30 results from a new concept in transistor logic which eliminates unnecessary, time-consuming cycling of stepping switches through their 9's and 0's positions. This increases accuracy, speed, reliability and usefulness, particularly in systems applications.

PLUG-IN ACCESSORIES can be mated in minutes with an NLS digital voltmeter to form hundreds of combinations. These include AC/DC converters, preamplifiers, input scanners, and virtually every type of data recorder.

"NO POTS AT ALL" STABILITY of the NLS V44 DVM is checked by the "boil in oil" test at 158°F. This feature eliminates all trimming of decade and amplifier circuits.

PLUG-IN OIL-BATH STEPPING SWITCHES in Series 30 instruments outlast dry switches by a factor of five ... completely eliminate periodic disassembly for manual lubrication of switches.
MARKETING

Survey Probes Defense Spending

"THE FUTURE for defense spending after fiscal 1961 is beyond any reliable means of estimate," says the marketing services division of Smith, Winters, Mabuchi, Inc. in its report issued this week—An Examination of Various Aspects of the Defense Market.

Future defense spending levels are uncertain at this time because they depend too heavily on political and international factors, the firm's marketing division says.

In the broad sense, funds committed to defense have been at a stable level for several years. So has the apportioning of monies to the various services.

The New York agency that issued the report has been in the marketing analysis business for many years, started to make marketing studies because it felt marketing techniques such as selling, advertising, sales promotion and publicity, can be applied intelligently only after market analysis.

Although the overall budget has been fairly static for several years uses of funds for procurement of equipment and for research and development have shown changes such as:

- Aircraft—moving down
- Missiles—moving up
- Electronics and Communications—moving up
- Research and Development—moving up

Of interest in the aircraft expenditure trend are two points:

- New obligations are at a comparatively stable level
- Expenditures are falling

The missile trend shows:

- Obligations now at a peak (which may be a plateau from which they will rise to new highs)
- Continuing increase in expenditures

Aircraft expenditures dropped from a peak of $8.3 billion in fiscal 1954 to $6.2 billion in fiscal 1960. Missile expenditures have risen from $1.2 billion in fiscal 1956 to $3.9 billion in fiscal 1960.

However, electronics will take a larger and larger share of the dwindling aircraft total. In fiscal 1956 the electronics share of total aviation expenditures was estimated at 25 percent and may rise to 40 percent in the sixties.

Our industry's share of missile expenditures will rise to 60 percent or more of the total in the sixties. In 1956 electronics' share of missile spending was 50 percent, the report states.

The gross expenditure picture and that for electronics do not quite agree because the electronics percentage of total expenditures is rising.

Next year, on the whole, will be another record year of business activity, reports McGraw-Hill's Department of Economics. M-HI's economic opinion is backed up by a score of leading business economists who participated in the company's economic conference panel. The economists recently traveled through many of the nation's industrial and financial centers where they obtained up-to-the-minute information on the outlook for the major industries.

However, there is widespread agreement that there will be a decline in many activities in the early quarters of 1961.

Some reductions in industrial output in gross national product are expected before business begins to move ahead in 1961, says the McGraw-Hill economics group. Their opinion is that the decline in gross national product and in industrial production in early months will be only half as severe as 1958. This opinion contrasts with that recently reported by economists of the Chase National Bank who look for a decline about equal to that of 1958 (ELECTRONICS, p 24-25, Oct. 14).

During the early months of 1961, industrial output will decline about 7 percent, reports Douglas Greenwald, Manager of Economics for McGraw-Hill.

A higher operating rate for steel
is expected in the months ahead because inventories are low; but production record for 1961 is expected to fall a little short of the 1960 mark, about 5 percent.

Auto industry sales for 1961 are expected to be down about 10 percent from 1960's total of 6.6 million units, including imports. This industry's production decline will be aggravated by the trend to lower priced compacts which could mean a still larger drop in dollar sales. Here is a summary of outlook for other industries:

1. Machinery and electrical machinery—inventories are high, relative to sales volume. Inventory problems of electrical appliance makers won't be solved quickly.

2. Nondurable producers and retail outlets (soft goods) outlook is relatively bright.

3. Chemical industry — expected to hold sales gains made this year despite expected cuts in industrial production.

4. Paper makers and petroleum producers—expected to fare better than industry as a whole. Manufacturers will feel a sharp bite on profits. It has already become evident. From a $45.7-billion annual rate in the second quarter of 1960, profits before taxes are expected to slip to $41-billion rate in the third quarter. The slide is likely to continue into mid-1961 and profits should begin to improve as production rebounds.

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**FIGURES OF THE WEEK**

<table>
<thead>
<tr>
<th>Thousands of Units</th>
<th>Production Week of 11-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOURCE: FTA</td>
</tr>
</tbody>
</table>

**Radio Sets Total**

- 591

**TV Sets**

- 142

**Auto Sets**

- 111

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**TRYGON ELECTRONICS, INC.**

111 Pleasant Ave., Roosevelt, L.I., N.Y.

FREEPORT 8-2800
THE FIRST SILICON DIODE WITH COMPUTER-PREDICTED RELIABILITY

YOU CAN'T ARGUE WITH COMPUTER LOGIC...

Computer processes applied to product on and performance analysis by Princeton Electronics Corporation are establishing new standards of reliability in silicon diodes. PEC manufacturers of silicon diodes for computers and other demanding applications, have developed the use of computer logic as a guide to production control and product quality.

The life history of every diode is computer recorded and available for analysis and evaluation — a major step forward in the overall effort towards complete reliability in electronic systems.

Every design engineer understands the need for extreme reliability in electronic components, particularly for complex systems. No engineer could deny the advantages of this newest, most exacting method of manufacture, testing and evaluating potential performance.

Write today for complete information on the silicon diode with computer-predicted performance.

P.O. BOX 127, PRINCETON, NEW JERSEY
NEC microwave carrier terminal equipment with transistor reliability

This fully transistorized carrier telephone equipment for microwave links provides 120 toll quality telephone channels. Characteristics meet or surpass all CCITT requirements.

It offers these advantages over conventional tubed equipment:

- 90% reduction in power consumption
- Lower operating temperature
- Less floor space
- Increased reliability, resulting in lower maintenance costs.

Each 300–3,400 c/s telephone channel can accommodate 24 voice-frequency telegraph channels operated at a keying speed of 50 bauds.

NEC will also make available within this year 600-channel transistorized equipment.
Today's combat decisions depend on lightning-fast calculations. The answer is rugged, high-speed computers in the field. Autonetics fills this need with compact, solid-state designs that give mobility, flexibility, reliability under military conditions: VERDAN, for missile checkout, airborne and submarine weapon systems; FADAC, for artillery fire control and support computations. These systems help keep America's military computer capability foremost in the world.

Electromechanical systems by Autonetics Division of North American Aviation
All your needs for dependable High Frequency Power Supplies can be found at one source—American Electronics' Precision Power Division. Here engineering skills and manufacturing know-how have been pioneering new Rotary Power developments for over a decade.

FIRST to introduce a brushless, inductor type 400 cycle generator. Field windings are cast integrally with the rotor. Windings are practically indestructible.

FIRST to furnish 1200 cycle generators as the power source for industrial and medical X-Ray equipment—equipment used to check the NAUTILUS and other atomic submarines for perfection of hull weldments and seams.

FIRST to meet the demands of the aircraft industry for 1600 cycle power to check out airborne computer systems.

FIRST to provide the high cycle generator as the power source for high speed routers for metal working.

FIRST to furnish power source for ultra high frequency lighting systems for more efficient lighting at lower cost.

Write or call for our Rotary Power brochure, which gives the complete story on these and other power supply units.
Freezing temperatures hold no threat for this hardy battery! The performance of Mallory's new low-temperature, wound anode mercury cell far surpasses that of conventional pressed powder anode cells at temperatures around 32°F. This improved performance yields increased capacity per unit volume for all-weather uses, such as navigational buoys, emergency beacons, air-sea rescue transceivers, survival kits, marker lights, warning devices, and many other applications.

The ribbon wound zinc anode of this new mercury cell has a large surface area in contact with the electrolyte. The interleaved absorbent retains the electrolyte and facilitates ionic transfer over the entire anode surface area. This lowers the temperature sensitive anode impedance in the freezing temperature zones.

Wound anode construction also increases cell efficiency. At drains up to 100 ma, 90% of available room temperature capacity is attained. Cell units can be packaged to yield up to 45 watt hours per pound.

Write for complete engineering data, including sizes available, suggested applications, characteristics curves and tables. Detailed information on current military uses is available to authorized companies.

Mallory Battery Co., North Tarrytown, N.Y.

In Canada, Mallory Battery Company of Canada Ltd., Toronto 4, Ontario

November 25, 1960
Simpson's New VOM featuring...

1½% Accuracy
Excellent Repeatability
Predictable Accuracy
over wide temperature range

Do you need to check day-to-day variations in circuit operation? Or know what accuracy you're getting at different temperatures? If so, you especially will appreciate the capabilities of this new volt-ohm-milliammeter. For example, any particular voltage value will give identical readings today, next week, next month at an accuracy you can pinpoint from 67° to 87° F. The 270 is an engineer's VOM. Its base accuracy of 1½% DC (77°F, at full scale) covers a wide range of critical checks. It is portable, self-powered, built to have the rugged dependability typical of all Simpson VOMs. Accessories include carrying case and a variety of probes. Look it over at your Electronic Parts Distributor soon.

Model 270
AC-DC VOLT-OHM-MILLIAMMETER

- MIRROR SCALE
- ½% RESISTORS
- GOLD BONDED DIODES
- FAMOUS "STAY ACCURATE" MOVEMENT
- POLARITY SWITCH

DC Voltage (20,000 ohms-per-volt): 0-250 mv; 0-2.5 v; 0-10 v; 0-50 v; 0-250 v; 0-1000 v; 0-5000 v. [Accuracy, 1½%]

AC Voltage (5000 ohms-per-volt): 0-2.5 v; 0-10 v; 0-50 v; 0-250 v; 0-1000 v; 0-5000 v. [Accuracy, 2%]

AF Output Voltage [With .1 microfarad internal series capacitor]: 0-2.5 v; 0-10 v; 0-50 v; 0-250 v.

Volume Level in Decibels [Zero DB equal to 1 milliwatt across a 600-ohm line]: —20 to +10 DB; —8 to +22 DB; +6 to +36 DB; +20 to +50 DB.

DC Resistance: 0-2000 ohms [12 ohms center]; 0-200,000 ohms [1200 ohms center]; 0-20 megohms [120,000 ohms center].

Direct Current: 0-50 μa; 0-1 ma; 0-10 ma; 0-100 ma; 0-500 ma; 0-10 amp.

Model 270, complete with test leads and Operator's Manual............... $59.95

Simpson ELECTRIC COMPANY
5203 W. Kinzie St., Chicago 44, Illinois
Phone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd.
London, Ontario

WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT
At Last – **High Reliability in Carbon-Film Potentiometers!**

Bourns Trimpot® carbon-film potentiometers now offer you twice the stability of any carbon unit heretofore available...at temperatures as high as 150°C! Now, for the first time, you can incorporate high-resistance, infinite-resolution potentiometers in your circuit without sacrificing reliability. The reason: Resistor®, a remarkable new carbon element that virtually eliminates the problems normally caused by extremes of temperature and humidity.

Thanks to this exclusive Bourns development, Trimpot carbon units can operate at temperatures up to 150°C—with resistance shift only half that of ordinary carbon elements. In addition, they far exceed the requirements of MIL-Specs for humidity and MIL-R-94B.

Trimpot Resistor units are available from factory and distributor stocks with three terminal types...three mounting styles...and standard resistances ranging from 20K to 1 Meg. Resistor elements are available in most Bourns configurations. Write for the new Trimpot summary brochure and list of stocking distributors and representatives.

---

**Number 10—Reliability Series**

November 25, 1960
The trick is in the adhesive. CDF's Di-Clad® printed circuit boards are tested for bond strength in this precision machine.

CDF has developed special adhesives for bonding copper foil to laminated plastic boards. These adhesives produce high peel strength, have excellent hot solder resistance, etch cleanly, and provide high insulation resistance.

In addition to its own adhesives, CDF makes resins and papers. This extends quality control several steps beyond simple pressing operations . . . provides you with Di-Clad boards of excellent and uniform properties.

CDF manufactures the largest selection of grades to meet every major civilian and military requirement. In addition to Di-Clad printed circuit boards, CDF has special combination materials to solve extra troublesome problems. Example: asbestos bonded vulcanized fibre for circuit breaker arc chutes where the fibre quenches the arc and the asbestos guarantees fire resistance.

If you don't see the grade you want in CDF's catalog in Sweet's PD file, write us.

CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Buhl COMPANY • NEWARK 16, DEL.
In Canada, 46 Hollinger Road, Toronto 16, Ont.

Vibration-free plug bases, fabricated by CDF. A special bond of CDF Dilecto laminated plastic and rubber.

High reliability printed circuits for military applications. Made from CDF's glass-base Di-Clad laminated plastic.

Low-Cost commercial circuits. Made from CDF's paper-based Di-Clad copper-clad laminate.
NEED MIL-T CANS Right Now?

HUDSON has them in stock!

MIL-T-27A SIZES FROM AF TO OA

WITH OR WITHOUT COVERS

MATERIALS: ALUMINUM, BRASS, COPPER, STEEL, MU-METAL, STAINLESS STEEL, NICKEL SILVER

DEEP-DRAWN CONSTRUCTION

FOR DETAILS, SEE OTHER SIDE
All These Sizes Available From HUDSON Stock

Add suffix to part number to indicate material:
1-ALUMINUM  2-BRASS  3-COPPER  4-STEEL  5-MUMETAL  6-STAINLESS STEEL  7-NICKEL SILVER

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MODIFICATIONS—All sizes can be supplied with holes, slots, cover stops, knockouts, screws, inserts, and other special features.

FINISHES—To MIL-T specifications. Alkali-etch, anodize, centrifugal hot-tin dip, electroplate.

FILE THIS SHORT-FORM CATALOG FOR REFERENCE—TEAR ALONG PERFORATION.

Get your complete HUDSON catalog—write on company letterhead today.
Roy Caprarola cooks up a new tube...

This engineer, so absorbed in “cooking” a glass tube base in a concentrated gas jet, has two important responsibilities that directly benefit you.

He's Roy Caprarola, Manager of our Receiving Tube Methods and Processes Lab. One of his jobs is to refine manufacturing processes to improve tube performance. Closer interelement tolerances, sturdier cage structures, tighter seals, higher vacuums are his objectives. Above, for example, he's working on an improved pin-sealing technique for the bases of our new developmental NOVAR tubes.

He has another responsibility. When our Advanced Development engineers come up with an idea for a new tube structure, it's Roy's job to develop a practical way to produce it. Case in point: the frame grid shown at right, the key element in the new RCA-6939 industrial twin pentode. The Methods and Processes Lab developed the manufacturing technique—and even took over initial production—for this vital element.

Roy's job has many facets, all of which present challenges. But the solving of these challenges means new advances: improved performance from your RCA Industrial Receiving Tubes. The work of the M & P Lab is typical of our determination to achieve top quality through constant research.

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA
GERMAN EXHIBIT SHOWS

Big switch to electronic control in West German industry brightens electronic business

By JAMES MORRISON,
McGraw-Hill World News

DUESSELDORF—EUROPEAN manufacturers are eschewing research and development to concentrate on re-packaging and transistorizing their measuring and control instruments. That's what many engineers concluded last month after visiting West Germany's eight-day International Congress and Exhibition of Measuring Instruments and Automation (Interkama).

Attendance at the big show this year totaled 110,000; some 7,500 engineers and scientists from 48 countries participated in the technical sessions. A total of 48 U.S. firms were represented at the exhibition; Great Britain had more firms present, France a few less. Hungary's one booth and a collective East German booth representing 14 firms constituted the Iron Curtain contingent at the show.

From a standing start in 1945, the electrical control industry in Germany has grown into a major enterprise employing 50,000 people and ringing up $260 million in annual sales. About $50 million of this is export business, mostly to other European countries; $5 million goes to the U.S.

Bright spots in the German business picture are the switch to electrical-electronic control in local industry, and the missile-control business expected if a NATO missile program gets underway. German instrumentmakers, however, are pressed by U.S. competitors who offer quick delivery on items that local firms would take a year to deliver. German manufacturers are also apprehensive over possible Japanese competition in off-the-shelf equipment.

Many German firms have teamed up with U.S. manufacturers. They wait until basic research and engineering are done in the U.S., then put small but highly skilled teams of experts to work redesigning the instrument for local production. Consensus at the show was that investment in R&D gives the U.S. industry about a year's lead on the European state of the art in most areas, two years in some. Europe's engineering fraternity is only now, for instance, coming to grips with transistorization, microminiaturization.

Hybrid solid-state switching and control devices are gaining increased use in Germany. Siemens and AED showed transistorized plug-in single-cell units with
PROGRESS IN CONTROLS

picture. Research effort lags but progress is evident in product development

printed circuits and magnetic-amplifier output. ACEC of Belgium showed prototypes of multiple units sealed in a common housing. Several companies displayed automatic data-logging systems.

Engineers at the exhibition noted that Europeans are veering away from five-channel punched-paper tape toward eight-channel tape. Punched tape is more commonly used in European digital systems than magnetic tape.

Analog computer systems continue to receive much attention from Europe's engineers. Principal trend in these systems is towards full transistorization. Use of function plugs, wired-core fixed memories and other preset devices has substantially reduced problem set-up time on the analog systems. Also, many systems are being designed to handle several related families of problems by means of fixed-memory cyclers and program devices such as patch panels.

On-line and laboratory analysis instruments were shown in abundance. By austere design, European manufacturers have been able to pare equipment prices down to about a third of going U.S. levels, but they are still finding it necessary to fight hard against stateside competition. European analyzer gear is especially good in the areas of gas-moisture monitors, refractometers and sulfur-trace monitors. The German industry seems to lead in automatic titration equipment.

Britain's Rank organization displayed an electronic level indicator designed by its Taylor, Taylor & Hobson division. The indicator is said to be capable of registering level changes of less than a second of arc, equivalent to five millioths of an inch of change in an inch. The instrument can be used to check either horizontal or vertical level. Conventional spirit bubble is replaced by a pendulum that operates on a pair of transducers to provide a displacement signal; this signal is amplified and fed to a zero-center meter. Meter is scaled in angular displacement and gradient. Equipment can be left in position for months with only one or two seconds deviation; rezeroing is simple.

ACEC of Belgium showed a model of a train-braking system now being field-tested on a stretch of railway between Brussels and Antwerp. Red, yellow and green block signals select one of three saturable reactors in a track unit clamped to the rails; these reactors control the tuning of a circuit that passes information on the state of the block signals, slowing speeds, and track gradients to a logic unit mounted on the locomotive. As the train passes over the track-mounted unit, the logic unit picks up one of fifteen input frequencies from the track circuit. Bandpass filters are used in the logic unit to direct the signal to an integrator and function generator that initiates an inverted velocity-time signal; this signal in effect sets the maximum permissible train speed that will allow the train to stop at the next red signal. This voltage is compared against velocity data from the train; if the train is going too fast, the brakes are automatically applied.

Pneumatic actuators are teaming up with electrical and electronic controls in some European designs shown at Dusseldorf. Some all-electric types were also displayed. Siemens unveiled an electropneumatic control system using electrical gear for measurement, electronics for transmission of data, pneumatics for control—especially recommending the latter use in explosive atmospheres.

Samson Apparatebau of Frankfurt/Main showed a two-stage pneumatic balance controller. Required and actual values of a physical parameter are fed to the controller by means of compressed air at pressures between 3 and 15 psi. Metal bellows are linked to the ends of a differential lever. Measured differences in pressure cause one bellows to move, opening and closing a pilot valve.

Elektro-Mechanik GmbH of Wendenhuette showed a rapid-reversing geared magnetic-particle clutch with a linear relationship between excitation current and transmission torque, capable of smoothly regulating torque between zero and 100 percent. The same firm showed an electrohydraulic edge control system using photoelectric techniques. Using either transmitted or reflected light, the system detects any wander of the edge of the measured material. Amount of deviation is measured and passed to a transistor amplifier, then on to a plunger-coil regulator that drives a servomechanism.

Blackburn Electronics, Brough, England, exhibited a rate-of-change temperature transducer for direct reading where thermocouple output is not sensitive enough and datum-setting or balancing is awkward. Rated sensitivity is 250 to 500 microvolts per degree C per minute, with a time constant of 60 to 250 seconds.

Telefunken showed a working model of a traffic analyzer that can distinguish among four kinds of vehicles—motorcycles, automobiles, trucks and truck-trailer combinations—and measure up to ten different speed categories to 3-percent accuracy. Speeds covered by the analyzer are from 15 to 70 mph. The German company also unveiled a transistor desk-type d-c analog computer. Basic unit can be cascaded to build up a large computer installation. Operational amplifiers in the system are chopper-stabilized so that long-time computations are possible. System consumes 90 v-a.

VEB Vakutronik displayed an ion source for possible rocket applications. The engine is a Manfred von Ardenne configuration, with an orifice size of just over 1 mi. It is a du-plasmatron type of engine, operating on 125 v, with a magnetic field strength of 6,250 ampere-turns, beam power of 500 w, exhaust beam current or ion current of 22 amp/cm². The device consumes propellant at the rate of 70 cc/hr, is rated as 99-percent efficient, produces a thrust of 0.035

November 25, 1960
Data Systems Featured At

Computers, data converters, transmission systems, document processors and teaching units are among electronic aids shown to nation's businessmen

LOS ANGELES—At least one management consultant thinks the consumer of tomorrow will do all his buying electronically.

At the recent Business Equipment Exposition here a spokesman for Booz, Allen and Hamilton verbally sketched a universal automatic credit-card system. At the center of the web would be a so-called financial utility where each consumer's account would be kept on magnetic tape. Employers would transmit payroll data digitally; utilities would be charged for by automatic metering, purchases would be charged by feedback from point of purchase.

But the equipment on display was more down to earth. According to John H. Howard, director of the data-processing group of the sponsoring Office Equipment Manufacturers Institute, the 64 manufacturers exhibiting account for 90 percent of a $44 billion-a-year business. By 1965, he predicts, this annual gross will swell to $8 billion. An increasing amount of this is becoming electronic.

Featured speaker Rear Adm. J. P. Monroe, while reviewing the country's satellite programs and deterrent missile capabilities, commended the achievements of business machine and computer systems developers. He called attention to the Navy's Spacescore exhibit at the entrance to the show's exhibit area. It was a visual readout of orbiting satellite locations determined by the Naval Ordnance Research Calculator. The NORC has a 13-decimal digit capacity and a speed of 15,000 operations a second. Intelligence comes from a six-station data-acquisition network stretched along a great circle from San Diego to Fort Stewart, Georgia. Triangulation, by groups of paired 108-Mc receivers 500 miles apart and a 50-Kw transmitter half-way between, enables the Navy's space surveillance system to position any object passing through its electronic fence.

Among commercial equipment at the show was Friden's tape-to-tape converter, designed to integrate data processing when two different tape code systems are used. The machine punches or reads Flexowriter 8-channel tape for conversion to or from a 5, 6 or 7-channel system. The converter is controlled by a panel that permits programming for practically any input or output. Clary demonstrated a compact wide-carriage printer, developed by Kienzle Corp. of West Germany. Completely transistorized, the printer can accept coded or decimal information using logical level inputs. In its final form, the machine will print five lines, or five blocks of figures a second.

A system that enables branch offices, regional warehouses or remote plants to interrogate a computer miles away was introduced by A. B. Dick. Information is displayed alphanumerically on the face of a 14-inch tv tube in an array of ten lines, 19 characters to the line, in response to the digital input signals.

Heart of the Videograph display console is a monoscope character generator, developed with Stanford Research Institute, which converts digital information retrieved from a memory unit into television signals.

The IBM 1001 data-transmission system enables firms with multiple locations to send information in machine language to a processing point over telephone circuits. Leased lines are unnecessary, and the system transmits both fixed data from prepunched cards and variable data manually entered on the keyboard. Data is received at the central point in punched card form and may be fed directly into the processing system.

IBM's 870 document-writing system enables one operator to produce business information simultane-
BUSINESS SHOW

By HAROLD C. HOOD,
Pacific Coast Editor

Punched cards and paper tape. Data, besides being introduced to the system manually, can be fed in by paper tape or cards.

West Coast bankers and businessmen got a look at Burroughs’ B251 Visible Record Computer that enables them to retain records in conventional form while processing at electronic speeds. The fully transistorized VRC consists of a sort-reader, computer, ledger processor and control console. In banking, checks are placed in account number sequence by the sort-reader, and dollar amounts and other information are relayed to the computer.

Electronic teaching machines were represented by Dictaphone’s Dictalab, a tape-teaching system for language comprehension. Students sit in sound-protected booths and listen through earphones to preprogrammed lessons. The teacher, at a control console, can monitor or communicate with students. Students listen, repeat and record at their stations, and compare their verbalism with those of the master tapes.

Businessmen were likewise able to run hypothetical problems on Royal McBee’s RPC-9000, a sophisticated descendant of the LGP-30. An internally programmed, solid-state computer, the machine features building-block design, in-line processing and an operating speed of millionths of a second. Capable of reading, recording and computing simultaneously, the RPC-9000 uses interchangeable cartridges containing 35-mm Mylar tapes that can hold up to 1 million alphanumeric characters. Internal memory of the computer is magnetostrictive delay lines from each of which 96 characters are available in less than two-thousandth second.

Next OEMI Exposition will be held in New York Coliseum, next April.

November 25, 1960
PSI MICRO-MESA SILICON DIODES

- A totally new standard of reliability!
- A totally new approach to equipment design!
- A totally new concept of cost!

PSI Micro-Diodes with their companion Micro-Transistors, offer exciting new opportunities to the imaginative circuit designer. They make possible revolutionary new mounting techniques...techniques contributing substantially to higher performance, higher reliability and lower construction costs!

And now eleven new Micro-Mesas have been added to the extensive line of PSI Micro-Diodes. These new types offer capacitance as low as 2 pf...recovery as fast as 2 nanoseconds as well as unusually low stored charge.

Note these outstanding specifications!

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<td>1.0 (~75V)</td>
<td>2</td>
<td>5.00</td>
</tr>
</tbody>
</table>

*Switching 10mA to ~6 volts recovery to 1mA.

RELIABILITY ≥ CONVENTIONAL DIODES!

PSI Micro-Diodes meet all environmental requirements of MIL-S-19500B. They are physically tough and rugged...are capable of withstanding rough handling in any production line procedure.

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Space Miniaturization: U.S. vs USSR

Soviet and United States photos of space gear show up Russia's lag in miniaturization techniques. We had to miniaturize because of vehicles but our achievements are now reaping benefits.

LIMITED THRUST, coupled with interest in a wide variety of space phenomena requiring different instruments for each, forced the U.S. to miniaturize space-borne equipment.

The Soviet Union, with thrust capable of propelling an elephant into orbit and narrower interests in space, has not been driven to such inventive measures. Soviet satellite gear is built largely with conventional components and packaged in a free and easy way.

In the long pull, our early hardships will pay off. With an operational Saturn plus miniaturized equipment we should move ahead at a good pace.

Left, are pictures showing a comparison of two devices carried in Soviet and U.S. space shots.

Top, left, is the ionization detector and amplifier built by the State University of Iowa that will go in the U.S. moon shot next year.

Top, right, is the ionization detector and amplifier used by the Soviets in Sputnik III. The American detector and amplifier are built in a package about six inches long. Unit has a circular potted amplifier, miniature connectors and an enclosed detector.

The Soviet gear is in two separate packages connected by a cable that appears to be about two feet long. The detector, shown exposed, is probably enclosed by a tubular section, like the American detector. It is probably bolted to its enclosure and then cabled to the amplifier, which in turn is bolted to the satellite structure. Note the use of bolt-hole lugs on both amplifier and detector. This physical separation of the devices may be to achieve correct internal weight distribution to avoid lopsided spinning.

Lower, right, shows the mass spectrometer tube and amplifier used in Sputnik III. Lower, left and center, electronic pulse-scaling and amplifying decks in Explorer IV built at the State University of Iowa.

Bulk, weight and complexity of the Soviet amplifier is typical of many other amplifiers used in Soviet space shots.

Components appear to be conventional in size and weight. The relays are bulky—one is completely exposed. The large stepping relay, capacitors, resistors and trimming potentiometers might well be used in manned aircraft. The wiring harness shows absence of printed circuits. Large mechanical connectors and conventional military-type cables and plugs connect the amplifier to its associated equipment.

The American printed circuit amplifiers are typical of those used in our current space missions.
Digital Facsimile Speeds Mail Transmission

LOS ANGELES—Technical details on a new high-speed facsimile scanner and automatic printing system used in the U. S. Post Office’s electronic speed-mail system were revealed here last week.

Speed mail makes possible transmission of mail to any point in the country in three seconds.

Systems manager for the program is Intelex Corp., an ITT subsidiary. Equipment developed by Stromberg-Carlson, San Diego, includes a high-speed facsimile scanner (S-C 6400) and an automatic printing system (S-C 6000) using the xerographic printing process of Haloid Xerox, Inc.

Letters prepared on special uniformly sized stationery, similar to World War II V-mail, are scanned at fifteen pages a minute and transmitted by coaxial cable or microwave link. This is 400 times faster than press picture-transmitting facilities. Special letter opening machinery and facsimile sealing equipment, developed by Pitney-Bowes, Inc., insures privacy.

Initial development contract with the P. O. Dept. calls for installation of 14 facsimile printers and eight mail scanners at test sites.

Stromberg-Carlson project engineer Kenneth Morgan says digital techniques make possible the high speed of the system. Advantages include: high signal-to-noise ratio and elimination of all noise in output signal of scanning photocells; the possibility of coding the system if intelligence information is to be sent; the reduction of bandwidth requirements, since white does not have to be transmitted—it can be synthesized. This third advantage opens up possibilities of using bounced signals from satellites.

Secondary advantages are: the possibility of selecting a high-contrast print-out medium, with resultant clearer pictures from a smaller amount of energy; ability to transmit grays using conventional half-tone techniques.

The S-C 6400 scanner operates by sweeping a spot of light across the face of a cathode-ray tube 360 times a second. This spot is focused on the mail being transmitted and the varying reflection is picked up by a multiplier phototube and converted to an electrical signal.

At the receiving end, a synchronized cathode-ray tube impinges on a light-sensitive selenium-coated drum on which an image of the letter appears. Black powder cascades over the drum, adhering only to those areas that have not been discharged by the light beam. The powder is transferred to paper as the drum rotates, and is permanently fused by heat.

The success of the system depends partially on a uniform light intensity in the scanning beam. To insure this, a half-silvered mirror is used to bounce 60 percent of the light to letter being scanned and allow the remaining 40 percent to be directed on a reference target. A second multiplier phototube picks up the reference reflection, and its signal is added algebraically to that of the primary scanning tube by connection with the crt grid.

Thus, uniformity of the light source is continuously monitored.

To make its system digital, S-C starts with an analog signal from the scanning multiplier phototube, selects an arbitrary percentage reference level as a demarcation between black and white, then clips the signal. Clipping level varies in voltage but remains constant as far as percentage. To accomplish this, the pulse is introduced to a delay line, analyzed to establish voltage corresponding with percentage level, then sent to gain control of an amplifier where gain is set for that pulse. By delaying pulse long enough for amplifier to adjust, clipping is accomplished at proper moment. Signal, as transmitted, is essentially a noise-free square wave.

A series of automatic checking points assures proper operation of both scanner and printer; otherwise, equipment is shut down and audible alarm sounds. One such safeguard is the scan verification signal. Three lines at the beginning of the scan section generate three pulses indicating that scan has started. A similar group of lines at the end indicates that scan has been completed. If these three pulses are not received by machine, it is automatically shut down until trouble has been fixed. The system is said to have a 3-sigma probability of accurately reproducing a letter if no trouble is indicated by interlock system. Checkout console, with selector knob, monitors major circuits and isolates trouble. With the exception of two tubes in the printer, all circuits are solid-state.
All 5 MIL Tantalum Foil Capacitor Sizes From OHMITE

MEET MIL-C-3965B — ALL VALUES IN STOCK

Plain and Etched

Whether you need immediate delivery from stock on prototypes, or production quantities of tantalum foil capacitors, Ohmite can handle your requirements.

Tan-O-Mite® Series TF foil capacitors now include all five MIL sizes in both plain and etched types, polar and nonpolar units, insulated and uninsulated cases—all in ratings to 150 VDC. Capacitance values for plain foil units range to 400 mfd; etched foil units, 580 mfd.

Write for Specification Bulletin 152G which lists 200 stock values, including all MIL values, and shows a handy scale for conversion between “equivalent series resistance,” “power factor,” and “dissipation factor.”

Ohmite Manufacturing Company
3610 Howard Street, Skokie, Illinois

November 25, 1960
Shooting Earth to Study Reentry

BOSTON—Last week at NEREM scientists from MIT's Lincoln Lab told how they are shooting at the earth to study reentering vehicles.

The five-inch payload of an experimental rocket is fired from 200 miles for antimissile research and to explore effects of the plasma sheet and related phenomena on communications and navigation during reentry of manned or unmanned space vehicles.

Experiments are being conducted by MIT Lincoln Laboratory under sponsorship of the Advanced Research Projects Agency through an Air Force contract. Radar and optical equipment are at the Lincoln Lab field station at Arbuckle Neck, Va., adjacent to NASA's Wallops Station.

A six-stage rocket designed by Langley Research Center and dubbed Trailblazer I is currently being used for the field studies. The 5-inch spherical rocket motor for payload weighs only a half-pound.

To permit heavier payload for reentry instrumentation and to permit more variation in shape for the final stage, a second-generation test vehicle will be available in about 6 months. Trailblazer II will be a 4-stage vehicle with two downward-firing stages, the last a 15-inch spherical rocket engine for payload. Trailblazer I has three downward-firing stages with the payload reaching a velocity of 16,000 miles per hour. The final stage carries a telemetry transmitter at 234 Mc.

Theoretical studies and lab experiments conducted by Lincoln Lab in cooperation with Ames Research Center of NASA provide a picture of the flow field about a hypervelocity object, also electron density profiles between the body surface and the shock wave, and microwave measurements of trail lengths as determined from the amplitude of reflected radiation at radar frequencies in uhf, S-band and X-band.

Velocities up to 25,000 ft per sec are obtainable at the Ames hypervelocity ballistic range. For supplementary measurements and instrumentation development, Lincoln Lab has constructed a hypervelocity range at its Lexington, Mass., field station.
Radar and optical equipment in the field measure radar cross-section, radiant intensity and spectral distribution. Three pencil beam radars at X-band, S-band and uhf are provided with two 60 ft. reflectors on modified 5-inch Naval gun mounts. The S-band radar is a tracking radar on one of the mounts. The uhf and X-band radars are duplexed onto the second reflector which is slaved to the S-band tracker. The X-band feed illuminates only the 34-ft solid center section of the reflector.

Lincoln Lab's uhf radar at Millstone Hill, Mass., is also used in the experiments, and hf measurements are being started.

Optical equipment includes a six-inch special spectrographic Schmidt camera and two super-Schmidt cameras borrowed from Harvard University's meteor group. A 12-inch reflector radiometer will be installed soon. A 48-inch spectroscopic tracking telescope is under construction.

Seven Trailblazer vehicles have been fired to date including three development shots.

Orders Data Subsystem
For Air Traffic Control

A $4-MILLION CONTRACT for a data processing subsystem at Boston Air Route Traffic Control Center has been awarded by the Federal Aviation Agency to Librascope division of General Precision, Inc.

This is the first of more than 20 such computer installations FAA will be placing in traffic control centers across the nation by 1965.

The high-speed, random-access computer will partially automate current instrument flight control procedures at Boston. It will tie in with display subsystem, costing an additional $4 million, designed by General Precision Laboratories.

The entire system will implement rather than replace current control procedures by performing virtually all routine calculations and clerical functions, which sometimes take up 80 percent of a controller's time. Traffic controllers will thus be freed to handle emergencies and unusual situations.

(Advertisement)

Broadness of Sprague's Line of Precision Toroidal Inductors
Offers Standard Units for Practically Every Application

DESIGNED FOR USE in commercial, industrial, and military apparatus, Sprague Precision Toroidal Inductors are customarily supplied to the close inductance tolerance of ±1%. The broad line of Sprague Precision Toroidal Inductors includes such styles as open coil, plastic-dipped, rigid encapsulated inductors with tapped or through-hole mounting, and hermetically-sealed inductors.

All styles, with the exception of the open coil type construction, meet the appropriate requirements of Military Specification MIL-T-27A.

Sprague Precision Inductors are manufactured in modern plants which are equipped with the most up-to-date facilities for winding, processing, and testing the cores. Production instruments used in the manufacture of Sprague inductors are calibrated periodically to assure desired levels of accuracy. Quality control and inspection departments, which function independently of each other, maintain close surveillance over all production operations.

Several core permeabilities may be obtained in each of the five basic sizes of Sprague inductors to give the circuit designer the optimum selection of desired Q and current carrying abilities. Further, each of the core sizes is available with several degrees of stabilization. Inductors made with cores which have not been subjected to the stabilization process exhibit low inductance drift with time and have a low temperature coefficient of inductance. Where a greater degree of permanence of characteristics is required, cores with two different stabilization treatments can be used for most types of inductors.

All standard inductors by Sprague may be operated over the temperature range of −55 C to +125 C. Temperature cycling of finished inductors is a standard production procedure in order to equalize internal stresses and insure permanence of electrical characteristics.

