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Electronics

December 13, 1965
Volume 38, Number 25

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→Circle 2 on reader service card
Readers Comment

Cathodic patent question

To the Editor:

I read with interest the article on "Regulating bias on a ship's hull" [Aug. 9, p. 84], and would like to call to your attention two U.S.A. patents, numbers 2,021,519 and 2,221,897, issued in 1935 and 1940 respectively, which cover substantially the same system described.

This development, which was conducted in part with a U.S. Navy contract, was applied to both naval vessels and lighter-than-air craft.

The patents were licensed to the American Telephone & Telegraph Co., and the system is used for the protection of buried cables and pipe lines.

I agree, with the authors of your article, that this approach should be a rewarding one for the protection of metallic components operating in the sea or other corrosive environment.

H. S. Polin
Director
Laboratoire de Recherches Physiques,
Geneva, Switzerland

The author replies:

Polin's patents are representative of a number issued over the last 50 years embracing the concept of impressed current cathodic protection, incorporating various manifestations of feedback principle to obtain potential control.

The attainment of a maintenance-free system of high-current output with high-loop gain has been far more recent, and is partly a result of the availability of reliable and efficient magnetic amplifiers and silicon controlled rectifiers.

A problem in the past has been the short life or high cost of anodes and an inherent unavailability in potential sensing devices due to polarization of the reference half-cell. The current Lockheed cathodic protection systems have features which overcome these problems. A patented lead-platinum bicolletode is used as the anode for ship systems. It possesses a very high current capacity, low driving voltage, very long life, an ability to repair...
**Did you know Sprague makes...?**

**SILICONTROL® SCR GATE DRIVES**
For balanced SCR firing in 3-phase a-c or d-c power control. Pulse rise time of 1 to 3 microseconds to meet requirements of high-current-rated SCRs.

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Fully shielded, ultra-tiny, yet performance is comparable to that of larger units. Inductance values from 0.1 to 12,000 uH. Molded for positive protection against humidity and handling. Meet requirements of MIL-C-15305.

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For complete technical data on any of these products, write for applicable Engineering Bulletin(s) to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts 01248.
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For fast response studies of filters, networks, amplifiers, transducers, and other devices operating in the audio range

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Easy to Use... Accurate...
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Here is an all-solid-state, servo-type recorder that plots the rms value of ac voltage logarithmically on a linear dB scale. It is coupled mechanically to a beat-frequency audio generator whose frequency characteristic over the audio range is flat within ±0.25 dB. To use this automatic recording system, connect the output of the generator to the device you are testing and apply the device's output to the recorder... Flick a switch and set the system into motion; the recorder and generator operating in synchronism provide you with a response curve of the device under test in a few seconds.

Call us for a trial demonstration and see for yourself what this recording system can do for you.
itself if damaged, and is relatively inexpensive. Additionally, the problem of unreliable reference electrodes has been solved by using a patented rejuvenation circuit which maintains laboratory accuracy of the silver-silver chloride half-cell.

E. L. Littauer
O. G. O'Brien
Lockheed Aircraft Service Co.
Ontario, Calif.

Facing reality

To the Editor:

When are the integrated circuit promoters going to face reality? Vasil Uzunoglu's discussion [Nov. 15, p. 114] of inductorless integrated circuitry ignores a basic fact: virtually all requirements for frequency-sensitive circuits are dictated by the specific frequency. A tuning mechanism is required to bring the circuit into alignment, yet the vast microcircuit industry has not come up with such a technique. Instead, it insists that the circuit user must learn to live with the cluttering junk the industry attempts to pass off as a useful linear circuit.

And it will have to come up with more than that voltage-sensitive capacitor that was so highly touted in those early days before someone got around to asking where the alignment voltage was to come from.

Yet, there is a type of component that might eventually be developed if the solid state people will lift their collective heads out of the Boolean sandbox long enough to look around them. They just might develop some sort of adaptive memory element such as the learning machine people have been searching for without marked success. Such an element could be incorporated as the alignment control in inductorless microcircuits and simultaneously find a large market with the adaptive machines people.

But until such components can be developed in a form compatible with integrated technology, stop cluttering up your magazine with "solutions" to the inductor problem.

A. J. Cote Jr.

Silver Spring, Md.

The author replies:

As its title implies, the object of the article was to make a review and analysis of the six possible methods to achieve bandpass characteristics without an inductance. The tuning of a stage to a required frequency was not the subject and for fixed tuned stages, such as intermediate-frequency, the alignment within limits can be incorporated on a microelectronic block. Also, the article points out clearly the difficulties associated with the methods in every case. For example, the notch filter feedback method suffers from instability, the digital filterings from complexity and fabrication difficulties, etc. No claim was made that in these methods lies the final solution to realize bandpass characteristics on microelectronic blocks. An awareness of the difficulties with the present techniques can open new horizons and lead to new investigations.

As a matter of fact, I am pleased to learn that the use of adaptive memory elements may be a solution to the problem of tuning inductorless circuits.

Vasil Uzunoglu

Scientist

Arinc Research Corp.

Annapolis, Md.
World’s Highest Power Tetrode—Machlett’s ML-8545

The Machlett ML-8545 general-purpose, vapor-cooled tetrode delivers 16% more power with 25% less plate voltage (plate modulation service) than the closest competitive tube. It is capable of 300 kW continuous output as a Class C amplifier or oscillator at frequencies to 50 Mc. Maximum plate input is 420 kW. Applications include: High-power broadcast and communications; all-purpose rf generation; particle acceleration. For details on the ML-8545 and the ML-8546 water-cooled version, write: The Machlett Laboratories, Inc., Springdale, Conn. 06879. An affiliate of Raytheon Company.

People

“Marketing industrial electronic products requires an entirely new set of techniques,” says Daniel M. Zinn, Gulton Industries, Inc.’s new assistant to the vice president. “The industrial user operates under different rules than does the military,” says Zinn. “For example, industrial users buy right to the specification, with no exceptions. And, perhaps most importantly, they must be shown that technological advances do pay off with results. They are more reluctant at present to accept technological advancement than is the government.”