In those cases where the extensive line of Sprague standard inductors is unsuitable for a particular application, the Special Products Division of the Sprague Electric Company will be glad to work with you to custom-tailor designs to meet specific customer requirements.

For detailed information on standard ratings, package sizes, Q, current carrying abilities, properties, etc., write on company letterhead for portfolio of engineering data sheets on precision toroidal inductors to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.
Installs Rolling Communications Net

CHICAGO—ROLLING NETWORK of 70 transistorized f-m transmitter-receivers started using the third rail of this city's North-South elevated-subway as the "antenna" for a train-phone communications system early this month.

Motorman's voice, converted to 32-watt, 85-Kc radio signal by 19-transistor, 16-lb portable unit, is transmitted through the third-rail power distribution system of the elevated line. Signals are tapped off each mile or so, fed into telephone cables on the track structure. Cables carry signals to a-c operated wayside receiver-transmitter stations for demodulation to voice impulses, which are led by telephone lines to central operations control room in the Merchandise Mart at the edge of the downtown Loop.

New system permits rapid action in emergencies—such as illness of passenger, failure of equipment, or necessity to warn other motorists of trouble ahead—through direct report to operations control. Central operations superintendent may also broadcast messages direct to passengers of any train involved in emergency situation.

North-South line serves some 360,000 passengers—about 65 percent of system's total traffic—on an average weekday. City Transit Authority plans to extend the system to six remaining rapid-transit routes, has also been experimenting with electronic method for recording intervals between in-service buses—using individual bus transceivers for interrogation by strategically-located stations along its route.

Computermaker Licensees Fight Japanese Companies

FOLLOWING up its recently signed agreement with Ministry of International Trade & Industry (see ELECTRONICS, p 40, Sept. 23), IBM last week signed provisional licensing agreements with eight Japanese manufacturers. Included were Hitachi, Tokyo Shibaura, Nippon Electrica Fuji Communications, Oki Electric, Matsushita Electronics, Mitsubishi Electric and Hokushin Electric.

Five-year contracts allow the licensees to manufacture punch-card equipment, call for 10-percent royalties in total sales. Approval by Japan's Foreign Investment Council is still required.

Six days later, MITI reactivated a 3-year-old proposal to establish a national electronic computer company with the expense to be shared half by government and half by private industry. MITI wants to promote Japan's computer industry, figures its former plan may take hold this time. The ministry plans on having the proposed company act as volume buyer of components for member firms, take half the computer output of its members and rent to users.
HOW TO GET FLAT FREQUENCY RESPONSE FROM 37 CYCLES TO 45 KC

Specify TI 2N734 Series Silicon Transistors for Your Amplifiers!

For your audio/servo amplifiers, power supplies and medium-speed switches, design in TI 2N734 Series Silicon Transistors. Obtain a flat frequency response of ±1.5 db from 37 cycles to 45 kc... guaranteed beta at 25°C (1 ma at 1 kc) (5 ma at 1 kc) (5 ma at 30 mc) and at −55°C (5 ma at 1 kc)... guaranteed 500-mw free-air dissipation... reduced equipment size and weight with TO-18 package.

For even greater power dissipation, investigate the design flexibility of the equivalent TO-5 packaged 600-mw TI 2N1564 Series Silicon Transistors.

GUARANTEED MINIMUM BETAS

<table>
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<th>Symbol</th>
<th>Parameter</th>
<th>Test Conditions</th>
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</table>
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the big difference in Teflon® Insulated Wire and Cable!

From the smallest single conductor hook-up wires to the most complex Teflon primary insulated and jacketed multiconductor cables, Brand-Rex Cablemanship makes the difference.

And what is Brand-Rex cablemanship? Of course it involves technology and skill. But more than that, it's a tightly-knit organization of broadly experienced cablemen backed by the vast resources of the American Enka Corporation. It's progressive cable design engineering. It's the production capability of three modern quality-controlled production plants, strategically located from coast to coast, operating around the clock with the most advanced high-speed equipment. Combine these with technical field service in depth and that's Brand-Rex Cablemanship!

In terms of your requirements for Teflon TFE or FEP insulated wire or cable, Brand-Rex cablemanship will pay big dividends to you... regardless of how varied, complex or rigid your requirements may be for conductors, lay-up patterns, shields, armors or jackets.

For complete information and samples, write today!

Shown: Special cable design includes 3 miniature coaxial cables, center, having Teflon TFE primary insulation. Other conductors insulated with Teflon FEP. Braids Dacron. Jacket Neoprene.

Left: Cables can be furnished with individual coaxials, pairs, triples or other components positioned within the cable exactly to specs. Center: Brand-Rex coaxial cables use Teflon dielectrics and meets all government and commercial requirements. Right: Brand-Rex quality-control procedures cover every step of manufacture.

Registered Trademark of DuPont
Missile men, especially, know the advantages of Neoprene jacketed cables... low temperature flexibility, abrasion resistance and resiliency. And missile men who are also cabemen know it pays at the count down to count on Brand-Rex Cablemanship! And you should too.

There's more to the absolute reliability of Brand-Rex cables than just rigid adherence to specifications. Brand-Rex Cablemanship combines technology, skill, broad cable engineering services, production capability of three coast-to-coast plants and technical field service... all delivered by a tightly-knit organization backed by the vast resources of the American Enka Corporation.

Whatever your requirements for wire or cable, regardless of the rigidity of your specifications for conductors, layup patterns, insulation materials, shielding or armoring, you can count on the Cablemanship of Brand-Rex.

Versatility Designed into X-Band System

BOSTON—A versatile X-band transmitter-receiver with a 120-ft precision Cassegrainian antenna will be built by the Air Force near Millstone Hill in Westford, Mass., for development and testing of new communications and radar-tracking concepts. Estimated cost of the Haystack Hill installation is between $4-$5 million.

Designed by MIT Lincoln Laboratory, Haystack will be built primarily to tie in with the new global microwave communications system announced in September before the International Scientific Radio Union in London. W. E. Morrow Jr. of Lincoln Lab proposed an orbital scatter technique using tiny reflective tuned dipoles orbited in belts above the earth (ELECTRONICS, p 43, Sept. 30).

The signals reflected from these needles will be detectable in the Haystack.

Flexibility, however, is one of the major considerations in design of Haystack, for adaptability to new missions. In addition to the tuned-dipole application, the installation will help develop and test new-generation communications satellite networks and also will lend itself to modifications for long-range radar tracking of satellites, missiles and space vehicles, probably in both skin-tracking and beacon-tracking modes.

Flexibility of design is reflected in provisions for the cab behind the primary feed. The cab will be readily interchangeable for a variety of applications, for use of low-noise receivers such as masers and parametric amplifiers, and to take advantage of new communications and tracking techniques.

In some respects, Haystack will be a next-generation Millstone Hill, the uhf research radar operated for the past three years by Lincoln Lab.

But where Millstone operates at 440 Mc, Haystack will have a nominal operating frequency of 8,000 Mc; Millstone uses a 84-ft parabolic antenna, Haystack will have a 120-ft dish.

Average transmitted power of Haystack will be 100 Kw. A high-duty-cycle transmitter will be installed, and provisions for a low-duty-cycle transmitter of comparable average power is under study. The antenna system will be adaptable to a variety of uses at frequencies decades below and perhaps somewhat above the nominal frequency.

The 120-ft antenna will be supported on an elevation-azimuth mount and will be protected from the elements by a CW-412 radome 150-ft in diameter with a rigid frame. Radome footing will contain office, lab and equipment space.
EYE TEST FOR RADAR

B&L optical-electronic-mechanical capabilities assure accuracy in missile tracking system

The strength of our missile defense program depends in part on extreme accuracy of radar tracking.

Bausch & Lomb has developed a camera lens for boresighting a radar antenna—in essence, this lens checks the performance of radar just as one's vision is checked in an eye examination.

Accuracy of this lens system easily meets the most extreme requirements.

The same skills that made possible this missile track radar camera lens are available to assist on your project. Write us for full details. Bausch & Lomb Incorporated, Military Products Division, 61411 Bausch St., Rochester 2, N. Y.

MEETINGS AHEAD

Nov. 29-30: Science and Engineering Symposium, Air Research and Development Command (ARDC); Statler-Hilton Hotel, Boston.

Nov. 30-Dec. 2: Electronics Exposition, Long Island Electronics Manufacturers Council; Roosevelt Raceway Exhibit Hall, Westbury, Long Island, N. Y.


Dec. 5-7: Electronic Equipment Maintenance, EIA; Hilton Hotel, San Antonio, Tex.

Dec. 5-8: Electrical Insulation, National Conf., AIEE, NEMA; Conrad Hilton Hotel, Chicago.

Dec. 8: Man's Environment in Outer Space, Institute of Environmental Sciences; Henry Hudson Hotel, New York City.

Dec. 11-15: American Nuclear Society, Winter Meeting, ANS, AIF; Mark Hopkins Hotel, San Francisco.

Dec. 12-14: USA National Committee, URSI, Fall Meeting; NBS, Boulder, Colo.


Dec. 16-17: Combined Analog Digital Computer Systems Symposium, Simulation Councils, Inc., General Electric; Sheraton Hotel, Phila.


Jan. 9-10: Plasma Dynamics; S. Methodist Univ., Dallas.

Jan. 9-11: Reliability & Quality Control, ASQC, AIEE, PGRQC of IRE; Bellevue-Stratford Hotel, Phila.
VISUAL MICROWAVE ANALYSIS 10 to 44,000 mc

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10 to 44,000 mc with five plug-in tuning units

MODEL TSA-S
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MODEL SA-84
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MODEL SA-84W
WIDE DISPERSION UNIVERSAL SPECTRUM ANALYZER
10 to 44,000 mc in one integrated self-contained unit – features over 80 mc dispersion

The scope displays shown opposite each Polarad Spectrum Analyzer serve two basic purposes—first, they illustrate the significant analysis capability of each instrument; second, they demonstrate the many microwave parameters that can be measured and displayed visually on Polarad's versatile analyzing equipment.

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☐ Model TSA-S  ☐ Model SA-84W
☐ Model TSA-W
☐ Model RW-T Antenna Pattern Receiver (see reverse side)

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2,000 to 75,000 mc in a single unit

A External Mixer. May be located at or near antenna, any distance up to 75 feet from receiver.
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Model RW-T Microwave receiver being used to make antenna pattern measurements on Polarad range.

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All CAMBION Components follow a careful quality control program because the quality of any component of course limits its reliability. And the ever-increasing importance of reliability is apparent on all sides. Take one type of missile with 32,000 components, all interdependent. If each individual component had a reliability factor of .99999, it would mean failure of 1 out of 4 such missiles. Success demands quality control of all components. And quality control is the reason why all CAMBION Components meet or surpass Government specifications.

Get complete details. Write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts.
5 new Inconel-protected instruments retain accuracy at missile speeds, heats

...point the way to more reliable high temperature parts design

CHICAGO, ILL.: Streaking through the air on mile-a-second missile nose cones...fixed in hot, corrosive fluid streams...the five new instruments described below operate reliably at glowing temperatures. Aero Research standardizes on Inconel® nickel-chromium alloy for parts of these instruments that bear the brunt of this demanding service.

(1) Total temperature probe— withstands 7400°F generated by friction during flight on missile nose cones. (See photos below.) For maximum reliability, its Inconel sheathing also withstands oxidation and thermal shock.

(2) Wide-range thermocouple— measures temperatures from as low as -320° up to +1900° F in high-velocity fluids. Inconel sheathing effectively resists these severe erosive-corrosive conditions.

(3) High-accuracy, high-temperature probe—measures between 0° and 1800° F. Again, Inconel sheathing assures reliability, protecting its accuracy in supersonic jet exhausts, high-temperature furnaces.

(4) Jet thrust measuring rake, water-cooled—operates in 3500°F jet afterburner gases. Inconel alloy construction provides essential high strength at high temperature, plus corrosion resistance.

(5) Sonic-speed, 4430°F, wind tunnel, water-cooled—Inconel alloy forms all major components, gives tunnel the backbone needed to stand up under terrific velocity and heat.

You, too, can give parts high temperature stamina with Inconel alloy. It retains useful strength through 2000°F, and can be easily welded and formed into intricate shapes.

Pertinent Literature: Write for Bulletin T-7: "Engineering Properties of Inconel and Inconel X", and "Inconel Nickel Alloys for Electronic Uses".

Sensitive transducer measures minute changes of pressure in human body

...Monel fluid chambers withstand corrosion, do not affect saline purity

WALTHAM, MASS.: This sensitive pressure transducer measures a wide range of physiological pressures—from 400 mm Hg down to less than 1 mm Hg.

Absolute and differential pressures travel from source (needle or catheter) through a saline-filled tube to actuate two small Monel® nickel-copper alloy diaphragms. Monel diaphragm rods pivot a tiny differential transformer coil, producing a signal which is fed to amplifiers for quick reading.

Monel alloy was chosen for the parts above because it withstands corrosive attack from all common saline and sterilizing solutions. As a result, Monel alloy does not affect saline purity. In addition, Monel alloy is easy to form, machine, to braze, solder and weld.

Pertinent Literature: Write for Bulletin T-6: "Engineering Properties of Monel and R Monel".
Newest, Smallest Bourns Trimpot®
—with the square configuration

Now... Bourns reliability is in an even smaller package: these new wirewound units measure just $\frac{1}{2}'' \times \frac{1}{2}'' \times \frac{1}{2}''$. In addition, they offer you a choice of two terminal types—insulated stranded leads or printed circuit pins.

Because of unique package design, Model 3250 withstands the most severe environmental conditions...meets or exceeds Mil-Spec requirements. Its 25-turn adjustment permits precise balancing, while the shaft head size makes possible the use of a standard screwdriver. Moreover, Bourns' exclusive clutch design, combined with positive end-stops, eliminates any possibility of damage to internal parts.

Like all Trimpot potentiometers, this new model is designed, built and tested to give you performance you can count on.

<table>
<thead>
<tr>
<th>Max. Operating Temperature</th>
<th>Power Rating</th>
<th>Resistances</th>
</tr>
</thead>
<tbody>
<tr>
<td>+175°C</td>
<td>1 Watt @ 70°C</td>
<td>100Ω to 50K</td>
</tr>
</tbody>
</table>

Write for complete data and list of stocking distributors.

November 25, 1960

Exclusive manufacturers of Trimpot®, Trimit® and E-Z Trim®. Pioneers in transducers for position, pressure and acceleration.
FAILURE-FREE STACK-HOURS!

RELIABILITY PROVEN BY 17,000 KW IN FIELD APPLICATIONS

WESTINGHOUSE SILICON HIGH-VOLTAGE RECTIFIER STACKS
New Westinghouse Stacks top their own failure-free record! Number of stack-hours for units currently in use has nearly doubled in less than six months! Proof not only of outstanding reliability, but of an increasing industry-wide acceptance of Westinghouse Silicon High Voltage Stacks.

Why Westinghouse Silicon Rectifier Stacks are the most reliable. They are made to highest standards of circuit design, quality control, and assembly. Exclusive Westinghouse circuits guarantee uniform division of reverse voltages, provide optimum steady state as well as transient and overload characteristics. Only MIL Type shunting resistors, capacitors, and mounting boards are used. All components are 100% tested before and after assembly. Spacing and cooling of components allows operating in ambient temperatures as high as 110°C. As a result of these and other Westinghouse quality features, there is no record of a single stack failure in any type of application.

Westinghouse Silicon Rectifier Stacks are available in a range of current ratings from 1.2 Amps to 18 Amps... from 9.6 K.V. to 35 K.V. For higher voltage requirements Stacks may be connected in series.

For full information, or engineering assistance, contact your local Westinghouse Representative or write: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Penna.

You can be sure... if it's Westinghouse

MIL TYPE COMPONENTS
Unique Westinghouse modular inserts feature MIL Type shunting resistors, capacitors, and mounting boards. All components are 100% tested before and after assembly.

APPLICATIONS
• Electrostatic precipitators
• Radio broadcasting transmitters
• Radar transmitters
• Ultrasonic transducers
• Radar pulse forming networks

November 25, 1960
For Space Applications, Raytheon offers proven, off-the-shelf techniques in CW Radar

Raytheon has been investigating, developing and producing Continuous Wave Radars for more than ten years. Impetus for the program was the anticipated problems of clutter rejection, ever-increasing intercept velocities, and low weight-high reliability requirements in the aero-space era.

This pioneering effort has resulted in several dramatic achievements: multi-kilowatt, low noise transmitters; unique antennas that transmit and receive simultaneously; a feed-through nulling device that adds isolation to the antenna; precise, highly sensitive Doppler data processors.

Raytheon CW Radar Systems incorporating these advances are light weight, low volume and low cost. They are also simple, reliable, and require considerably less input power.

For satellite intercept, space rendezvous, lunar or planet soft landings... for any space application requiring velocity data ... Raytheon can now offer empirically proven CW Radar techniques. Existing Raytheon CW hardware is now operational in Missile Guidance, Altimetry and Doppler Navigation Systems.

For CW Radar Brochure, write:
DIRECTOR OF MARKETING,
Equipment Division,
Department L-3, Raytheon Company,
West Newton, Massachusetts

RAYTHEON EQUIPMENT DIVISION
EXCELLENCE IN ELECTRONICS
Save on labor costs

Centralab's heat-stable plastic shaft controls

SNAP into place

You can save on installation costs—up to $10.00 per thousand units—because Centralab Model 2 variable resistors SNAP into position.*

This exclusive “Snap-Tite” design is but one of the many features that make the Model 2 so practical. The thermo-setting plastic shaft is UL approved. You have a choice of six shaft lengths—and the shafts have service adjust screwdriver slots front and rear. The shaft and contact rotor are molded in one piece for rigid, vibration resistant construction.

SPECIFICATIONS

Resistance element: Composition
Resistance range: 250 ohms to 10 megohms
Taper: Available in seven standard tapers
Effective Rotation: 300°
Shaft Lengths: 1\(\frac{1}{2}\), 1\(\frac{1}{4}\), 1\(\frac{1}{8}\), 3\(\frac{1}{4}\), 3\(\frac{1}{8}\), 1"
Terminals: Standard, plug-in or wire-wrap
*Mounting: Interchangeable with panel piercing for bushing and twist tab mount


Centralab

A DIVISION OF GLOBE-UNION INC.
914 E. KEEFE AVE. • MILWAUKEE 1, WIS.
In Canada: 669 Bayview Ave., Toronto, 17, Ont.
NEW! CONTROLLED SWITCHES

TSW31S- TSW201S PNPN bistable switching devices in T0-18 packages, with maximum holding current of 1 ma.
- High gate sensitivity 20 µa to fire
- Covers current range from 1 ma to 200 ma @ 75°C ambient
- Voltage ratings up to 200 volts available
- Temperature range: -65°C to +150°C

CIRCLE 220 ON READER SERVICE CARD

NEW! TO-5 PACKAGE
CONTROLLED RECTIFIERS

Two series of diffused silicon PNPN bistable switching devices with very low triggering requirements and micro-second switching.

TCR251-TCR4001 series featuring:
- Low leakage: 100 µA @ 125°C case
- High gate sensitivity: 200 µA @ 25°C
- Low Holding Current: 5 mA maximum @ 25°C
- Current rating: 1 amp at 80°C case or 600 ma at 25°C ambient
- Voltage ratings: Up to 400 volts

Plus 2N1595-2N1599 series with same current and voltage ratings

CIRCLE 221 ON READER SERVICE CARD

NEW! 2N1600-2N1604
and TCR505-TCR4005 series diffused Silicon Controlled Rectifiers
- Current ratings: 3 amps at 80°C case; 1 amp @ 125°C case
- Voltage ratings: Up to 400 volts
- Package: ½" hex base

CIRCLE 222 ON READER SERVICE CARD

NEW! 10 Amp Series
- Current ratings: 10 amps @ 25°C case; 5 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: ½", hex base

CIRCLE 223 ON READER SERVICE CARD

NEW! 20 Amp Series
- Current ratings: 20 amps @ 25°C case; 10 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: ½", hex base

CIRCLE 224 ON READER SERVICE CARD

NEW! 50 Amp Series
- Current ratings: 50 amps at 100°C case
- Voltage ratings: Up to 400 volts
- Package: 1¼", hex base
THE BINISTOR
(by-mis-tor)
Transistor’s new silicon NPN Tetrode offers
tinner, more reliable, more economical
switching and storage circuitry. The key
parameters of this bistable, negative resis-
tance device are determined by external cir-
cuitry, providing remarkable stability and
uniformity over wide temperature ranges.
The signal and output swings are compatible
with present transistor and diode circuits.
Two series are available. The wide tempera-
ture range or military types and the com-
mercial and industrial computer types. The
stability and uniformity of each unit in the
military series is absolutely guaranteed by
the method of specification at critical tem-
peratures (−65°C and +150°C).
CIRCLE 225 ON READER SERVICE CARD
ABSOLUTE MAXIMUM RATINGs

<table>
<thead>
<tr>
<th>J3N6</th>
<th>J3N7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector to Emitter Voltage (V_{ce})</td>
<td>15 Volts</td>
</tr>
<tr>
<td>Collector Current at +25°C (I_c)</td>
<td>30 mA</td>
</tr>
<tr>
<td>Storage &amp; Operating Ambient Temp. Range</td>
<td>−65°C to +150°C</td>
</tr>
</tbody>
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J3N6 MILITARY TYPE
SPECIFICATIONS & TYPICAL CHARACTERISTICS (At Noted Ambient Temp.)

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<tr>
<th>TURN-ON</th>
<th>AMBIENT TEMP</th>
<th>MIN</th>
<th>TYPICAL</th>
<th>MAX</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.C. Collector Saturation Voltage (V_{ces})</td>
<td>+25°C</td>
<td>+150°C</td>
<td>−65°C</td>
<td>−65°C</td>
<td>0.46</td>
</tr>
<tr>
<td>Critical Collector Current (I_{cc})</td>
<td>0</td>
<td>+25°C</td>
<td>0</td>
<td>−150°C</td>
<td>0</td>
</tr>
<tr>
<td>Base CutOff Current (I_{b})</td>
<td>+25°C</td>
<td>+150°C</td>
<td>0.20</td>
<td>2.0</td>
<td>0.02</td>
</tr>
</tbody>
</table>

J3N7 COMPUTER TYPE
SPECIFICATIONS & TYPICAL CHARACTERISTICS @ 25°C

<table>
<thead>
<tr>
<th>TURN-ON</th>
<th>MIN</th>
<th>TYPICAL</th>
<th>MAX</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.C. Collector Saturation Voltage (V_{ces})</td>
<td>0</td>
<td>0.7</td>
<td>1.0 V</td>
<td></td>
</tr>
<tr>
<td>Critical Collector Current (I_{cc})</td>
<td>0</td>
<td>0.28</td>
<td>0.5 mA</td>
<td>0.25 mA</td>
</tr>
<tr>
<td>Base CutOff Current (I_{b})</td>
<td>0.86</td>
<td>1.5 mA</td>
<td>0.5 mA</td>
<td></td>
</tr>
</tbody>
</table>

THE TRANSWITCH
A PNPN bistable silicon computer element
that can be turned on and off with gate current.
The device is available in the 7028B
package, and is designed for miniaturized
memory circuits, ring counters, shift
registers, controlled rectifier drivers, and flip
flop equivalents. A 100 mA series (TSW-31A-
TSW-201A) has been added to the Transwitch
series. Both series (50 mA and 100 mA) are
available in voltage ratings up to 200 volts.
For commercial and industrial applications,
The SW-30 type is now available. This unit,
especially designed for lower temperature
applications, features maximum collector
current rating of 30 mA and maximum volt-
age rating 30 volts.
CIRCLE 226 ON READER SERVICE CARD
ABSOLUTE MAXIMUM RATINGs

<table>
<thead>
<tr>
<th>SPECIFICATIONS (AT 25°C)</th>
</tr>
</thead>
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<tr>
<td></td>
</tr>
<tr>
<td>Max. Saturation Voltage (V_s)</td>
</tr>
<tr>
<td>Max. Forward &quot;OFF&quot; Current (I_Fo)</td>
</tr>
<tr>
<td>Max. Reverse Current (I_r)</td>
</tr>
<tr>
<td>Max. Forward &quot;OFF&quot; Current (I_Fo)</td>
</tr>
<tr>
<td>Max. Reverse Current (I_r)</td>
</tr>
<tr>
<td>Max. Gate Voltage to Switch &quot;ON&quot; (V_{gs} on)</td>
</tr>
<tr>
<td>Max. Gate Current to Switch &quot;ON&quot; (I_{gs} on)</td>
</tr>
<tr>
<td>Max. Gate Voltage to Switch &quot;OFF&quot; (V_{gs} off)</td>
</tr>
<tr>
<td>Max. Gate Current to Switch &quot;OFF&quot; (I_{gs} off)</td>
</tr>
<tr>
<td>Max. Holding Current (I_h)</td>
</tr>
</tbody>
</table>

In writing for further information on these devices, refer
to the following bulletin numbers:

Controlled Rectifiers & Switches

<table>
<thead>
<tr>
<th>Series</th>
<th>Bulletin Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSW-31S</td>
<td>TE-1365E</td>
</tr>
<tr>
<td>TCR-251</td>
<td>TE-1359A</td>
</tr>
<tr>
<td>2N1550S</td>
<td>TE-1365C</td>
</tr>
<tr>
<td>2N1880S</td>
<td>TE-1365B-1</td>
</tr>
<tr>
<td>TCR-50S</td>
<td>TE-1366B</td>
</tr>
<tr>
<td>10 amp series</td>
<td>TE-1356A-1</td>
</tr>
<tr>
<td>20 amp series</td>
<td>TE-1360A</td>
</tr>
<tr>
<td>50 amp series</td>
<td>TE-1356AA</td>
</tr>
<tr>
<td>3N56</td>
<td>TE-1357A</td>
</tr>
<tr>
<td>3N57</td>
<td>TE-1360B</td>
</tr>
</tbody>
</table>

Distributor:

Transistor electronic corporation
wakefield, melrose, boston, mass.

“Leadership in Semiconductors”

SEE YOUR AUTHORIZED DISTRIBUTOR FOR QUANTITIES FROM 1-999
Du Pont announces—New Resistor Compositions that permit varied resistance values without changing geometric form... simplify design, save space

Now, new Du Pont Resistor Compositions offer a second dimension for controlling resistance. You can vary resistance values by changing the composition of the resistor without the need for altering the geometric form. These new resistor compositions give you greater design flexibility, essential for miniaturized circuits. Du Pont Resistor Compositions are available at three approximate resistance values: 500, 3,500 and 10,000 ohms/square per mil thickness, and they can be blended to give a range of intermediate values.

Du Pont Resistor Compositions are easy to apply... may be brushed, dipped, screen-printed or sprayed. Surfaces can be fired under normal atmospheric conditions in the 1100-1400°F range.

Printed resistor patterns and coated rods have abrasion and impact resistance similar to fired silver coatings and show only small variations in resistivity under humidity, overload, temperature and voltage conditions as typical laboratory data show:

- Temperature coefficient: \(350 \text{ ppm/°C} \) from -55°C to +125°C.
- Voltage coefficient: Less than 0.02%/volt, negative.
- Humidity exposure: \(1\%\) change after 250 hr. @ 95% relative humidity.
- Overload: \(0.5\%\) change with standard short-time overload.
- Temperature cycling: \(1\%\) change after 5 cyclings from -55°C to -125°C.
- Load life: \(2\%\) change after 1,000 hr. at 70°C at full load.

Fired samples are available for your own evaluation. Request them on your letterhead, indicating application you have in mind. Complete technical information will also be sent. Write: Du Pont, Electrochemicals Dept., Ceramic Products Div., Wilmington 98, Delaware. Du Pont does not manufacture resistors... produces only resistor compositions and other high-quality conductive coatings: gold, silver, platinum and palladium.
Subminiature pulse transformers—
Only 6 times larger than the head
of a pin . . .
JAMES MILLEN MFG. CO., INC.
MALDEN
MASSACHUSETTS

CIRCLE 230 ON READER SERVICE CARD

ALL OF THE EQUIPMENT, FACILITIES & SYSTEMS OF THE
$20 MILLION
SOUTHERN CALIFORNIA COOPERATIVE
WIND TUNNEL
TO BE SOLD AT
PUBLIC AUCTION
TUES., DEC. 13 & WED., DEC. 14 at 9:30 A.M.
Inspection Daily to date of sale
AUCTION TO TAKE PLACE ON THE PREMISES OF
COOPERATIVE WIND TUNNEL
950 SOUTH RAYMOND AVE. • PASADENA, CALIF.

The Southern California Cooperative Wind Tunnel, located at
950 South Raymond Ave., Pasadena, California, was modernized
in 1956 for testing, analysis, and solution of problems which are a
part of the development of High Speed Aircraft and Guided Missiles.
Typical testing included North American Sabre Jet, and Super
Saber; Lockheed F-80 and F-94; McDonnell Banshee and Voodoo;
Douglas's DC-6, DC-7, DC-8, and X-3; Convair's F-102 and B-58.
In the field of missiles are the "Corporal", " Honest John", "Nike", " Navajo", " Sparrow", and "Hermes."

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In Lots to Suit Buyers Convenience. Formerly owned by
CONVAIR • DOUGLAS AIRCRAFT CO., INC. • LOCKHEED AIRCRAFT
CORP. • MCDONNELL AIRCRAFT CORP. • NORTH AMERICAN
AVIATION, INC.
Formerly operated by CALIFORNIA INSTITUTE OF TECHNOLOGY

AUCTION SALE

POWER PLANT EQUIPMENT • AERONAUTICAL SYSTEMS
ENGINEERING EQUIPMENT • GENERATORS & TRANSFORMERS
LABORATORY EQUIPMENT

• 40,000 HP Steel Wind Tunnel, Supersonic, Transonic, Subsonic Carts
Tunnel Weight Approx. 2500 Ton, 210 ft. long, 39 ft. max. diam., with
accessory components
• 20,000 / 16,000 HP Fan Motors
• Wind Tunnel 6 Balance System
• Main Drive Systems, 3200 / 10,400 HP A.C.
• Generator Power Plants up to 1200 KW
• Variable Frequency Model Power Systems to 400 KW - 0 - 450 Cvc.
• Low & High Pressure Air and Vacuum Compressors to 7500 C.F.M.
• Kathabar 4 Stage Air Dryer System
• Force Data Metering System
• Schlieren System 16° Diameter Field
• B. J. Emery Readout System
• Laboratory Test Data and Observation System & Equipment
• Motors up to 1500 HP A.C. • Transformers up to 25,000 KVA
• Westinghouse Metal Clad Switch Gear
• Cooling Towers and Pumping System • Replacement Parts
• Modern Machine Shop, late type Precision Tools
• Bridge Cranes to 12 Tons • Maintenance Equipment
• Fire Equipment • Plant Equipment and Offices

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or Mr. William Sassen, Auctioneer Representative on the premises.
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measure rf to 1000 mc without replacing plug-ins

It's all here in two easily-movable cabinets—a digital frequency-measuring system of wider range and lower price than any comparable equipment on the market. The counter in the top cabinet measures all frequencies from 10 cps to 10 Mc. Heterodyne converters—added to the bottom cabinet as you need them—extend range to 110 Mc, 220 Mc or 1000 Mc. • This provision for expanding the system simply and economically makes the equipment a wise long-term investment. Buy only the range you need now, rest assured that you can cover higher frequencies whenever need arises. • Accuracy is .00004% or better from 1 Mc to 1000 Mc. Sensitivity is unequalled: 2 mV from 10 Kc to 10 Mc, 10 mV to 110 Mc, 20 mV to 220 Mc and 1 mW to 1000 Mc.

WRITE FOR DETAILED TECHNICAL BULLETINS ON MODEL 7570 SERIES

Beckman® Berkeley Division Richmond, California

November 25, 1960
Southeastern Michigan's Scientific Climate—where the electronics industry can best grow. Basic to the electronics industry are the technical skills and experience of capable men and women—those adept at developing, producing and testing intricate equipment. In this respect Southeastern Michigan has the advantage. Here is plenty of skilled manpower to produce complex and sensitive missile guidance computers, data processing systems, communication equipment and the like.

Southeastern Michigan possesses other resources of prime interest. Respected universities are nearby. Their proximity and reputations encourage graduate work. They make staff members available as industrial consultants; undertake on-campus research and development for industry.

Many communities in the area have comprehensive land use plans, industrial subdivisions, non-profit development corporations. In short, there are very tangible reasons why Southeastern Michigan offers an excellent environment for electronically oriented firms.

Plant location is one of our special interests. May we suggest that you write to us—Plant Location Service, Area Development Division, Detroit Edison Company, Detroit 26, Michigan.

Detroit Edison
New, tri-dimensional packaging and interconnecting of modern electronic functions.

Here is simplicity from start to finish . . . the most complicated designs worked out on AMP-MECA’s graph layout sheets in hours rather than days or weeks . . . finished modular construction that’s “building-block” easy . . . extreme reliability and complete resistance to shock and vibration.

Electronic functions are encapsulated for complete throw away or functions are assembled in open base cells for individual component replacement. Easily replaced, pluggable AMP-Cells work independently of or in harness with each other when programmed into AMP’s 3-D circuit boards.

Available in 0.1” or 0.2” grid systems, AMP-MECA offers tri-dimensional flexibility—cells can be made larger or smaller—stacked, spread or lined-up in unlimited scope to accommodate your design needs. And production can be set up to fit your goals . . . by hand, or by programmed automation.

Learn how AMP-MECA can make it simple for you. Send for the full story on simplified interconnection of circuit functions and information on prototype assembly kits.
The entire world recognizes the success of the Tiros—the world's first weather observation satellite. We are proud that the superior performance of Allen-Bradley composition fixed resistors contributed significantly to the more than 22,000 television pictures of the earth's cloud cover obtained from the Tiros. The highly complex electronic systems within the satellite and the vast array of associated ground equipment used strictly standard Allen-Bradley Type EB (1/2 watt) and Type GB (1 watt) composition resistors.

Allen-Bradley fixed and variable composition resistors—made by A-B's exclusive hot molding process—have never experienced catastrophic failure in service. Make certain of this same measure of reliability and superior performance in your electronic equipment—always insist on Allen-Bradley quality electronic components. For complete information, send for Publication 6024, today.

The Tiros Satellite
Watches the Earth's Weather
From 400 Miles High

ALLEN-BRADLEY HOT MOLDED RESISTORS WERE SELECTED—BECAUSE OF THEIR TIME PROVEN RELIABILITY.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wisconsin

In Canada: Allen-Bradley Canada Ltd., Galt, Ont.
EL84 6BQ5

high slope output pentode

Output pentode rated for 12W anode dissipation, primarily intended for use in a.c. mains operated equipment.

characteristics

\[
\begin{align*}
V_A & \quad 250 \quad V \\
V_{CE} & \quad 250 \quad V \\
I_C & \quad 45 \quad mA \\
I_E & \quad 5.5 \quad mA \\
V_A & \quad 7.3 \quad V \\
g_m & \quad 11.3 \quad mA/V \\
r_h & \quad 38 \quad k\Omega
\end{align*}
\]

SUPPLIES AVAILABLE FROM:
IN THE U.S.A.
International Electronics Corporation
81 Spring Street, New York 12, N.Y.
Worth 6-0790

IN CANADA
Rogers Electronic Tubes & Components
116 Vanderhoof Avenue, Toronto 17, Ontario.
Hudson 5-8621

Mullard ELECTRONIC TUBES

BRITAIN'S FIRST CHOICE FOR FIRST EQUIPMENTS

MULLARD OVERSEAS LTD, MULLARD HOUSE,
TORRINGTON PLACE, LONDON, ENGLAND

November 25, 1960
Highly Reliable

**HITACHI "SEMI-CONDUCTORS"**

For Industrial Use
Switching Transistors and Diodes

Hitachi semi-conductors provide the basis for the excellent capacity of the Hitachi Electronic Computer HITAC 103.
These 'Little Giants' Withstand Shock and Vibration

Micro-Miniature Ruggedized Continental Connectors

- Smallest size without sacrificing performance
- Available with 5, 7, 9, 11, 20, 26, 29, 34 and 44 contacts
- Reversed guide pin and socket for positive polarization
- Supplied in various molding compounds
- Available with hoods, screwlocks and shells

Continental Connector's Series MM22 precision micro-miniature connectors simplify interconnection of compact sub-assemblies where space limitations demand the smallest components and highest reliability.

**Electrical and Mechanical Ratings**

<table>
<thead>
<tr>
<th>Voltage Ratings</th>
<th>Breakdown</th>
<th>Recommended Test</th>
</tr>
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<tbody>
<tr>
<td>At Sea Level</td>
<td>2400V. RMS</td>
<td>1600V. RMS</td>
</tr>
<tr>
<td>At 70,000 Ft.</td>
<td>650V. RMS</td>
<td>425V. RMS</td>
</tr>
</tbody>
</table>

Current Rating: 3 Amps
Minimum Creepage Between Contacts: 1/16"  
Minimum Air Space Between Contacts: .040"  
Contacts, Center-to-Center: 3/32"  
Pin Diameter: .030"  
Solder Cup: #22 AWG Wire

Technical data sheets on micro-miniature and other Continental Connectors are available on request. Specify your requirements to Electronic Division, DeJur-AMSCO Corporation, 45-01 Northern Boulevard, Long Island City 1, N. Y. (Exclusive Sales Agent.)

November 25, 1960
Gardner-Denver Wire-Wrap® roundup

Choose from Gardner-Denver’s complete line of hand-held “Wire-Wrap” tools and put your electrical connections on a 3-second production schedule. That’s all the time it takes to make a permanent electrical connection using the solderless wrapping method.

Proved superior by leaders in communications and electronics, these connections are lastingly secure, conquer vibration failure and corrosion. Only Gardner-Denver offers a complete line of equipment to make such connections, including...

**automatic “Wire-Wrap” machines** like the one at right. If you have a special problem in multiple operations of connecting wires, it’ll pay you to see Gardner-Denver first. Want details? Write for bulletins.

**EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW**

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario
The problem some people have is finding a good subminiature "on-off" relay that will work in their circuits — e.g., if it's really subminiature and sensitive enough, it won't take the surrounding vibration or shock ... or it may work under 30 g's to a couple of thousand cycles, but only on watts instead of milliwatts. Worse still, the relay "works" but not according to its specs, resulting in real system troubles. The possible combinations and permutations of these individual requirements can grow to agonizing proportions.

Here is a relay designed to tranquilize such agony. There is plenty of built-in safety margin to guarantee that it will work according to all the ratings published here, without any fudging. Power drain and heat dissipation are kept to a minimum by the small power requirements of the "33". And you don't have to give it more than the rated 100 mw. required, to be sure that it will always work. Calling it a "gang" may not be dignified, but if these are the specs you need in one relay, dignity is the least of your problems. The official designation is the Sigma Series 33.*

*This isn't the magnetic latching member of the family — that's the Series 32.
PERFORMANCE

Sigma Series 33 Subminiature Relay
(See reverse side for basic design & application data.)

SIGNAL "INPUT"—SWITCHING "OUTPUT" The "33" is a DPDT polarized relay with magnetic bias (Sigma Form Y): when the coil is abruptly energized by a signal of given polarity and sufficient magnitude, the armature transfers from its normally-closed position to its second position; signal removal returns the armature to original position. Required energizing power is 100 mw. (VG Adjustment), or 200 mw. (VW Adjustment). Contact load rating is 2 amperes at 28 VDC/120 VAC (resistive) for 100,000 operations minimum at +125°C, max., with standard silver contact material; gold alloy contacts are recommended and available for dry circuit applications. Contact resistance is 100 milliohms, max., after 100,000 operations at rated load.

ENVIRONMENTAL CAPABILITIES The "33" will not open its contacts, whether energized or de-energized, at 30 g to 5000 cps vibration or under shock and constant acceleration of 70 g for VG Adjustment, 100 g for VW Adjustment. All ratings apply over an operating temperature range of -65°C to +125°C.

TIMING CHARACTERISTICS AND THERMAL STABILITY of the relay are shown in the graphs, Figs. 1 and 2.

MOUNTING STYLES, CONNECTIONS, MECHANICAL DATA All series 33 relays are hermetically sealed in enclosures 0.80" x 0.40" x 0.90" high. Weight is approximately 18 grams, depending on mounting style and connections. Mounting styles available as illustrated: flange, side bracket or stud; connections: J-hook solder terminals, 9-pin plug-in or 3" wire leads. All connections spaced on 0.200" grid.

FOR FURTHER INFORMATION AND APPLICATION ASSISTANCE . . . write to Sigma, outlining in as much detail as possible your application, the relay driving and load circuits, and the required speed and rate of operation. We can then help you get the relay performance you want.

SIGMA

SIGMA INSTRUMENTS, INC.
14 Pearl Street, Sa. Braintree 55, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (SINCE 1939)
MICROMINIATURIZATION

By M. M. PERUGINI, Associate Editor, and NILO LINDGREN, Assistant Editor

Photo shows vapor growth of silicon crystals (IBM)

Component-Oriented Approaches
New Form Factors
Circuit-Oriented Approaches
Function-Oriented Approaches
Equipment and Systems
INTRODUCTION

Microminiaturization seems to be the answer to the next generation of engineering developmental problems—it promises high reliability, eventual low cost, and reduction in size, but much of this promise is yet to be realized.

FOR SEVERAL YEARS there has been much discussion of the need to make electronic components, circuits and systems orders of magnitude smaller. Many new names have been attached to techniques of making them smaller, but the name that seems most likely to stick is microminiaturization.

Microminiaturization is not aimed at size reduction for its own sake—rather, small size is inherent in solid-state technology, and solid-state technology plays a key role in present engineering development work.

However, there are also good arguments for size reduction in itself. Because today's systems have grown so fantastically complex, composed of increasingly large numbers of components, the reliability of these systems has become increasingly important; despite the fact that individual components are being produced to more stringent reliability standards, this greater component reliability has not offset the increasing probability of system breakdown. Various forms of microminiaturization promise greater inherent reliability, but to achieve this promise, a significant research and engineering development program is necessary. The electronics industry is now engaged in this program.

In many cases, the predicted inherent reliability of microminiaturization has not yet been proved. It is still too early. However, on the grounds alone that electrical components and systems can be made significantly smaller than existing components, it is argued, redundancy can be built into systems without any increase in overall system size, and this redundancy will increase reliability.

There are arguments against this stand—for instance, methods for switching standby circuits into action may be less reliable than the redundant circuits. Nevertheless, industry at large is convinced that microminiaturized systems will be more reliable.

EFFECTS ON INDUSTRY—Eventually, microminiaturized components, circuits and systems should cost less, because many microminiaturized forms lend themselves to automation and regularized fabrication techniques. However, the initial cost outlay to develop techniques and equipment is large. In many cases, only large companies have the capital to make such outlays.

Some idea of the cost of getting into microminiaturization is given in a Navy report: "As a very general guide line . . . it appears that small but meaningful research projects can be established for about $50,000 to $100,000 per year (2- to 4-man effort); experimental device development and application projects will cost between $200,000 and $500,000 per year; and the development of prototype equipment for an average sized system may run from $500,000 to $1,500,000 per year."

As more advanced microminiaturization methods take hold, the impact of microminiaturization on industry will be tremendous. From the same report quoted above: "The impact of microelectronics on the electronics industry, generally, is likely to be a profound and basic one. Its effects are not limited to a small class of devices but strike at the underlying manufacturing, fabrication, and assembly processes of electronic circuitry. The necessity of participating in this evolution is fully realized by both the industry itself and by cognizant government agencies. Even at present, with only vague lines of application apparent, the total investment in developing microelectronics is conservatively estimated at upward of 100 million dollars, of which at least 20 to 25 millions are directly furnished by government support."

GENERAL APPROACHES—Microminiaturization is taking many forms . . . almost as many forms as there are companies engaged in this work. Naturally, as in any new field, clear lines of direction are not yet evident, concepts have not yet fully crystallized; and considerable effort goes into defining and categorizing, and into inventing trade names, often as not for products not yet fully developed; in the early stages of microminiaturization, this tended to create confusion. In this survey, we are
Photographic techniques: Microcircuit layout is a twolayer plastic tape pattern on two transparent plastic wafers. The two wafers with patterns are photographed down to actual size. (In the case of Sylvania, shown here, final wafer size is ½ inch square.) Two photographic negatives are produced, one with the conductor pattern and the other with the vacuum-deposition mask pattern through which films will later be vacuum-deposited.

Novel packaging and interconnection schemes are being explored throughout the industry. Here is an experimental design by Arma for its guidance computer with circuit wafers mounted on flexible interconnection strip that is folded accordion-fashion into housing.

Surface Passivation: If there can be generated on the semiconductor surface a strongly bound chemical film layer that does not adversely affect surface electronic properties, and which lends to acceptable device characteristics, then hermetic sealing will not be required. Here, PSI's technique of surface passivating a mesa diode is indicated. Process involves substitution of various organic groupings into structure of oxide film, since oxide films alone have been found inadequate.

Sputtering: Metals may be vacuum-deposited on ceramic substrates by sputtering. Metal to be volatilized is made the cathode, and substrate to be coated is placed near and parallel to cathode. Grounded chamber is anode. After evacuation, high voltage is applied between the electrodes, and metal emitted from the cathode splatters onto substrate. Photo is from Bell Labs.

Electron and ion beam processing: Entire microelectronic circuits on semiconductor or other substrate materials can be produced by sequenced ion or electron-beam cleaning, heating and surface alloying operations and evaporation procedures, in high vacuum. Equipment here is used by CBS Labs. Inside bell jar is a fixture for holding the semiconductor crystal, evaporation sources for the deposition of surface layers and the two electron guns, one for large-area cleaning and heating and the other for fine-spot heating up to allowing temperatures. Electron-beam processing promises high resolutions.
starting with those approaches which, because they are relatively modest extensions of the state-of-the-art, have already been well-developed and are being applied, and follow with those approaches whose inherent sophistication requires greater development time—from a few years up to a decade or more.

Component oriented: Includes tighter packaging techniques using conventional components, miniaturization of conventional passive and active components, and miniaturization of hardware accessories.

New form factors: These are essentially component-oriented approaches, in which all components have a common form, such as shape, area or thickness.

Circuit oriented: Substrates containing circuits and subcircuits. Usually a one-to-one correspondence between circuit diagram and substrate elements. Generally, these are thin-film approaches.

Function oriented: Those approaches in which a single piece of semiconductor material is altered to get the desired functions. Includes approaches in which there is little correlation with conventional circuits.

Microminiaturized systems are discussed last.

GENERAL PROBLEMS—Approaches using individual components have the immediate advantages of not requiring large-scale developmental effort and of providing high production yields. Even with new form factors, where relatively more development is required for perfecting reliable components, smaller companies can be readily geared into production programs. But, component-oriented approaches yield lower packing densities than other methods and the number of interconnections required is high.

Circuit-oriented approaches, those that place circuits or subcircuits on a single wafer, feature high space efficiency, fewer interconnections and, generally, fewer processing steps. Whole circuits can be placed in a protective environment, and deposition methods can achieve better connections than those possible with soldering and welding. Before these advantages can be fully realized, however, adequate encapsulation procedures must be developed and stability of components and quality of the circuit must be assured. Subjecting each wafer to an entire series of process steps may decrease yields.

Function-oriented devices offer a significant weight and size reduction when compared to other techniques. Reliability of these devices should increase as connections are reduced and as surface protection techniques are improved. Actual producibility of wider classes of functions must be proved before these solid-state devices become satisfactory design tools. Economic production of these devices will not be obtained without further extensive research into techniques and materials.

Problems common to all microminiaturization methods have to do with heat dissipation, interconnections and signal interactions.

Because system packages are getting smaller and more tightly packed, it is difficult to remove the heat generated internally. This problem may be overcome by keeping signal levels low, designing more efficient devices, developing devices with low quiescent power and using heat exchangers.

As the size of components and circuits decreases, interconnections require a greater proportion of total space; less and less surface area is available for interconnections, yet input and output leads are still required. To solve these problems, designers are using flexible printed wiring, multilayer printed wiring, multilayer welded wiring matrices and multilayer deposited connections. In one case, even optical coupling has been proposed.

The means of making interconnections is presently a subject of much debate in the industry. Over thirty companies are using or investigating welding as an interconnection method. Other manufacturers insist that in many cases, such as when components are mounted between printed circuit boards, soldering is the most reliable method. The Air Force is currently making a comprehensive investigation into the applicability and reliability of welding in electronic systems.

The small separation of signal carrying paths in microminiature devices and circuits requires special attention to contact arrangements and geometries as well as to interconnections and high-frequency shielding. Even conventional circuits must often be redesigned.

In the scaling down in size of electronic components, large values of inductance and capacitance are hard to obtain. These problems are being circumvented by designing circuits that do not require such large values. Research is going into new methods of making inductors and capacitors with semiconductors and thin films.

Many manufacturers produce active devices mounted in microminiaturized hermetically sealed cans; but now controversy centers on the standardization of the size and shape of these cans. Efforts to reduce size even further by surface passivation techniques are being pursued; diodes have been successfully surface passivated. Transistors, apparently, still present some problems.

REFERENCES


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microminiaturization

Transistor amplifiers with three (A), four (B) and five (C) transistors are used in Dictograph's Acousticon hearing aids

COMPONENT-ORIENTED APPROACHES

Equipment and system builders must make use of presently available components, yet their approaches must be flexible enough to incorporate advances in all other fields of microminiaturization.

SYSTEM PLANNERS today cannot wait for breakthroughs in microminiaturization to help them solve their problems. Systems must continue to be designed, and they must be built with available components. Such systems should have the flexibility to incorporate advances in components and other fields of microminiaturization. Approaches having these capabilities and some of the conventional components used with these approaches are covered in this section.

WELDING APPROACH—A recent trend in system packaging is to use welding for interconnections. The high-density packaging technique shown in Fig. 1 features an overall package design based on a specific study of the system to be miniaturized. The technique uses encapsulated throw-away elements composed of mutually supported components connected by resistance-welded conductors. Multiple layers of encapsulated interconnecting or back panel wiring interconnect modules.

In the encapsulated elements, most of the components are arranged with their leads parallel to each other and with their bodies packed closely together to provide mutual support. Mylar film with accurately punched holes for locating each component lead are used at both ends of the components. Long components are turned on their sides and their leads welded to wires parallel to the rest of the component leads and extending through the positioning films. To make circuit connections, nickel or copper ribbon is welded to the component leads directly above the positioning film. In circuits requiring a large number of connections two levels of wiring are used. Prewelded wire matrices may be used for one or both layers of wiring.

Heat-producing components are cemented in aluminum heat-transfer blocks. These blocks provide a conductive path through the potting compound to the surface of the elements. Heat is picked up at the surface of the element by aluminum foils located between the elements. These foils are connected to the frame of the assembly or to cold plates that can be cooled by air or by other means.

An encapsulated wiring module interconnects the elements by wire-wrap terminals. (For applications where modules will not be disconnected more than 4 to 6 times interconnections are made by welding.) The wiring module also serves as a termination for cables to other parts of the system. The wiring module is a multiple pin, female connector with self-contained wiring. The self-contained wiring has prewelded metal ribbon ma-
traces laid between the terminals. These matrices are stacked one above the other within the connector.

Cable connections to other units are handled in two ways. One technique is to lay single conductors from a flat cable in the same channels occupied by the nickel ribbon matrices and to provide a grommet or cable clamp where the cable leaves the encapsulated module. A more flexible method uses nickel ribbon matrices to carry the signals to the outside edge of the wiring module where a second set of wire-wrap terminals connects to a matrix wiring unit.

This matrix wiring unit permits connections to adjacent units of a similar design without previous knowledge of the exact signal termination at the pins. If certain interelement connections are carried to this unit, a change in the interelement wiring may be accomplished by replacing the matrix wiring unit rather than the wiring module.

Since the elements possess high compressive strength and have rectangular form factors, they are normally designed with a mounting hole in the center for stacking. Stacks of four to nine elements are pulled in compression between plates by a stud through the mounting hole. These element stacks may be tied into a frame structure composed of aluminum plates, cold plates or honeycomb panels, depending on the size of the package and the thermal requirements.

Based on welding experience in vacuum-tube production, it is estimated that in assemblies each containing 700 welds, only 1 in 10,000 assemblies will be rejected because of bad welds.

**CHIP APPROACH**—The Macro-Module concept is said to miniaturize complete systems in such a way that problems of interconnection, heat, service, component availability and continuous updating are easily solved. Three features of the concept are: use of available components; constructing circuits in two dimensions, the system in the third; and including the heat exchanger within the construction. Advantages include: reduced bulk and weight, reduced wiring length and increased mechanical strength. Finally, the technique simplifies shipping, handling, maintenance and repair.

The chip is the basic component of the Macro-Module. It contains the smaller elements—resistors, transistors, capacitors—shown in Fig. 2 in the circuit pattern. These chips are integrated into the complete system as shown in Fig. 3. Progress in miniaturization of the chip will occur as advances are made in component miniaturization.

**MULTIPLE APPROACH**—One manufacturer has approached the packaging problem by two techniques: the multilayer laminate and the welded module. Multiple circuits used with multilayer circuit boards eliminate receptacles and increase the number of interconnections that may be made in the board. Figure 4 is the top view of a high-speed computer multiplier using this technique. The figure shows the in-line attachment of the individual modules to the multilayer circuit board. A transparent view of the multilayer board (Fig. 5) shows the many layers of wiring available for circuit interconnections and interconnections. A module is removed by heating each pin with a soldering iron and blowing the molten solder away with air. This can be done many times without damaging the laminate material. Elimination of connectors is one of the advantages of this technique.

The welded module allows much higher density than that obtainable with conventional two-dimensional construction. This method permits superior thermal cooling because liquid or forced air circulation can be used. Elimination of solder joints and their problems offers...
another advantage. In addition, thermal damage to semiconductors is eliminated.

Welded construction provides a flexible technique for interconnecting purchased components in a minimal volume, the limiting factor being the geometry of the components. Modules so constructed are usually restricted to use where a throwaway maintenance concept is dictated, since repair is difficult and often impractical.

**CUBES**—Republic Aviation's Missle Systems Division is manufacturing digital circuit elements in cube-shaped encapsulated modules. Interconnections within the module are accomplished by using two printed-circuit boards between which conventional pigtail components are mounted. Duplicate circuits on board surfaces of each printed-circuit board and plated-through holes are provided to improve reliability. Soldering is by flow-solder techniques. A thin rubber coating on critical components prevents damage from differences in expansion coefficients. Modules are molded in filled epoxy. Component leads are brought out on a 0.025-in. grid for module connections. Multilayer circuit techniques permit tight packaging of the modules. Conventional printed-circuit techniques can also be used. Among others, Diamond Ordnance Fuze Laboratory and Harman-Kardon are using techniques similar to Republic’s.

**OTHER PACKAGES**—Amp, Inc., provides, under the name MECA, plastic cells for modules. These cells have interconnection clips in the cell walls. Chips, wafers or standard components can be mounted within the cells. Cells are plugged into special mounting boards. The MICRAM approach, a joint venture of Aerovox, Cleveland Metal Specialties, Pacific Semiconductor, Raytheon and Sylvania, packages microminiaturized individual components in standard modules or in special modules to meet specific customer needs. Cambridge Thermionic Corporation is producing input-gate, bistable-multivibrator and level-trigger modules operating at 10 Mc. Representing a compromise of speed and reliability with cost and size, the units have a form factor of 0.75 in. × 0.635 in. × 0.75 in. They have been subjected to extensive testing—reliability checks on the multivibrator indicates a 0.7-percent failure rate per 1,000 hours at
90-percent confidence level. Packing density is in the order of 400,000 to 500,000 components a cubic foot.\(^{15}\)

**COMPONENTS**—The components in these packaging systems are getting smaller. Practically all the major transistor manufacturers have introduced miniaturized devices. A subcommittee of the EIA is attempting to establish geometries for both semiconductor and passive elements, hoping that these geometries can be the basis for future standards.\(^{18}\)

Recent advances in the semiconductor field include Motorola's use of a thin organic film to protect semiconductors and the development of epitaxial transistors. Dendritic crystal growth and applications of tunnel diodes are other areas of interest. Some manufacturers are providing uncased transistors for thin-film approaches. The outlook for making active elements using thin-film techniques is discussed under circuit-oriented approaches.

An example of smaller components are microdiodes and microtransistors. Figure 6 shows use of these devices in various methods of miniaturization. Pacific Semiconductors Inc. has recently completed life test on microdiodes made over a year ago. Results of 8,000-hour tests show that during the first several hundred hours the failure rate is relatively high but decreases to a constantly low level for the rest of the test. These higher initial failures are now being eliminated by a 200-hour 200 C burn-in period on all units.

Failure rate for these surface passivated diodes in storage- and operating-life tests are low. Rates vary from 0.01 percent per 1,000 hours to 1 percent per 1,000 hours depending upon the test and the definition of failure.\(^{19}\) Although these figures give some indication of the reliability of surface passivated diodes, there is no comparable data on surface-passivated transistors. It will be a year or two before there will be enough data on surface passivated transistors to establish any significant reliability figures.

Work is progressing in miniaturizing other components. Though these devices may seem large when compared to other miniaturized components, they represent effective use of volume for the job they must do.

**INDUCTORS**—Obtaining high values of inductance in a small volume is a difficult problem. Shielded r-f chokes 0.375 long with a 0.157 inch diameter cover a range of 0.01 to 56,000 \(\mu\)h. The small size results from reducing the size of the core walls (Fig. 7), using different magnetic materials and by employing a duolateral winding technique.\(^{20}\) The manufacturer of these inductors is tooling up to make inductors ranging to 0.1 henry in a 0.310-inch long by 0.125-inch diameter package. These units will use 1-mil wire for core windings. Theoretical analysis for still smaller devices has been completed. If these are practical to manufacture, they will have half the volume and twice the range of the 0.310 by 0.125-in. units.

Research by Varo Mfg. indicates the feasibility of making transformers and other inductive components by vacuum deposition.\(^{21}\) Pinhole-free dielectrics can insulate winding from magnetic materials, making possible closely coupled yet well insulated conducting films. One experimental deposited transformer has aluminum film windings of 150 ohms resistance and a measured inductance of 1 mh. Although Varo claims no conclusive results, increased research effort in this field seems warranted. The method outlined in Fig. 8 is used to obtain thin-film inductors.\(^{22}\)

Many attempts are being made to develop practical semiconductor inductors.\(^{19,10,20}\) These inductors can be used as components or can be integrated into the function-oriented approaches. Another approach to the inductance problem is to redesign circuits to eliminate the need for an inductive element.

**MEMORIES**—A significant reduction in the volume of memory systems using ferrite cores can be achieved by using continuous wire drive lines through memory planes and then folding the planes. General Ceramics claims a memory stacked in this manner will occupy as little as 2 percent of the volume of its conventional counterpart.\(^{23}\) A prototype of twelve 16 \(\times\) 16 planes, along with the heating element and controls needed to keep temperature of the cores constant, measures 2 \(\times\) 2 1/4 \(\times\) 2 1/4 in. Operating range is from -55 C to 125 C.

Other attempts being made to reduce memory size include the use of ferrite planes, thin films, twistors and
cryotron. One company is investigating the use of silicon whiskers measuring 1 mil in diameter by 10 mils long in a solid-state memory plane. Plans are to use these whiskers to form such circuit elements as linear resistors, capacitors and active devices such as tunnel diodes. The planar array shown in Fig. 9 will be used to stack these elements.

Circuit properties of these elements will be fed into a conventional computer. This computer will determine the interconnection scheme for a specific memory plane using the elements. A mask of these interconnections will be made by photolithographic techniques.

**DELAY LINES**—A delay line that makes use of the relatively good dielectric properties of many ferromagnetic materials to provide capacitors is under development. A section formed from a ferrite disk is illustrated in Fig. 10A. The print wiring is equivalent to a toroidal winding while the capacitors consist of the opposed metalized areas displaced by the thickness of the disk. In another approach miniaturized inductors are combined with two dimensional capacitor strips made from thin copper-clad Teflon. Overall dimensions are then governed almost solely by the total size of the inductors (Fig. 10B). The ultimate in this approach (Fig. 10C) is where inductors and capacitors are etched out of copper-clad Teflon. Sections may be arranged in linear fashion (potted dimensions for the 10-nanosecond, 50-ohm, 80-Mc delay line of Fig. 10C are $5 \times 1.5 \times 0.1$ in.) or stacked module fashion with thin ferrite shields between them. The manufacturer is also working on an approach to miniaturize long audio delay networks by using the apparent inductance of thermistors.

Wire sonic delay lines by GE presently have a maximum bandwidth of 1.25 Mc. Delay lines operating at one megacycle have been packaged in units as small as...
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microminiaturization

NEW FORM FACTORS

In some microminiaturization programs, conventional components are being redesigned to standardized forms. These programs aim at higher packaging densities, regularized fabrication techniques, possible automation and the encouragement of a broad base of participating companies.

IN ADDITION to methods for packaging circuits using conventional components, there have been significant developments in reducing discrete components, both passive and active, to a rigidly standardized geometry.

The micromodule program, one of the more extensive of such development programs, is sponsored by the U. S. Army Signal Corps. Prime contractor is the Radio Corporation of America. It has been conservatively estimated that the government is presently putting between $20 million and $25 million into microelectronics per year. Of this, nearly $15.4 million will by 1962 have gone into the Signal Corps micromodule program. Of this, $7.4 million will have gone into the development of microelements, $3.3 million into equipment and $4.7 million into production engineering measures.

This program was originally meant to work within the state-of-the-art of engineering and material development. To some extent, the work has gone somewhat beyond this. The program was also partially intended to spur industry-wide interest in microminiaturization. The thinking was that if a large sector of industry did not actively participate in such programs, then, like earlier approaches, such programs would fail. Some forty or more companies have had subcontracts in the micromodule program, supplying various types of components. Table 1 shows companies involved and the

November 25, 1960

FIG. 1—Layout of a typical microelement wafer, and same wafer with solder pads. This kind of wafer is the basic building block of micromodules.

FIG. 2—Microelements developed for micromodule program: trimmer capacitor from Centralab, range of 3 to 10 pf (A); ceramic filter (4.3 Mc) from Clevite Corp. (B); transistor from RCA (C); four microelement diodes mounted on single wafer, supplied by PSI (D); transistor package from Hermetic Pacific, Inc. (E); and (F) combination of inductor and ceramic capacitor (RCA).
components in which they have specialized.

The micromodule program is involved in five areas: development of a range of microelements, single components mounted on individual substrates of a standardized configuration; design and development of equipment and systems; development of a production capability, that is, processes, tooling and production techniques for large-scale production of a variety of active and passive microelements. These three areas of development are complemented by a program of dissemination of technical information, both within RCA and throughout industry.

A fifth aspect, not directly related to the micromodule development, includes advanced developments in integrated electronics, techniques which may yet be three to ten years away, but which conceivably would be compatible with the micromodule method (that is, mounting complete solid-state circuits on single micromodule wafers).

**MICROELEMENTS**—Building block for this method is a ceramic substrate 0.31 inch square and 0.01 inch thick (see Fig. 1).

Wafer substrates for microelements are made of ceramic or glass-base material, depending upon the electrical component built upon it. The twelve rounded notches in the edges of the wafer are terminals for the component and for the riser connecting wires that run vertically through the module. These notches are metalized and provided with solder pads. The index notch in the corner of the wafer is for orientation.

The microelements built on these wafer substrates include general-purpose, precision and tantalum-electrolytic capacitors, resistors, inductors (transformers and chokes), transistors, semiconductor diodes, piezoelectric crystals, as well as combinations of components. A number of multicomponent substrates have also been developed, such as the four-diode wafer shown in Fig. 2D. Some microelements developed by different companies for this program are shown in Fig. 2. Table II provides more detailed data on the microelement program. Latest reliability data on microelements appears in Components and Materials, p 138, of this issue of *Electronics*.

**BUILDING MODULES**—The method by which microelements are assembled into micromodules or circuit packages is shown in Fig. 3. Actually, two types of wafers have been developed, the notched, as shown, for insertion of interconnection riser wires that are soldered to the wafer, and a noteless design for connection by flat ribbon conductors welded to the connection points. Stacking of the microelements to achieve the best electrical characteristics, with spacing between wafers for electrical decoupling, results in the micromodule, a complete circuit package that can be sealed by molding or encapsulation to form a solid body resistant to environmental effects. Figure 4 shows how the individual module packages or subassemblies can be plugged into a printed-wiring board. Micromodules are specially adapted to

**TABLE I**—Components Participating in Micromodule Program (RCA—Surface Communication Div. in Lead Conductor)

<table>
<thead>
<tr>
<th>Component</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>Weston Instrument, Glass Products, Chicago Telephone Supply, Corning Glass, Centralab, Microelectronics, Mallory, Duven</td>
</tr>
<tr>
<td>Capacitors</td>
<td>Magnavox, Aerovox, Sprague, Mallory, C-D, Erie, Centralab, RCA</td>
</tr>
<tr>
<td>Inductors</td>
<td>ARF Products</td>
</tr>
<tr>
<td>Transistors</td>
<td>Philco, RCA, Texas Instruments, Rheem, Fairchild, Sylvania, Transistor</td>
</tr>
<tr>
<td>Power Transistor</td>
<td>CBS Laboratories</td>
</tr>
<tr>
<td>Transistor Package</td>
<td>Isotronics, Hermetic Pacific, Zell</td>
</tr>
<tr>
<td>Diodes</td>
<td>PSL, General Instrument, Hoffman Semiconductor, Transition</td>
</tr>
<tr>
<td>Crystals</td>
<td>Midland Mfg. Co., Union Thermolectric</td>
</tr>
<tr>
<td>Cores</td>
<td>Radio Cores, Polymer, RCA</td>
</tr>
<tr>
<td>Materials</td>
<td>American Lava, ACF Industries, Corus Porcelain, National Beryl, Lava, Ceramic for Industry, Kawai Chemical, Mitronics</td>
</tr>
<tr>
<td>Processes</td>
<td>RCA, General Instruments, Hoffman Semiconductor, Transition</td>
</tr>
<tr>
<td>Others</td>
<td>Sanders Associates</td>
</tr>
</tbody>
</table>

**TABLE II**—Catalogue of Micromodule Elements (Sept. 15, 1964)

<table>
<thead>
<tr>
<th>MICROELEMENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESISTORS</strong></td>
<td></td>
</tr>
<tr>
<td>Deposited alloy and metal film</td>
<td>10 to 100 kilohms, 150 v, 1/4 w per element or 1/2 w per wafer, temp coeff, 200 ppm per deg C; resistance tolerances, ± 1, ± 3, ± 10 percent</td>
</tr>
<tr>
<td><strong>CAPACITORS</strong></td>
<td></td>
</tr>
<tr>
<td>Precision, single layer</td>
<td>0.5 to 1000 pf; capacitance tolerance, ± 1, ± 3, ± 10 percent; 500 v dc; temp coeff, ± 0.2 percent; 50 pf to 1000 pf; capacitance tolerance, ± 1, ± 5, ± 10 percent; ± 0.2 percent; 500 v dc; temp coeff, ± 0.2 percent</td>
</tr>
<tr>
<td>Precision multi-layer</td>
<td>0 to 5000 pf; capacitance tolerance, ± 10 percent; ± 0.1 percent; 500 v dc; temp coeff, ± 0.1 percent</td>
</tr>
<tr>
<td>General purpose, single layer</td>
<td>0.01 to 50 pf; capacitance tolerance, ± 20 percent; ± 0.1 percent; 500 v dc; temp coeff, ± 0.1 percent</td>
</tr>
<tr>
<td>Multilayer</td>
<td>0.01 to 50 pf; capacitance tolerance, ± 20 percent; ± 0.1 percent; 500 v dc; temp coeff, ± 0.1 percent</td>
</tr>
<tr>
<td>Electrolytic</td>
<td>Solid tantalum up to 50 mf; capacitance range 0.1 to 30 mf; 25 v</td>
</tr>
<tr>
<td><strong>INDUCTORS</strong></td>
<td></td>
</tr>
<tr>
<td>Ferrite core</td>
<td>Inductance up to 1.5 mh for 4.3 Mc, 11 Mc and 60 Mc</td>
</tr>
<tr>
<td>Powdered iron</td>
<td>Inductance up to 1.5 mh for 4.3 Mc and 11 Mc</td>
</tr>
<tr>
<td><strong>TRANSISTORS</strong></td>
<td>Equivalent to: 2N706, 2N699, 2N119 and 2N697 are under development</td>
</tr>
<tr>
<td><strong>DIODES</strong></td>
<td></td>
</tr>
<tr>
<td>Group F. (1N277)</td>
<td>Low frequency rectifier—detector</td>
</tr>
<tr>
<td>Group G. (1N643)</td>
<td>Fast switching type</td>
</tr>
<tr>
<td>Group H</td>
<td>Zener reference type</td>
</tr>
<tr>
<td><strong>CRYSTALS</strong></td>
<td>Quartz 7 to 70 Mc range</td>
</tr>
</tbody>
</table>

**FIG. 3**—How the microelements forming a complete circuit are mounted and soldered on riser wires and then encapsulated to form a single plug-in unit (RCA)
printec-wiring board methods. Leads are indexed into holes and soldered into place.

**COMPLETED MICROMODULES**—Micromodule circuits or subassemblies that are commercially available include a large range of types. Some of these are: an autodyne converter stage intended for a-m receivers; single-stage 455-Kc i-f amplifier for a-m receivers; 455 Kc i-f detector stage for a-m receivers; single-stage low-level audio amplifier for radio receivers and other audio-amplifier applications; one half of a binary divider (a complete divider is made from two of these halves.

More recent module designs include gyro temperature controls, resolver amplifiers, counting pulse generators, reset blocking oscillators, compensation networks, double emitter followers, NOR gates, AND gates and bridge-T networks.*

**MULTICOMPONENT WAFERS**—Integrated electronic techniques are directed towards developing complete circuits that perform the functions of large numbers of discrete components. Figure 5, for example, shows an experimental adder circuit for computers.

Equipments and systems being developed to demonstrate the compatibility of the micromodule technique include a field computer and a helmet radio transmitter and receiver.

**COSTS**—In the design of micromodules, RCA stresses reliability, size and cost. Micromodular equipment now costs about two to one-and-one-half times as much as conventional equipment.†

**HUGHES MICROELECTRONICS**—Another scheme for standardizing electronic components to a single form factor is proposed by the Hughes Aircraft Company. Dubbed Microelectronics, this concept is based upon diodes, transistors, resistors and capacitors packaged within envelopes essentially 0.05 inch in diameter and 0.03 inch high.‡ These standardized components are mounted in a perforated circuit board. The components are contained within the board with interconnecting circuits carried on the two surfaces.

Figure 6A shows the relation of the components and circuits. The circuit, shown raised on the surfaces of the board, can be formed by evaporation, chemical etching or deposition. This method allows for freedom in the formation of passive components. They may be formed by film techniques on the board surfaces or inserted into the board as are the active devices.

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*Figure 6—Microelectronics format proposed by Hughes Aircraft Co.: method of assembly (A) of circuitry and components (B and C); and formation of a half flip-flop (D). Dark areas are connections.

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Diode and transistor construction is indicated in Fig. 6B. Diodes, resistors and capacitors have gold-clad end plates. Transistor construction is as shown, although in this approach, active components will also be supplied in other forms such as in Fig. 6C. As an example of the packaging capability of this approach, a single board measuring 0.04 × 2× 2½ inches can hold a full adder consisting of some eighty-five active and passive components spaced 0.1 inch apart.

An illustration of the relative simplicity of this form of circuit is shown in Fig. 6D. Here is the circuit of a half flip-flop on the top and bottom faces of the circuit board. This half flip-flop is one element of a larger circuit built to demonstrate the feasibility of this method. The larger circuit, a full adder is shown in Fig. 7.

A ramification of this approach is that the components are constructed with one face slightly magnetized, thus providing polarity discrimination for elements such as diodes and, additionally, providing a ready approach to automation of microelectronic circuits.8

**PELLET APPROACH**—Another approach is contemplated by the Mallory Company. They intend using pellet-shaped active and passive components inserted in a 62 mil base material. Component pellets will have dimensions of 100 to 250 mils in diameter, with length equal to the base material thickness, 62 mils. Interconnections are made with metal-filled paste, printed wiring and other methods. Connector pins are brought out from one side of the base material to provide subassemblies with plug-in capability. (See photos below.)

A number of resistors and capacitors in pellet form are under development. In full engineering production are two capacitors: RMC Discaps, 0.235 inch in diameter to 1 inch in diameter, 0.001 µf to 0.1 µf, with and without leads and coating; and tantalum slugs, 0.07 inch by 0.21 inch, encased, 1µf to 10 µf.

**TIMM'S PACKAGES**—A departure from other micro-miniatuization approaches is that embodied in the thermionic integrated micromodules. Although in this approach standardized component packaging is employed, transistors are not. Instead, small heaterless electron tubes are used, auxiliary cooling is eliminated and heat losses generated within the equipment produce thermionic cathode emission. The approach, known as TIMM's, has been developed by the General Electric Company. Figure 8 shows typical TIMM's packages, a multivibrator circuit and a double NOR circuit used in a computer. One fea-

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8. Refer to the original text for the full explanation of the approach and its implications. 

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ture of TIMM's is resistance to radiation.

Components in this approach are constructed from ceramic and metals (titanium and carbon). All components for circuit functions are exhausted and sealed in a vacuum at about 1,000 deg C, using metal-ceramic techniques now used in the manufacture of ceramic receiving tubes. Thermionic diodes, triodes, resistors, capacitors and inductors have been made by this technique. Figure 9 shows how circuits are built up from these modules. These circuits operate at a temperature of 580 C. Overall size of TIMM components is 0.32 inch in diameter; although some components are larger. Constructional features are shown in Fig. 10.

By operating at high temperature, individual heaters and thermal isolation associated with cathodes are eliminated. Titanium electrodes provide a continuously getter vacuum enclosure for both tubes and other circuit components. Once circuits begin operating, passive and active components generate enough heat to sustain tube operation with the circuit enclosed in an insulated box. Circuits are stable and reliable, rugged in construction, and radiation tolerant—devices have operated in an atomic reactor for 1,600 hours without deterioration. Transconductances up to 2,000 micromhos per ampere have been achieved at low plate voltages. Component density can be as high as 10⁶ parts a cubic foot.

Some difficulties with TIMM's appear in the area of capacitances and inductances—even using synthetic mica sheets in capacitors, only small capacitances have been obtained. TIMM's cannot be used across the frequency spectrum, so that their communications uses are somewhat limited. However, such disadvantages can be partially offset by circuit design.

Development of TIMM's, which started some four years ago, has now reached the point where a whole range of components is being produced. Life tests on resistors have been run out to 18,000 hours without their exhibiting significant change. Many subassemblies have been constructed, including many non-circuit logic arrangements. One system, a servo amplifier, has been designed, built, and is now being flight tested (see last section). A ballistic missile computer has also been designed and is now under consideration for use in a missile that has not yet been flown (see last section).