Gulton has started to reorganize its resources to increase its share of the industrial electronics market. Its instrumentation group has been almost entirely relocated in Hawthorne, Calif.

In his new position, Zinn will coordinate the technologies of the corporation’s nationwide divisions and subsidiaries. He is on an extended tour of Gulton’s facilities to acquaint himself both with the company’s products and personnel.

“Those who follow are always behind.” These words, expressing Robert H. Rediker’s philosophy, are on a printed motto he will take to his new job as professor of electrical engineering at the Massachusetts Institute of Technology. Rediker, a leader in the field of solid state physics, headed a team at MIT’s Lincoln Laboratory that obtained coherent light emission from gallium arsenide in 1963. That work coincided with similar developments by teams from the General Electric Co. and the International Business Machines Corp. The work of the three groups initiated the
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technology of semiconductor lasers.

Since then, Lincoln's applied physics group, headed by Rediker, has been one of the most persistent in extending the semiconductor laser technology. The group has achieved laser action in indium arsenide, indium-gallium arsenide and indium antimonide, and extended it to all three types of excitation: injection in p-n junctions, electron-beam pumping and optical pumping.

Rediker has also made major contributions to the development of magnetically tuned semiconductor lasers, to the discovery of laser action in lead salts, pressure tuning of these lasers to coherent radiation far into the infrared, and to the development of optically excited and electron-beam excited bulk semiconductor lasers.

In addition to teaching duties, Rediker will supervise the research efforts of graduate students. He intends to continue his own work in semiconductor development.

He says, "I hope to be doing work in what is going to be important: tomorrow's research today, not today's research tomorrow."

The appointment of Finn J. Larsen once again places an electronics specialist in the post of deputy director of defense research and engineering.

Larsen, until recently a vice president of Honeywell, Inc., will have a more restricted role than his predecessor because of a recent reorganization of the department that centralizes electronics programs under Thomas Rogers as deputy director for electronic and information systems.

Larsen will have considerable responsibility for the over-all management of the $7-billion annual military research and development effort. He will be second in command to the recently appointed director, John Foster.

At Honeywell, Larsen directed planning, sales and the advanced development of avionics, space, weapons and reconnaissance systems.
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- Mine Equipment or
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Watertight construction; resistance to damage by weather, water, salt spray or corrosive fumes permit use of TRON fuseholders in exposed locations where safety and long life are of vital importance.

For Protection of Circuits of 600 Volts or Less

TRON Waterproof Fuseholders fill the need for a watertight holder that is easy to install to give fuse protection to circuits in exposed locations.

Crimp-Type Tubular Terminals Available in Many Sizes

The crimp-type tubular terminals on TRON fuseholders are available in sizes to take many sizes of solid or stranded wire.

If desired, Load-side terminals can take one size wire, while Line-side terminals take another size wire.

A crimpable insulating sleeve covers each terminal. This provides a good surface for taping after crimping. When properly taped the crimped terminal is completely insulated and waterproof.

CAN BE USED AS TAP-OFF CONNECTOR

TRON Waterproof Fuseholders can also be used as Tap-Off connectors by having the Line-side terminal large enough to permit the two ends of the Line-wire to be crimped into it. This eliminates costly line connections and labor.

Two Models Available
Both rated at 30 amps at 600 volts or less

The TRON HEB Fuseholder takes fuses 13/32 inch diameter by 1 1/2 inches long.

The TRON HEH Fuseholder takes fuses 13/32 inch by 1 3/4 inches long.

Write for BUSS Bulletin SFH-11

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BUSSMANN MFG. DIVISION, McGraw-Edison Co., St. Louis, Mo. 63107

Electronics | December 13, 1965

Circle 11 on reader service card
Fairchild invented Dual in-line packaging for manufacturers of commercial equipment. Dual in-line is a little larger than military-aerospace type packages. It is also a lot easier to work with. (Insert it by hand or by machine.) Its leads have dimensional tolerances to fit holes drilled to commercial standards. Use standard circuit boards. Flow solder it. In fact, handle it the way you would any discrete component.
Dual in-line saves you trouble in the field, too: it has an all-ceramic body to prevent accidental shorts. Leads can be probed from the top, where they are visible to the serviceman. And, should you ever have to replace a circuit, a pair of pliers and a soldering iron are all the equipment you need. We have a complete line of logic functions available in Dual in-line. Your distributor has them in stock. Or, write for brochure.
Meetings

American Association for the Advancement of Science, AAAS; University of California, Berkeley, Dec. 26-31.


Sealab II Symposium, U.S. Navy; Statler Hilton Hotel, Washington, D. C., Jan. 11-12.


Instrumentation for Process Industries Conference, Texas A&M University; College Station, Tex., Jan. 19-21.


International Symposium on Information Theory, AFOSR, IEEE; University of California, Los Angeles, Jan. 31-Feb. 2.

Integrated Circuits Seminar, IEEE, Basic Sciences Committee; Stevens Institute of Technology, Hoboken, N.J., Feb. 2.


Call for papers

Audio Engineering Society Convention, AES; Hollywood Roosevelt Hotel, Los Angeles, April 25-28. Jan. 28 is deadline for submission of abstracts on all aspects of audio engineering to John C. Baumann, Papers Chairman, Ampex Corp., 8467 Beverly Blvd, Los Angeles, 90048.

Symposium on Electron and Laser Beam Technology, IEEE, University of Michigan; University of Michigan, Ann Arbor, Apr. 6-8. Jan. 15 is deadline for submission of 50- and 500-word abstracts on the physics of electron, ion, and light beams, and the application of energy beams to microfabrication and thin films (integrated-circuit construction), to Dr. G. I. Haddad, Electrical Engineering Department, University of Michigan, Ann Arbor, Mich.


* Meeting preview on page 16
Faster set-up, more automatic control, immediate feedback of test results. Wherever data is gathered and searched on magnetic tape, the Model 5600 Tape Search System can provide these advantages. First, because it combines Time Code generation and translation of time/ID information into one compact, programmable unit.

MULTIPLE OPERATIONS
You have complete control over the RECORD, SEARCH, and PLAYBACK of magnetic tape transports. In RECORD, the unit provides both automatic and manual control; and generates serial time codes for mag tape transports and oscillographs. In SEARCH and PLAYBACK, the 5600 translates and uses previously recorded time/ID data as a reference in programming the tape transport. This means you can check back over your test results immediately, providing unusual flexibility in planning or re-designing experimentation, and rapid correlation of data.

MULTIPLE ECONOMIES
The Model 5600 allows numerous economies lacking in conventional tape search procedures, particularly in applications with numerous, repetitive data runs. In bio-medical applications, for example, separate generation and translation systems usually mean high equipment costs, laborious set-up, and delays in interpretation of up to one day or more.

IRIG "B" TIME CODE: Model 5600 generates and translates IRIG Format B time codes, modified to include BCD seconds, minutes and hours, and the 3-digit identification code.

SELECTABLE ASTRODATA "A" TIME CODES:
Four speeds are available for output to oscillographs. Rates range from a time frame of 1 second to 10 min.

FOUR MODES OF SEARCH: Searching may be accomplished by RECYCLE, SINGLE CYCLE, SEARCH/STOP, MANUAL SEARCH. The search select may be set to TIME, ID ADDRESS, or combined TIME-ID ADDRESS.

WIDE ANGLE SUPER NIXIE DISPLAYS: Accumulated time-of-day or elapsed time in hours, minutes and seconds, along with ID data programmed into the time code, appears on the front panel with polarized filters for maximum visibility. Up to three remote displays can be connected.

CARRIER FILTERS: Ten band-pass filters are selectable from two front-panel rotary switches. One switch selects the proper filter for tape playback speed; the other selects the proper filter for search speeds. Extra switch positions permit by-passing a filter or inserting external filter via connector.

SYNCHRONIZATION MODE (ERROR BY-PASS): This enables operator selection of by-passing 0, 1, 2, 3, or consecutive time words decoded erroneously without reflecting these errors in the output register.

SINGLE-CYCLE NOISE REJECTION: Noise or dropout of a single cycle or less occurring on the input will not affect the decoding process.

For complete technical information, contact your nearest Astrodaxa representative or write direct on your company letterhead.
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1. Natural shoulder packaging. The slim, Ivy League JA weighs in at just 2.5 ounces per pole, including hydraulic-magnetic actuating element, silver-alloy contacts and an uncommonly efficient arc-quenching device.

2. Pizazz—The JA is the first breaker with snap-on color-coding caps that you can mix or match for functional or decorative purposes. Also included: a very dressy white handle.

3. Convenience. The JA's 'universal' terminals are made to accept soldered, crimped-type, or screw-type connections; you can use whichever you're tooled for—or overstocked with.

4. Economy. This is the surprise. The JA actually costs less, model for model, than our Series AM12 breakers, which it can replace to your advantage.

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Circle 16 on reader service card
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Vector pioneered in microtelemetry with the world's smallest production-model VCO - only .109 cubic inch, shock tested in excess of 20,000 G's.

Produced by the most advanced microelectronic circuit techniques, Vector components and systems have the high reliability characteristics which can come only from using true microcircuit design and production methods.

A family of multiplexers and A to D converters already exists. Vector also has design experience in signal conditioners, processors, synchronizers and demultiplexers. From this firm base, Vector offers complete follow-through - from systems design to hardware production - with the highest possible reliability.

Vector telemetry components and systems are used on a wide variety of space projects, including Saturn, Gemini, and Apollo.

Existing, proved micro-hardware... system design and follow-through capability... experience - good reasons why Vector is uniquely qualified to fill MOL requirements for airborne and ground-based data acquisition, handling and processing systems.
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Cut down-time and increase production with Eagle Cycl-Flex time and count controls. You can remove them, check them and replace them in 5 seconds or less...no tools needed!

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Compare. You'll choose Eagle.

NEW—Now standard on all Cycl-Flex timers, a built-in pilot light, to indicate, even from a distance, that the timer is operating.

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New Eagle relays...more than 3,000 types...are the best you can get anywhere. Be crafty. Check the specs and the product. Convince yourself.

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- Low breakover voltages: 8-12 volts
- Low junction capacitance: typically 35 pF @ 8-12 \( V_c \)
- Fast switching speeds: typically \( t_{on} = 50 \text{ nsec}, t_{off} = 100 \text{ nsec} \)
- Packaged in D0-7 "glass" case (\( P_0 = 150 \text{ mW} \))

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...with UNIBLOC® Performance and Reliability Features!

- NPN / PNP for complementary circuit design
- Complete "h" parameters specified
- Gain specified from 100 \( \mu \text{A} \) to 100 mA
- High voltage — 40 volts (min)

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NPN — 2N3904-6
PNP — 2N3905-6

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... to best fit your particular performance/cost requirements!

- Fan-out capability up to 5
- 12 nsec - typical propagation delay
- 15 mW/NODE Dissipation

- MC900G series - designed for MILITARY extreme environmental applications. Operating Temp. Range: -55°C to -125°C
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- Available in standard or reverse polarity

CURRENT VS. TEMPERATURE DERATING CURVE

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... for non-saturated switching

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- Germanium Power Transistor Selection Guide
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- **RIPPLE:** Less than 0.1 mv rms
- **HIGH TEMPERATURES:** Up to 71°C
- **CURRENT LIMITING:** Now so sharp, it’s practically automatic crossover current regulation
- **PROGRAMMING:** By resistance, voltage or current. High speed capability available.

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Westernizing Japan

Japanese developments in electronics are moving almost as fast as the trains on the new Tokaido line, the railroad the Japanese are so proud of because it is the world's fastest. They still lag behind the United States, as most Japanese will frankly admit, but they are racing to catch up. That's the really significant inference of our special report on Japanese electronics (pp. 77-112).