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Some of the laboratory operations involved in packaging pellet components, as practiced by P. R. Mallory & Co.

November 25, 1960
Thin film techniques are being used now to lay down only the passive portion of a circuit. Experiments point to the capability of producing both active and passive components in thin-film form.

A natural extension of form factor approaches, such as the micromodule, is to place circuits, subcircuits or functioning stages on a single wafer or substrate. Many companies are doing this with thin films. In these thin-film approaches there is usually a one-to-one correlation between the components in thin film and conventional form.

A typical method of producing these circuits is indicated in Fig. 1. The methods of laying down thin film are many and varied. Present technology allows film making by reactive deposition, evaporation, sputtering, photolithographic techniques, etching and many combinations of these. Work has been done with both active and passive substrates of various types.

Thin Film Technology—The literature on thin films is already vast, and the extent of research and development in thin films has been growing steadily. The reduction of components and circuits to thin-film form has as objectives: an increased reliability of these components and circuits, a significant decrease in size and (because thin films promise a high degree of automation in their fabrication) an eventual real cost saving in construction of complex equipment.

Many types of thin films are being developed—magnetic films, insulator and conductor films, superconductive films—but, to date, most components and circuits being reduced to thin-film form are still in the developmental stage. Real progress has been made. Manufacturers have not hesitated to push the work in thin films to the greatest of their capability, but it may yet be a few years before we will be seeing commercial-type equipment based on thin-film circuits as routine items.

Despite the magnitude of the technological problems involved in developing thin-film circuits, such circuits will be developed because the complexity of modern systems demands some such technological tool. Although some manufacturers are expending their biggest efforts on function-oriented approaches, they are working hard in the thin-film area too, for it is the common belief that functional devices that are reliable, reproducible and cheap are about seven to ten years away, and the thin-film approach is an excellent interim technology.

Vapor Growth—Growth of thin single crystalline layers of semiconductors from the vapor state may prove to be one of the most fruitful techniques yet developed in thin-film technology. Although not fully developed, vapor growth could be used in depositing active elements in thin-film circuits. However, many problems remain to be solved before its potential can be realized.

Many companies are working with vapor growth and many have had success (see function-oriented approaches). The methods of vapor growth have been well discussed recently in the technical literature. Although its role in the deposition of active elements directly into thin-film circuits is still far in the future, it has a high poten-
APPROACHES

FIG. 1—Exploded view shows how thin films are used by Intellux to make circuits. Commercially available active devices are connected to the thin-film circuit and the entire unit is hermetically sealed in glass.

FIG. 2—Circuit on 1/4 x 1/4 x 0.01-in. alumina ceramic wafer by Sylvania is 20-Mc binary divider. Wafer has glass-hat hermetic seal.

FIG. 3—Exploded view of module construction shows method of making interconnections (Sylvania).

One problem in building thin-film circuits on substrates of various sizes is interconnection. Substrate sizes must be decided upon, and methods must be fully developed for interconnecting the various subassemblies. The interconnection problem and substrate size are related directly to the maintenance problem. How much of a circuit is one willing to throw away when some portion of it ceases to operate? Or, how can one get the optimum reliability with reasonable cost? A larger substrate, presumably carrying a larger equivalent number of components, may be more likely to fail sooner than a smaller substrate with a smaller number of equivalent components. On the other hand, with smaller substrates, easily thrown away, the interconnection problem gets worse and reliability falls off.

FUNCTIONING STAGES—A common approach to thin films has been to have a functioning stage on an alumina substrate. In one approach a notched 0.5 x 0.5 in. wafer is used and each stage is hermetically sealed. After hermetically sealing, the individual stage can be treated as any sealed component.

Figure 2 shows a sealed wafer. To make sealing possible, a glass ring is fused around the edge of the wafer after the conductors have been laid down but before the circuit is made. After the circuit is made, a glass hat is fused to this ring at 1,200 F without adversely affecting the transistors. Fusing is accomplished by bringing an...
The Role Of DOFL

Industry-wide efforts in microelectronics have been influenced by the Signal Corps and the Diamond Ordnance Fuze Laboratories. The Signal Corps effort is discussed elsewhere.

DOFL's role has been seminal. It began work early in microminiaturization, it stimulated interest in the industry, it is working in all types of microminiaturization to remain competent to appraise industry results and it held a major symposium on microminiaturization in 1958.

Although DOFL has programs on all levels of microminiaturization, from tiny assemblies of minute commercial parts to functional networks, their major efforts in the past year have been concentrated on what they call the 2-D level. They have built linear-as well as digital circuits, have used most of the major techniques in the fabrication of their wafer-mounted circuits (photolithographic techniques, thin-film deposition using vacuum, chemical and screening methods, conductive adhesives, ultrasonic drilling and air abrasion to form substrates and devices), they have worked on interconnection and shielding problems of individual wafers to form subassemblies, and in conjunction with Sprague Electric they have been buying contract quantities of binary counter wafers to study circuit margins, manufacturing problems, and for evaluation of interconnection schemes. They are planning to construct a program timer with about 500 parts to make field evaluations of a digital system. They are also developing with 2D techniques parts of missile fusing and telemetry systems.

In another direction, DOFL has worked on producing large arrays of diodes on germanium wafers with good success using a variety of techniques and micro-handling equipment which it has developed.

REFERENCE
Private Communication, N. Doctor, Research Supervisor, Microminiaturization Branch, Diamond Ordnance Fuze Labs, Wash., D.C.
approach to thin-film circuits, one large transistor manufacturer started by redesigning its transistors, then moved on to the designing of the passive components. Choosing silicon as the semiconductor and using photolithographic techniques to make the devices, Philco decided to use bipolar transistors because of their relatively low power dissipation, ease of fabrication and adaptability to thin-film techniques.

In its general philosophy of approach, the firm is not concerned with standardizing substrate size or developing interconnection methods between substrates. Rather, it is developing larger circuit functions on single substrates with as many as 20 to 100 active elements in one system. It is approaching circuit synthesis using simple topological arrangements as well as coupling techniques, and it is considering circuits with a high degree of tolerance to component variation and low operating power levels needed for high speeds.

Philco fabricates circuits by using a thin layer of silicon on a ceramic substrate and forming isolated lumped constant components on this silicon by photolithographic techniques. One-sided transistors are made by this technique, silicon resistors are obtained by diffusion (common diffusion techniques are used for both transistors and resistors), conductors are formed from evaporated metal film such as aluminum, gold, silver and chromium.

COMPONENTS—Typical geometry for a 10,000-ohm resistor is a diffused area of 5 × 250 mils. Electrical properties of these components are closely related to the resistivity of the bulk silicon crystal, geometry being controlled by oxide masking and the reproducibility of diffusion. In separate studies, aluminum and tantalum capacitors have been formed on various substrates by anodization and oxidation of metallic films. This approach was favored over the diffused p-n capacitor because of the higher possible capacitance values per unit area that were attainable, plus a lower dissipation factor. Aluminum capacitors were more moisture sensitive than tantalum. However complete circuits ultimately will be hermetically sealed.

To demonstrate the feasibility of its approach, the manufacturer fabricated a number of bistable silicon flip-flops on substrates measuring 0.375 in. square and 0.03 in. thick, tested them in a complemented binary counter, and found that they operated satisfactorily. Switching times indicated a maximum input rate of 0.5 Mc.

TUNNEL DIODES—In addition, Philco has built scaler or counter circuits using arrays of tunnel diodes on a single substrate, building arrays of as many as nine diodes. With further development, using gallium arsenide tunnel diodes, the company expects to produce scalers that will count reliably at 2.5 Mc. Other programs under investigation include thin-film memories and tunnel-diode memories. In these programs, they are aiming at developing design techniques that will allow fabrication of devices in array form.

MULTILAYERED STRUCTURES—A method that aims at carrying the design of circuits to the system level and which aims at achieving extremely dense interconnection networks relies on multilayered structures of thin films. Work done at IBM on multilayer vacuum-deposited interconnections shows promise at achieving these aims. Six different circuit types for switching and communication applications have been fabricated using multilayer films as the resistive, capacitive and inductive networks. In these networks, unencapsulated transistors were at-

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**Characteristics of Thin Film Resistors**

<table>
<thead>
<tr>
<th>Component</th>
<th>MIL-R-11</th>
<th>MIL-R-10509C Characteristic B</th>
<th>Thin Film Resistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°C Load Life Time</td>
<td>1,000 hours</td>
<td>1,000 hours</td>
<td>750 hours</td>
</tr>
<tr>
<td>Avg. Percent Change</td>
<td>6</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Short Time Overload</td>
<td>2.5 percent</td>
<td>0.5 percent</td>
<td>0.09 percent</td>
</tr>
<tr>
<td>Temperature Coefficient</td>
<td>625 to 1250 ppm/C</td>
<td>500 ppm/C</td>
<td>150 ppm/C</td>
</tr>
<tr>
<td>Voltage Coefficient</td>
<td>0.02 percent/volt</td>
<td>Not Required</td>
<td>0.0014 percent/volt</td>
</tr>
<tr>
<td>150°C No Load Time</td>
<td>130°C 1,000 hr</td>
<td>1,000 hours</td>
<td>1,000 hr</td>
</tr>
<tr>
<td>Avg. Percent Change</td>
<td>6</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*The percent change is a function of film resistivity and power loading per unit area.*

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tached to the waters by thermocompression bonds.

In this fabrication process, thin glass substrates measuring 0.6 inch by 0.6 inch by 0.02 inch are coated in vacuum with alternate patterns of conductors and insulators. Nichrome is used for resistors, silicon monoxide for insulation and aluminum for conductors. These conductors and insulator materials are heated until they evaporate. Substrates are maintained at a lower temperature than the material source so that the evaporant condenses upon it. Thus, there is formed a multilayer structure to which a variety of devices or circuits can be connected without feedthrough pins, plated holes or jumpers.

This kind of fabrication method promises to lend itself to low cost, automatic production not only of passive elements and circuits and a variety of microminiaturized bulk elements, but be compatible as well with the deposition of active elements by vapor-growth methods.

PROCESS—The fabrication process consists of eight steps: (1) Layout topology, based on the geometrical capabilities of the deposition process, taking into account distributed effects, the end result of which is a set of masks as seen in Fig. 4. (2) Mask fabrication by such techniques as photoetching, are erosion and milling, holding close tolerances. (3) Substrate preparation: as in all thin-film processes, careful substrate preparation is important for high yields. Substrates are screened for imperfections, chemically and ultrasonically cleaned, and then stored in isopropyl alcohol. The final and important step in substrate preparation in the IBM process is to vacuum-deposit an undercoat of silicon monoxide. (4) Conductor deposition: on the prepared substrate are laid down the interconnection lands of aluminum. Although copper and gold can be used for conductors, aluminum is used because it is most compatible with silicon monoxide. Conductor thickness can be between 5,000 and 50,000 angstrom units. (5) Insulator deposition: insulator deposition has been a key problem in multilayer depositions. Silicon monoxide and silicon dioxide are used. Gaps in the insulator films allows for conductive connections between layers. (6) Additional conductor and insulator layers: additional layers, as shown in Fig. 4, are deposited through successive masks. The final insulating layer of SiO covers the entire structure with the exception of the land areas to which other circuits or active devices are attached. (7) Device and circuit connections. Fig. 5 shows the connection plate. The raised cubicle areas represent the built-up circuits which have been fabricated by the multi-layer process. Once these multilayer circuits have been tested, they are attached to the connection plate by soldering, conductive adhesives, or thermal compression bonds. Figure 5 also shows a series of test joints made by the solder reflow process. Pretinned land areas are placed in contact with pretinned lands on the raised circuit blocks, and the entire assembly is baked briefly in a vacuum oven until the solder fillets reflow. (8) Installation of outer package: final packaging is dictated by the application—this could range from a conformal coating to hermetic sealing of the total assembly in a container.

ACTIVE SUBSTRATE—In many thin-film approaches only the conductors, resistors and capacitors are deposited. The active elements such as diodes and transistors are subsequently attached. Litton has developed positive and negative coefficient thermistors as well as diodes and rectifiers in a barium-titanate substrate. It is possible that with further research passive and active components may be developed into one unit.

With a barium titanate substrate, only three depositions are required to achieve an operational circuit. Inactive substrates require four to eighteen depositions for the same circuit. The peculiarity of the titanium atom of a crystal of barium titanate in reacting to vibration with reproducible characteristics is expected to be useful in computer memory applications.

How Lockheed Builds a Bandpass Amplifier

The fabrication of this amplifier was not complicated by elaborate mechanisms or automation. The conductive patterns were deposited using a sequential evaporation of copper and then indium onto an American Lava T-172 substrate. The substrate was then removed from the chamber and the external connections and the transistors were attached. The assembly was replaced in the chamber and the necessary electrical connections were made between the circuit and the external test equipment. A typical NRC vacuum system was used and the evaporation was from tungsten boats. Nichrome was used for the resistive material.

REFERENCE

An incoming pulse stimulates the titanium atom to be displaced in proportion to the vibration level, altering the polarity in the crystal, which generates an electrical signal similar to unbalance of a bridge. Readout is binary 1 or 0, depending on the polarity, which is a function of the original pulse.

This technique has the advantage of retaining polarity for long periods. In practice the polarity (and the binary symbol) will be retained until subjected to a new electrical pulse. Actual period varies with temperature, but it is as high as 25 years at 0°C.

Another crystal vibration memory application is in remembering the phase of the electrical current until a current with a new phase is applied. Because a resonance is established and maintained, the power requirement is reduced. This phase reversal method of providing a binary indication is used in the parametron computer.

OTHER EFFORTS—An R-C coupled i-f amplifier using mesa transistors and thin film passive components has been built by Motorola. Although making a major effort in combining thin film and semiconductor technologies, Motorola is also studying the function-oriented approach. Haloid-Xerox is working with etch-formed circuits. In this approach layers of materials are evaporated without using masks. Then etching and etching form the R-C pattern. Active elements are mounted on end plates that connect the R-C wafers.

Within one or two years Lear expects to be able to deposit active elements as well as passive components. Presently they are evaporating passive components and attaching uncased transistors in their thin-film work. Magnetic thin films have promise as computer elements because of small size, switching speeds obtainable, low power requirements and high reliability. Honeywell Research Laboratories have investigated the intrinsic and the functional characteristics of these films. Fabricated films now vary less than 10 percent in thickness within batches or from batch to batch, permitting mass production of identical circuits.

EVALUATION OF THIN FILMS—Although much has been published recently on methods and approaches to reducing the size of electronic assemblies, and although much stress has been given to reliability, little, as yet, has been published on the actual performance and reliability of such assemblies. One of the first such definitive papers was presented at the 1960 Electronic Components Conference in Washington, D. C. on May 11, 1960, by the International Resistance Co. The general approach by IRC has been to build thin-film circuits on thin glass and ceramic substrates by laying down passive components by vacuum deposition. Active components are secured from other manufacturers and mounted into the IRC, so-called mu-circuit. Micro-cased and uncased transistors have been used. IRC has not pursued the interconnection of their substrate assemblies to completion, although a number of interconnection schemes are being explored. However, they have made environmental and life tests on their thin-film resistors. Figure 6 shows some of the results.

The table compares thin-film resistors with MIL specifications. These resistive elements were designed to show results under maximum thermal stress to demonstrate the maximum range of resistivities and power levels that could be used. Resistive films used in these tests have protective coatings. In its report, the firm concludes that elements consistent with MIL-R-10509C requirements can be produced.

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Potential of the Crossed-Film Cryotron

The present generation of digital computers is made of transistors, cores, etc., that are individually wired. The development of the crossed-film cryotron, which makes it possible to deposit simultaneously large arrays of switching and storage elements, together with their interconnections, at negligible cost. CFC's have been operated for both switching and memory and are far simpler to fabricate than either the existing semiconductor or magnetic devices.

The photograph shows two views of a CFC shift register compared with a stained section from the brain of the cat. This demonstrates that the separation in one dimension between active cross-overs of the shift register is already comparable to the separation of nerve cells in the cat brain. The component density of this shift register is of the order of 18,000 active elements per square foot. Because the d-c dissipation of a CFC is only a few microwatts, it should be possible, using the attained component density of 18,000 per square foot, to fabricate computers containing more than one million elements in a one-foot cube of liquid helium, with a total average dissipation of less than one watt.

Used as amplifiers, CFC's of the low dissipation type which can readily be produced in large arrays with good yields have operating speeds of the order of 1 Mc. Operating at this speed, it is estimated that CFC systems of moderate cost and physical size will outperform even the fastest and largest existing computers, because of the large number of virtually cost-free CFC's which can be used in a given system.

Moreover, in the area of gigacycle computers, it appears that CFC's or some other type of superconducting film arrangement will prove to be the best component for use in a random access memory.

Because of all these attractive features, we may confidently expect that in the next few years several types of superconductive data handling systems will come into use.

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General Electric Research Laboratory

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FUNCTION-ORIENTED APPROACHES

Semiconductor crystals that are altered to perform required circuit functions offer high parts density. Look at one future microminiaturization method shows return to discrete vacuum devices

IN FUNCTION-ORIENTED APPROACHES, the individual circuit elements become difficult to distinguish. Making a direct comparison with a conventional circuit becomes more difficult and less important as these functional devices or circuits become more sophisticated. In many cases attempts are made to correlate these functional devices with conventional circuits because there are no simple procedures to translate a circuit into a functional device by other means.3

A major effort is being made to fabricate the equivalent of a complete circuit on or in blocks of semiconductor material. Generally, conventional transistor processing techniques can be used to make these semiconductor devices. Manufacturers are combining oxide masking, diffusion, metal deposition, alloying, electron-beam machining and surface shaping to produce single-crystal semiconductor wafers.

TOOLS—Structures that are incorporated into these functional devices range from some simple ones that have component counterparts to those that perform functions that have no correlation to the circuit being re-
between coupled capacitance components.

**FIG. 1—**Semiconductor is modified to provide resistor (A), R-C network (B) and phase shift network (C). Unipolar transistor used for gating (D) and to get direct coupled logic (E). Darlington amplifier (F) and fourlayer diode oscillator (G) are more complex functions placed. Figure 1 shows some typical structures. A resistor (Fig. 1A) is formed by diffusing antimony into a p-type block to obtain a thin skin of n-type, low resistivity silicon. Because the substrate-to-skin resistivity ratio is greater than 100, the thin slit shown isolates the region that has leads. Typical slotting methods include: fine diamond sawing, sandblasting and etching through photoresist masks. Leads are attached by furnace fusion, welding and thermocompression bonding.

Attaching metallic areas to each side of the diffused junction gives the circuit shown in Fig. 1B. Capacitance and resistance vary with the applied voltage. These variations can be useful in some applications. The configuration of Fig. 1C results in a deviation from discrete components. This phase shifting and low-pass filter has capacitance and resistance distributed through the block.

**UNIPOLAR TRANSISTOR**—Properties of the unipolar transistor can be used to obtain gating action as shown in Fig. 1D. The cut in the p-layer extends close enough to the depletion layer region so that when reverse bias is applied the resistance between points 1 and 2 is high. With zero bias this resistance is low. Thus, the bias on the n-p junction gates the path between 1 and 2.

This concept can be extended to obtain the direct-coupled logic of Fig. 1E. The top slots form a resistor between the unipolar transistors. If none of the gates is biased there is a signal path from 1 to 2. If one or more of the gates are strongly reverse-biased no current will flow from 1 to 2.

The Darlington amplifier circuit (Fig. 1F) can be constructed from a solid block. A metal electrode on the p-region forms the collector connections. Base areas are provided by a metal that forms an n-connection with the n-region. The transistors are completed by a p-alloy junction to the n-region. Transistors are connected by allowing the p emitter of Q1 to fuse at one point to the n base of Q2. This simplified illustration omits temperature compensating resistors and coupling capacitors. These can be included to get more stable operation with temperature variations.

A block that has little analogy to the circuit it replaces is the four-layer diode oscillator of Fig. 1G. With the load resistance shown by the dotted line, the circuit will have two stable states. Using a higher load resistance (R) the circuit will oscillate with a sawtooth output. Output frequency is a function of the applied voltage. These devices can be incorporated to provide more complex functions.

**TRANSLATING CIRCUITS**—Although comparison between the more complex semiconductor network and conventional circuits are best made on a functional basis, it is possible to translate a circuit into its equivalent semiconductor block by relating known circuit elements to conductance paths in the semiconductor. One procedure for making a circuit semiconductor begins with the circuit shown in Fig. 2A. This nor circuit has one transistor, four diodes, three resistors and one capacitor.

Resistor-capacitor combination R, and C are changed to a distributed R-C network as indicated in Fig. 2B. Since the voltage applied to C does not change polarity, a p-n junction capacitor can be used. Resistivity of silicon can be used to form the resistors. Using 2-mil thick 10 ohm-cm silicon, resistor R, needs an area of 10 by 20 mils, Rs requires 10 by 50 mils and Re 10 by 10 mils.

Resistors and other components are arranged as shown in Fig. 2B. A starting wafer of n-type silicon (Fig. 2C) forms the transistor collector region, the resistors and the cathode of each diode. A layer of p material is then diffused to provide the transistor base region, the
anodes for the diodes and the capacitor over $R_4$. An $n$-type diffusion is required for the emitter region. These steps are typically applied to a 210 by 440-mil silicon wafer. After the contacts are deposited, this large wafer is separated to form 16 complete NOR circuits. As a final step, input and output connections are provided and internal jumpers attached. Jumper connections are made with thermally bonded gold wires.

**CUSTOMER NEEDS**—Although it sells Solid Circuits from stock, the majority of Texas Instruments' present efforts have been directed to the designing and fabricating semiconductor networks to meet specific customer requirements. They feel custom designing is one of the characteristics of the function-oriented approach. Functions delivered to date have been principally in the digital field. These include such functions as bistable multivibrators, logic elements, gates, inverters, and buffers. All of these have been made from silicon and have been encased in a hermetically sealed package.

To establish production capabilities, TI is reducing to practice an orderly design approach; has established a pilot line that has been operating consistently for the past few months; has decided on a definite package form factor (this is a hermetically sealed enclosure); and is investigating various means for interconnecting networks. Additional catalog items will be released during the coming months. These will be in the area of digital circuits. The company has no immediate plans to market analog or bandpass devices.

**FUNCTIONAL BLOCKS**—Using design criteria that a single piece of semiconductor be used, that no wires connect parts internally and that there be no cementing of parts, Westinghouse has developed 18 different types of functional blocks.

In April of this year Westinghouse completed a study for the Air Force. The possibility of using functional blocks in a uhf receiver, telemetry system, reconnaissance system, adaptive flight control system and an infrared application where studied. Second phase of this $2.3 million contract is to deliver, by Oct. 1961, the following: a 250-Mc superhet receiver using functional blocks from the i-f section on, and telemetry and reconnaissance systems with key functions using functional blocks.

In producing the blocks three basic structures are used: alloyed structures, base diffused structures and double-diffused oxide-mask structures. Figure 3 illustrates the substitution of functional block in an audio amplifier. The low-level and high-level amplifiers of Fig. 3B replaces the 4-transistor amplifier in Fig. 3A.

**LOGIC FUNCTIONS**—Fairchild Semiconductor combines the characteristics of several transistors in a packaged element. Presently a JEDEC TO-5 package with eight leads is used, future plans call for a TO-18 can. Elements developed include: buffer, flip-flop, gate, half-adder, counter adapter and half-shift register. Work is underway on other micrologic elements. Techniques used in diffused mesa transistor operation are employed to make these elements. Interconnections of elements are made by using a printed-circuit board.

A 1,000-element 7.5 Mc computer requires 0.15-cc with an infinite heat sink.

---

**FIG. 2**—Development of Texas Instruments' NOR circuit: schematic diagram of circuit (A), three-dimensional schematic (B), and circuit in semiconductor form (C)

**FIG. 3**—Two Westinghouse functional blocks (B) replace four transistors and associated components (A). Blocks are shown actual size.
Multiple-collector semiconductor devices can be used as a building block in the design of large digital computer.

A two-collector device is shown in Fig. 4A, switching action in Fig. 4B.

**VAPOR GROWTH**—Contiguous deposition of single crystal silicon layers on a single crystal silicon substrate by vapor-growth methods is a new approach to building solid-state circuits. Laminar layers formed in this process can be controlled in conductivity type, resistivity, and thickness. By combining this technique with oxide masking, diffusion, and alloying techniques, these deposited configurations can be made into microcircuits. Full description of this process will appear in *Electronics* next week.

**SILICON DIGITAL SYSTEMS**—A corporation dealing in digital systems is working on fabricating digital functions. Using techniques somewhat similar to the approach of Westinghouse and TI, the Sperry’s Semiconductor division is fabricating inverters, NOR circuits, and flip-flops. Their present package for these functional circuits is a TO-5 type transistor case with eight leads. Eventually, the firm expects to use a flat package, to match the form of their silicon wafer more exactly. Connection leads will project from the four smallest area faces of the parallel-piped. This package is still under development and its configuration will depend to some extent on system requirements.

Briefly, the fabrication method is as follows: silicon is properly doped, sliced, lapped and polished; proper im-

![Diagram of two-collector semiconductor device of IBM](image1)

**FIG. 4—Two-collector semiconductor device of IBM (A) has operating cycle shown in (B)**

This same circuit operating in free air with an ambient of 25 C would require a cube with a volume of 77 cc. Devices now in development are expected to reduce power dissipation by a factor of five.

**SOLID LAMINATES**—A method of depositing films to form a three-dimensional self-supporting matrix capable of performing a function has been suggested by a capacitor manufacturer. This method of generating solids composed of a group of compatible materials has been used by Vitramon to make capacitors. Demonstrations going back to the late 1940's indicate that this is a practical way to produce entire systems. A laminant is generated of strata of solid particles with different layers, each layer having selected properties, but all being fusible into a single solid. It is possible for chemically reacting ingredients or doped strata to provide a broad range of functions and properties.

Available for use in such an approach are: porcelains, ferrites, titanates, piezoelectric and other ceramics, voltage and heat sensitive semiconductors, and conductive and semiconductive metals.
purities are diffused (by a double diffusion process) in
certain areas of the polished silicon slices to obtain the
device configurations; metal contact points are vacuum
deposited on the slices; external connections are thermo-
compression bonded to some of the metal contact points;
the devices are sealed and given final electrical tests.
Trademark for these microelectronics devices is Semi-
Nets.

THE FUTURE—A number of machine generations from
now we may be seeing computers being built that have
the complexity of human neural networks and that will
have achieved a spectacular and unprecedented reduction
in size. Work at the Stanford Research Institute has as
an objective the design of a data processing system com-
posed of 10⁹ active components, occupying 100 one-
inch square substrates, assembled in a package measur-
ing only one cubic inch.19

We are not speaking now of functional blocks and of
distributed effects, but of the excruciatingly careful ma-
chinizing of discrete components in the molecular domain
by electron microscope techniques. An average com-
ponent would have outside dimensions of about one
micron and an equivalent thickness. In building com-
ponents at this level, resolutions of construction tech-
niques must be on the order of 100-200 angstrom units.

SRI researchers feel their dream can be realized,
and they are designing and building the equipment and
techniques with which they can do it. Under de-
velopment now at SRI is an integrated apparatus consisting
of an ultrahigh vacuum system containing an electron
microscope optical system, deposition and etching cham-
ber, vacuum locks and mechanical manipulators. Using
simple vacuum deposition equipment and a commercial
electron microscope, SRI workers have already dem-
onstrated to some degree that their goals for elec-
tron-beam machining are attainable.

Figure 5 is a series of micrographs which depict stages
of the micromachining process. In this process, a 200
A thick film of molybdenum was deposited on a 200 A
thick aluminum oxide film by thermal evaporation (Fig.
5A), the films being supported on an electron micro-
scope specimen screen. Following this, the molybdenum
was coated with triphenylsilanol (which under electron
bombardment decomposes to form a silica resist), and ex-
posed in the electron microscope with a reduced pattern
of a screen wire mesh. Then the molybdenum was etched
in chlorine. The resulting image of the screen wire

FIG. 5—Molybdenum film deposited by thermal evaporation (A) is etched to obtain pattern shown in (B) with low magnification and in (C) with high magnification

pattern is shown with low magnification in Fig. 5B and
with high magnification in Fig. 5C. The image is dis-
torted into a pincushion shape by the electron-optical
system. In Fig. 5C, image size is such that the screen
wire spacing is 2,500 A or 100,000 mesh per inch.
Resolution is about 300 A. Figure 6 shows screen of
silicon on silicon dioxide made by similar techniques.

Many micromachining techniques are being de-
veloped in the program: both solid and gaseous sources
have been used with molecular beam techniques in high
vacuum to etch surfaces of materials to convert them to
volatile compounds; the etching of holes in thin films
with depth-to-diameter ratios of 10:1 has been explored;
atomic-beam etching methods for application to low
temperature etching, the use of ion beams to sputter
material from a substrate to produce straight-sided etch-
ing with no undercutting and depth-control methods ef-
tective to one percent have all been worked on.

At the present time, the fabrication of one-micron
sized components is limited by construction techniques,
but it is expected that with the perfection of these
micromachining techniques and equipment such com-
ponents will be fabricated and (according to Kenneth
Shoulders who heads up this work), conceivably, fabri-
cated in vast arrays by self-formation methods.

But, what kind of components will these be?

COMPONENT CONSIDERATIONS—In scaling down

November 25, 1960
electronic components to the one-micron domain the designer encounters new problems: interconnection between widely-separated (relatively speaking) components would be constrained by high electrical resistance of the transmission lines—active components of high impedance are required; switching times shorter than 10⁻¹¹ second result in excessive interconnection loss at room temperature and above; L-C filters would have extremely low Q; R-C filters would be prone to temperature drift; small sizes give high surface-to-volume ratios that causes materials to migrate under the action of surface tension forces and causes increased carrier recombination at semiconductor surfaces; production of uniform crystallinity in films is extremely difficult.

TUNNEL EFFECT COMPONENTS—To answer some of these problems Shoulder proposes a new component based on quantum mechanical tunneling of electrons from a metal into a high vacuum. Having an estimated switching time of 10⁻¹ⁱ second, immunity to temperature variations and adaptable to self-forming fabrication methods giving component uniformity, this type of tunnel-effect component seems particularly suited for a microelectronic system built on the scale proposed.

Using only stable metals and dielectrics in various geometries, it is expected that diodes, triodes and tetrodes can be fabricated. Figures 7A and B show two tunnel-effect devices, a tetrode and a triode.

PRACTICAL METHODS—Serious investigation has gone into practical methods for fabricating these tunnel-effect components as well as accessory devices. In Fig. 7B, the multiple-tip field emission cathodes with radii of 100 A are expected to be made uniformly by self-formation methods which have been devised; unique methods for creating the device vacuum chamber have been developed; Fig. 7C shows a thin-film transmission-type electron multiplier that may be used with tunnel-effect devices; internal interconnection between substrates may be performed by optical coupling on as many as 10' channels by using light generators, possibly aluminum oxide coated on tungsten field emission tips, and light detectors like that in Fig. 7C; switching for low-level signals would be accomplished by electrostatically operated mechanical relays with frequencies up to 10 Mc; simple metal and dielectric diaphragms or small metal splitters would serve as electromechanical filters between 4 Mc and 600 Mc; substrates are to be of sapphire one inch square and 0.01 inch thick; interconnections on a single substrate may be made by electrically steerable, periodically focused electron guides (called salons focusing).

The expectancy is that this work will lead to the development of a highly parallel machine that has the capabilities of an intelligent technician. Considerable theoretical work has been done by others on the features and organization of a machine made of such microelectronic components.

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(7) P. E. Low and S. Gilmor, Multiple-Collector Semiconductor Devices in Molecular Electronics, AIEE Summer Meeting, June 22, 1960.

electronics
Microminiaturization approaches are beginning to reach the system stage. Designs are tentative and aim at proving feasibility of different approaches and concepts.

Computers get most attention

INTRODUCTION. What kinds of systems are actually being designed and built today using available and interim-type microminiaturization techniques and components? A few systems based on different approaches are described here, but it is certain that many more are being developed than can be yet revealed for reasons of military secrecy and proprietary protection of patent rights. Typically, many manufacturers who answered our inquiry remarked that they were deeply involved in microminiaturization but were not yet able to reveal the nature of their work.

MICROMODULE EQUIPMENT—To prove that micro-modules can be used effectively in equipments at least two different types of equipment are being built. First deliveries on these equipments, which are being built to military requirements, are slated for the middle of 1961.

One set of equipment, the AN/PRC-34, consists of a single-channel helmet-mounted receiver and a single-channel pocket-mounted transmitter. Each unit is complete with antenna, batteries and transducers (see Fig. 1). Range of the transmitter-receiver system is 500 yards, signal is frequency modulated with either voice or tone, and operating frequency is 51 Mc. Temperature operating range is —20 to 110 F.

Eight types of micromodules make up the receiver: r-f amplifier, crystal oscillator, mixer, i-f amplifier (4 per set), limiter, discriminator, audio amplifier, and squelch.

Heterogeneous system: Special glass substrates with thin-film components are used along with conventional components (by Minneapolis-Honeywell) in this summing amplifier for the B-58 center-of-gravity control system.

FIG. 1—Micromodular AN/PRC-34 transmitter and receiver: transmitter (left) is hand-held for tactical field communications. Receiver (right) is a helmet-mounted unit (RCA)

FIG. 2—This MicroPac tactical field computer is one of two equipments being delivered by RCA under the U. S. Army micromodule production program.
amplifier. Specifications for the receiver are: sensitivity, 4 µv or less; audio power output, 2 mw, max.; bandwidth (with Clevite resonators), 50 Kc at 6 db, and 200 Kc at 60 db. The receiver weighs 4 oz.

Six types of micromodules make up the transmitter: modulator-tone oscillator, crystal oscillator, phase modulator, tripler, doubler (2 per set—one operates as intermediate power amplifier), and power amplifier. Specifications: power output, 100 mw; battery supply, 7 N-cells (10.5 v); deviation, ± 4 Kc at 100-percent modulation; weight, 5 oz.

MICROPAC COMPUTER—Another equipment intended to prove out the micromodule concept is a field-data computer, called MicroPac, that will become a part of an integrated automatic data-processing system or part of a corps or division tactical operations center.

The unit (Fig. 2) is a small, stored-program general-purpose computer, a binary synchronous, serial machine with a 38-bit word length. Only the memory is in micromodular form.

Using a coincident-current, magnetic-core memory with a 2,048 word storage, the computer can perform twenty instructions. Operating speeds are: add and subtract, 80 µsec; multiply and divide, 1,000 µsec; transfer of control, 40 µsec; memory access, 40 µsec.

Three modes of input-output access are provided: the control console, which is integrated in the front panel, paper tape units, and a real-time input-output channel that connects the memory with digital-data terminals or real-time sources.

Less than three cubic feet in volume, and weighing 55 pounds, the computer is one-third the size of an equivalent field computer whose memory is not micromodular. The computer contains nearly 3,000 micromodules. Of these, 1,400 are diode-input transistor gates, and 500 are flip-flops. Pair delay for the gates is 60 nanosec, and each gate is capable of driving four similar circuits. Clock rate is 1.5 Mc. Temperature range: 125 to −25 °F. Alternating-current power requirements are less than 2.5 Kva at 0.8 power factor.

INERTIAL GUIDANCE PLATFORM—An unusual application of the micromodule packaging is a lightweight (21.5 lb) inertial reference platform developed for missile and short-range aircraft guidance. The electronics portion of the gyro, in a micromodular package, is mounted on the innermost gimbal. With this construction, stray pickup is kept to a minimum, fewer slip rings are required, and system reliability is increased.

MISSILE COMPUTER—Serious consideration is being given to the development of a TIMM's ballistic-missile computer for a missile that has not yet been flown. The ceramic modules should be useful in space vehicles since they require no cooling and are radiation resistant. Table I shows a comparison between a transistorized version of the ballistic-missile computer and a TIMM's version. Both computers have the equivalent of a 1,500-bit memory, including drivers, and approximately 750 multivibrator flip-flops. Figure 3 shows a full-scale mockup of the proposed computer.

A servo amplifier built with different-sized TIMM's

---

FIG. 3.—Mockup of ballistic missile computer designed with GE TIMM's. Internal operating temperature is about 880°F; external temperature during operation will be about 100°F.

FIG. 4.—This four-stage servo amplifier built with TIMM's micromodules operates with a 400-cps signal voltage, exhibits a gain of 500 volts per volt, and delivers a driving power of about 5 watt d-c to the load. Entire module weighs about 30 grams, occupies about one cubic inch. Unit is now in flight test.

FIG. 5.—Disassembled Polaris guidance computer consists of 54 sticks. Assembled, this unit occupies 0.12 cubic foot, containing 7,500 components. Sticks are color coded, orange for logic, light blue and light purple for memory (Francis Associates).
appears in Fig. 4. This four-stage amplifier weighs about 30 grams, measures one inch in diameter and stands one inch high. It is presently being flight tested.

**MICROLOGIC COMPUTER**—Effectiveness of the micrologic approach to miniaturization may also be measured by a comparison with techniques presently used. Fairchild Semiconductor, as Table II shows, has compared the characteristics of a typical real-time computer using transistor-resistor logic and one using their microelements.\(^*\) Prices are based on production units of the elements. Fairchild expects the numerical reliability of the micrologic element to be as good or better than that of a transistor. Fewer interconnections should increase reliability.

The sizes quoted are for elements in a TO-5 package mounted on a printed-circuit board.

**POLARIS COMPUTER**—Figure 5 shows a disassembled IX-4 Polaris guidance computer packaged for MIT. This high-density package weighs approximately one-half that of a printed-circuit package.