After reading Yasuo Tarni's survey of integrated circuit activity (p. 90), it's hard to believe the first development started only 18 months ago. And this without benefit of a gigantic military or space program to subsidize the work. One of the biggest government research projects supporting integrated circuit activity is for $80,000, a sum puny by U.S. standards. Yet six companies are sharing in the award to develop six different IC equipments.

Semiconductor production is the nucleus of Japan's electronics industry. Takuya Kojima and Makoto Watanabe have surveyed not only some unusual Japanese devices but how some of their associates use components in circuits (pp. 81-87). While the technology may not be impressive to a student of advanced semiconductor phenomena, nearly every U.S. consumer-products company uses Japanese devices—an impressive fact.

In solid state microwave technology, Japan may well be on a par with the United States. Its terrain and economy have encouraged use of wireless communication instead of coaxial lines so that Japan today has the densest network in the world, as Isao Someya reports on page 99. Solid state systems save installation and construction costs, keenly important in a country whose resources are sharply limited.

Because the Japanese desire greatly to be considered an advanced people, they tend to take a gamble on the new even before it is proven. This has been particularly true in industrial plants, many of which were destroyed during World War II. Rebuilding from scratch during the post war boom, which accelerated sharply from 1960 to 1964, many manufacturers installed industrial electronics instead of conventional electrical or mechanical controls. Japanese companies have shown far more willingness to change to electronics than their counterparts in U.S. industry. Today, even in the face of a recession, Japanese industry is buying more numerically controlled machine tools (p. 106) and computers for process control (110) than ever before.

Progress has created a demand for a lot of new products too: radio, television and tape recorders. Now the fads are air conditioners, central heating and hot water heaters. At Sanyo Electric Co. Ltd., a major appliance manufacturer, executive managing director Kaoru Iue explains the pressure: "In the summer, the average Japanese has always come home after work, taken off his clothes and sat nude in front of a fan to keep cool. Thousands of Japanese who have traveled to the U.S., now believe that is no way for an advanced people to behave—so they want air conditioning. In the same way, Japanese housewives have learned the desirability of having hot water in the morning, after centuries of doing all the morning chores in cold water."

All this activity and dynamism in Japan poses a considerable threat to the U.S. electronics industry, clearly the world's leader. The Japanese are particularly attuned to the infant markets of Asia and Africa and have serious designs on maturing markets in Europe. For several years now, they have been raising havoc in certain parts of the U.S. electronics market.

But the most serious threat to U.S. electronics firms may be something the Americans are doing themselves. Manufacturer after manufacturer is buying Japanese consumer products with the U.S. company's nameplate riveted on at the end of the production line. If U.S. manufacturers continue to abandon their engineering and production for Japanese products, they are headed for oblivion because they cannot compete with the purely merchandising organizations such as Sears, Roebuck & Co. and Montgomery Ward which buy Japanese products too. These merchandisers own outlets through which they can retail the Japanese products; the manufacturers must resell the goods to independent retailers who then have to compete in price with the Montgomery Wards and Sears stores.

The two things the Japanese fear most are the fast rate of development of U.S. technology and U.S. automation. To offset the phenomenal progress the Japanese are making, U.S. companies will have to pour more effort and money into product development and automation of production facilities. This is no time for American companies to be complacent.
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SOLID STATE TIME DELAY—You get excellent timing characteristics in these knob-adjustable solid state relays. Timing range: 0.6 to 60 seconds, AC or DC models. Internal DPDT relay rated at 10 amperes, 115V AC resistive. For continuous duty over temperature range of -40°C to +55°C.

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Chances are, you’ll save both time and money when you order standard P&B relays from an authorized distributor. You’ll get speedy service at factory prices. Your P&B distributor has available more than 60 basic relay types totalling 627 coil voltages and contact arrangements. All are shown in our new Stock Catalog 100... free from your electronic parts distributor. Ask for a personal copy today.
Electronics Newsletter

December 13, 1965

Satellite-to-home broadcasts weighed
The National Aeronautics and Space Administration is showing increased interest in satellites that can broadcast radio signals directly to home receivers.

The agency has requested industry proposals for studies of such direct-broadcast satellites. It is considering orbiting one or more such satellites late in this decade or in the early 1970's. The satellites would be able to broadcast programs throughout the world. Operating in the f-m mode, they would relay voice broadcasts to home or car radios equipped with directional antennas.

NASA officials believe that direct television-broadcast satellites could also be orbited by 1977, using a Snap-8 nuclear-power supply with 35 kilowatts of power.

High cost of money: who gets hurt?
When the Federal Reserve Board increased the cost of borrowing money this month to a 35-year high, its action hit particularly hard at two kinds of companies: those whose consumer products are sold largely on installment, such as television receivers, and those planning rapid expansion.

One result of the increase in banks’ discount rates—to 4.5% from 4%—may be to make small-business investment companies more attractive sources of loans [see p. 142]. SBIC’s raise money through the sale of stock, so are not affected by the change in bank rates.

The FRB says its move was designed not to slow down business expansion but to prevent the expansion from increasing too fast.

U. S. airlines seek microwave network
United States airlines are in the market for a nationwide network for microwave communications. The network, expected to cost about $50 million, is planned by the commercial airlines’ own communications company, Aeronautical Radio, Inc. (Arinc). Bids are due April 1. The airlines currently use the Bell System’s bulk leased-wire communications service, called Telpak.

The commercial airlines’ move to their own communications network was prompted by two factors that threaten the future of Telpak. Critics of the bulk-wire service are battling it in court, contending that it’s unnecessary and discriminates by offering lower rates to large users; in addition, the massive investigation of the entire Bell System, announced recently by the government, may result in the Federal Communications Commission’s ordering substantial rate boosts for bulk users.

Arinc estimates it would cost the airlines $12 million a year to operate their own communications network. Without Telpak, the airlines would have to spend about $65 million a year for telephone and teletype service. With Telpak, the charge for this year is estimated at $48 million.

Soviet fails again to land on the moon
The Soviet Union failed in its fourth attempt to gently land a package of instruments on the moon. Soviet scientists indicated, however, that further efforts are planned.