**COMPREHENSIVE DESIGN PROGRAM**—A design program for a 1961 developmental computer to be built using microminiaturization techniques shows how one systems manufacturer sees the start-of-the-art.

In early 1959, the Arma Division of the American Bosch Arma Corp. started a program of microminiaturization to produce a reliable, small, lightweight, flexible and inexpensive digital computer for ballistic-missile guidance, space navigation and extended-time navigation. During this program, the company evaluated various microminiature concepts for their applicability to circuits previously developed for the computer. A number of subcontracting companies were asked to apply their techniques to the adder of the computer. In all, some thirty-five subcontractors and consulting companies were involved.

Among the approaches considered were: the DOFL approach of using wafers with a multiplicity of components with fabricated photolithographic transistors and diodes, printed resistors and small surface-mounted capacitors; the RCA micromodule approach that uses wafers containing single components; the Texas Instruments Solid Circuit approach of using a single semiconductor crystal and performing all circuit functions within the crystal; the Varo approach of vacuum mixing pure metals in gaseous atomic form and controlling their deposition on a substrate to create alloy characteristics that determine, in part, the properties of the circuit—in this approach, fully-cased semiconductors were assembled with the deposited circuit; the molecular electronics approach as practiced by Westinghouse; the GE TIMM's approach of using titanium and ceramic micromodules that operate at high temperatures and which can withstand nuclear environments; and others, including the early Navy sponsored Project Tinkertoy that had been directed primarily toward high-volume production of electronic equipment, but never achieved widespread use.

Arma asked four companies to use their fabrication techniques to make adders—Aerovox, Centralab, Sprague and Texas Instruments. Semiconductors were supplied by Transistor, Inc., General Transistor Co. and Pacific Semiconductor Co. Texas Instruments supplied both circuits and semiconductors in their approach. The full adders were checked under operational conditions, including checks for reliability under shock, vibration, temperature and humidity.

Problems considered in the design concerned volumetric efficiency and relative reliability. Reliability, in turn depended upon the number of solder joints, number of components on a wafer, number of wafers in functional block assemblies, level of hermetic sealing (whether for individual semiconductors, wafers, larger functional assemblies or the entire computer) and methods of interconnection (conventional wiring, printed wiring, multilayer printed wiring, flexible printed wiring, spotwelded connections).

After completing its first-phase study program, the company concluded: "The preliminary evaluation of various concepts has indicated that although the solid-state concept is most promising, it has not been developed far enough to be adapted for Arma's computer of 1961. Therefore, an approach similar to a 2-dimensional ap-

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**TABLE I.—Ballistic Missile Computer, Comparison**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TIMM Version</th>
<th>Weight</th>
<th>Volume</th>
<th>Power</th>
<th>Cooling</th>
<th>Radiation Tolerance</th>
<th>Tolerance</th>
<th>Repet. Rate</th>
<th>Clock Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>lb</td>
<td>in(^3)</td>
<td>w</td>
<td></td>
<td>(10^7) R/sec</td>
<td>R/sec</td>
<td>1 Mc</td>
<td>500 Kc</td>
</tr>
<tr>
<td>Weight</td>
<td>25 lb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 (10^7) R/sec</td>
<td></td>
<td>1 Mc</td>
<td>500 Kc</td>
</tr>
<tr>
<td>Volume</td>
<td>1,000 in(^3)</td>
<td>3 lb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>110 w (63 is unreg)</td>
<td>160 w</td>
<td>560 in(^3)</td>
<td>110 w (73 is unreg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 (10^7) R/sec</td>
<td></td>
<td></td>
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<tr>
<td>Tolerance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 Mc</td>
<td></td>
</tr>
<tr>
<td>Repet. Rate</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1 Mc</td>
<td></td>
</tr>
<tr>
<td>Clock Freq.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>500 Kc</td>
</tr>
</tbody>
</table>

**TABLE II.—Relative Characteristics of Typical Real-Time Computer (Top Section)**

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>TRANSISTOR—RESISTOR LOGIC</th>
<th>MICROLOGIC ELEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed (serial)</td>
<td>Greater Than 2 Mc</td>
<td></td>
</tr>
<tr>
<td>Power requirements</td>
<td>160 w at 4.4 v</td>
<td>30 w at 3 v</td>
</tr>
<tr>
<td>Ambient operating temperature</td>
<td>-55 C to 125 C</td>
<td></td>
</tr>
<tr>
<td>PHYSICAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of components</td>
<td>2,000 Transistors</td>
<td>1,000 Elements</td>
</tr>
<tr>
<td>No. of printed circuit boards</td>
<td>22,000</td>
<td>8,000</td>
</tr>
<tr>
<td>No. of printed circuit conductors</td>
<td>500 ft</td>
<td>60 ft</td>
</tr>
<tr>
<td>Length of harness wiring</td>
<td>125 ft</td>
<td>5 ft</td>
</tr>
<tr>
<td>Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prototype</td>
<td>$200,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Each succeeding unit</td>
<td>100,000</td>
<td>25,000</td>
</tr>
</tbody>
</table>

**November 25, 1960**
A diagram showing the internal components of a computer.

**Fig. 6—Diagrammatic view of microminiature computer being designed by Arma. Cutaway view to right shows final assembly of circuit wafers and interconnections. The comprehensive design program carried out by Arma in the development of this 1961 computer reveals some of the problems confronting the systems designer who wants to microminiaturize now.**

An approach would be the most practical concept for the first developmental-model microminiature computer of 1961. A

Arma finally decided on a combined flat-plate and Tinkertoy packaging method (see Fig. 6) based on multiple-component wafers, though the number of components to be printed on a single wafer was not to exceed ten. Single-component wafers, they felt, resulted in too many interconnections and were wasteful of space gained otherwise, thus canceling the advantages of high-production yield and individual component reliability.

In the computer design, resistors are printed carbon, capacitors are thin square wafers with one side soldered directly to the linework and a lead soldered from the other side to the linework; linework consists of thin metallic ribbons of screened and fired silver paint, or applied by photolithography or vacuum deposition; transistors are inserted into 0.1-inch diameter holes and diodes into 0.06-inch holes. Some evaporated resistors and capacitors will also be used.

Major interconnection wiring between functional blocks will be multilayer welded wiring matrices. Although hermetic sealing for the entire computer was considered most efficient, sealing on the functional block level was considered best for maintenance. To reduce the size of the information storage package, a flat-plate method of mounting memory cores that would reduce wiring was explored. Case structure for the computer is a precision-cast magnesium alloy. Weight of the computer is not to exceed 15 pounds. Figure 6 shows some details of the assembly.

**CONCLUSION—**Depending upon a systems manufacturer's needs and objectives and on the many types of microminiaturization methods and techniques becoming available, it is conceivable that many different types of systems designs will be arrived at. The systems discussed here are only a beginning or interim points along a line of engineering development. Certainly, as these different techniques and approaches are perfected and proved reliable, the electronics industry will find itself enriched in the possibilities it can exploit.

**REFERENCES**

1. T. J. Zawlos, Private Communication, RCA, Camden, N.J.
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For more information contact our nearest regional office, or write direct.

Typical properties of Dow Corning polycrystalline silicon, together with resistivity and life-time curves for an evaluation crystal, are shown below.

<table>
<thead>
<tr>
<th>Typical Properties of Polycrystalline Silicon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptor Impurity Content: 0.15 part/billion</td>
</tr>
<tr>
<td>Donor Impurity Content: 0.5 part/billion</td>
</tr>
<tr>
<td>Rod Diameter: up to 26 mm (1.0 in.)</td>
</tr>
<tr>
<td>Rod Length: up to 450 mm (17.7 in.)</td>
</tr>
<tr>
<td>Resistivity (vacuum zoned evaluation crystal): &gt;1000 ohm cm</td>
</tr>
<tr>
<td>Lifetime (vacuum zoned evaluation crystal): &gt;400 micro sec.</td>
</tr>
</tbody>
</table>

Free brochure — "Hyper-Pure Silicon for Semiconductor Devices." Write Dept. 3511.
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CORPORATION MIDLAND, MICHIGAN
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November 25, 1960
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Non-scanning Character Reader Uses Coded Wafer

Noncritical lenticular-array character reader can recognize patterns, letters or numerals without use of scanning, special inks or complex logic circuits


In many applications it would be desirable to use an electronic character reader with documents such as adding-machine and cash-register tapes and typewritten ledgers and bills if the character reader were simple and did not require a special format or type font.

When timing is required as in scanning or correlation methods of recognition, exacting specifications must be imposed on speed, skew, slippage and synchronization capabilities of document-handling equipment. A major source of expense and criticality of operation can be eliminated by specifying a synchronous reading that is not dependent on timing, positioning or speed regulation of the input characters during reading.

Many systems become complex in their logic sections. If a general-purpose high-speed computer is used, a large degree of reading flexibility may be programmed. However, the cost is high and the reliability may be questioned because of the complexity. The logic manipulations required are extremely complex in sorting out myriads of desired combinations of character elements from closely related groupings that represent erroneous readings. If logic or logical method can be simplified, cost and reliability can be improved.

The approach to character recognition outlined in this article has permitted simplification without sacrifice of functional performance.

A laboratory model of a reading-head assembly is shown at the left. Shows the document-feed channel, a reflection-projection lens surrounded by prefocussed long-life bulbs and the logic reader with output leads at which fully decoded numerical digits are available.

The wafer, shown in Fig. 1, (inset) is both the logical and optical array that serves as a multiple sieve-funnel combination that sorts characters of different charac-
The wafer is a direction sensitive optical message-bearing unit known as a lenticular display. Forms of this wafer are used in presenting two or more views as the lens array is tilted to change the viewing angle. The number of messages written on this wafer may vary from two to about sixty four. Figure 1 shows a magnified view of the message area used for thirty six patterns selectable from a corresponding six-by-six directional matrix pattern.

The lenticular array consists of two sets of minute hemispherical ribs positioned at right angles to each other. Each lens coordinate is a minute spherical lens. Operation of the lenticular lens is shown in Fig. 2A. Each composite lens of the lenticular array acts as an independent spherical lens to direct the light from a parallel source to discrete positions on the viewing plane. As shown in Fig. 2A, at points A, B and C of the viewing plane, the light is focused respectively to each position from a series of multiplexed positions across the surface of the lens array. Thus, light passing through points C, C\textsubscript{1}, C\textsubscript{2}, \ldots C\textsubscript{n} is directed to point C on the viewing plane. The same operation applies to points A and B (and all other) points of the viewing plane.

By applying a parallel light source to the lens array and masking all points C\textsubscript{n}, points A and B will receive light while point C will receive less light. Conversely, substituting a light source for point A of the viewing plane will cause light to be seen at all points A, across the lenticular array.

If a large screen with the geometrical pattern shown in Fig. 2B is illuminated, each minute spherical lens will focus the pattern into a related small screen directly behind each lens. The reverse is also true and if identical small-screen patterns behind each lens were illuminated, then this geometrical pattern would show on the large screen. Photocells could be substituted for each of the black dots making up the geometrical pattern of the large screen shown in Fig. 2B, and an opaque mask substituted for the shadow mask. Then, if holes were punched in the same place in each small screen and a parallel light source applied from behind the shadow mask, only one photocell would receive light.

To make the wafer shown in Fig. 1, photographic film is placed at the shadow-mask position. The number of photocell positions (one for each message—with each pattern, numeral or letter to be identified being one message) is then established in some geometrical array at the large-screen position. A small light bulb is substituted for each photocell. Individual message transparencies such as digits of the type font (or any other pattern, numeral or letter) to be used are selected. The message transparency is then registered with the lenticular array to cast its shadow on the film in some desired position.

The light bulb at the chosen photocell position for that particular message is momentarily lit to expose the film. A new message transparency is then selected and the light bulb at the new chosen photocell position is lit to expose the film. This process is continued until all messages are on the film. The film is then developed.

Each message is then written across the shadow mask in a half-tone-like dot matrix of points exposed by the light beam from a single direction. In a typical case, the numeral 8 would be composed of all the right-hand corner dots of each small screen while the numeral 4 would be composed of all the dots in the corner left-hand corner, and so forth. The small screens then become single-plane multiplexed message sources. Figure 1 shows a section of such film made for 36 messages.

When a specific numeral is displayed and illuminated in the document-feed channel, light will pass through some holes of some tiny screens while other holes are shadowed by the darker numeral background. One photocell then will receive less light than the others.

Mechanical registration to control the position of a misaligned printed character may be accomplished by a motor-cam combination that wobbles the lenticular wafer. The wafer is small and light enough to be almost an inertialess mass. The assembly may be moved parallel to the viewing plane without changing the selection angle viewed by the photocells. Although the dots on the screen are about 0.002 in. apart, the photocells may be moved greater than a quarter inch without misregistration with another message. Thus, assuming horizontal presentation of a character strip with an added vertical camming action, the misregistration of alignment may be as great as the amount of vertical motion.

Motion of horizontal presentation need not be carefully controlled and may even be jerky as with a paper tape punch or card punch because identification occurs instantaneously upon static operation of matching and does not require stability, timing or positioning during the scanning action. Since neither dynamic reading speeds nor timing regularity need be attained, mis-multiplexing of characters is not a problem.

To take care of a wide range in contrast variations resulting from changes in paper, ink, light level and photocell temperature, the most prominent signal selection...
system is used. If the waveforms at the photocells are observed while drawing a printed character through the document feed channel, some signal is observed at each photocell with the largest signal appearing at the required photocell. Depending on the contrast range, these signals will vary in amplitude, the chosen signal always having the largest amplitude.

The circuit shown in Fig. 3 selects the single channel that has the greatest amplitude. This is done by a single NOR-like transistor circuit per channel where the base mixer resistance network establishes a signal-bias level at the greatest signal level encountered in all except the designated channel. The transistor conducts when the designated signal at the emitter becomes greater than all other signals. Since only one signal is greatest, a unique selection appears as an output pulse. The bias control selects a threshold level above noise conditions.

In addition to variable-contrast operation, there also occur pinholes produced by exposure (or severe change in contrast) of part of a character area due to faulty ribbons, oily paper and other mechanical reasons, and smudges caused by ink that has gotten outside of the character area. In this example, the logic selection for 10 characters is made by twenty photocells, two for each character (10 transparent characters on opaque background and 10 opaque characters on transparent background). One photocell provides a select match and the other a reject match. In the simplest form, the character patterns to be matched in the respective cases will be a positive or transparent mask of the character shape and a negative or opaque mask of the character shape for reject.

Operation of select and reject is shown in Fig. 4. In the select condition (upper portion) the mask is opaque with a numeral 7 cut out. The characters to be recognized are a 7 with a smudge that forms a partial 9 and a 9 with pinholes that forms a partial 7.

The mask is located between a light source and a photocell. If the photocell output is observed while passing both the 7 and 9 past the 7 cutout, the waveform will null when the cutout 7 on the mask is completely covered.

In the reject position (lower portion) the mask is transparent and the numeral 7 is opaque. Now when the opaque 7 is passed across the mask, the output waveform goes down when the opaque 7 enters the mask and then goes to a peak when the opaque 7 is directly superimposed on the mask opaque 7. If the numeral 9 or smudged 7 passes through, the waveform goes down as the character enters the mask then raises to a peak as the character superimposes on the mask 7. However, some portion of the 9 or the smudge on the 7 is exposed as superimposition occurs, so that the waveform does not reach the same level peak as with the clean 7. The action of the photocells shown in the partial schematic of Fig. 4 is additive in a differential sense so that the combined output will provide a peaking output for the selected character.

Variable resistors associated with each photocell may be used to weight the individual effect of the selecting or rejecting action on the output signal.

Thus, in selection, pinholes tend to reduce the peak and, in rejection, smudges tend to reduce the peak. By weighting the effect of the positive and negative signals in this (or any other convenient way), a threshold selection can be made tolerable to the appearance of a limited amount of either pinhole or smudge character distortion. In addition, the double-cell action provides enough redundancy to assure reliable selectivity for almost any type font without special shaping of characters or extra post-recognition logic circuits.

Typical voltage levels provided by matched photocells when using 25-message masks and sampling with 50 dot-elements per inch from good quality 5-in. characters show that the selected character signal has about 1-volt differential above the highest unwanted character signal. Under ideal conditions, thyratron or transistor circuits with threshold settings may be actuated directly from the photocells for relay closure.

Contributions to this effort made by Stuart F. Nadeau in photographic and lenticular techniques are gratefully acknowledged.

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**Fig. 3—Most-prominent-signal contrast-control circuit**

**Fig. 4—Differential weighted output technique; simplified circuit**

**November 25, 1960**
Data Recorder for Airplane Flight

Continuous record engraved on metal tape is designed to survive air accidents

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AIRCRAFT ACCIDENT INVESTIGATION will be made easier under a new FAA mandate requiring all commercial carriers flying turboprop or turbojet aircraft to carry a flight data recorder aboard each plane. This will provide a crash-resistant, fire-resistant record of time, air speed, altitude, heading and vertical acceleration. Recorder will produce an indestructible record of the events immediately preceding a crash or accident, available for later analysis. The record must be able to withstand an impact of 100 g's, flames of 1,100 °C enveloping at least 50 percent of the case for 30 minutes and immersion in sea water for 36 hours. For utmost reliability, all electronic circuits should use solid-state components.

This flight data recorder is composed of two sections. An aluminum casting houses the tape magazine and the electromechanical portions of the system, while the rear section is an aluminum chassis housing electronic circuits. The magazine can record up to 400 hours of aircraft performance on Inconel (stainless steel) foil approximately 5 in. wide and 0.001 in. thick. Four cam-actuated scriber arms with diamond cutting edges are placed in contact with the foil twice a second while the foil moves through the magazine at 12 in. per hour. The result is a series of small engraved marks on one side of the foil. Although the marks occur intermittently they overlap so that a continuous line record results. The magazine protects the record from flying shrapnel and provides for easy removal for reloading.

Four primary channels of information are recorded on the tape. Two of these, the altitude and speed indicators, use pneumatic sensors and involve no electronic or electromechanical action. The arms of the sensors are free to move without any load for approximately 90 percent of the time. During the other 10 percent of time a cam action places the arms against the foil to make a mark. This intermittent motion provides a dithering action to relieve mechanical friction while allowing an accurate indication due to the absence of mechanical load on the sensors.

The heading system consists of a servo position followup on the compass signal. A vertical accelerometer at the center of gravity of the aircraft feeds the vertical acceleration channel, using a differential transformer transducer.

The maximum vertical-acceleration signal in each ¾ second period is recorded. The servo portion of the recorder uses an a-c tachometer to provide rate feedback for stabilization of the servo system and a feedback potentiometer to provide position signal.

Time is recorded by a sprocket drive on the metal foil, driven by a hysteresis synchronous motor supplied with 440 cps independent of line voltage and temperature variations. A trip and date encoder is a part of each recording system. This device may be mounted in the cockpit and is used to indicate the flight number and date. An event button allows the pilot to insert an indicating mark whenever some unusual occurrence is noted.

In addition to the four scriber...
Analysis

arms, four binaries are supplied for providing additional information and there is space for five additional servo driven scribe arms and two more binaries that can record simultaneously on the reverse side of the foil.

The precision frequency generator provides 440 cps at 115 volts for the timing motor. It uses a saturating-transformer oscillator and auxiliary regulating circuits to maintain precise voltage and frequency. The normal saturating-transformer square-wave oscillator frequently employed with transistors has an output frequency directly proportional to applied voltage and output voltage directly proportional to input voltage. Since both vary linearly with applied voltage, it is possible to sense the output voltage and supply a correction to the oscillator that will provide a constant output voltage and a constant output frequency.

Figure 2 is a schematic of the precision frequency generator. Transistors Q, and Qs, are the oscillating transistors with feedback provided through windings 4, 5, and 6 and output voltage for the servo motor taken from winding 10, 11, and 12. Input power is applied to the emitters through the feedback winding and to the collectors through the collector winding. The base voltage which determines the collector voltage swing of the transistors is produced by the voltage drop across resistor R,. The output voltage is sampled by winding 7, 8 and 9, rectified by diodes D, and Ds, and applied to a differential amplifier stage consisting of Q, and Qs. A portion of the output voltage is applied to the base of Qs, through the network R, and R,. A reference voltage obtained from R, and Ds is applied to the base of Qs. The amplified difference voltage is applied to the base of Qs, whose emitter is tied to a fixed reference, permitting regulation of the voltage across R, to maintain constant output voltage and frequency. Resistors R, and R, are a thermistor and a Sensistor respectively, mounted on the chassis and on the saturating transformer to maintain a constant output frequency irrespective of temperature variations. Transistors Q, and Qs, are power transistors mounted on heat sinks since, in contrast with normal saturating transformer multivibra-

Front portion houses crash-resistant data magazine, shown at the aircraft performance on stainless-steel foil

November 25, 1960
The vertical acceleration channel of the recorder accepts a phase-reversible 400 cps signal from the vertical accelerometer which is in phase with the reference voltage for positive accelerations with respect to +1 g and has 180-deg phase shift with respect to the reference voltage for negative accelerations with respect to +1 g. The acceleration input is fed into the amplifier modulator shown in Figure 3. Transistors $Q_1$ and $Q_2$ form a feedback amplifier with an open loop gain of approximately 10,000 reduced to a closed loop gain of approximately 1.6. Degenerative feedback is supplied from the collector of $Q_1$ through $R_1$ and $R_2$ to the emitter of $Q_2$ with $R_3$ functioning as a gain adjustment for calibration. The feedback amplifier thus serves also as an impedance matching network providing a high input impedance for the accelerometer and a low output impedance for driving the demodulator. Due to the high negative feedback the slight gain is relatively stable with respect to temperature and voltage variations. The output is coupled through transformer $T_2$ to the two full-wave synchronous demodulators consisting of diodes $D_2$ to $D_7$ and transformer $T_7$. The synchronous demodulators separate the positive and negative signals. Positive output signals corresponding to in-phase signals are applied to the base of $Q_3$, while negative output signals corresponding to out-of-phase signals are applied to the base of $Q_4$. Transistors $Q_3$ and $Q_4$ provide impedance transforming action or current amplification for respectively the positive and negative output signals to minimize loading of the demodulator. The storage capacitors shown as $C_1$, $C_9$, $C_a$ and $C_s$ are alternately connected to the positive and negative signal output positions by a commutator. Thus a positive and a negative storage capacitor is always connected to the accelerometer. While one capacitor is being read out another capacitor is being charged for storage. At this point both positive and negative acceleration signals are separated and stored as capacitor charges.

The stored signals from the capacitors are applied simultaneously to a polarity detector which selects the signal with larger absolute magnitude and applies it to the servo system. A phase-reversible 400-cps signal is produced to drive the servo motor one way or the other to achieve a null at the summing junction.

The servo amplifiers used for heading and acceleration channels are identical, each providing approximately 4 watts of power to drive a size 8 servo motor.

The flight number and date encoder consists of a group of decade selector switches and a switch or commutator which scans the outputs of the selector switch and applies 28 volts d-c to a binary solenoid providing a time-multiplexed signal indicating, in decimal form, the trip and date along the edge of the foil.
Solid-State D-C Switched Regulators

Switching system, analogous to phase control of thyratrons in a-c circuits, permits higher efficiency than the series regulators are able to provide.

By ALBERT A. SORENSON, Space Technology Lab., Inc., Los Angeles

IN VOLTAGE REGULATOR circuits a constant output voltage is produced irrespective of changes in input voltage or output load. The voltage regulator is characterized by its nominal input voltage, permissible input voltage range, nominal output voltage, load range, ripple voltage and output voltage regulation.

Physical specifications include efficiency, size, weight, cost and reliability, which in some cases are more important than the electrical specifications.

Conventional series regulators are usually elaborations of the simple rheostat. For a given load resistance \( R_L \), and an input voltage \( E_i \) there always exists some series resistance \( R_s \), that will produce an output voltage \( E_o \), as long as \( E_i \geq E_o \) and \( R_s \neq 0 \). The series resistor \( R_s \) is equal to

\[
R_s = R_L (E_i - E_o)/E_i
\]

If either \( E_i \) or \( R_L \) varies, \( R_s \) may also be varied to hold \( E_o \) constant.

Series resistor \( R_s \) is usually a transistor or a vacuum tube, whose resistance is varied by feedback to stabilize the output level.

Series element \( R_s \) must dissipate power to provide regulation. The power to the load is \( P_L = E_o^2/R_s \) and total power input is \( P_i = E_i^2/(R_s + R_L) \).

The circuit efficiency is then

\[
\eta = \frac{P_i}{P_L} \times 100
\]

\[
\eta = \frac{E_o^2}{E_i^2} \times 100\%.
\]

If \( E_i \) has a large range, the lowest efficiency occurs for the largest \( E_i \). All series regulators are limited to the efficiency of Eq. 1 as a maximum.

The power dissipated in \( R_s \) is

\[
P_s = (E_i - E_o)^2/R_s.
\]

This power must be dissipated by the series vacuum tube or transistor necessitating high-power transistors, large heat sinks and good cooling, all of which are weighty and space consuming.

In a-c regulators, series regulation has generally been abandoned. Instead, switched regulators are used to control the output voltage by controlling the conduction period of each a-c cycle. Common circuits of this type use magnetic amplifiers, controlled rectifiers or thyratrons.

Similar circuits have now been built for use as d-c regulators, and will be called switched regulators. Figure 1A shows the simplest switched regulator.

Assume that switch \( S \) is opened and closed at a regular rate. Filter \( L, C \), is designed so that voltage \( E_t \) will be some fraction of \( E_i \) and have a low ripple content. Diode \( D_t \) permits energy stored in \( L \) to be delivered to the load while \( S \) is open. This diode must carry the maximum load current and have a voltage rating of the maximum value of \( E_i \).

The inductance should be made just larger than the minimum, that is \( L_{max} = R_{max}/6 f_{min} \) where \( R_{max} \) is the load resistance at the minimum load, and \( f_{min} \) is the frequency of the minimum repetition rate at which \( S \) is opened and closed. The filtering capacitance must be just

\[\text{FIG. 1—Principles illustrated with mechanically operated switch (A); mechanical switch replaced by transistor (B); waveforms show operation of transistorised regulator (C).}\]
larger than $C_{\text{min}} \approx E_i/(2 \pi f_{\text{min}}^2 \sqrt{L E_{\text{rms}}})$, where $E_{\text{rms}}$ is the maximum output rms ripple voltage. The voltage rating of the filter capacitor, which may be electrolytic, is determined by $E_i$, maximum.

The output voltage is varied by altering the relative periods for which $S_i$ is open and closed. The proportion of time $X$, in which $S_i$ is open is $X = (E_i - E_o)/E_i$ where $0 \leq X \leq 1$. This may be solved for $E_o$ as

$$E_o = (1 - X) E_i \quad (2)$$

With perfect components the total efficiency is 100 percent, independent of $E_i$ and $E_o$. This is because the power is switched in time and not amplitude.

The difference between perfect and actual components is small. The inductance can have low d-c resistance, silicon diodes already have small forward voltage drops and capacitors are near-perfect components anyway. By using a transistor for the switch a near-ideal switch is achieved since the transistor has low leakage when open and low voltage when closed. The transistor may be small and will dissipate little power. Usually no heat sink is necessary.

Comparing conventional and switched regulators of the same rating, the conventional circuit requires a large, high-powered transistor and heat sink, and has an efficiency of perhaps 60 percent. The switched circuit uses a small, low-powered transistor without heat sink, has an efficiency of about 90 percent, but requires a diode, inductor and capacitor. Using powdered iron high-mu materials and high switching frequencies, the inductor may be small. The capacitor will also be small at high frequencies, especially when using tantalum capacitors.

The simplest circuit for a switched regulator is shown in Fig. 1B. The network consisting of transistor $Q_i$, four-layer diode $D_o$, capacitor $C_o$ and resistors $R_o$ and $R_n$ form an oscillator to switch $Q_n$ on and off and also provide some regulation. Assume that $Q_i$ is on. Resistor $R_o$ is chosen so that $Q = \beta_{\text{min}} R_{C_{\text{min}}}$, where $\beta_{\text{min}}$ is the minimum beta of transistor $Q_i$ and $R_{C_{\text{min}}}$ is the resistance at maximum load.

Technician adjusts the circuit for optimum ratio of $R_i$ and $R_o$ (see Fig. 2) for best stabilizing performance.

FIG. 2—Optimum regulation is achieved with $R_i$ greater than $R_o$ (A); improved circuit has the four-layer diode anode returned to stabilized output (B).

FIG. 3—Zener diode introduces a higher stability (A); final circuit uses d-c amplifier and Zeners for optimum performance (B).
The resistor \( R_c \) will thus hold \( Q \) on.

A four-layer diode is a bistable switch. As the voltage across it is increased from zero, no conduction occurs until the breakdown voltage \( V_a \) is reached, it then conducts with little drop and continues conducting until either the voltage is reversed or the current drawn becomes less than the holding current.

As long as \( Q \) is on, \( D \) will be off. Capacitor \( C \) charges through \( R \) and the emitter-base path of \( Q \). When the voltage across \( C \) reaches the breakdown voltage \( V_a \) of \( D_a \), \( D_a \) is turned on and back-biases the emitter-base diode of \( Q \), by the voltage across \( C \), turning \( Q \) off. Capacitor \( C \) then charges in the opposite direction through \( D \) and \( R \). Resistor \( R \) also draws current through \( D \). When the sum of these two currents has decreased to less than \( I_t \), the holding current of \( D_a \), or the voltage across \( C \), has reduced to the \( V_a \) of \( D_a \), and \( Q \) is permitted to turn on. The minimum value for \( R \) is \( E_t/I_t \). Resistor \( R \) may be varied to control the output voltage \( E_c \). Repetition frequency is proportional to \( C \).

Since the switching frequency of the four-layer diode is fast, \( Q \) is also switched rapidly. The fall time and minority carrier storage time of \( Q \) is made small because of the high initial reverse base current. See the waveforms of Fig. 1C.

For the circuit to oscillate \( E_t > V_a \). Capacitor \( C \) charges to \( V_a \), with aiming potential \( E_t \) and time constant \( t_l \), it is \( R_C E \), thereby determining the on time; then discharges from \( V_a \) to 0 with aiming potential \( -E_t \), and time-constant \( t_s = R_C E \), to determine the off time. Expressions for the on and off times, \( t_l \) and \( t_s \), are

\[
\begin{align*}
 t_l &= R_C C \ln \left( \frac{E_t}{E_a} \right) \\
 t_s &= R_C C \ln \left( \frac{E_a}{E_t} \right)
\end{align*}
\]

The output voltage is found from Eq. 2 to be

\[
E_c = E_t \left( \frac{t_l}{t_l + t_s} \right) = E_t \left( \frac{1}{1 + \frac{t_s}{t_l}} \right)
\]

and from Eqs. 3, 4 and 5

\[
E_c = E_t \left[ 1 + \frac{R_C C \ln \left( V_a + E_t \right)}{R_C C \ln \left( E_t - V_a \right)} \right]
\]

This indicates that \( E \) is independent of \( C \). If \( E_t = n V_a \),

\[
E_c = n V_a \left[ 1 + \frac{R_1 \ln \left( n + 1 \right)}{R_2 \ln \left( n - 1 \right)} \right]
\]

Figure 2A shows \( E \) plotted against \( E_t \) for \( V_a = 20 \) v and for three different values of \( R_c/R_t \). This curve indicates that for optimum regulation \( R_c < R_t \). A range of nominal output voltages may be obtained by choosing different types of four-layer diodes each with a different value of \( V_a \). In general, \( V_a \) must be smaller than the lowest value of the input voltage, but should be as large as possible. Capacitor \( C \) should be chosen to give a high operating frequency, but not so high that the rise and fall times of \( Q \) become appreciable in comparison to \( t_l \) or \( t_s \).

Performance is improved by returning the anode of \( D \) to the output terminal. This provides better regulation by using simple feedback to produce a more constant voltage for \( D \) reference as Fig. 2B shows. Here \( C \) charges to \( V_a \) while aiming at \( E_a \) and discharges to 0 while aiming at \(-E_a \). Writing the expressions for \( t_l \) and \( t_s \),

\[
\begin{align*}
 t_l &= R_t C \ln \left( E_a - V_a \right) \\
 t_s &= R_t C \ln \left( E_a + V_a \right)
\end{align*}
\]

and from Eqs. 6, 7 and 8

\[
E_c = E_t \left( 1 + \frac{R_C C \ln \left( V_a + E_t \right)}{R_C C \ln \left( E_t - V_a \right)} \right)
\]

which is transcendental. Since this is only solvable by substitution, the best design approach for the more complex circuits is to have an understanding of the effect of change of value of the portions of the circuit and then to design the circuit by building it and varying component values (mainly \( V_a \) and \( R_t \) for this circuit) to obtain the output voltage and regulation. This circuit also provides some load regulation, which the simpler circuit did not.

These first two circuits will provide no better than \( \pm 5 \) percent regulation for \( \pm 20 \) percent input variation. For some purposes this is adequate, but mainly the description of these circuits illustrates basic principles. Further improvements in regulation are possible by increasing the negative feedback and/or introducing a more stable reference than the four-layer diode, such as a Zener diode. To do this resistor \( R_c \) must be replaced with an active circuit. Circuits embodying such improvements are shown in Figs. 3A and 3B.

The circuit of Fig. 3A gives \( \pm 1 \) percent regulation for a \(-15 \) percent, \( \pm 30 \) percent input voltage variation and the circuit of Fig. 3B, for which the circuit values are given, provides \( \pm 0.5 \) percent regulation for the same input variation. The efficiency of the latter circuit ranges from 90 percent to 95 percent. An equivalent linear series regulator would have an efficiency of from 83 percent to 50 percent over the same range.

Circuits of this same general type have been built up to 50 watts output, but there is no reason to limit the capacity to that level. For higher power an amplifier transistor should be used to drive \( Q \).

If more than one output voltage is desired, the best method is to have a single input switched regulator driving a static converter from which the several output voltages are obtained by separate conventional winding-diode-filter arrangements. One of the static converter outputs may then be used to feed back to the regulator.

The resistor \( R_e \) consumes the major amount of power dissipated in the circuit. When using a static converter in conjunction with the switched regulator, an extra winding may be added to the winding of the converter, which through rectification and filtering will provide the turn-on voltage for \( Q \). Another, higher resistance, resistor should then be run from the base of \( Q \) to either the collector of \( Q \), or to ground to start oscillations.

More elaborate circuits may also be developed to provide current limiting action. When using a static converter with a switched regulator it is best if the regulator frequency and the converter frequency are different. This prevents one frequency from locking on the other.

Credit for these designs should go to Richard A. Nylander, who invented them, and who has developed them.

BIBLIOGRAPHY


Tunnel Diode Generates Rectangular Pulses

Negative-resistance characteristic enables fast rise time independent of signal frequency

By G. B. SMITH,
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TUNNEL DIODES have found many practical applications since the discovery by Leo Esaki in 1958. This article shows how fast-rise-time rectangular pulses can be derived with the tunnel diode.

Figure 1A shows the voltage-current characteristic of tunnel diodes compared to conventional low-power junction diodes. Typical values of peak current \( I_p \) and ratio of peak current \( I_i \) to valley current \( I_v \), measured on a batch of type JK 11A tunnel diodes, are

\[
I_i = 2.5 \text{ ma} \quad V_i = 75 \text{ mv} \\
I_i = 25 \text{ ma} \quad V_i = 240 \text{ mv}
\]

If a resistance \( R \) greater than the numerical value of the negative slope resistance of a given tunnel diode is connected in series with the diode, only two stable states are possible for a given supply voltage, and are shown by points A and B in Fig. 1B.

Consider the voltage waveform across the tunnel diode when a sine-wave emf with peak value greater than \( V_i \) is applied. This waveform can be plotted on a load-line diagram as shown in Fig. 2.

From point A on the tunnel-diode characteristic, follow load line PB to point B on the voltage axis. Projecting across to point C on the input voltage curve find point E, giving the time when the tunnel diode reaches voltage OD. By repeating this procedure for a number of points on the characteristic the tunnel diode voltage waveform can be plotted.

Note that on the negative-slope part of the characteristic the input voltage has no control over the diode voltage. This causes the diode voltage to change from \( F \) to \( G \) when the input voltage is increasing, and from \( H \) to \( J \) when it is decreasing, at a rate determined by the junction capacitance of the tunnel diode. When operated in its reverse direction, a tunnel diode has low resistance so that during the negative half-cycle the diode voltage is zero for all practical purposes.

The minimum peak sine-wave emf required to drive the circuit satisfactorily is determined by the position of point \( F \) and the value of \( R \). For a given \( R \), the supply emf must be such that the load line at peak voltage passes through or above point \( F \). However, in order to make use of the whole negative-slope portion of the characteristic, we could use as the minimum value of \( R \) the factor

\[
\frac{V_i}{I_i} - \frac{V_i}{I_i}
\]

(see Fig. 1A), and thus find the required input emf by projecting the load line from \( F \) to the voltage axis.

When finding the optimum value of \( R \), the maximum current available from the source must also be taken into account, the maximum peak current required being \( I_i \) (see Fig. 1A).

A similar design procedure can be used when the input signal is already in pulse form. The circuit can then be used to improve the rise time of rectangular pulses that have deteriorated after passing through many stages.

The small amplitude of pulses available from the basic circuit makes it impractical for most applications. However, the circuit will work satisfactorily even when heavily loaded. For example, it can feed directly into a common-base transistor amplifier with the advantage of its high cut-off frequency so that little or no deterioration of the pulse edges occurs. To obtain a variable duty ratio, \( R \) can be made variable and the input signal d-c restored to obtain duty ratios greater than one half. A typical circuit is shown in Fig. 3A. The transistor base bias resistor must be chosen so that the transistor does not switch on until the pulse skirt voltage (OK in Fig. 2) is reached. Measurements on this circuit showed that at 50 cps the pulse rise times at test points 1 and 2 were respectively 100 and 110 nanoseconds. The measurements were repeated at 10 Kc and showed no change in rise time.

An improvement in the output-voltage waveform can be effected by using Zener diodes as shown in Fig. 3B.

This method of obtaining sharp-edged rectangular pulses from sine waves has the advantage, over clipping diodes and amplifiers, that rise time is virtually unaffected by signal voltage frequency.

Junction capacitance of a JK 11A tunnel diode is of the order of 1,300 pf and gives a rise time of 100 nanoseconds. Contemporary tunnel diodes, available in the U. S., have much lower junction capacitances of the order of 5 pf or less. Used in the circuit described, this would give much faster rise times.

BIBLIOGRAPHY


FIG. 1—Comparison of voltage-current characteristics of tunnel diode against conventional junction diode (A): characteristics of tunnel diode in series with resistance (B).

FIG. 2—Graphical method of determining tunnel diode pulse waveform directly from signal waveform and series resistor value.

FIG. 3—Practical tunnel-diode pulse circuits with common-base transistor amplifier (A), addition of Zener diodes to improve output waveform (B).

November 25, 1960
FIG. 1—Checking flow of cooling air through a stacked-circuit gate for IBM's solid-state STRETCH computer. Total air flow of 360 cfm is required to maintain acceptable ambient temperature in a space where 864 circuit cards are mounted in tight layers. Air is forced through the 5-ft gate into test chamber at left by two double-inlet units in housing at right end of gate. Blowers provide long, thin air flow across section while occupying an unusually narrow space. Specified output of 180 cfm for each blower unit is delivered against static pressure of 0.5 inch of water at impeller motor speed of 5,700 rpm.

EQUIPMENT DESIGNERS can gain by becoming familiar with air cooling. Such knowledge will equip them to specify blower characteristics realistically and help them design the air-flow path to minimize the blower load and thus keep down blower size, cost and power consumption.

Forced cooling of ground or airborne electronic equipment requires a blower that contributes minimum weight, space and cost. The blower must frequently meet a large number of requirements, with design standards well above those of other blower applications. Variety of blower characteristics makes it unlikely that a standard, off-the-shelf unit will give the best results; therefore custom design is common.

Major requirements of an equipment cooling system are:

(1) Air-flow rate $Q$, determined by the amount of heat transfer required.

(2) Static pressure $p_s$, determined by the total system resistance that must be overcome to maintain $Q$.  

FIG. 2—Photographs illustrate two types of axial blower units. Partially cased impeller (A) and vane-axial impeller (B).  

electronics
for Electronic Equipment

Intelligent selection of blower type coupled with design of air flow path can pay dividends in blower efficiency and economy

By ADAM M. WILCZENSKI and KENNETH A. MERZ,
The Torrington Manufacturing Co., Torrington, Conn.

(3) Density \( \rho \) of air or other fluid circulated.

(4) Flow distribution—the shape and size of flow cross-section for good distribution over the heat source. This factor is not important when the blower unit merely maintains air circulation in an enclosed space.

(5) Electrical characteristics—frequency, voltage, maximum current and power and motor type. Total electric power must be shared with many other components, often little is left for the blower. Power consumption is critical in portable or airborne equipment.

(6) Noise and vibration—noise limits may exist, for example, in communications equipment or in medical electronics. Vibration may have limits to avoid disturbing other elements.

(7) Space—one of the most troublesome requirements. If cooling is considered early enough in design, sufficient space can be provided in the expected air flow path. Otherwise space may be too small or of awkward shape, affecting both cost and efficiency.

(8) Weight—usually critical in portable and airborne equipment.

(9) Environmental specifications—the blower unit may have to pass environmental tests of specifications like MIL-E-5272A and MIL-E-5422B. The specifications include resistance to external vibration, shock, corrosion and fungi.

(10) Mounting method and hardware—horizontal or vertical position, flange dimensions and bolt-hole sizes.

(11) Life—projects have requirements for operating life in hours of continuous or intermittent duty without failure or attention.

Where the circuit elements can cool themselves by free convection, the blower need only ventilate the enclosure. The relation between heat-dissipation rate, permissible temperature rise of the air, and flow rate enables the flow rate to be computed; then the system resistance characteristic may be established by test.

More commonly, the circuit elements are cooled by forced convection and air-flow testing is necessary. The significant parameter is surface temperature of the circuit element, which is affected by local rather than average, air velocity and temperature. It is then necessary to supply air to the unit from whatever air source is convenient, while the unit is operated at rated output and control temperatures of the elements are monitored. When the cooling rate is obtained by adjusting the air-flow rate and direction, flow rate and pressure drop through the unit may be measured. Flow testing may be done with any reliable method, although such tests are more conveniently performed by the blower manufacturer. Figure 1 shows such tests being conducted on a stacked-

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FIG. 3—Pictures show forwardly-curved impeller blade blower unit (A), high-altitude "pancake" blower unit (B) and a compact forwardly-curved impeller, double-scroll unit (C)
circuit gate of IBM's Stretch computer.

Blower units include an impeller, housing or orifice to govern the flow of air and driving motor. They are classified, according to the impeller type used, as axial or centrifugal.

Axial units are of three types: the partially cased impeller, Fig. 2A, where a simple impeller operates in a shallow orifice that merely channels flow through the impeller; tube-axial, where the impeller operates in a section of duct; and vane-axial, Fig. 2B, where one or more impellers operate with one or more sets of straightener vanes in a duct. Tube-axials are more efficient than partially cased impellers because of reduced leakage past blade tips, but the air still flows helically and the tangential component of flow represents wasted energy. In vane-axial units the straightener vanes remove the tangential component and convert its energy to pressure. Thus, vane-axials have the highest pressure characteristics and highest efficiency of all the axial types.

Centrifugal units are classified by the type of impeller blading: forwardly-curved, Fig. 3A, where the discharge edge of the blade is inclined forward in the direction of rotation; radial-bladed, and backwardly curved. No one type is clearly superior to the others; highest peak efficiencies are attained with backwardly curved wheels, highest speeds are possible with radial wheels, and greatest flow and pressure for a given size and speed are possible with forwardly curved impellers.

The two centrifugal units in Fig. 3B and 3C show how blower units can be adapted. The pancake blower in Fig. 3B, designed for cooling at high altitudes, was constructed to provide high performance (500 cfm at a static pressure of 2.4 inches of water at 65,000-ft altitude) and yet the impeller housing is only 3.08-in. wide. In Fig. 3C, two scrolls have been combined with a motor to provide 400 cfm at a static pressure of 0.8 inch of water.

The most efficient blower unit produces the necessary air horsepower with minimum power input, smallest motor, and least weight, cost, and noise. While efficiency in the conversion of electrical power to air power is always desirable, blower units in air conditioners,
EQUATIONS FOR COOLING BLOWER SELECTION

Heat removed by air flow, based on average specific heat of 0.24 Btu/lb is

\[ Q_p (T_s - T_f) \cdot 237 \text{ kilowatts} \]  

where \( Q \) = air flow in cu ft/min, \( s \) = air density in lb/cu ft, \( T_s \) = air inlet temperature in deg F, and \( T_f \) = air discharge temperature, deg F.

The heat dissipated from a single circuit element by forced convection cooling is

\[ W = 0.293 h_s A (T_s - T_f) \text{ watts} \]  

where \( h_s \) = forced convection heat transfer coefficient in Btu/hr-sq ft-deg F, \( A \) = cross-sectional area through which heat flows in sq ft, \( T_s \) = maximum surface temperature of heat source in deg F, and \( T_f \) = mean circulating air temperature at heat source in deg F. The independent variable in equation (2) for a given flow system is the heat-transfer coefficient \( h_s \), itself a function of Reynolds number, Nusselt number, thermal conductivity of the fluid, and some dimension of the object being cooled. For a particular object being cooled by air under a particular set of conditions, \( h_s = V^v \text{ Btu/hr-sq ft-deg F} \); \( V \) is the air velocity in ft per min, and \( v \) depends on the type and orientation of heat transfer surfaces (\( v = 0.6 \) is commonly used for electronic equipment cooling systems).

Since \( Q = A \times V \), \( V \) may be changed by varying either \( Q \) or \( A \). However, \( V \) varies more slowly than \( V \) (doubling \( V \) increases \( h_s \) about 50 percent). Once the flow cross-section \( A \) has been established, holding the maximum surface temperature \( T_s \) to desired values requires a certain velocity \( V \) and then becomes a blower-system problem of producing \( Q \) cubic feet per minute.

Static pressure \( p_s \), added to a cooling system by a blower to overcome flow resistance is related to air flow \( Q \) in cfm by the expression

\[ p_s = KQ^p \text{ inches of water} \]  

The three solid curves in Fig. 6 show the system-resistance characteristics of three air-flow paths of decreasing system-resistance constant \( K \), to \( K_r \), representing lower total resistance in the path. To maintain a flow rate \( Q_r \) along a flow path, higher static pressures \( p_s \) to \( p_s \) to \( p_s \) must be introduced by the cooling blower as the resistances in the system increase.

Air horsepower \( P_a \), defined as the energy a blower delivers to an air-moving system, is

\[ P_a = Q \times p_s \times 6,360 \text{ horsepower} \]  

For a heat transfer coefficient resulting in flow rate \( Q \), the air power input depends directly on the system resistances. Comparison of this equation with the relation between \( h_s \), air flow rate, and air flow path area shows how important it is to channel air closely over components requiring a high \( h_s \), so that \( Q \), and consequently air horsepower, may remain small.

The static efficiency of a blower unit is

\[ n_s = \frac{P_a \times 100}{Q \times p_s} \times 100 \text{ percent} \]  

where the air horsepower \( P_a \) and electrical power input to the impeller \( P_e \) are in identical units, either watts or horsepower. Each type of air impeller will reach peak static efficiency at one combination of air flow rate, static pressure and motor speed. This is expressed by a factor called specific speed, given by

\[ N_s = \frac{Q \times p_s}{h_s^{1/2}} \]  

where \( N_s \) = impeller speed in rpm. This characteristic is not truly dimensionless and it is customary to evaluate it when the blower is handling air at standard temperature (0.075 lb/cu ft).

Static efficiency is plotted in Fig. 7 as a function of specific speed for each of the major types of axial and centrifugal impellers. These curves demonstrate several facts:

1. Each type of impeller has a single peak efficiency.
2. There are large differences in the magnitudes of peak efficiency.
3. The specific speed of different impeller types at peak efficiency varies widely.

Desired values of flow rate \( Q \), static pressure \( P \), and a motor speed \( N \) may be substituted in Eq. 6 to obtain the particular specific speed for a cooling blower that will properly match the flow system.

For a given impeller type, size and speed, changes in air density \( \rho \) affect flow rate \( Q \), static pressure \( p_s \), and impeller power \( P_e \) in the following manner.

\[ Q_e = Q_e \]  

\[ p_s = p_s (\rho / \rho_e) \]  

\[ P_e = P_e (\rho / \rho_e) \]  

Flow rate is thus independent of altitude, and the static pressure and power required to maintain a given flow rate become smaller as altitude increases. Thus it is easy to compute blower performance at altitude conditions.

EXAMPLE

Forced-convection cooling must remove \( W = 180 \text{ watts} \) of heat from a single electronic circuit element whose maximum allowable surface temperature \( T_s = 180 \text{ F} \). The heat-producing element is in a location where mean circulating air temperature is 85 F. It is necessary to determine the flow rate \( Q \), static pressure \( P \), and the type of impeller unit that will most efficiently fulfill these conditions.

The initial performance test used an available propeller fan at 11,000 rpm and showed the measured \( T_s = 210 \text{ F} \), 30 deg above the maximum desired value. Other measurements give \( Q = 57 \text{ cfm} \), \( p_s = 0.5 \text{ inch of water} \) and \( P_s = 3.4 \text{ watts} \). To reduce \( T_s \) to 180 F, Eq. 2 is used as follows:

From initial test

\[ 180 = 0.293 h_s A \text{ (210 - 85)} \]

then

\[ h_s = \frac{180}{0.293 A} = 125.95 \text{ or } h_s = 1.2595 \text{ inch of water} \]

It is then necessary to increase \( h_s \) by 30 percent, which may be accomplished in either of two ways. First, by increasing \( Q \) with no change in the full area of the air flow path:

since \( h_s \sim V^v \)

then \( h_s = h_s \) and \( V \) = \( V_s / V_1 \)

so \( p_s = p_s (Q_s/Q_1) = 0.57 \text{ inch of water} \)

and \( P_s = 1.2 \times 68,636 = 0.016 \text{ hp or 12 watts} \)

Second, by decreasing the area of the flow path with no change in flow rate:

Since \( Q_s = Q_s = 57 \text{ cfm} \)

then \( V_2 = (1.3)^{1/5} V_1 = 1.545 V_1 \)

so that the area of the flow path must be reduced

\[ \left( 1 - \frac{1}{V_2/V_1} \right) \times 100 = 35.3 \text{ percent} \]

\[ p_s = (V_2/V_1)\rho = 1.545 \rho_1 \]

\[ = 1.2 \text{ inches of water} \]

(as it should be, the calculated \( p_s \) is the same with either method)

\[ P_s = 1.2 \times 57 \times 6,360 = 0.0107 \text{ hp or 8 watts} \]

If the area of the flow path can be conveniently reduced by 35 percent, this is a more efficient method for reducing \( T_s \), since only two-thirds of the air horsepower is required. The specific speed and most efficient types of impellers can be determined in Fig. 4 and the performance limits are plotted in Fig. 6. The efficiency based on lower right indicates that for \( N_s = 75 \text{ rpm} \), the variable-axial impeller will be the most efficient type.
ventilators and other domestic units are often operated at less than peak efficiency to obtain some other advantage such as lower cost, higher flow rate or a particular motor speed. In electronic cooling applications, however, there is usually little extra power or space available to accommodate an inefficient blower unit.

Specific speed presents a simple way to determine which type of blower will be most efficient in any application. Each type, regardless of size, develops its peak efficiency at a characteristic specific speed. Once motor speed is decided upon for a given application, it is possible to compute the specific speed at which the impeller efficiency must peak and to choose a unit that does peak at that speed. Figure 4 helps to determine the specific speed and the types of impeller with high static efficiency at any given specific speed. While any specific speed that occurs in the range of a shaded bar indicates satisfactory efficiency for that impeller type, the peak value is found around the midpoint of each bar. Whatever the refinements in design within a type of impeller, such as a forwardly curved blower wheel or vane-axial unit, the effect is usually to increase peak efficiency rather than to cause it to occur at a different specific speed.

Figure 5 illustrates how excessive power consumption can develop when blower type is not properly chosen. Motor speed is fixed, and a partially cased impeller, curve A, is ideally matched to the application, with specific speed of 129,000. By cut-and-try methods a centrifugal blower, curve B, is found which seems to do the job. However, its power input is 0.38 hp, compared to the power requirement of 0.09 hp for the partially cased impeller. Comparison of the required specific speed of 129,000 with the optimum specific speed of about 28,000 for the centrifugal unit (Fig. 4) would have warned initially that the cooling job was not suitable for this type of impeller.

Once the most efficient blower type has been determined on the basis of flow rate, static pressure and motor speed, the size of the blower unit can be estimated. The space occupied in the equipment depends on (1) the design of the blower and (2) the dimensions of the scroll or fan orifice, motor, flange and other accessories. Unless a blower has been selected off the shelf, exact dimensions of the unit cannot be known until a prototype has been built and tested. Dimensions can be predicted but where basic data is not at hand, impeller size, and hence unit size, can be estimated from

$$D = K_D \sqrt{\frac{P_b}{N}}$$

and

$$D = C_D \sqrt{\frac{Q}{N}}$$

where $K_D$ and $C_D$ are constants that may be obtained from ratings of geometrically similar units by substituting values taken from the desired portion of the performance curves.

The best cooling job with the least difficulty for the electronic designer is thus most likely to be attained by taking advantage of the blower manufacturer's specialized knowledge. The designer must then determine and specify fully and accurately the required operating parameters to the blower specialist.

REFERENCES


**FIG. 7**—Peak static efficiency is shown for different impeller types, plotted against impeller specific speed.
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Regulated Power Supply
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Simple power supply provides 0.1 percent current regulation for thermocouple gage application

By WILLIAM V. LOEBENSTEIN,
Surface Chemistry Section, Div. of Chemistry, NBS, Washington, D. C.

LABORATORY INSTRUMENTS requiring a fixed input immune to fluctuations in line voltage often need a current or voltage supply regulated to ±0.1 percent. One application is in heating a thermocouple vacuum gage. To be economically feasible, the regulator should be simple as compared with other available instruments of comparable performance.

A thermocouple gage that needed a source of constant current was custom-built. Its heater required a high current (140 ma) compared with commercial gages. Voltage developed by the thermocouple (output of the vacuum gage) was plotted on a chart recorder. The recorder trace showed fluctuations caused by changes in the heater current when these variations were greater than 0.2 ma. Therefore, regulation of the heater current to tighter limits was necessary. However, there was no need to strive for better than 0.1-percent regulation because changes in room temperature produced second-order voltage fluctuations of equal magnitude.

The possibility of using an available regulator circuit was investigated. A comparison of the more common circuits is discussed in the Navy's Handbook of Preferred Circuits. It was desirable that the circuit be no more complicated than preferred circuit No. 1, which consists of a regulator triode, a single-pentode d-c amplifier and a series-connected voltage regulator reference tube. This circuit, however, is rated for only one-percent regulation.

The key to improved regulation seemed to depend upon a more careful design of the screen supply network of the pentode amplifier. Advantage can be taken of the fact that there is no need to make frequent changes in the load. Also, since no fluctuations requiring regulation originate in the load, the circuit gives better overall regulation than with a variable load.

It is known that line-voltage variations can be overcompensated for by supplying the screen from the input side of the regulator. It can also be verified experimentally that undercompensation results if the screen is supplied from the output side. Between these two extremes it is possible to locate an optimum setting for the screen supply.

A regulator circuit, which has now been in satisfactory use for more than two years, is shown in the figure. Provision has been made for adjusting the screen supply. Settings for the potentiometers were determined using the following procedure:

Nominal value of the voltage at A, required to give the desired current through the load, was first obtained by adjusting potentiometer R. Potentiometer R, was next adjusted until no voltage drop occurred between A and B.

The final and most difficult setting was that of potentiometer R. The line voltage was deliberately varied by 15 percent in each direction using a variable autotransformer set alternately at 95 and 125 volts. Simultaneously, a constant fraction of the output voltage was fed to a recorder equipped with a zero-point suppression control so that changes of less than 0.1 percent were detected. When the setting of R, was too close to B, an increase in line voltage resulted in a decrease in the output, indicating overregulation. The opposite was true when the wiper of potentiometer R, was too close to A. A few trials located a setting for R, such that the output voltage showed no tendency to increase or decrease when the line voltage was changed.

Similar circuits examined in the literature have, at most, one potentiometer to serve the function of R, and R, The circuit in the figure, in which R, is used for the selection of unregulated voltage supply before balancing out the ripple with R, requires no readjustment of R, to compensate for the change in operating point of the pentode. Also, a more linear correction for ripple can be expected.

The recorded voltages showed that the regulator held the output to within ±0.1 percent over extended periods of time. The unregulated line showed brief fluctuations of about four percent and long-period drifts as large as 8.5 percent. Performance of this circuit was compared with that of other experimental circuits and with that of a larger regulator. The regulator described in this article performed better than any of the other units.

REFERENCES

ELCO VARICOM Series 7001 and printed circuit board. Note 3 types of contact terminals: for conventional soldering; "bus;" and Keller wrap wiring.

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November 25, 1960
Algebraic Method Finds Target Information

By J. H. MORRISSEY,

POSITION of a target detected by multiple-unit radar or sonar systems, velocity of the target or both can be determined using linear algebra and geometry. A wide variety of navigation and tracking applications are expected for the system, which could ultimately modify or replace some existing position-finding and tracking systems.

The new method is called Mulcap when applied to position finding and Mulcave when used to determine velocity vectors. The desired information is yielded by means of a data-processing algorithm involving presolution of two redundant systems of linear simultaneous algebraic equations.

Suitably extended and modified, it could replace traditional systems using the intersections of quadratic loci (hyperbolas, hyperboloids, ellipses, ellipsoids, circles or spheres). Instead, the data-processing algorithm could be described geometrically as target location by intersecting planes. Multiple roots of quadratic equations are eliminated, and a single unique estimate of target position, velocity or both is provided regardless of the number of intersecting planes involved. Direction cosines of the planes are determined in advance by the configuration of the stations and are independent of the target.

Inputs are differences or sums of arrival times of a target-transmitted or target-reflected signal among n fixed stations. In general, the stations can be regarded as constituting a field consisting of p transmitters and q receivers, where \( p + q = n, 0 \leq p \leq (n - 1) \) and \( n \geq q \geq 1 \). For three-dimensional applications, \( n = 5 \) and for plane applications, \( n = 4 \).

Outputs are three cartesian coordinates of target position, velocity or both. Variations can yield position alone, position and then velocity or a simultaneous estimate of the six coordinates.

Families of planes (lines in plane applications) are each associated with a distinct transmitter-receiver or receiver-receiver pair. If \( p \) transmitters and \( q \) receivers locate or track a reflecting target, \( pq \) families of such planes are available. Similarly, with \( n \) receivers only, \( (n/2)(n - 1) \) families of planes are available.

Each member of a family is exactly parallel to every other member of the same family. Thus each family shares a common set of three direction cosines—those of a line joining one pair of the elements in the field. The common intersection of the planes of each family is target position. The direction cosines of each plane forming the locating cluster are the same regardless of target position.

Noise would prevent the intersecting of all planes at a single point. A residual sum-of-squares measure of departure of the planes from the intersection provides a measure of the precision of target location.

Position coordinates are computed from \( x = x_0 - 2plk, y = y_0 - 2pmk \) and \( z = z_0 - 2pnk \). Direction cosines \( l, m \) and \( n \) are those of a unique line on which the target must lie; \( x_0, y_0, z_0 \) is a point within the field that locates the unique line translationally; and \( p \) is mean range to target from all \( n \) field elements. The un-normalized direction cosines \( lk, mk \) and \( nk \) are linear transformations of the covariance between observed time delays among \( n \) field elements and the projection on the \( x, y \) and \( z \) axes, respectively, of the corresponding spatial separation among the \( n \) field elements.

Mean range to target \( p \) is computed by minimizing a parabolic

---

Scimitar Antenna Test

Scimitar type antenna is type used on B-52 bomber. Tests are being made at Boeing laboratory, Wichita, Kansas.
KEPCO'S "SM GROUP" sets a new transistorized design standard

In Performance

These 15 new transistorized voltage regulated power supplies reconcile ruggedness and wide power capability (without mag-amps) with excellent ripple reduction, regulation, and negligible transient response characteristics.

In Reliability

Unique "fail-proof" design inherently protects series "pass" transistors from damaging overloads (dissipation requirements of pass elements actually reduced under high load demand or short circuit).

Size-Wise

New sophisticated circuit simplicity permits greater reduction in size (without "shoehorn" techniques). Five wide voltage ranges, in three panel height groups scaled to popular power requirements. All models standard rack width 19", depth 13".

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DC OUTPUT VOLTS</th>
<th>DC OUTPUT AMPS.</th>
<th>PANEL HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM 14-30</td>
<td>0.14</td>
<td>0.30</td>
<td>8 3/4</td>
</tr>
<tr>
<td>SM 36-15</td>
<td>0.36</td>
<td>0.15</td>
<td>5 1/4</td>
</tr>
<tr>
<td>SM 75-8</td>
<td>0.75</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>SM 160-4</td>
<td>0.160</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>SM 325-2</td>
<td>0.325</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>SM 14-15</td>
<td>0.14</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>SM 36-10</td>
<td>0.36</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>SM 75-5</td>
<td>0.75</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>SM 160-2</td>
<td>0.160</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>SM 325-1</td>
<td>0.325</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>SM 14-7</td>
<td>0.14</td>
<td>0.7</td>
<td>3 1/2</td>
</tr>
<tr>
<td>SM 36-5</td>
<td>0.36</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>SM 75-2</td>
<td>0.75</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>SM 160-1</td>
<td>0.160</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>SM 325-0.5</td>
<td>0.325</td>
<td>0.0.5</td>
<td></td>
</tr>
</tbody>
</table>

INPUT REQUIREMENTS FOR ALL MODELS: 105-125 VAC, 60-1/2 cps.
METERS OPTIONAL: Model Nos. listed in table are for unmetered units.
To specify metered units, add "M" to Model No. (e.g. SM 14-30M)
*0.01% REGULATION MODELS AVAILABLE ON SPECIAL ORDER.

FOR DETAILED SPECIFICATIONS ON MORE THAN 150 STANDARD MODEL POWER SUPPLIES SEND FOR KEPCO CATALOG B-601

November 25, 1960

CIRCLE 135 ON READER SERVICE CARD
THE SPOTLIGHT’S ON PERFORMANCE

with CEC’s newest strain gage pressure transducers

And the accent’s on versatility! As a family, these three cover a pressure range from 0 to 10,000 psi in gage, absolute, and differential models...always provide top performance, even in applications with great extremes of environmental conditions.

Above, TYPE 4-325 is the smallest—only 8 grams—and extremely valuable where size is critical. Differential models cover the range from ±5 to 50 psi, while absolute and vented gage units measure pressures from 10 to 200 psi. Write for Bulletin CEC 1630-X9.

Outstanding TYPE 4-326 has the finest inherent performance capabilities of any comparable product now manufactured. It’s rugged—usable in a 1000 g environment—and measures absolute and gage pressures from 0 to 10,000 psi. Write for Bulletin CEC 4326-X4.

New TYPE 4-328 has a built-in thermal heat shield, making it ideal for airborne applications. Sealed gage and absolute models are available for low, medium, and high-pressure measurement. Bulletin CEC 4328-X4.

Other strain gage pressure transducers in the CEC family are described in Bulletin CEC 1308-X23.

Machine-Animal Analogies

COMPLETELY RANDOM pattern recognition machines are not practical. So said Theodore Kalin of the Computer and Mathematical Sciences Laboratory recently.

This is in contradiction to the beliefs of other investigators who have designed experimental random machines based on the apparent example found in mammals, including human beings. They assume that the visual cortex of the brain must learn to assemble randomly distributed bits of light and shadow it receives into a meaningful pattern because there are few if any traceable nerve pathways within the visual cortex that would automatically assemble patterns. Machines, they say, might also learn to assemble random pattern elements even though all connections and logic circuitry are randomly connected.

From purely mathematical considerations, Kalin has shown that connections between the eye and higher cortical centers cannot be assumed random. His work involved a systematic study of mammalian visual-system neuroanatomy. He found that a minimum of organization must exist. In the theory developed, he says that neurons in the cortex receiving visual signals should be functionally arranged in a plane with an even density of incoming fibers over its surface. Even though this seems to
Balloon-Borne Gear
Counts Cosmic Particles

INSTRUMENTS for measuring cosmic radiation were recently lifted by balloon to 112,000 feet, where the altitude is sufficiently rare to make precise measurements of heavy primary cosmic particles. Purpose of the flight is to gather more information about this radiation, which presents a hazard to manned space flight.

The program is a joint venture of the Air Force Cambridge Laboratory and RIAS, the Martin Company's Basic Research Institute. The helium-filled, one-million cubic foot balloon was launched from Lordsburg, New Mexico.

As well as telemetering and other electronic equipment, the 100-pound payload included a double ionization chamber to measure radiation. Telemetered results were recorded on magnetic tape for later analysis. Specific information sought includes the source of the heavy primary particles, their size and number, and whether changes related to the radiation take place from day to night.

The present experiment is one of a series using balloons, rockets and satellites. The high altitudes are required to measure the primary particles before collisions with denser atmosphere disintegrate them to form secondary particles. At the 112,000-foot altitude, both primary and secondary radiation was detected.

The chamber contains a cylinder filled with argon under pressure. A high-speed particle passing through the chamber removes an electron from each atom it encounters. The free electrons collected by a positively charged conductor at the center of the chamber are counted. The amount of ionization produced is measured, which enables precise determination of the particle.

What type of connector for you? CEC can meet virtually any application need with its line of standard connectors and its capability in the design of special types.

Look at the variety of CEC's standard connectors: rectangular types with snap-in, crimp-type contacts in 14- to 104-contact configurations... rack and panel types with high-strength, die-cast polarizing shell containing both standard and coaxial contacts... circular MS types (MIL-C-26500) with immersion-resistant characteristics in 15- to 55-contact configurations for use in critical environments... and circular types for non-critical industrial applications.

Regardless of the application, you can depend on CEC know-how and experience to meet your connector requirements. From CEC's extensive engineering and manufacturing facilities comes a complete line of connectors with a full guarantee of reliability.


Electro Mechanical Instrument Division

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell • FASTER PRODUCTS THROUGH IMAGINATION
Evaluation Report of Microelements
DEVELOPED FOR A MICROMODULAR PROGRAM

By MICHAEL F. TOMAINO,
Associate Editor

AS A RESULT of RCA's Micromodule Reliability Program*, 171 digital micromodules now meet equipment requirements at the 1,000-hour life-test point, the half-way mark in a 2,000-hour test program.

These module tests encompass 1.3 million hours of element operation without a circuit failure. The types and quantities of components used for these modules are shown in Table III. Eight types of circuit modules are included: binary divider, binary gate, sawtooth generator, time modulator, 192-Kc oscillator, clipper, pulse shaper, and output amplifier. This reliability level was attained as a result of an overall reliability program involving an additional 5.2 million element test hours to make 6.5 million total element test hours. One additional type of digital micromodule and seven types of communication micromodules must yet be tested.

The Micromodule reliability program was designed to include continuous in-process testing and data

Table I—Microelement Environmental Tests—1960

<table>
<thead>
<tr>
<th>Component</th>
<th>Shock (50g)</th>
<th>Within 21 Hrs</th>
<th>After * Aging</th>
<th>Vibration (2000 cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Layer Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision</td>
<td>0/38</td>
<td>1/38</td>
<td>0/38</td>
<td></td>
</tr>
<tr>
<td>Gen. Purpose</td>
<td>0/40</td>
<td>4/10</td>
<td>0/10</td>
<td></td>
</tr>
<tr>
<td>Multilayer Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision</td>
<td>0/20</td>
<td>0/20</td>
<td>0/20</td>
<td></td>
</tr>
<tr>
<td>Gen. Purpose</td>
<td>0/20</td>
<td>1/20</td>
<td>0/20</td>
<td></td>
</tr>
<tr>
<td>Electrolytic Capacitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0/21</td>
<td>0/21</td>
<td>0/21</td>
<td></td>
</tr>
<tr>
<td>Resistors</td>
<td>0/12</td>
<td>0/12</td>
<td>0/12</td>
<td></td>
</tr>
</tbody>
</table>

Legend—units failed/units tested
a—units aged at normal ambient conditions and retested approximately two months after moisture resistance test.

Table II—Microelement Life Test Data—Passive Microelements

<table>
<thead>
<tr>
<th>Component</th>
<th>Tests</th>
<th>Life - Hours (X 10⁵)</th>
<th>Catastrophic Failures</th>
<th>Limite</th>
<th>Degradation</th>
<th>Analysis</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single layer ceramic</td>
<td>201</td>
<td>402</td>
<td>8</td>
<td></td>
<td>33 failures due to high dissipation factor. Of these, 33 had diss.fact. no greater than 1.07 x the specified value</td>
<td>all capacitor tests at 85C. Run at 3 times rated voltage. All units encapsulated in test modules</td>
<td>run at twice rated voltage</td>
</tr>
<tr>
<td>general purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>precision</td>
<td>199</td>
<td>398</td>
<td>5</td>
<td>0.318%</td>
<td>1 unit-0.378%</td>
<td>i unit-6.5 meghoms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multilayer ceramic</td>
<td>170</td>
<td>310</td>
<td>3</td>
<td>5.0%</td>
<td>all within limits</td>
<td>all within limits</td>
<td>run at rated voltage</td>
</tr>
<tr>
<td>general purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>encapsulated</td>
<td>200</td>
<td>400</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unencapsulated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>195</td>
<td>390</td>
<td>1</td>
<td>0.286%</td>
<td>all within limits</td>
<td>all within limits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>400</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitor-electrolytic</td>
<td>95</td>
<td>190</td>
<td>3</td>
<td>leakage 120% of initial</td>
<td>1 unit-high leakage</td>
<td>run at rated voltage</td>
<td></td>
</tr>
<tr>
<td>encapsulated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unencapsulated</td>
<td>419</td>
<td>2095</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistor Wafers-metal film</td>
<td>202</td>
<td>404</td>
<td>3</td>
<td>10%</td>
<td>17 paths 1.0-2.0%</td>
<td>all within limits</td>
<td>resistors tested at 71 C ambient with 110 C hot spot</td>
</tr>
<tr>
<td>(four resistor paths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per wafer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inductors</td>
<td>121</td>
<td>218</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend—units failed/units tested
a—dissipation factor; b—insulation resistance
ADVANCED CBS MEMORY CUBE

Now available for evaluation

For customer evaluation, CBS Electronics offers a working 16-bit sample memory cube. Its "new-concept" design features plastic-encapsulated ferrites and deposited conductors, resulting in compactness, light weight, and shock resistance never before achieved.

Check the features, unique construction and technical information. Order the CBS M-267 sample memory cube from stock... nominal charge $50.00. Evaluate for yourself, firsthand, the benefits of its advanced design.

CUSTOMIZED SYSTEMS

After your evaluation of the M-267, CBS Electronics can supply development facilities for custom-designing memory systems for your military computer requirements. This typical CBS customized memory pack, a multi-aperture, nondestructively-sensed, word-organized system, achieves a density of 15,456 bits in less than 23 cubic inches. Other CBS custom designs include nondestructive readout memories and ferrite logic systems. The ferrite cores in the memories meet a wide range of requirements for signal output, switching time, and current drive.

CBS ELECTRONICS, Danvers, Massachusetts, A Division of Columbia Broadcasting System, Inc.

November 25, 1960
Every component in the U.S. Navy's TARTAR, newest supersonic surface-to-air guided missile must meet the highest standards for statistical reliability. No exception is the Bristol Syncroverter chopper used in the TARTAR's guidance system. The TARTAR, produced for the Bureau of Naval Weapons by Convair (Pomona) Division of General Dynamics Corporation, is slated to form the primary antiaircraft weapon aboard destroyers and secondary antiaircraft batteries aboard cruisers.

The Bristol Syncroverter chopper has a long history as a component in U.S. guided missiles. It's the ideal miniature electromechanical chopper for use in d-c analog computers or wherever utmost reliability is required.

BILLIONS OF OPERATIONS have been completed without a failure on Bristol's continuing life tests—aimed at improving the Syncroverter's already superlative characteristics. Just one sample: A group of five choppers, with 400 cps drive and 12v, 1 ma resistive contact load have been going for more than 26,000 hours without failure. That's more than 2,96 years continuous operation or more than .37 billion complete cycles.

No matter what your chopper requirements, we're sure you can find the model you need among the wide selection of Syncroverter choppers and high-speed relays available... including low-noise, external coil types. For complete data, write: The Bristol Company, Aircraft Equipment Division, 150 Bristol Road, Waterbury 20, Conn.

Technician assembles microelements prior to life tests

tabulating to facilitate identification of failure mechanisms at each vendor's plant. Recognition of the failure mechanisms and the resulting corrective actions aided materially in quality improvements.

Life and environmental microelement tests were conducted by the component vendors and RCA at the prototype and final program phases. Most microelement tests were made in simulated modules operated at or above maximum ratings. The same assembly and potting facilities were used for producing the test modules and micromodules.

The microelements were purchased to specifications designed to be more rigid than Mil Specifications. Exemplifying this are the life test requirements of 2,000 hours where Mil Specs require only 1,000 hours.

Approximately 160,000 microelements have been produced for this program.

Table III—Microelement Life Tests

<table>
<thead>
<tr>
<th>Components</th>
<th>Units</th>
<th>Tested</th>
<th>Unit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2N104 .</td>
<td>248</td>
<td>218,000</td>
<td></td>
</tr>
<tr>
<td>Type 2N384 .</td>
<td>2</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>Diodes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 1N277 .</td>
<td>198</td>
<td>198,000</td>
<td></td>
</tr>
<tr>
<td>Type 1N613 .</td>
<td>102</td>
<td>102,000</td>
<td></td>
</tr>
<tr>
<td>Capacitors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>405</td>
<td>105,000</td>
<td></td>
</tr>
<tr>
<td>Resistors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>312</td>
<td>312,000</td>
<td></td>
</tr>
<tr>
<td>Inductors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>19,000</td>
<td></td>
</tr>
<tr>
<td>Crystals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>19,000</td>
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</tr>
<tr>
<td>Totals</td>
<td>1,335</td>
<td>1,335,000</td>
<td></td>
</tr>
</tbody>
</table>

*—data resulted from operation in micromodule performance testing at 70 C and 75 C.
Tables I, II and III present the first data released on environmental and final phase life tests.

Safety Fuse

Controls Reactor


The fuses automatically shut down research reactors without external controls. While all reactors contain control systems to make them safe, a fuse provides additional protection in certain types of experimental reactors.

The devices are compared to electrical fuses which shut off power to overload. Fabrication was done at Atomics International's Canoga Park, Calif., laboratories.