The crash landing on the moon, it is believed, was caused not by mechanical trouble aboard the spacecraft, Luna 8, but by unexpected characteristics of the moon. Some space experts in the United States suspect that the moon’s surface may not be reflecting the spacecraft’s radar properly. The radar is used to keep track of the distance between

25
A new role for the F-111

At first it was simply the TFX, for tactical fighter experimental. Then it became a two-service plane and its name was changed to F-111A for the Air Force and F-111B for the Navy. Now the Pentagon has given it a new role—reconnaissance—and a new name—RF-111A.

The General Dynamics Corp. has received a $12-million contract to develop the new version of the variable swept-wing aircraft outfitted with the latest in electronic sensors. No production commitment has been made yet.

Defense Secretary Robert S. McNamara is said to favor further modifications to convert the plane into a strategic bomber. If that happens the name will be changed again—to B-111.

Read diode's power and efficiency lifted

Silicon p-n-i-n diodes are being pushed to higher power and efficiency levels. Bernard C. De Loach Jr. and Ralph L. Johnston of Bell Telephone Laboratories have increased the power of the Read oscillator to 147 milliwatts from 19, and its efficiency to 5% from 1.5%. The continuous-wave output has a frequency of 5.3 gigacycles.

Messerschmitt wins space contract

Two familiar names in German aeronautics—Junkers and Messerschmitt—have won a contract that puts them solidly into the space industry. Junkers Flugzeug und Motorenwerke AG, now a subsidiary of Messerschmitt AG, has been chosen as the major contractor for an international satellite called HEOS. The satellite is a project of ESRO, the European Space Research Organization, and has the backing of eight European countries. The contract, for development and production of the satellite, totals $6.5 million.

When HEOS goes up in the second half of 1968, it will investigate the far fringes of the earth's atmosphere in a highly eccentric orbit that will take it about 150,000 miles from the earth.

Other members of the industry group of which Junkers is the head, are: the British Aircraft Corp.; Etudes Techniques et Constructions Aerospatiales, in Belgium; and Societe National D' Etude et de Construction de moteurs D'Aviation, in France.

A boost for PAL

Britain's Television Advisory Committee has made its recommendation on the color system it would like to see adopted. The recommendation, made to Postmaster General Wedgewood Benn, the final arbiter for Britain's tv networks, is that West Germany's PAL system should be used with a 625-line horizontal scan. PAL is a modification of the United States' NTSC system which Britain favored earlier.

Addendum

The Air Force will seek bids soon on a major contract covering operations and maintenance of facilities at its Western Test Range at Vandenberg, Calif. Among other things, the contract will cover operation and upkeep of data-collection and communications systems, radars and displays and launch equipment.
Obviously photography is the neat way to capture information and record data

You would like to try it. (You have heard that photographic processing is now so fuss-free and compact that it can go on all by itself in unmanned spacecraft.)

But photo-technology may not be your game. And your needs are special.

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5 points to check
- and 3 questions for your supplier

☐ 1. NOISE IMMUNITY
FLIP CHIP Modules use DTL clamped logic, provide a threshold value of 1.2-1.5 volts of noise immunity.

☐ 2. DRIVING CAPABILITY (Fan Out)
Based on 1 ma = 1 unit load, FLIP CHIP gates have a typical fan out of 18 unit loads; flip-flops have a typical fan out of 15 unit loads.

☐ 3. COST
FLIP CHIP gates cost out at about $4.00 per gate — mounted, tested, and ready to go. A built in design feature permits additional diode inputs to be added at an average cost of 60¢ each.

FLIP CHIP flip-flops run about $11.00 each and provide multiple functions (JK, RS, T, and RST). Since the same flip-flop can be used in a variety of applications — counters, shift registers, jam transfer buffers, BCD counters — inventory can be held to a minimum, reducing costly spares.

☐ 4. SPEED
Two frequency ranges are offered in our standard FLIP CHIP line:
   - R Series — up to 2 mc
   - B Series — up to 10 mc

Both series are fully compatible with our earlier line of System Modules.

☐ 5. RELIABILITY
FLIP CHIP Modules are rigidly tested and warranted for 10 years. Printed specifications are included with each module.

What is the breadth of my suppliers’ line?
You need only one supplier when you select Digital. FLIP CHIPS take you from input to output. Logic level converters standardize incoming and outgoing signals. Digital has a complete line of: interface modules — including relay drivers, lamp drivers, bus drivers, Schmitt triggers, A-D and D-A modules, and mounting hardware and power supplies. All the equipment necessary to build a complete system.

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—the HP 230A 10 Mc to 500 Mc
Power Amplifier

The Hewlett-Packard Model 230A is the ideal RF amplifier for both high and low-level applications. With a typical noise figure of 6 to 8 db, the instrument provides up to 30 db gain and a maximum power output of 5 watts.

Typical Applications include:

- **SIGNAL GENERATOR POWER AMPLIFIER** — Provides up to 15 volts output from standard VHF signal generators for receiver testing, watt and voltmeter calibration, antenna testing, and attenuation measurements. May also be used to drive antennas for remote systems testing such as aircraft ILS.
- **RECEIVER PRE-SELECTOR** — When used as a pre-selector with conventional communications receivers, fractional microvolt sensitivities are attainable.
- **TUNED SELECTIVE FILTER** — Provides a convenient means for the selective amplification of RF signals in the 10 to 500 Mc range with excellent rejection of undesired frequencies.
- **HARMONIC AMPLIFIER** — May be used to amplify desired harmonics in the output of signal generators and frequency synthesizers thereby extending their useful range.
- **FREQUENCY COUNTER PRE-AMPLIFIER** — As a pre-amplifier for conventional frequency counters, such as the hp 5245L, will provide a 15 to 30 times improvement in input sensitivity. Remote, off-the-air frequency measurements of FM broadcast and communication transmitters may be readily performed.
- **RF MILLIVOLTMETER PRE-AMPLIFIER** — Used as a pre-amplifier for RF millivoltmeters, such as the hp 411, the 230A will provide 15 to 30 times improvement in sensitivity.