Completely self contained in a cylinder, a fuse is partly inserted in the core of a reactor where atomic fission takes place. The part outside the core contains boron trifluoride gas. In an operational device the gas is released automatically into the other part of the cylinder in the event of a power surge. The gas absorbs neutrons required to maintain the chain reaction, bringing the reactor under control instantly and without damage.

Atoms International began early work on a safety fuse in 1952 and has been developing the present concept for the AEC since 1957. Operational experience of the safety fuse concept will be gained as part of the experimental program at General Atomic.

November 25, 1960

Here's an EYEFUL of technical data on precision resistor and potentiometer wire

Two new catalog-manuals containing complete information on

TWO NEW Hoskins 800 OHM ALLOYS

If you make potentiometers or precision wire wound resistors, these manuals are meant for you! They're loaded with helpful technical information—show all physical properties and electrical characteristics, list bare and enameled wire specifications. And they contain much useful application data compiled especially to help you produce more and better control components with these two new performance-proved alloys:

CHROMEL-R: A modified 80-20 type nickel-chromium alloy possessing electrical resistivity of 800 ohms per cm/ft at 20° C., low temperature coefficient controlled within 0 ± 15 ppm per °C.—plus exceptional linearity and stability from —65° to +150° C.

Alloy 815-R: A lower density, higher resistivity ferro-alloy material that gives you 14% more ohms per pound. Has good strength and ductility, excellent resistance to wear and corrosion. Resistivity is 815 ohms per cm/ft at 20° C., temperature coefficient 0 ± 10 ppm per °C. in the range from —65° to +150° C.

Send for copies today—plus samples of both alloys!

Hoskins MANUFACTURING COMPANY

4551 Lawton Avenue  •  Detroit 8, Michigan

In Canada: Hoskins Alloys of Canada, Ltd., 45 Racine Rd., Rexdale P.O., Toronto, Ontario

Producers of Custom Quality Resistance, Resistor and Thermo-Electric Alloys since 1908

CIRCLE 141 ON READER SERVICE CARD 141
Better Breadboards Save Time, Parts

By ALBERT T. OWENS

Advanced Projects Lab., Eng. Div.,
Hughes Aircraft Co., Culver City, Calif.

CIRCUIT DEVELOPERS have gotten a lot of mileage from the terminal boards normally-used for breadboarding, but there are faster and better methods. The improved methods shown cover the entire frequency range from d-c to uhf.

Valuable "inspiration" circuit ideas are often lost by the time-consuming nuisance of assembling a conventional breadboard. Furthermore, a clean layout is needed so that the breadboard circuit will resemble the schematic design. The resemblance leads to faster assembly and easier circuit diagnosis.

A foam breadboard was developed for temporary lower frequency breadboards. The stray capacitance and inductance of the clips used may become objectionable as frequencies rise into the megacycle region.

The base is a Styrofoam slab about 2 x 12 x 18 inches. Terminals are made by soldering together small alligator clips, sockets and short pieces of wire. The clips are crimped slightly with pliers so they bite leads better. Clips and sockets can be inserted anywhere in the slab and components and jumpers routed without the inhibitions of predetermined terminal spacing or the necessity of soldering connections.

The multivibrator illustrated was made in four minutes, while the same circuit took 34 minutes to assemble on a conventional breadboard. The saving in time is significant since breadboarding is usually done by high-paid personnel. Components are not damaged, the circuit can be disassembled without soldering and the components and jumpers can be reused.

An array of taper pin sockets and transistor sockets on an epoxyl glass board is especially well-suited to digital computer work. This board is also used for high-temperature circuit testing, the temperature limit being the melting point of the solder used on permanent jumpers. It is being used now to test at 240 C.

Terminals are regular CTC tapered solder terminals. Transistor
MAGNETIC

NEED BETTER

PROPERTIES?

Check These Grain Oriented Materials from A-L

<table>
<thead>
<tr>
<th>NAME</th>
<th>DESCRIPTION</th>
<th>SPECIAL PROPERTIES</th>
<th>TYPICAL USES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silectron</td>
<td>Grain oriented silicon strip. Available in coils and laminations in thicknesses of .012 and .014 inch.</td>
<td>Very low 60 cps core losses, high permeability, and low exciting currents at high inductions in the rolling direction.</td>
<td>Power and distribution transformers, large turbo generators, small power and audio transformers.</td>
</tr>
<tr>
<td>Thin Gage Silectron</td>
<td>Grain oriented silicon strip. Available in coils in thicknesses of 1, 2, and 4 mils.</td>
<td>Low core loss and high permeability at frequencies greater than 60 cps in the rolling direction.</td>
<td>High frequency transformers, pulse transformers, magnetic amplifiers, communication equipment.</td>
</tr>
<tr>
<td>Deltamax</td>
<td>Grain oriented, 50 percent nickel, balance iron. Available in coils and laminations.</td>
<td>Low coercive force and rectangular hysteresis loop developed after a high temperature, hydrogen anneal.</td>
<td>Magnetic amplifiers, computers, mechanical rectifiers, saturable reactors.</td>
</tr>
</tbody>
</table>

For the utmost in magnetic properties, design your flux paths to take advantage of directional properties of Allegheny Ludlum's grain oriented materials. By careful control of rollings and quality processing, Allegheny Ludlum creates grain oriented materials that permit the ultimate for design consideration and economic application.

Allegheny Ludlum Silectron®, a grain oriented cold rolled 3 percent silicon steel, is much superior to the corresponding nonoriented grade when magnetized in the rolling direction. Iron-silicon alloys are usually graded on the basis of core loss or watt loss. Silectron's core loss is only .659 watt per pound measured parallel to the rolling direction compared to 1.11 for the corresponding nonoriented alloy. (Both measurements made at 15 kilogausses and 60 cycles per second.) In fact, Allegheny Ludlum Silectron is so superior to conventional grades that it gives better results even when 20 percent or more of the flux path is cross grain.

Allegheny Ludlum Deltamax is a 50 percent iron, 50 percent nickel alloy which has equally good magnetic properties in three directions—in the rolling and cross rolling directions and also normal to the plane of the strip. Deltamax has a rectangular hysteresis loop with a very high peak induction at a magnetizing force only slightly greater than the coercive force. Its high residual induction and superior permeability at peak inductions is combined with a reasonably low coercive force.

When your magnetic requirements are exacting, consult with Allegheny Ludlum. A-L makes a complete line of magnetic materials, is glad to supply you with the technical data you need in design and manufacture. Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Dept. E-11.
Give Uncluttered Panel Appearance—display only the essential pointer-scale relationship.

Human Engineering Advantages—give fast, accurate readout for balancing circuits, position indicators, any comparative readings.

Greater Readability in Less Space—only ½ the panel area of round or square meters, but with equal accuracy.

PARTIAL SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>MODEL 1120</th>
<th>MODEL 1135</th>
<th>MODEL 1145</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>4 oz.</td>
<td>9 oz.</td>
<td>10 oz.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 3% of full scale for DC, ±5% for AC</td>
<td>± 2% of full scale for DC, ±5% for AC</td>
<td>± 2% of full scale for DC, ±5% for AC</td>
</tr>
<tr>
<td>Scale Length</td>
<td>1.2”</td>
<td>2.1”</td>
<td>2.7”</td>
</tr>
<tr>
<td>Panel Area</td>
<td>0.9 sq. in. (cutout 1.687” x .531”)</td>
<td>2 sq. in. (cutout 2.656” x .781”)</td>
<td>5.5 sq. in. (cutout 3.450” x 1.300”)</td>
</tr>
<tr>
<td>Zera Adjuster</td>
<td>Internal</td>
<td>Front, external</td>
<td>Front, external</td>
</tr>
</tbody>
</table>

Meters available as DCUA, DCMA, DCA, DCMV, DCV, ACV, with zero at center, left or right and with scales for vertical or horizontal mounting. Also VU and DB meters. For ranges and other specifications, send for engineering data sheets.

WRITE NOW FOR ENGINEERING DATA SHEETS on our complete line of side indicators, electronic control meters, 1½” ruggedized meters, 1” and 1½” panel meters, miniature multimeters.

P. O. Box 2954, New Haven 15, Connecticut.
Cable: “INTERINST”

sockets (Loranger, Warren, Pa.) are partitioned internally so leads cannot be shorted while the transistor is being inserted or removed. Resistors, diodes, capacitors and jumpers are prepared by crimping taper pins to their leads. The components can be reused indefinitely. Transistors need no preparation.

Milliminiature circuits usually require two breadboard stages. In the first, the circuit is tested without regard to its size. Breadboard flexibility must be maintained when it is next built in its final size, so that components and jumpers can be changed readily.

Laminated fiberglass sheet is ruled into a 0.10-inch grid and cut into the desired shapes. Holes punched at the corners of the grid squares provide proper spacing, insulation and support for leads.

Top view of printed wiring prototype board

Bare wiring on bottom simulates etched wiring

The two modules of the audio amplifier illustrated were breadboarded separately. The components in each module are mounted vertically, with the leads projecting through the rectangular inner sheets. This mounting allows components to be changed. Leads are connected on top of the sheets.

After each module is made and tested, the outer, T-shaped sheet is added and the connections between modules made on this. Only module interconnections are brought out through this insulator.

Preparing etched wiring circuit drawings directly from a schematic
Covered breadboxes provide high-frequency shielding.

Two breadboxes being used to prepare uhf circuits.

Investigate today's most productive semi-automatic Coil Winder — the Leesona No. 108. Winds up to 30 coils simultaneously on short or long runs. Handles wire from No. 19 to No. 42 (B&S) and finer. Finger-tip control... quick set-up... versatility. Leesona Corporation, P.O. Box 1605, Providence 1, Rhode Island.

(formerly Universal Winding Company)
New On The Market

Printed Circuit Modules
INTERLOCKING BOARDS

PRINTED CIRCUIT boards for modular construction consist of crossed printed circuit boards interlocking to form a structural column. End plates may also be printed circuits and can carry tube sockets or transistors and plug-in connectors.

The structure can be made in a wide variety of shapes and sizes including a subminiature version about 1 inch square. The structure offers advantages in miniaturization by providing maximum circuit board area in a given space, as well as providing a rugged, self-supporting structure resistant to high shock and vibration. The patented Plus modules are being manufactured by Arthur Ansley Mfg. Co., New Hope, Penn.

Stereo Headphones
30 CPS TO 20 KC

FEATHERWEIGHT K-50 stereo headphones are now available with frequency response from 30 cps to 20 Kc. Coupled with its light weight of only three ounces, including the cable, the clarity and fidelity of reproduction help reduce fatigue during long hours of quality-monitoring in broadcast and recording, in communications work, and in private home-music listening.

Requiring less than one milliwatt input, the headphones have a high output when used with line and cathode-follower circuits with the U-50 transformer, and thus can be used without a power amplifier. It converts between binaural and monaural without soldering; price is $31 retail net from Electronics Applications, Inc., Stamford, Conn.

Transistor Socket
FOR PRODUCTION TESTING AND MOCK-UPS

Sockets for production testing 3- or 4-lead transistors is available from Jettron Products Inc., 56 Route 10, Hanover, N. J. Socket occupies a volume 1/4 square by 1½ inch long. Designed for 1/16 panel mounting in keyed hole, and retained by a snap ring, sockets may be mounted on 0.812 centers. Double fingered spring contacts grip leads close to base of transistor with frictional force in excess of 50 grams on 0.017 diameter lead wires. Large entry funnels assure ease of lead insertion; contacts are beryllium copper, silver plated and terminate in rigid solder terminals on each face of body; body is molded of glass filled Dial FS-5; socket weight is less than 9 grams; cat. No. 72-101.

Turret Attenuator
ONE-DB STEPS TO 59 DB

TURRET ATTENUATOR TAB-50 is designed for use from d-c to 1,250 Mc. A knob and dial allows the attenuation to be set in 1 db steps at any value between 0 and 50 db.

The unit can be used either un-mounted as a laboratory device, or panel-mounted in a complete instrument or system, and in a variety of environments. Outside dimensions of the case are 3 x 4½ inches; weight is 44 ounces.

Two separate turret attenuators, assembled with concentric shafts and electrically connected in series, make up the unit. One of the attenuators is adjustable in 10-db increments from 0 to 50 db; in series is a 0-10 db unit adjusted in 1-db increments. Decad values are set by an outside dial, while individual db units are set by an inner knob.

Attenuation is achieved by resistive elements within precision-machined rotor assemblies that are designed for optimum match. As each shaft is rotated, separate attenuator pads connect to the input or output BNC connectors and to the interconnecting cable between...
Now you can cut precious inches and ounces from your assemblies with space-saving, weight-saving MAX-C Sealcaps.

The surprising increase in range of the Max C trimmer capacitor is obtained by embedding the electrode band in the glass cylinder. This design provides the thin dielectric required for a large capacitance range while retaining the ruggedness and mechanical strength of a heavy wall glass tube.

Included in the Max C design is the Sealcap construction which provides the additional stability safeguard of a completely sealed interior.

The Max C retains all the advantages of glass tubular trimmers: Working voltage of 1000 VDC, Insulation Resistance of $10^9$ megohms, Q of 500 at 1MC, operating temperature range of $-55^\circ C$ to $+125^\circ C$, and high stability. It meets or exceeds the applicable performance and environmental requirements of Mil-C-14409A.

Escape from the design limitations of conventional trimmers by specifying JFD MAX-C Sealcaps for your current and projected circuitry. Write today for the complete catalog describing MAX-C Sealcaps and other JFD precision electronic components. Other JFD components are...

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SEAL CAP
TRIMMER CAPACITORS
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51 McCormack Street, Toronto, Ontario, Canada

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Pioneers in electronics since 1929

November 25, 1960

CIRCLE 147 ON READER SERVICE CARD 147
the two units.

Accuracy from 0 to 10 db varies from ±0.2 db at 200 Mc to ±0.5 db at 900 Mc. Above 10 db, accuracy is ±2 percent ±0.2 db to 200 Mc and ±5 percent ±0.3 db at 900 Mc.

Insertion loss is 0.1 db to 300 Mc, and 0.4 db at 900 Mc; power rating is 1 watt; input impedance is 50 ohms and vswr is 1.2:1 to 300 Mc and 1.35:1 at 900 Mc.

Units are available at $225.00 in single-unit lots from Telonic Industries, Incorporated, Beech Grove, Indiana.

CIRCLE 304 ON READER SERVICE CARD

Silicon Transistor
TRIPLE DIFFUSED MESA

SILICON power transistor, PT530, triple diffused mesa is a medium power vhf communications transistor; having extremely low saturation resistance, it is also suitable for switching applications.

Power output is 5 watts at 30 Mc with a power gain of 10 db minimum with collector at 28 v. Useful oscillator power is obtained to 200 Mc.

Because of its high power output, the unit will perform well as a transmitter final amplifier stage or as a driver for high frequency transistors. It can be used to obtain upward of one watt at 1,000 Mc.

Structure of the transistor is n-p-n-n'. The line emitter, dual base contacts, and low collector region resistance result in a device optimized for vhf power operation.

Evaluation quantities are immediately available. Price per unit in these quantities is established at $125. Detailed specifications may be obtained at any PSI sales office or from Pacific Semiconductors, Inc., 12955 Chadron Avenue, Hawthorne, California.

CIRCLE 305 ON READER SERVICE CARD

Digital Readout
SUB-PANEL MOUNTED

SUB-PANEL, miniaturized digital readout is mounted 13/16 inch behind a lucite viewing screen, with the readout projected onto the viewing screen. Readout units are easily accessible for replacement or maintenance since the viewing screen is not an integral part of the readout and may be swung out of position.

Digits are visible from any angle and are uncluttered by mounting holes or other detail. The Series 12000 Digital Readouts are for use with digital computers, control equipment, instruments, aircraft equipment, production and inventory control, and other equipment.

Character size on the viewing screen is 3/8 inch high, with light obtained from subminiature lamps No. 327, 328, or 330, operating on 6 to 28 v.

Using module construction with aluminum case, dimensions are 3 1/4 long, 1 wide, and 1 3/4 in. high; weight is 31 ounces. Unit price is $35.00, available in single units or in assemblies thirty days after receipt of order, from Industrial Electronic Engineers, Inc., 5528 Vineyard Ave., North Hollywood, Calif.

CIRCLE 306 ON READER SERVICE CARD

Resistance Cards
METAL FILM ON GLASS

METAL FILM resistance card is a highly stable microwave attenuator material with a base of fine-weave glass cloth impregnated with high temperature thermostetting resin that meets MIL-P-18177. Resistance material is a thin film of pure metal, approximately 50 millionths of an inch thick, uniformly deposited on one surface of the plastic. A protective coating is provided over the metal film.

The fibre glass plastic base is dimensionally stable and has extremely low moisture absorption. Special machining techniques are not required and the cards can be punched, drilled, sheared, machined and sanded. Maximum surface temperature should be limited to 130 C.

Standard resistance cards are 5
BMEWS... the Ballistic Missile Early Warning System is the free world's first warning of enemy ICBM attack.

Powerful radars with an accurate range of thousands of miles can detect incoming ICBMs minutes after launching. The transmitters for this defense system are being built by Continental Electronics... specialists in super power transmitting equipment.

Provided under sub-contract to General Electric and R.C.A., these transmitters from Continental Electronics are another contribution to our country's defense.
WEIGHT of your system can be cut if you specify components capable of outstanding performance. Example: high output lets one Sperry traveling wave tube replace two ordinary tubes in Nike-Zeus. If weight reduction is a knotty problem for you, call Gainesville, Florida, FRanklin 2-0411 collect, for full information about Sperry capabilities.
SPECIFY RAPIDLY AND ACCURATELY WITH SPERRY’S SPECI-FILE

Now you can have Sperry's complete family of klystron and traveling wave tubes right at your fingertips for faster, more accurate tube selection. Attractively packaged and comprehensively indexed, the Sperry's Speci-File gives you complete electronic and physical characteristics of every tube in the Sperry line.

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SPERRY ELECTRONIC TUBE DIVISION
Gainesville, Fla.

Please send me a FREE Sperry Speci-File:

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State________

by 12 inches and 0.025, 0.032 or 0.062 inch thick. Resistivity range is 25 to 750 ohms per square. Standard values from stock include 50, 100, 125, 150, 180, 200, 300, 377, 400, and 500 ohms per square. Material is being manufactured by Filmohm Corp., 48 West 25th St., N. Y., N. Y.

CIRCLE 307 ON READER SERVICE CARD

Double-Duty Connector
MULTIPLE CONNECTIONS

DOUBLE-DUTY quick-connect terminal #300H21AB provides multiple connections to the same terminal. Space saving and simplified wiring result from use of this female connector, which is for attachment to the male terminals normally furnished on many switches, timers, motors, sockets, relays, solenoids, transformers and junction boards. The connector also has an integral male terminal to which another female connector or double-duty connector can be attached, thus increasing the number of wires that can be attached to one terminal.

Heavy-gage brass construction meets UL requirements for strength and current rating. Accommodating wires #18 to #12, with normal insulation, the connector is available individually or in continuous strips for automatic attachment, from Ark-Les Switch Corporation, 51 Water Street, Watertown 72, Massachusetts.

CIRCLE 308 ON READER SERVICE CARD

Recording Paper
ELECTROSENSITIVE

WESTREX CORP., a division of Litton Industries, 540 W. 58th St., New York 19, N. Y., has introduced Timemark, a new electro sensitive chart recording paper which may be used in many applications, including XY, XYZ, depth, event and facsimile recorders. It also is suitable for use in multistylus applications with places as close as 15 thousandths. Analog and digital information can be recorded at much higher rates of speed than with single stylus equipment. Timemark is a dry recording paper that is clean, white and permanent. It is capable of handling high writing speeds due to its low voltage and stylus pressure requirements.

CIRCLE 309 ON READER SERVICE CARD

Switching Transistor
HIGH SPEED

SYLVANIA ELECTRIC PRODUCTS INC., Woburn, Mass. Type 2N1605A 151 rpm high speed germanium alloy switching transistor offers extra collector-to-base voltage (40 v max.) for h-v circuitry, low reverse leakage voltage (10 uA max.) at 40 v, maximum power dissipation of 200 mw at 25 C, and junction temperature ratings of -65 C to +100 C. It is designed in a TO-5 JEDEC package with base connected to metal case.

CIRCLE 310 ON READER SERVICE CARD

Tachometer
FOR VERY LOW SPEEDS

SERVO-TEK PRODUCTS CO., 1986 Goffle Road, Hawthorne, N. J. New tachometer indicates speeds of 10 rpm and lower without annoying pulsations and with an accuracy of better than 2 percent of full scale. System is self-powered with a low-torque d-c generator having virtually unlimited brush life. The 4½
customize efficiency & accuracy
with trio labs’ BUILD-IN instruments

BEFORE...3 external instruments were used to measure AC and DC voltages...cluttered, tedious, wasteful, subject to error.

AFTER...3 trio labs’ miniature VTVMs integrally built-in now are always on hand to measure just the parameters you designate.

the industry’s
pioneer & complete line of
MINIATURIZED ELECTRONIC INSTRUMENTS

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for MIL-E-5404A & MIL-T-945A applications.

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ruggedized
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D Series
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multi-range
AC VTVMs $327.

G Series
ruggedized
single or multi-range
DC VTVMs $356.

J Series
ruggedized
low-level
multi-range
DC VTVMs $345.

COMMERICAL

E Series
single-range
AC VTVMs $99.50

Model 109-1
low-level
multi-range
AC VTVM $199.

F Series
single-range
DC VTVMs $84.50

Model 125-1
null Meter $125.

By building in trio labs’ panel-mounting instruments you...customizes test patterns, setups and instruments; save space (average model is 4” x 4” x 4”); save time with at-a-glance monitoring; save money; make monitoring foolproof (“go-no go”); improve system reliability; increase overall design freedom. Choose from many “standard” or “special” models—to consult us for new designs for your needs. Write for free “How to” Engineering Guide to Dept E-11

Trio Laboratories, Inc. Plainview, Long Island, New York

in. panel-mounted meter is shielded to minimize the effects of surrounding magnetic materials such as steel panels. The entire package consists of indicator, tachometer generator, 15 ft. of connecting cable and mounting and coupling accessories. Total price is $107, with delivery from stock.

CIRCLE 311 ON READER SERVICE CARD

Extruded Tubing
POLYCARBONATE

ANCHOR PLASTICS CO., INC., 36-36 36th St., Long Island City 6, N. Y., has available extruded polycarbonate tubing. The new General Electric material trade-marked Lexan has been successfully extruded in diameters over 1 in. and with wall thicknesses over 0.100 in. Tubing diameters which can be ordered, range from 0.040 in. to 1 1/2 in. and wall thicknesses from 0.015 in. to 0.125 in. Samples of previously extruded tubing are available to designers intending to use the new material. In addition to tubing, strips, small rods and profiles can also be extruded.

CIRCLE 312 ON READER SERVICE CARD

Tiny Relay
FOR P-C BOARD USE

FILTERS, INC., Port Washington, N. Y. The Pillbox is a microminiature relay made especially for use where high-density packaging is required; it is particularly applicable for use on printed circuit boards. It incorporates a completely new relay configuration in which the header has been rotated 90 degrees so that the relay terminals project from the side of the relay rather than the end as in other crystal case relays, permitting it to be mounted on the side with the greatest area. The Pillbox relay is smaller and lighter than standard...
November 25, 1960

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- Consumption of rated life of critical equipment or components?
- Mean-time-to-failure?

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**MODEL WT-1**
**Actual Size**

1½” O.D. x 1½/8” 3 OZ.

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Whether it's for reliability and life testing, design or system analysis, utilization studies . . . or to continuously monitor and log critical equipment or components . . . when you incorporate the Waltham WT-1 in your plans, you add that "measure of reliability" so important for military acceptance.

The WT-1 meets MIL-E-5272A and is available "FROM STOCK" Write Now for Bulletin 5001!

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**PRECISION INSTRUMENT COMPANY**
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Try this simple test. Tie a piece of Gudelace around a pencil in a half hitch and pull one end. Gudelace's flat, nonskid surface grips the pencil—no need for an extra finger to hold Gudelace in place while the knot is tied!

Gudelace makes lacing easier and faster, with no cut insulation, or fingers—no slips or rejects—and that's real economy. Gudelace is the original flat lacing tape. It's engineered to stay flat, distributing stress evenly over a wide area. The unique nonskid surface eliminates the toot-tight pull that causes strangulation and cold flow. Gudelace is made of sturdy nylon mesh, combined with special microcrystalline wax, for outstanding strength, toughness, and stability.

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**GUDEBROD BROS. SILK CO., INC.**
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12 South 12th Street
Philadelphia 7, Pa.

CIRCLE 153 ON READER SERVICE CARD
Transducer Calibrator
SINGLE CHANNEL

B & F INSTRUMENTS, INC., 3644 North Lawrence St., Philadelphia 40, Pa., announces a versatile, inexpensive single channel portable strain gage transducer conditioner and power supply for use in field or laboratory. Model 110T will accept any resistance transducers and record on any galvanometer, millivolt recorder, or oscilloscope directly or through amplifiers. In the lab it may be used for calibrating transducers prior to installation in data acquisition systems or for single channel measurements. It may be used with 4, 6, 7 or 8 wire input cabling system, thus means are provided to cancel out cable losses. Shields are carried through to permit grounding at one point to eliminate ground loops. The instrument has available four steps of single and/or double shunt resistance calibration in both directions. Bridge voltage is Zener regulated 10 v, 0.1 percent, at 150 ma.

PNPN Semiconductors
SILICON DEVICES

SOLID STATE PRODUCTS, INC. One Pingree St. Salem, Mass., has extended its line of silicon Trigistors
to the 100 v range. The 3C100 and 3C100A employ all of the design features which have made the Trigistor so valuable in the design of four-layer logic and control circuitry. These features include: reliable operation at low logic levels (down to 1 ma); extremely high sensitivity with firing levels below 50 μa; cold-welded package with all leads isolated; and MIL-S-19500 capability. The new h-v Trigistors have been characterized to fulfill definite system needs and will offer design flexibility to the circuit engineer.

CIRCLE 318 ON READER SERVICE CARD

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**Trimmer Potentiometers**

**SUBMINIATURE**

HANDLEY, INC., 12960 Panama St., Los Angeles 66, Calif. Model 540 WeeTrim subminiature trimmer potentiometer has demonstrated ability to stand up under 50 g's vibration, and 100 g's shock and acceleration, well above MIL-R-27208/4 specifications. Standard features include 2-w rating, operation to 200 C, and humidity proofing. Unit also excels in resolution, insulation and dielectric strength, and noise free operational life.

CIRCLE 319 ON READER SERVICE CARD

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**Current Source**

**BATTERY OPERATED**

GYRA ELECTRONICS CORP., Washington & Elm Sts., La Grange, Ill. Model CS-51 current source is especially useful in any laboratory using

---

The KINNEY McLeod Gage answers the many objections to other gages now in use. Its advanced design compacts superior performance into a rugged, versatile instrument that may be permanently mounted on bracket, tank, panel or pipe or, if affixing demountable legs, used as a portable unit.

The KINNEY McLeod Gage covers a broad range of pressures... accurate readings from 150 mm Hg to 1 Micron Hg. This exceptional range of pressure readings is achieved by incorporating two separate capillaries having separate compression ratios, making available measurements of 150 mm to 2 mm and 2,000 microns to 1 micron. Unlike other McLeod Gages, the reading capillary tubes are completely separate and replaceable — easily detached from the main body at the knurled sealing glands. Because these tubes are reproducible, complete accuracy between each gage is assured.

The KINNEY McLeod Gage requires less mercury and it is supremely simple to add mercury, remove it for cleaning or recharge the gage. Operation requires no special skill ... readings are achieved quickly, easily and confidently. Write for full information and prices today.

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KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY
3555 L. WASHINGTON STREET - BOSTON 30 - MASS.

Please send me Bulletin No. 3821.1 and prices on the KINNEY McLeod Gage.

Name ____________________________
Company ________________________
Address __________________________
City _____________________________ State __________

CIRCLE 155 ON READER SERVICE CARD 155
Another "impossible" job done by the Airbrasive...

abrading * cutting * deburring * stripping * drilling * cleaning * scribing

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When Eclipse-Pioneer, Division of The Bendix Corporation, hand-lapped shallow inclines in these alloy steel thrust bearings to depths of 0.0002" to 0.0004", it took eight hours of laborious effort.

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Here is a unique industrial tool of many uses...cutting semiconductors...adjusting microelectronic circuits...removing microscopic burrs...cleaning surfaces...and many others. It performs its magic with a superfine stream of abrasive particles and propellant gas that quickly cuts almost any hard, brittle material.

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S. S. White Industrial Division
Dept. EU 10 East 40th Street, New York 16, N.Y.

CIRCLE 156 ON READER SERVICE CARD

Electrometers of any manufacture, where constant accuracy of the electrometer is of paramount importance. It is a portable, battery operated supply of current, which, when attached to the input of the electrometer, allows the user to check the accuracy of the ranges, heat damage to the resistors, and subsequent change in value, as well as a ready check of the entire circuit for accuracy. The current source has a ten step vernier current multiplier which varies the current from one to ten extending the maximum range to 1 x 10^4 amps.

CIRCLE 320 ON READER SERVICE CARD

Counter-Timer
PROGRAMMABLE
SYSTRON-DONNER CORP., 950 Galindo St., Concord, Calif., has developed a solid state 10 Mc programmable counter-timer guaranteed to MIL Spec designed to meet rugged environmental conditions. Measurements include frequencies from 0 to 10 Mc and time intervals to 10 sec with an accuracy of 0.1 μsec. Designed for use as the basic measuring unit in automatic checkout consoles, this unit provides maximum reliability and insures minimum down time for critical missile checkout. Other Systron-Donner modules can be provided to make up a complete checkout system.

CIRCLE 321 ON READER SERVICE CARD

C-C Tv Camera
HIGH RESOLUTION

TELE-TRONICS CORP., 12786 Western Ave., Garden Grove, Calif., announces model 700 c-c tv camera, with the option of built-in sound channel for intercom and educa-
ional tv applications requiring crisp voice communication. It is priced at $1,295. Features include: low-noise cascode video input; 8-Mc video bandwidth amplifiers provide 600-line horizontal resolution; linear phase type aperture correction provides real "snap" to picture; automatic target sensitivity (exposure) control; interlacing sync generator; no-scan protection circuitry for Vidicon; totem-pole high-level video output, source termination; remote control of beam, target and focus.

CIRCLE 322 ON READER SERVICE CARD

Low Noise TWT

SOLENOID FOCUSED
HUGGINS LABORATORIES, 999 East Arques Ave., Sunnyvale, Calif. The HA-76 low noise twt amplifier is solenoid focused and operates in the S-band at 2,300 to 2,900 Mc with a maximum noise figure of 6 db. Small-signal gain is 30 db minimum, and saturation power output is 0 dbm minimum. The HA-76, without solenoid, weighs 1 lb and measures 1 in. in diameter and 22½ in. long.

CIRCLE 323 ON READER SERVICE CARD

Transistors

MEDIUM-POWER
MINNEAPOLIS-HONEYWELL REGULA-
TOR CO., 1015 Sixth St., South, Min-

November 25, 1960

THE BIG ADVANTAGE OF BEING SMALL

The demonstrated high performance and outstanding reliability of our new SILDISC — only 3/16" in dia. x 1/6" thick — is all the more impressive because of its small size. We think there's also an advantage in being a small, newly-created division of Controls Company of America — which we are. For one thing, we're small enough to give our customers' problems our immediate, high-priority attention. And small enough for all our top scientists, engineers and production brains to get together in one room — so each can benefit from a thorough definition and discussion of the problems to be solved.

Back of us there's a big company, with vast experience we can draw upon — a company whose 1960 expenditures for research, engineering and product development will exceed $2,000,000.

Though small, we specialize in tackling big problems. If you've got one, we'd welcome an opportunity to talk with you.

Sildiscs: in General Purpose Diodes, Zener Diode, Double Anode Diode, Low Voltage (1.5 volt to 3 volt) Zener Diode
Silicon Low Power Junction General Purpose and Zener Diodes
Silicon Medium Power Junction General Purpose and Zener Diodes
Silicon High Power Industrial Rectifiers

Write for Your Free Copy of Catalogues and Data Sheets:

CIRCLE 157 ON READER SERVICE CARD
Boesch's new MAXITOR Toroidal Coil Winding Machine covers a wide range of applications, including exceptionally large diameter, heavy wire gauge winding jobs. The coil shown above is typical. It is being wound with #10 wire on a MAXITOR machine using Boesch's HW-200 winding head and continuous-winding core holder. Segmental-winding holder is also available.

Two other interchangeable heads are available which make MAXITOR a really versatile machine. The HW-300 head winds wire gauges as large as #7 to finished O.D. as much as 14". HW-100 handles gauges from #40 to #22 to maximum O.D.'s of 10".

And MAXITOR is packed with "dream" features. Pushbutton drive ring and magazine positioning saves set up time. A dial control on the operator's panel provides micrometer brake settings for easiest variable speed tension control. Turn spacing is infinitely variable at the turn of a knob. And the range of winding applications for MAXITOR is apparent in the table below.

<table>
<thead>
<tr>
<th>Head Type</th>
<th>Min. Final I.D.</th>
<th>Max. Final O.D.</th>
<th>Max. Final Height</th>
<th>Wire Range AWG #</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW-100</td>
<td>¼&quot;</td>
<td>10&quot;</td>
<td>6&quot;</td>
<td>40 to 22</td>
</tr>
<tr>
<td>HW-200</td>
<td>1&quot;</td>
<td>10&quot;</td>
<td>6&quot;</td>
<td>24 to 10</td>
</tr>
<tr>
<td>HW-300</td>
<td>2&quot;</td>
<td>14&quot;</td>
<td>10&quot;</td>
<td>20 to 7</td>
</tr>
</tbody>
</table>

WRITE TODAY for complete specifications, prices and delivery information.

Microwave Absorber
HIGH TEMPERATURE
CUSTOM COMPONENTS, INC., Caldwell, N. J., has available a new microwave absorber capable of operation at temperatures up to 800 C with no detectable change in electrical or physical characteristics. The new permeable dielectric, CMA 701, has a dielectric constant of 50 at 20 Mc, and an attenuation of more than 38 db/cm at 8,200 Mc, and of more than 26 db/cm at 10,000 Mc. It has a density of 4.05. The material can be machined or molded into shapes suitable for waveguide termination, such as stock shape illustrated.

Servo Clamps
SOLID ALUMINUM
THETA INSTRUMENT CORP., 520 Victor St., Saddle Brook, N. J., is offer-
electronics fills you in on every phase of the electronics industry each week featuring engineering and technical data every issue. Latest economic trends, technically interpreted, to help you make sound plans. Facts you’ll want to file and keep. Subscribe now. Mail the reader service card (postpaid) to electronics, the magazine that helps you to know and to grow! Rates: three years for $12, one year for $6; Canadian, one year for $10; foreign, one year for $20. Annual electronics BUYERS’ GUIDE (single issue price $3.00) included with every subscription.

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RESEARCH

DESIGN

PRODUCTION

MANAGEMENT

SUBSCRIBE TODAY TO electronics!

November 25, 1960

Toggle Switches
WITH TAB TERMINALS

KULKA ELECTRIC CORP., 633 So. Fulton Ave., Mt. Vernon, N. Y., announces a complete line of s-p and d-p, aircraft-type toggle switches having 1 in. wide male tab connections for use with Burndy, AMP, or Kent female connectors. The single and double throw switches meet all applicable military specifications. They are available in all circuit configurations including momentary on/off modes. The switches are designed for either d-c or a-c applications up to 1,000 cycles. The company’s barrier design is employed between all connections for longer leakage paths and minimum chance of direct contact short circuits. The new tab connections are made of brass, electro-tinned to prevent corrosion. Switches are supplied with mounting nuts and sleeve lock-washer.

Circle 327 on Reader Service Card

Spectrum Analyzer
HIGH-SPEED

FEDERAL SCIENTIFIC CORP., 615 W. 131st St., New York 27, N. Y., announces Simoramic spectrum analyzer model 53. This high-speed fine-resolution analyzer operates in real time, and simultaneously cov-

Let us show you how our precision wire forms
CUT COSTS!

LEADS FOR RESISTORS, DIODES, TRANSISTORS, CAPACITORS, ETC.

Send a sample or blue print for estimates.

When Art Wire tackles the job, big gains in precision and uniformity are possible on small components . . . resulting in big savings in time and production costs. In addition, Art Wire’s modern production methods produce a wide variety of components more economically.

Art Wire specializes in wire forms designed for today’s automatic production lines . . . manufactured to assure the economy of an uninterrupted work flow.

ART WIRE AND STAMPING CO.
18 Boyden Place, Newark 2, N. J.

Circle 159 on Reader Service Card
MEET THE NU116
A product of NATIONAL UNION research and engineering resources, the NU116 is a low voltage pentode regulator/amplifier tube that matches—in precision performance and operating stability—the high standards applied to NATIONAL UNION’s well-accepted line of high voltage regulator tubes covering a range of 1kV to 10kV.

Your current project may be made to order for the NU116. But, in any case, you’ll find NATIONAL UNION design and engineering service of definite value in meeting any tube needs. Write for further help on either standard or special-design tube needs.

NU116 CHARACTERISTICS
Range: 300 to 1500 volts Stability: Excellent. Tested and stable, both electrically and mechanically. Versatility: Designed for use as amplifier or in either shunt or series regulator circuits.

National Union Electric Corporation
Electronics Division
Developers and Manufacturers of Special Purpose Electron Tubes
BLOOMINGTON, ILLINOIS

CIRCLE 200 ON READER SERVICE CARD

"Honest, Ivan, he wasn't spying.
He was going to Texas and his guidance system went haywire!"