**Specifications**

- **Frequency range:** 10 to 500 Mc (MHz) in six bands: 10 to 18.5 Mc; 18.5 to 35 Mc; 35 to 65 Mc; 65 to 125 Mc; 125 to 250 Mc; 250 to 500 Mc.
- **RF gain:** 30 db (10 to 125 Mc);
  27 db (125 to 250 Mc);
  24 db (250 to 500 Mc).
- **RF bandwidth:** >700 Kc (10 to 150 Mc);
  >1.4 Mc (150 to 500 Mc).
- **RF output:**
  - **Range:** up to 15 volts across external 50-ohm load.
  - **Impedance:** 50 ohms
  - **Calibration:** 0.2 to 3 volts f.s.; 1.0 to 10 volts f.s.; 2.0 to 30 volts f.s. (increments of approx. 5%).
  - **Accuracy:** ±1.0 db of f.s. (10 to 250 Mc);
    ±1.5 db f.s. (250 to 500 Mc).
  - **Leakage:** Effective shielding is greater than 40 db.
- **RF input**
  - **Level:** (for 10 volt output into 50 ohms):
    ≤0.316 volts (10 to 125 Mc);
    ≤0.446 volts (125 to 250 Mc);
    ≤0.630 volts (250 to 500 Mc).
  - **Impedance:** 50 ohms
- **AM range:** reproduces modulation of driving source 0 to 100% up to 5 volt maximum carrier output.
- **AM distortion:** <10% added to distortion of driving source.
- **FM range:** reproduces modulation of driving source except as limited by RF bandwidth.
- **FM distortion:** negligible distortion added to distortion of driving source for deviations and modulation frequencies <150 Kc.
- **Incidental AM:** <10% added to modulation of driving source at 150 Kc deviation.
- **Power:** 105 to 125 v or 210 to 250 v, 50 or 60 cps, 150 w.
- **Mounting:** cabinet for bench use; by removal of extruded strips suitable for 19" rack mounting.
- **Price:** $1200, F.o.b. factory.

For your application, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

**Electronics** | December 13, 1965
In studies of the structure of matter, magnetic properties have long been of paramount importance in providing information of a fundamental nature. This has been true in such widely diverse fields as the study of free radicals in bio-chemical systems, the study of the deHaas-Van Alphen effect in metallic crystals at low temperatures and investigations of the nature of the bonds in intermetallic compounds. The limitations imposed by classical methods of magnetic measurements, those of low sensitivity and of high field homogeneity, have however made precise meaningful measurements difficult and slow and hence have restricted their ultimate useful employment.

The development by Foner of a versatile and sensitive Vibrating Sample Magnetometer and its commercial availability through PAR now make possible the extension of magnetic measurement techniques both to experiments requiring sensitivities and resolutions heretofore unobtainable, and to routine measurements which require simple set up procedures and quick sample changes. With this magnetometer, permanent and/or induced magnetic moments may be precisely measured in a uniform magnetic field as a function of temperature, field, crystallographic orientation, or time. This is done by placing a small sample of the material whose magnetic moment is to be determined in a sample holder located at the end of a vibrating rod and vibrating it perpendicular to the magnetic field of the magnet. The resulting oscillating dipole field induces an AC voltage in a pair of stationary pick-up coils mounted securely to the pole faces of the magnet. The induced voltage is measured electronically in a system whose signal-to-noise ratio is near the limit set by the Johnson noise of the pick-up coils. From the magnitude of this measured voltage, the magnetic moment of the sample is deduced.

An extremely wide range of magnetic moments can be measured with high precision and the instrument has a simple calibration procedure, exhibits very high stability, and minimizes most sources of error. Cryogenic techniques may be used to measure moments over an extended range of temperature down to the liquid helium range. Magnetic moment measurements of Ferromagnetic, Paramagnetic, Diamagnetic, Ferrimagnetic, Antiferromagnetic, Metamagnetic and Superconducting materials have been made utilizing this system. Various versions of this instrument have now replaced most of the classical methods for magnetic moment measurements in numerous laboratories throughout the world. Price $12,500. Your inquiries on specific magnetic measurement problems are invited.

*Manufactured exclusively by PAR under license in U.S. Patent No. 3,046,948.

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Space electronics

Bootstrap calibration

The Air Force wants to know if it's possible to precisely define a satellite's orbit from ground radar data and then use that same orbit as a standard by which to calibrate the same radars.

"We sometimes call it bootstrap calibration," says Charles W. Hunter, a mathematician at Air Force Electronic Systems division, Hanscom Field, Mass.

The project, being done for the National Range Division, is not just an exercise in mathematical acrobatics. One objective is to improve the accuracy of ballistic missiles by reducing errors in the missile-range radars which track them. The other is to determine the position of orbiting satellites more accurately. "Five times more accurately than is now possible," says Hunter, project manager at ESD's directorate of aerospace instrumentation.

In orbit. Next June, the first of two satellite payloads designed to test the feasibility of the calibration technique will ride down the Western Test Range atop an Atlas booster. It will go into an equatorial orbit aboard the OVI-7, one of a series of vehicles being launched for the Air Force Office of Aerospace Research.

In August of 1966, another calibration payload will ride piggyback on an Atlas-Agena down the Western Test Range and then inject itself into a polar orbit. This project will be accomplished by the Air Force Space Systems division.

The satellites will carry transponders tuned to most of the radars on the missile ranges [Electronics, March, 8, p. 108].

Ground work. Meanwhile, ESD and the Mitre Corp., Bedford, Mass., will be modifying existing computer programs for a limited reduction of the radar data acquired from each of the two satellites.

A comparative analysis center will be set up in Bedford. It is hoped that the final phase of the analysis, to determine if the technique is feasible, will start in December of 1966.

Says Maj. John Musterman, chief of the Metric Systems division at Bedford: "This over-all analysis will, we hope, tell us if self-calibration will work or if it is necessary to stick to the old system of optical beacons. If feasibility is proven, the analysis should also tell us that range radars should be calibrated before each shot, or once a month, or what."