Guidance or communications system failures can cause problems! Guard against them with Reeves-Hoffman oscillator reliability. Get the whole story.

Reeves
Hoffman
Division of
Dynamics Corporation of America
Carlisle, Pennsylvania

CIRCLE 160 ON READER SERVICE CARD

Pulse Generator
HIGH CURRENT

E-H Research Laboratories, Inc., 163 Adeline St., Oakland 20, Calif. Model 121 is a high current pulser delivering a 50 v pulse into 50 ohms, either polarity. Rise and fall times are less than 5 nanoseconds. Widths are variable from 10 μsec to 200 μsec. Repetition rate from 10 cps to 10 Mc. It is ideal for ferrite and magnetic switching studies, applications in high speed transistor and diode switching, and the design of logic and memory circuits.

CIRCLE 329 ON READER SERVICE CARD

Coax Switches
BNC TYPE CONNECTOR

Barker & Williamson, Inc., Bristol, Pa. The company’s multiposition coax switches are now offered with BNC type connectors. Model 560 is a single pole, 5 position switch and provides contacts for switching
MIXER-PREAMPLIFIERS for EXTREME MINIATURATION

Featuring rugged construction and small size, low weight and power consumption, the LEL MMX-4 Mixer-Preamplifier utilizes all solid-state components to provide design engineers with an ideal microwave receiver front end, for wide applications.

Noise Figure 10db typical
Low Power Requirements +20V @ 10ma, -20V @ 10ma
Small Size 2-1/4" x 1" x 4-5/16"
Lightweight Less than 9 oz.
Gain 20db Microwave to IF
Bandwidth 20mc

Send for comprehensive Microwave, IF, RF Amplifier Catalog.

LEL — AKRON STREET, COMPIAGUE, N. T.

FIRST CHOICE OF ALL 4!

Because it is organized and edited to serve all four segments of the industry, it contains more advertisers than any other industry guide...gives more information. No wonder it is the accepted buying book of the industry.

gives more to all 4!

electronics BUYERS' GUIDE and REFERENCE ISSUE

November 25, 1960
the success of the mission of this huge missile may depend on 

the reliability of this tiny THERMISTOR 

...that's why ...

leading missile manufacturers select 

VECO THERMISTORS 

The missile weighs tons, the weight of the thermistor is measured in milligrams, yet engineers know that VECO thermistors are rugged enough to do the job — they can always be depended upon to perform their function accurately and reliably.

More manufacturers specify VECO thermistors and varistors than any other, because VECO is a leading pioneer in the field of high reliability thermistors and varistors and can guarantee they'll do the tough jobs engineers require. Be sure to find out how VECO products can help solve your particular problem in thermal or electrical measurement and control.

Other VECO products:
- Varistors
- Chopperettes
- Combustion Analyzers
- Thermistor Catheters and Needles
- Matched Thermistors
- Thermal Conductivity Cells
- Thermistor Kits
- Varistor Kits
- Hypsometers
- LOX Thermistors — and many others.

FREE: Write for Thermistor-Varistor Catalog SB 52 for additional information on VECO thermistors, varistors and other products.

VECO glass enclosed thermistors are not adversely affected by radiation.

Our quality control processes are accepted under MIL-Q-5923 standards.

110 SPRINGFIELD ROAD, UNION, N. J. • MUrook 8-7150

Power Amplifiers

FLIGHT PROVEN

UNITED ELECTRODYNAMICS, INC., 200 Allendale Road, Pasadena, Calif., features a complete family line of flight proven r-f power amplifiers for use in the 215 to 260 Mc telemetry frequency range. They are doing service in the missile and space programs. Output power of 10 w to 100 w may be obtained with 2-w r-f drive. Model PA-10 features a nominal 10-w output and is the smallest and lightest of the amplifiers. Model PA-11 has 10 to 25 w output with no cooling required. Model PA-14 has a self-contained blower for 100-w operation.

Silicon Transistors

TWO PNP TYPES

CRYSTALONICS, INC., 249 Fifth St., Cambridge, Mass., announces two new pnp silicon transistors designed for d-c amplifier use at
collector currents of 10 μA. Both have a maximum guaranteed I<sub>c</sub> of 1 nanoampere. Types C118 and C119 have current gains of 15 and 25 respectively at 10 μA collector currents. Both units are available from stock.

**CIRCLE 332 ON READER SERVICE CARD**

Double Triode Tube

**FOR TV RECEIVERS**

GENERAL ELECTRIC CO., Owensboro, Ky. The 6EA7 is a new low-high plate dissipation double triode tube for vertical-deflection oscillator and amplifier applications in TV receivers. Tube contains both a high-mu triode (section one) and a low-mu, high-perveance triode (section two). It is an octal "GT" type. Section one has a design maximum rating of 350 plate volts with peak negative grid voltage of 400 and plate dissipation of 1.0 w. Section two, with a design maximum plate voltage rating of 550 v d-c, is rated at 10 w plate dissipation and 175 ma of peak cathode current.

**CIRCLE 333 ON READER SERVICE CARD**

Power Supplies

**FOUR MODULAR TYPES**

DRESSEN-BARNES CORP., 250 North Vinedo Ave., Pasadena, Calif., announces four new modular power supplies which are completely transistorized and packaged to make components accessible for replacement. New split-chassis design provides adequate self-dissipation of

**WHAT THIS UNUSUAL AC-DC "PLUG-IN" TRANSISTORIZED POWER SUPPLY DESIGN GIVES YOU...**

One piece finned aluminum extrusion, achieving high heat dissipation. Most units need no external heat sink to 55° C ambient. All units have adjustable output. Platform mounted standardized subassemblies and components enable quick delivery of a wide range of voltages and currents.

**Specifications:**
- Input: 105 to 125V AC, 45 to 420 cps, single phase
- Regulation: 0.1% (line or load)
- Stability: Better than 0.25% for 8 hours
- Ripple: 0.02% rms
- Response time: less than 100 microseconds
- Low dynamic impedance

All solid state — zener diode reference, transistor amplifiers and regulator
Output Voltages: from 2.0 to 300V DC
Output Power to 30 Watts
Reliable short circuit protection
All components readily accessible

**CONSOLIDATED AVIONICS CORPORATION**

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**CIRCLE 163 ON READER SERVICE CARD**
There's a lot that's special about Regatron Constant-Current Power Supplies... 0.1% regulation (above 2.2 ma)... a modulation input... zero to maximum-range vernier... wide range (see diagram above). And for use in automatic or semiautomatic applications, you'll have the advantage of the exclusive Regatron programming feature.

Push Button Switches
SNAP ACTION

TRUCO ENGINEERING CO., 289 Fairfield Ave., Hartford, 6 Conn., offers a new design in snap action push button switches. They are available in both illuminated and non-illuminated versions. Of one piece construction they are available in either momentary or alternate action configurations. This design eliminates the need for external accessories. The mounting arrangement allows unusually rigid mounting in virtually any panel thickness. Available configurations include 1 or 2 spdt switches with ratings of 5 amperes at 220 v a-c and 0.25 ampere at 220 v d-c. All switches are rated at one million operations. Prices range from $7.55 to $9 in unit quantities.

Signal Simulator
RUGGED AND COMPACT

TELEMETRICS, INC., 12927 S. Budlong Ave., Gardena, Calif. An electronic signal simulator, producing precise pam, pdm, or pam/nrz pulse trains for calibration and checkout of telemetry ground station, is announced. Model ESS-204
For Electronic Applications

RELIABLE
General Electric Inductrol

Induction Voltage Regulators

General Electric's complete line of 50-, 60-, and 400-cycle Inductrol regulators gives you extra values in reliability and compactness. In ratings up to 600 volts, 750 load kva—single phase, and up to 2000 load kva—three phase, you get these special features:

• SIMPLE, NO-BRUSH DESIGN—fewer maintenance problems.
• HIGH SHORT-CIRCUIT STRENGTH—will withstand up to 25 times normal current, for 2 seconds.
• HIGH OVERLOAD CAPACITY—will withstand up to 100% overloads for one hour.
• HIGH EFFICIENCY—97% to over 99% at full load.
• NO HARMFUL WAVEFORM DISTORTION.
• ECONOMICAL, COMPACT DESIGN—requires less floor space.
• DRIFT-FREE CONTROLS—voltage automatically held to ±1% bandwidth.

FOR MORE INFORMATION about General Electric's complete line of Inductrol regulators, contact the voltage regulator representative at your nearby General Electric Apparatus Sales Office. Or, write to General Electric Company, Section 457-03, Schenectady 5, New York.

*Registered trade-mark of General Electric Company.

VOLTAGE REGULATOR PRODUCT SECTION

GENERAL ELECTRIC

PITTSFIELD, MASS.

Regulated, multiple voltage output +250 volts, +150 volts, +70 volts, +70 volts, +250 volts, –35 volts, –50 volts, –60 volts, –70 volts, –250 volts D.C. 6.3 volts, 115 volts, A.C. Total power capacity approx. 15 KW

EXPERIENCE and SKILL are an inherent component of every ACME ELECTRIC built POWER SUPPLY

"Know your supplier" is pertinent advice as it applies to the design, engineering and construction of power supplies. Acme Electric not only knows the state of the art but is a recommended supply source. That's why you can expect specific advantages based on engineering experience, and backed-up by manufacturing facilities and trained manpower.

If power supplies are an important part of your products, it will pay you to investigate the part Acme Electric can play in your procurement program.

ACME ELECTRIC CORPORATION

3111 Water St.
Cuba, N. Y.

In Canada: Acme Electric Corp. Ltd., 50 Northline Rd., Toronto, Ont.

Series regulated
Output 120, ±1% dc
@ 0-6 amps.

ACME-ELECTRIC

TRANSFORMERS

November 25, 1960

CIRCLE 206 ON READER SERVICE CARD

CIRCLE 165 ON READER SERVICE CARD
Super-Temp...
Nation's HQ for TEFILON TAPE

High temperature tape... Type B, sintered and etched, and Type B unsintered... all sizes. Use it for coil wrappers, slot liners, coil tapping, conductor insulation, etc. You get it fastest from Super-Temp.

ALSO: Magnet Wire, Airframe Wire, Hook up Wire Miniature Cables, Coaxial Cables, Jumbo Cables Teflon or Silicone Rubber Insulations

Save Time with Super-Temp
American Super-Temperature Wires, Inc.
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General Sales Office: 195 Nassau St., Princeton, N. J. • Walnut 6-4450
A Subsidiary of Haveg Industries, Inc., Wilmington, Del.

TEN STEP
5 megacycle stepping rates
PROGRAMMED
20 millimicrosecond pulse widths
CURRENT
2 ampere pulse amplitudes
PULSE
10 millimicrosecond rise time
GENERATOR

Model 1200 Programmed Millimicrosecond Current Pulse Generator for research and development of very high speed magnetic materials, solid state devices and computer circuits. Write for Bulletin 60-B.

features a continuously variable pulse rate from 20 to 7,000 pps, programmable signal levels, zero and full scale pulses anywhere within the frames, and provision for application of noise to the pedestal and information levels of the wave train. The simulator offers excellent linearity—within 0.15 percent of full scale; and stability in output (pam) and pulse width (pdm) within 0.15 percent of full scale for 12 hr after 45 minutes warmup. It employs standard plug-in digital logic units, facilitating maintenance or replacement.

CIRCLE 336 ON READER SERVICE CARD

Tubular Relay
HANDY SHAPE

WHEELOCK SIGNS, INC., Long Branch, N. J. High vibration and shock immunity is predominant in series 123 tubular relay. The relay also features exceptional switching capacity and contact life; low coil power; and small size, handy shape, and simplified mounting. It has been approved for and is used in missiles. Its construction lends itself to in-line chassis mounting for printed circuits or conventional clamping or encapsulation where high shock and vibration are encountered. Ambient temperature: 65 to 85 C. Mechanical life: 200 million operations.

CIRCLE 337 ON READER SERVICE CARD

Bridge Balance
AND CALIBRATOR

B & F INSTRUMENTS, INC., 3644 N. Lawrence St., Philadelphia 40, Pa. A new input conditioning (bridge balance and calibrating) module for feeding oscillographs directly or
TAPCO ELECTRICAL POWER COMPONENTS

Tapco Group primary and auxiliary electrical power systems for space, missile, aircraft and ground power applications are tried and proven. Systems performed under environmental conditions including nuclear radiation, high-temperature, liquid metal vapor, zero-G and vacuum.

Below are typical Tapco components now available for integration into systems for such applications. Other available Tapco electrical power components include tachometer generators, speed sensors, high temperature electromagnets and solenoids, nuclear reactor rod drive controls, static inverters, voltage regulators and electronic power conversion devices.

ALTERNATORS
Among the special purpose rotating machines designed by Tapco is a series of high temperature alternators. These range in capacity from a few watts to 15 kw at temperatures up to 1000°F.

PERFORMANCE DATA: TYPICAL ALTERNATOR—Power Rating: 3 kw, 0.8 pf lagging.
Inherent Voltage Regulation: ±5%. Harmonic Content: 5% total. Efficiency: 85%.
Weight: 9 lbs w/o shaft and bearings. Size: 3½" OD, 5¾" long. Special Conditions:
Operates in mercury vapor.

VOLTAGE REGULATION AND SPEED CONTROLS
Associated with the Tapco alternator and drive systems are system speed and voltage controls for extremely accurate frequency and voltage regulation. The unit shown is adaptable to many drive systems.

Environmental Conditions: -65 to -200°F, 50g shock for 11 milliseconds, vibration 0.1g double amplitude from 3 to 23 cps, 1kg from 23 cps to 10 kc. Weight: 10 lbs.
Size: 12" x 6" x 5".

LIQUID METAL PUMPS
A rotating permanent magnet driven by an external source induces pumping force in the liquid metal within a hermetically sealed system. This concept provides operation without friction-producing rotating seals and provides exceptional reliability and life.


Tapco Group Export Representative:
American Aviton Inc. • Mamaroneck, N.Y.
Advanced engineering projects at Tapco offer excellent career opportunities for qualified engineers and scientists. Write Personnel Director.

Tapco Group
Thompson Ramo Wooldridge Inc.
DEPT. EL-1160 • CLEVELAND 17, OHIO

Designers and Manufacturers for the Aircraft, Missile and Space, Ordnance, Electronic and Nuclear Industries

November 25, 1960

CIRCLE 167 ON READER SERVICE CARD 167
HOW DO YOU RATE AS AN ELECTRONICS DESIGN ENGINEER?

RELAY APPLICATION QUIZ

CHANCES are that a circuit with more than one relay will use the contacts of one relay to energize the coil of a second relay. Which curve best represents the emf induced by interrupting the power to a standard subminiature 28-volt, d-c relay coil: A, B, or C?

When the current through a relay coil is interrupted, the emf induced opposes the change of current which caused it. The magnitude of the emf equals \(-L \frac{di}{dt}\), and, since the time increment is practically instantaneous, the induced emf assumes very large proportions, often reaching values of 1200 to 1500 volts. The answer is A.

What does this mean in terms of relay circuit design?

It means that there isn't a subminiature or microminiature relay that can handle 1200 volts between open contacts without arcing. Arcing erodes contact surfaces and creates radio-interference problems.

Most contact erosion occurs during contact break. The rate of erosion correlates closely with the amount of energy in the load which is approximated by the relation \(W = \frac{1}{2}LI^2\) where \(W\) is energy in joules, \(L\) is the load inductance in henries, and \(I\) is the steady-state current. The \(L/R\) ratio has little effect on the erosion rate.

A life of 100,000 operations is a limit for contacts handling a 1.5 to 2.0-joule load; reducing the load by a third will extend the probable life by a factor of 10.

Filtors has developed an efficient arc-inhibiting circuit that is sealed within the relay. The increase in relay reliability and life more than offsets the small additional cost.

FILTORS, INC., SPECIALISTS IN THE DESIGN AND MANUFACTURE OF SUBMINIATURE AND MICROMINIATURE RELAYS.

Plug-In Converter

ANADEX INSTRUMENTS, INC., 14734 Armita St., Van Nuys, Calif., announces a new plug-in module frequency to d-c converter for flowmeters, tachometers, and other frequency measuring applications. Model PI-400 pulse rate integrator furnishes a low impedance d-c output voltage and current precisely proportional to the frequency or pulse rate of the input. In addition it provides a visual meter indication of input frequency and a pulse output for operating counters and recorders. It is designed for use in the fields of ground support test equipment, engine test stands, control applications, and other types of instrumentation where precision analog forms of frequencies and pulse rates are required.

CIRCLE 359 ON READER SERVICE CARD

Silicon Rectifiers

MODULAR TYPE

SARKES TARZIAN, INC., Bloomington, Ind., announces three series of modular silicon rectifiers—S-5536
through S-5541, S-5544 through S-5549, and S-5462 through S-5467. The rectifiers are designed for use individually—as open bridges—or in a variety of circuit combinations, and are designed for printed circuits or terminal strips. The S-5544-49, for connections into 3 phase half wave, or 2 modules into 3 or 6 phase connections; and, S-5462-67 for use as open bridge for magnetic amplifiers or connected into bridge, and also as half wave sections—individual, series or parallel. Units are compact, rugged, and easy to assemble. Prices range from $2.05 to $6.50 in sample quantities.

CIRCLE 340 ON READER SERVICE CARD

Dynamic Focus Coil
FOR LARGE ANGLE CRT'S
SYNTRONIC INSTRUMENTS, INC., 100 Industrial Road, Addison, Ill., offers a new dynamic focus coil which provides exceptionally sharp overall focusing for 14 in. neck diameter flat faced large angle cathode ray tubes. Type F40 is engineered for high resolution applications such as 1,000 line tv, radar and advanced photo displays. Optimum alignment results from combining static and dynamic coils into a single unit. Increased efficiency at high frequencies is obtained by new core material and design. Circuits can be simplified and power saved because double gap design isolates the coils from each other. Efficient heat dissipation permits using unit up to 25

CIRCLE 169 ON READER SERVICE CARD

November 25, 1960
The worldwide success of Japan's transistor radios is a tribute to their highly efficient yet minute components, of which the ultra-small Mitsumi FT Poly-vari-con is typical. With other superb Mitsumi parts, it is being extensively used by leading radio manufacturers.

Power Transistor
SAVES SPACE, WEIGHT
CBS ELECTRONICS, 100 Endicott St., Danvers, Mass. A single new 85-w pnp power transistor saves space and weight and reduces costs by replacing two 40-w or four 20-w paralleled transistors. These high-power transistors (nine types) can provide 30 w Class A, 100 w Class B, or 1,000 w switching. Collector voltages up to 100 v are available. A large signal current gain of 70 at 5 amperes collector current can be achieved. Maximum working current of 15 amperes is permissible for all types. The emitter has a low-distortion ring construction. All of the new transistors are hermetically sealed in the welded JEDEC TO-36 male industrial case.

Transistor Radiator
FOR TO-8 PACKAGES
THE BIRCHER CORP., 745 S. Monterey Pass Road, Monterey Park, Calif., has developed a radiator to reduce heat and permit up to 25 percent more efficient operation of all transistors having TO-8 packages. The model 3AL-705 is designed for horizontal or vertical mounting on p-c boards or metal chassis. When mounted vertically on the board the unit also serves as a retainer for the transistor. Vertical mounting is accomplished by means of a 6-32 tapped hole in the
base of the radiator. Overall dimensions are 1 in. maximum diameter by 0.312 in. thickness. Inside diameter is 0.480 in. with a counterbore for the transistor base 0.078 in. deep and 0.609 minimum to 0.619 maximum in diameter. Material is aluminum and finish is black anodize per MIL-A-8625.

**CIRCLE 343 ON READER SERVICE CARD**

Beacon Transmitter
TRANSISTORIZED

GENERAL ANTRONICS CORP., 9036 Culver Blvd., Culver City, Calif., announces the model BT 201 uhf-vhf transistor beacon transmitter. It measures 5½ in. by 3½ in. by 1½ in. including self-contained mercury batteries. The transmitter and batteries weigh 1 lb 12 oz. Power output is 250 mw at either 121.5 Mc or 243 Mc, and the battery life is 20 hr. Either frequency is available upon order. Crystal control is used to maintain the chosen frequency. The transmitter is modulated class A2 by a 1,400 cycle tone, approximately 3 pulses per sec. It is designed for extreme conditions of shock, vibration, and temperature.

**CIRCLE 344 ON READER SERVICE CARD**

Insertion Tool
FOR TAPER PINS

AMP INC., Harrisburg, Pa., has developed a tool for inserting both

---

Antenna System's new solid surface, high precision 30-foot antenna (model 103) is designed to set a new standard for accuracy in the fields of radio astronomy, tropospheric scatter propagation, tracking radar, and experimental test installations. It features:

- High precision — The static surface tolerance of the first unit has been measured. The deviation from the ideal curve measured 0.033 inches RMS.
- Has an f/d ratio of 0.417 which readily adapts to a wide variety of feed systems.
- Fully machined sections are interchangeable and easy to assemble.
- Solid surface panels permit use at any frequency.
- Useable with a wide variety of feed support systems.
- Built to withstand 150 MPH wind with 4" ice.
- Can be mounted on either the top or side of a tower with azimuth and elevation adjustments, on el-az or equatorial pedestals, self-contained trailer tower mounts, or other types of mounts.

Write for specification sheet.

**ANTENNA SYSTEMS INC. HINGHAM, MASSACHUSETTS**

**CIRCLE 171 ON READER SERVICE CARD**
The Application of
DATA PROCESSING TECHNIQUES

... in tracking, timing, guidance and test systems is a familiar problem to Anlex® Systems Division engineers.

For almost ten years, they have worked together in the development of logical solutions to special military problems of air, land and sea operations, including equipment for MIL. Space environments. During this time, they have also developed unusual systems for industrial and commercial applications.

Finished equipment required for these systems may be produced by the customer or by the Anlex manufacturing facility under the direct supervision of the engineering group. This division is staffed by technicians and skilled craftsmen who have specialized in the production of sophisticated data processing equipment.

We will be glad to tell you frankly and promptly whether your particular requirement is within the capabilities of our Systems Division.

for further information, write or telephone

ANelex CORPORATION
150-F CAUSEWAY ST., BOSTON 14, MASS.

172 CIRCLE 172 ON READER SERVICE CARD

its formed and solid taper pins into shielded patchcord programming systems and panels. A single push to insert, and then a single pull on the tool's pull test handle, will properly seat and inspect the taper pin insertion. The insertion spring of the tool is calibrated at 18-20 lb. When this insertion pressure is reached, the spring will "give", and a dished washer will be actuated which will make a very positive audible click. The pin is then seated. The pull test device on the tool, which may be used as a standard tool for patchcord programming systems, is calibrated at 61 lb. This poundage is achieved as soon as the pull test handle starts to be displaced from its normal position. Price of the tool is $26.

CIRCLE 345 ON READER SERVICE CARD

D-C Amplifier
COMPLETELY STATIC

VAPOR HEATING CORP., 6420 West Howard St., Chicago 48, Ill. announces a new d-c amplifier for either temperature control or pressure control applications. This compact, completely static amplifier can be used with either a temperature pickup, pressure pickup, or potentiometer—anywhere amplification of low level signals is required. The unit can be used also as a relay driver; its parameters are easily adjusted to provide essentially bistable action. In this configuration, a relay can be energized with a signal voltage change of 1 mv.

CIRCLE 346 ON READER SERVICE CARD

Program Board
WITH GOLD CONTACTS

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y. The Seallectro-board is now available with gold-
plated contact strips to meet the needs of specialized applications requiring extremely low contact resistance over long periods of time. It is a cordless program board that offers the added versatility of component interposition. It is offered in all configurations with virtually unlimited X- and Y-axis functions. The standard Sealecto board incorporates silver-plated contacts for the usual requirements. The new gold-plated version is ideal for use in installations handling extremely small electrical flows, such as thermocouple programming, in which cases the gold-plating assures corrosion-free, low contact resistance connections.

CIRCLE 347 ON READER SERVICE CARD

Computing Resolvers
HIGHLY ACCURATE

VERNITRON CORP., 123 Old Country Road, Carle Place, L. I., N. Y., has available 0.05 percent accuracy computing resolvers with non-bifilar compensating winding capable of withstanding 500 v d-c between stator and compensator for 1,000 hours, and equal accuracy units with bifilar compensating windings. In 23, 15, and 11 frame sizes, the resolvers have an inter-axis error of ±2' minutes. All units are designed and manufactured to MIL-R-14346 specifications.

CIRCLE 348 ON READER SERVICE CARD

Solderless Terminals
ONE-PIECE CONSTRUCTION

MALCO MFG. CO., 4025 W. Lake St., Chicago 24, Ill., has available a line of solderless terminals designed for

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Whenever you have potentiometer applications calling for resistance variations other than linear, turn to TIC for the solution to your problem. TIC non-linear function pots are offered in 14 standard types—7 servo units, 6 panel controls, and a rectilinear unit. To meet your most critical needs, TIC also produces special windings, including sine-cosine pots, all of which incorporate TIC's patented double-contoured resistance element card.

Among the uses of TIC non-linear pots are as panel controls, components of servo-mechanism computing elements, and position transmitters in feedback control systems in a wide variety of equipment. Because of the versatility of TIC precision pots, these non-linear pots can be included as a cup in a ganged assembly made up of linear functions, other non-linear functions, switches, commutators, clutch-spring return mechanisms, and clutch-brake modules.

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fast, easy and stable wire connections. Smooth funneled mouth gathers frayed wire leads. Multiple V-notch in the barrel insure positive contact and exceptional holding power. A 1/2-in. shank facilitates wire location when crimping and provides a large crimping area for permanent, vibration-free, moisture-proof connections. The terminals are of strong, one-piece construction and are made of pure soft copper, electro-tin plated for maximum corrosion resistance. Load carrying capacity is greater than that of the wire itself. Types and styles are available for all popular applications and are stocked in 22-16, 16-14 and 12-10 wire ranges.

CIRCLE 349 ON READER SERVICE CARD

Logic Trainer
VERSATILE UNIT

EPSCO, INC., 275 Massachusetts Ave., Cambridge 39, Mass. The TDC digital logic trainer is a versatile, easy-to-use instruction and demonstration tool designed for training in digital circuit operation, logic design bread-boarding and testing digital circuits. The trainer effectively demonstrates basic circuit operation, as well as effects of loading and timing on circuit and network performance. The coupling of various circuit types for control, storage, timing, and logic can be easily understood. The front panel contains 50 pre-wired S100 digital circuits, with logic symbols for each clearly identifying input-output connections and their function. All connections may be made on a large patch-board front panel with pin jack jumpers. Input-output jacks are color coded for direct observation of terminal function. Circuits, switches, and controls are clearly marked for instruction in use of the trainer.

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NOVEMBER 25, 1960

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CIRCLE 177 ON READER SERVICE CARD
Literature of the Week

DIGITAL VOLTMETER Cubic Corp., 5575 Kearny Villa Road, San Diego 11, Calif. A recent catalog sheet contains features and specifications for the four-digit V-45 digital voltmeter, a fully transistorized, accurate, economically priced unit.

CIRCLE 351 ON READER SERVICE CARD

SILICON TRANSISTORS Sperry Semiconductor Division, Sperry Rand Corp., Norwalk, Conn., has released a specification sheet covering the electrical and physical characteristics of a series of silicon pnp alloy junction transistors.

CIRCLE 352 ON READER SERVICE CARD

FREQUENCY COMPARISONS Tektronix, Inc., P. O. Box 500, Beaverton, Ore. A 4-page pamphlet gives a detailed presentation of high-ratio frequency comparisons using roulette patterns on the crt of Tektronix types 502, 503, and 536 oscilloscopes.

CIRCLE 353 ON READER SERVICE CARD

VHF FREQUENCY METER Gertsch Products, Inc., 3211 South La Cienega Blvd., Los Angeles 16, Calif. Two-color data sheet describes a continuously variable frequency meter designed to measure and generate over a frequency range from 20 to 1,000 Mc, with guaranteed accuracy of 0.0001 percent.

CIRCLE 354 ON READER SERVICE CARD

HIGH-VOLTAGE PENTODE The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 8, Ohio. A four-page bulletin is illustrated with cutaway section of the type 7683 high-voltage pentode, gives dimensional and schematic data, and illustrates typical circuits in which the pentode can be used as a series regulator or as a shunt regulator.

CIRCLE 355 ON READER SERVICE CARD

LOGIC TRAINER Epso, Inc., 275 Massachusetts Ave., Cambridge 39, Mass., offers a four-page brochure and instruction booklet on a unique new, self-contained logic trainer for training in digital circuitry and logic. The trainer described can be used in classroom or laboratory for studying basic, as well as complex operations of various circuits.

CIRCLE 356 ON READER SERVICE CARD

STANDARD BRIDGE Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N. J. A two-page bulletin describes model 801 standard bridge which extends the range of accurate resistance measurement to 10⁴ ohms. Description includes bridge accuracy plotted against test potential up to 1,000 v, and electrical data, price and delivery.

CIRCLE 357 ON READER SERVICE CARD


CIRCLE 358 ON READER SERVICE CARD

VARIABLE DELAY NETWORKS ESC Electronics Corp., 534 Bergen Blvd., Palisades Park, N. J., has published a bulletin describing the series 700 miniature variable delay networks designed for printed circuit mounting.

CIRCLE 359 ON READER SERVICE CARD


CIRCLE 360 ON READER SERVICE CARD

THERMAL SWITCHES Control Products, Inc., 280 Ridgedale Ave., Hanover, N. J., has prepared an eight-page brochure describing eleven bimetal thermal switches.

CIRCLE 361 ON READER SERVICE CARD

SEMICONDUCTORS International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif., has published an up-to-date 24-page catalog covering over 800 semiconductor devices. Also included is a comprehensive listing of JEDEC rectifier types, with cross reference to device classification, rating and page number. Copies should be requested on a company letterhead only.
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At no extra cost, Spectrol trimmer potentiometers meet or exceed all applicable military specifications for altitude, fungus resistance, salt spray, sand and dust, humidity, temperature cycling, shock and vibration. Guaranteed load life, 1000 hours minimum.

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Prices in 1-9 quantities: Model 50—$7.50 each, Model 60—$6.50 each. Spectrol trimmers are ready now for immediate delivery from your local distributor. For complete technical information, call your Spectrol representative or write Dept. 42.

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November 25, 1960

CIRCLE 179 ON READER SERVICE CARD 179
Sylvania Building Tube R&D Center

SYLVANIA ELECTRIC PRODUCTS INC., a subsidiary of General Telephone & Electronics Corp., has begun construction of a new electron tube research and development center in Emporium, Pa.

Matthew D. Burns, president of Sylvania Electronic Tubes, a major division of the company, said research and engineering activities are being intensified "because we have evidence that tube uniformity and reliability can be increased twofold by the imaginative use of new materials and new designs."

First stage of the R&D construction program is a 42,000-sq-ft facility to house research activities on "Sarong" cathode coating and various types of "stacked-tubes", Burns said. A portion of the new structure also will be made available for the division's chemical development research, currently performed in three separate buildings in Emporium.

Sylvania's "Sarong" is a cathode in which the electron-emitting materials are in the form of a skin-tight film wrapped around the tube cathode. In conventional tube manufacture, cathode coating is sprayed on in liquid form. The "stacked-tube", introduced by Sylvania in 1954, employs a "planar" or sandwich-type mount structure where elements are stacked one upon the other. In conventional tubes, the elements are built around a common axis. Both developments assure more stable tube characteristics and longer tube life, Burns said.

Occupancy of the new facility is scheduled for mid-1961. Additional buildings, still in the planning stage, are scheduled for completion in 1963.

Kramer Assumes New Position

EMERSON RADIO & PHONOGRAPH CORP., Jersey City, N. J., recently announced that Herbert Kramer has joined its technical products division as chief of industrial engineering.

Kramer's most recent position was that of chief of industrial engineering, ultrasonics, for Acoustica Associates.

Thermosen Appoints General Manager

NATHAN H. MAGIDA has been named general manager of Thermosen, Inc., Stamford, Conn. The company is presently engaged in the manufacture of emission limited diodes as well as other special types of vacuum tubes.

Prior to joining Thermosen, Inc., Magida was marketing manager for industrial products for Consolidated Avionics Corp., Westbury, N. Y.

Rheem Semiconductor Names E. J. Quirk

EDWARD J. QUIRK has been appointed works manager at Rheem Semiconductor Corp., Mountain View, Calif. He will direct manufacturing, manufacturing services and quality control and the man-
New PDM Telemetering Keyer

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permits sampling in center of pulse

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*Case Histories on File.

KEystone ELECTRONICS Elects President

THE KEystone ELECTRONICS CO., INC., Newark, N. J., manufacturer of crystal ovens, crystal filters and discriminators, and quartz crystals, recently elected Adolph M. Groas to the office of president. He is also treasurer and a director of the company.

Since 1956, Groas has been president of Electronic Enterprises, Inc., a subsidiary of Keystone, and vice president of Keystone.

Davison Joins ITT Division

WALTER C. DAVISON has been named product manager of closed circuit television systems at the industrial products division of International Telephone and Telegraph Corp., San Fernando, Calif.

He joins the division after heading his own management consultant firm for four years.

Victory Engineering Plans New Plant

A MODERN 43,000 sq ft executive offices and research laboratory building will be constructed for Victory Engineering Corp. of Union, N. J., on a five-acre site in Springfield, N. J.

New factory will facilitate production of thermistors, varistors and other electronic products now manufactured by Victory in the Union plant.

Lockheed Electronics Advances Basarab

JOHN BASARAB, JR., who joined Lockheed Electronics Co., Plainfield, N. J., four years ago as a design engineer, has been named supervisor engineer in the company's shipboard electronics department, military systems division.

He assume engineering responsibility for some of the division's major Navy contracts, including those concerned with the Regulus guidance system, gunfire control systems, and various radar equipments.

Dynamic Science Corp. Has New Facilities

MARSHALL INDUSTRIES' subsidiary, Dynamic Science Corp., recently occupied new facilities in South Pasadena, Calif. The corporation, operating as an autonomous subsidiary, will maintain separate facilities from the manufacturing and sales divisions of the parent company.

The new 14,000-sq ft facility provides research laboratories and offices for 100 senior scientists and engineers. M. Edmund Ellion is president and Melvin Gerstein vice president of the new advanced research and technical development organization.

Specialty Electronics Names Wolf G-M

ARNOLD M. WOLF has joined Specialty Electronics Development Corp., Syosset, N. Y., as general
November 25, 1960

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BLILEY TYPE: BG61AH-5

Hughes Names Mueller To New Position

WILLIAM M. MUELLER has been appointed assistant manager of manufacturing for the microwave tube division of the Hughes Aircraft Co., Los Angeles, Calif. In addition to management responsibilities, involving microwave tube production, he will be in charge of special development projects in the manufacturing department.

Mueller formerly was a member of the technical staff of the Hughes Research Laboratories in Malibu, Calif.

Etu Joins Aerovox As Manufacturing Mgr.

J. ROGER ETU, formerly production manager at General Electric, Irmo, S. C., has been appointed manu-
Electro-Mechanical Names Two Executives

ALAN M. BROWN has been named president and Bernard Klibaner vice president in charge of engineering and manufacturing of the Electro-Mechanical Corp., New Rochelle, N. Y. Company manufactures precision electronic equipment.

Both men formerly held executive positions at Adler Electronics.

Tensor Organizes New Division

TENSOR ELECTRIC DEVELOPMENT CO., INC., prime and sub-contractors of electronic test equipment for the military for the last 10 years, recently formed a commercial products division.

Company, which maintains offices and production facilities in Brooklyn, Flushing and Manhasset, L. I., N. Y., has already commenced introduction of its equipment to the commercial market.

Microwave Electronics Appoints Section Head

ROBERT W. DEGRASSE has joined Microwave Electronics Corp., Palo Alto, Calif., as an engineering section head. He will take leading responsibility in the development of a program in low-noise microwave devices.

DeGrasse came recently from Murray Hill, N.J., where he was a member of the technical staff of Bell Telephone Laboratories for three years.

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CIRCLE 381 ON READER SERVICE CARD
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CIRCLE 189 ON READER SERVICE CARD

CIRCLE 216 ON READER SERVICE CARD
November 25, 1960
FIRST AGAIN!

New Babcock 10 amp Magnetic Latching Relay

New subminiature Model BR-9, meets Mil R 5757C, 2501B. With vibration to 30g@10-2000 cps, 50g shock@11 milliseconds over -65°C to 125°C range. Bulletin BR-594.

BABCOCK BR-15 RELAY

Miniature, hermetically sealed BR-15S requires only 5 mw power, features very critical pull-in to drop-out ratios, 10,000 op. min. and —65°C to 125°C ranges. Meets Mil R 5757C, 6106C, 2501B. Bulletin BR-593.

BABCOCK RELAYS

BABCOCK BR-7 RELAY

Subminiature 10 amp, DPDT relay with 0.2" grid spaced header accepts 30g vibration @10-2000 cps, 50g shock @11 milliseconds over range of —65°C to 125°C, 100,000 op. min. @+125°C. Meets Mil R 5757C, 2501B. Bulletin BR-592.

BABCOCK BR-8 RELAY

Subminiature A.C. or D.C. crystal can relay, 250,000 op. min. @+25°C, Vibration, 30g, 40 - 2000 cps. at —65°C to +125°C. Available with adjustments for repeatability over millions of operations. Meets Mil R 5757C, 2501B. Bulletin BR-591.

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Duty cycle — up to 0.001. (For the BL-221, it is 0.00055)
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Shock — 50 g’s at 4 millisecond
Lightweight — 7.25 lbs
Mounting — mates to modified standard flange
Ruggedized — Ceramic and metal construction
Fixed tuned

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