Satellite gear. The Eastern Test Range will track the first satellite on its calibration runs next June. The calibration experiment will be one of five aboard the OVI-7 experimental satellite, built by the General Dynamics Corp. The satellite will go into a 550-nautical-mile high orbit, and will be gravity-gradient stabilized. It will carry a transponder for Clotrac radars and one for C-band radars. The outputs from these will go into a diplexer and then to a single antenna. It will not be possible to include a transponder for the Mistram radars because it would require too much power—about 150 watts, compared with 42 watts for Clotrac and 25 for the C-band transponders.

The second satellite, scheduled for an August launch, will be a P-11 made by the Lockheed Missiles and Space Co., a division of the Lockheed Aircraft Corp. It will orbit at an altitude of 500 nautical miles. The P-11 has its own propulsion unit and is spin-stabilized. Solid-fuel rocket engines will allow the
The most complex space feat ever attempted is under way with the orbiting of the two-man spacecraft, Gemini 7. The rendezvous mission's most delicate phase was scheduled to begin Dec. 13 when another two-man capsule, Gemini 6, is launched.

During its 26 hours in orbit, Gemini 6 will try to catch up with the first spacecraft, sidle up to it—probably as close as 30 feet—and then literally fly rings around it for about two orbits of the earth.

Gemini 7's astronauts haven't been idle during their nine-day wait in orbit. Frank Borman and James Lovell have conducted a series of experiments, including the first attempt to use a laser beam to carry voice signals between a spacecraft and the ground.

Tight fit. The first big problem will be timing at the launching of Gemini 6. The National Aeronautics and Space Administration will have only 47 minutes—a record for brevity—in which to shoot the capsule through its keyhole in the sky.

For most of its catch-up sprint, Gemini 6 will be guided by earth-bound radars and computers. For the last 250 miles, however, Astronauts Walter Schirra and Thomas Stafford will be able to control it, aided by on-board radar and a digital computer. Such rendezvous maneuvers are considered essential for Project Apollo, whose goal is to land Americans on the moon by 1970.

On target. The astronauts in Gemini 6 will measure their distance from Gemini 7 by transmitting radar pulses and measuring the magnitude of the return signal voltage or the time of the signal's return. Bearing will be plotted by interferometry.

When the spacecraft are in the same orbit they will share a single ultrahigh frequency channel for communications. Telemetry from both will be displayed at ground stations in real time. The craft will not communicate directly with each other; voice messages will be relayed by ground stations. Because the two craft will be on adjacent command frequencies, the astronauts in one will turn off their receivers to avoid interference from commands sent to the other spacecraft from the ground.

Ground radars will track both spacecraft simultaneously. This will be possible because the ships' transponders will return radar pulses at different intervals—threemicrosecond intervals for Gemini 7 and five-microsecond for Gemini 6.

Laser experiment. For the laser experiment, Lovell aims a six-pound laser transmitter at ground receivers in Hawaii, Ascension Island and White Sands, N.M. The transmitter, developed by the Radio Corp. of America, is 3 by 6 by 8 inches. Its four gallium-arsenide injection lasers pulse 100 times per second while the astronaut is trying to make contact with the ground; after contact is made, he switches to 8,000 pulses per second, and this higher pulse rate is modulated to carry the astronaut's voice to the ground.

The lasers can deliver 16 watts of light power at 9,000 angstroms. With a telescopic sight, Lovell aims them at another beam coming from an argon-gas laser mounted on the receiver on the ground. The receiver, 30 inches in diameter, contains a collector and focusing unit, with a photomultiplier at its focal plane.

Another experiment on Gemini 7 constitutes the first test of an electroencephalograph (EEG) in space, to check for changes in Lovell's brain-wave patterns. Four electrical leads run from Lovell's head to a signal conditioner, which amplifies the waves; the waves are then recorded on tape aboard the spacecraft for comparison with other EEG's in a brain-wave library being developed by NASA.
vhf, and f-m bands, an f-m monitor receiver for the pilot, an intercommunication system, and an ADF (automatic direction finder) for navigation. The console will weigh 40% less than existing equipment with these capabilities, and may use integrated circuits.

The Lockheed Aircraft Corp. is developing the AAFSS as a replacement for about 400 armed versions of the UH-ID, originally a small transport chopper that was converted into an armed helicopter by attaching weapons to it. Now the AAFSS is being designed from the outset as an attack helicopter.

The AAFSS will be equipped with station-keeping equipment but the design of the airframe is too far along to include terrain-avoidance radar. The Army is working on terrain-avoidance radar and hopes to have such equipment ready for the STAAS (surveillance and target acquisition aircraft system), the follow-on to the Mohawk fixed-wing plane.

**May use IHAS.** The Army is footing part of the bill for development of the Navy's integrated helicopter avionics system (IHAS), being developed by the Teledyne Systems Corp. IHAS will use microcircuits and a small computer to provide automatic navigation, terrain-avoidance radar and station-keeping features. This system, or parts of it, augmented by fire-control features, may be used in AAFSS.

Other Army aviation projects include a ground-based command and control system for use when planes are in action; an air traffic regulation system, compatible with the Air Force and the Navy craft, for flight over friendly territory; and a system to control the terminal flight phase, when aircraft approach an airfield's traffic pattern.

**Project Hindsight**

Pentagon engineers, studying the genesis of military inventions made over the past two decades, have reached tentative conclusions that, if confirmed, may lead to profound changes in the management and financing of weapons research.

The project chief, Chalmers W. Sherwin, sees four recommendations as likely results of the study:

- Creation of "program oriented" laboratories similar to the Electronics lab at the Massachusetts Institute of Technology.
- Greater stress on research aimed at specific end-products of immediate value to the military.
- Less emphasis on individual research projects by "some professor who's got a good idea."
- More flexibility for the contractor in apportioning military funds, with less control from Washington.

**Genealogy.** The engineers in Project Hindsight found evidence to support the notion that necessity is the mother of invention; not vague, long-range necessity, they emphasized, but specific, immediate needs.

Eight out of ten inventions in the development of systems seem to have been achieved at the local level to solve an immediate problem in a program under contract, the study says. This is the kind of invention that comes as a result of a research group's discovery that it cannot fulfill its contract without a new kind of device or material.

Furthermore, Sherwin's group continues, 85% of military inventions seem to have been made in the course of an organization's study in a broad area, rather than an individual researcher's work on a single narrow project.

Yet these "one-shot" projects receive 50% to 75% of the research money spent by the Defense Department, the report says.

**Case histories.** Project Hindsight was created in response to congressional criticism of the way in which the Pentagon has spent $10 billion on defense research since 1945. Sherwin, deputy director of research and technology in the Defense Department, organized the study around five case histories: the development of the Bullpup and Lance missiles, the 105-millimeter howitzer, the C-141 aircraft and the SPS 48 radar. Lance, for example, includes more than 120 inventions.

The Pentagon engineers traced the development of each system to see where, how and why each invention came about. More than 1,000 interviews have been conducted so far. Eventually, Sherwin hopes to trace the development of every invention that has found its way into a U.S. weapons system.

**The outlook.** Would his recommendations result in less federal funds for independent research? No, says Sherwin, but they would focus defense spending more sharply on military needs, leaving more basic science support to the National Science Foundation.

As for the new laboratories, Sherwin says the first probably would be two electrochemistry labs to specialize in basic-materials problems that have been encountered in recent research on energy conversion.

"We'll want to build a capability in one place," he explains, "with top scientists and graduate students, rather than fund a bunch of guys doing independent research."

**Advanced technology**

**Bird's eye viewed**

The biological system of animals performs pattern recognition so brilliantly that some scientists have attempted to construct electronic systems with properties resembling those of living organs. Such systems would be invaluable in signal analysis—for example as radar target discriminators.

The photograph shown below, for...
instance, is an analog of a pigeon's eye. It’s not sophisticated enough to recognize a crust of bread, but it does have the remarkable property of detecting motion in a single specific direction.

The eye, built at the Astropower Laboratory of the Douglas Aircraft Co. Missile and Space Systems Division, is made up of photodiodes and special-purpose circuits connected in a manner that closely resembles the cones and neurons in an actual pigeon's eye. Since biologists are by no means sure of the function of each neuron, the electronic analog is necessarily only approximate. Still, it works. When a ball is passed from left to right through a beam of light that shines on the photodiodes, the device will produce an output, manifested as a beep on a loudspeaker. But when the ball swings back, the speaker is silent.

Cones, neurons, and ganglia. To design an electronic structure that did not violate what was known about the biological structure, the Astropower staff, under Sam S. Viglione, worked closely with Richard L. Binggeli of the University of Southern California Medical School's anatomy department. Binggeli is studying the retinas of vertebrates.

In the real pigeon's eye, impulses from rods and cones, the sensors in the pigeon retina, are transmitted through a network of bipolar nerve cells, called ganglia, when the cells are stimulated at a certain threshold. The impulses travel through the optic nerve to a part of the brain. About 30% of all the ganglia are direction-sensing; each stimulates a different part of the brain. What Astropower has built is a single ganglion, with its associated inputs.

There are a number of cells, called amacrines, in the eye which apparently have no direct route to the brain. They may connect two cones, or two bipolar cells. Biologists have postulated that these cells act as inhibitors, that is, although one cone may be stimulated by a moving object, an adjacent one might not be if connected to the first through an amacrine. Similarly, if a bipolar cell were stimulated simultaneously by a cone and a nearby amacrine, the impulses would cancel each other out, and the cell would not fire. Astropower simulated the action of the amacrine with an inverter circuit combined with diodes so arranged that the triggering sequence for the bipolar circuits was only correct when the ball moved from left to right.

Building a model. The bipolar cell circuitry consists of a Kirchhoff adder, an integrator (a resistance-capacitance element), a multivibrator or blocking oscillator, and a function generator. The adder sums inputs from a number of diodes—in the eye a number of cones may be stimulated at the same time. The output from the adder goes to the integrator, which has a capacitive function; in the eye, a bipolar cell might not fire from a single stimulus, but a second and third stimulus, at later points in time, might push the potential over the threshold level.

The multivibrator simulates the slow decay of the potential across the bipolar after it has fired, the so-called refractory recovery period; and the function generator is inserted in a feedback loop between the multivibrator and the integrator so that the multivibrator produces a standard pulse output, like the pulses in the real eye. The width and amplitude of the pulses are always the same; the spacing of the pulses is a function of the spacing and amplitude of the impulses to the entire circuit.

It's a long step from the electronic eye to whole pattern recognition. But Binggeli reports that he's already getting feedback from the Astropower model. "I'm learning what questions to ask," he says. And, perhaps, what patterns to look for.

Manufacturing

Squeegee-printed transistors

Screen printers, which now have a firm base in the printing of passive networks for hybrid integrated circuits, may soon be used for large power transistors. One supplier of printing equipment hopes to convince transistor manufacturers that one swipe of a squeegee blade across a printing screen can do the work of several photoetching processes.

Affiliated Manufacturers, Inc. (AMI) of Whitehouse, N.J., has found that it can print etching resist on silicon wafers with a pattern tolerance of one mil (0.001 inch). Dots as small as one mil in diameter, which require even tighter tolerances, have been printed experimentally on other materials. The resolution is still far too crude for small, high-speed transistors (see related story on p. 237) but it is good enough for etching the electrodes of large devices, contends Alex F. Sopru, AMI's engineering manager.

The resist used is a tar-based wax, called apiezon, that is often used to prepare printed circuit boards for etching. The wax is softened with solvents, forced through holes in a printing screen with a squeegee, and dried. The holes in the screen are made by etching a film supported on a fine wire mesh. The wax hardens, the substrate exposed in the resist can be etched. For electrodes, the substrate would be a thin film of metal on the silicon wafer. As a final step, the wax is dissolved.

The new process would eliminate three additional steps semiconductor manufacturers now use between application and removal of a photosensitive resist: putting a mask on the resist, exposing the resist and developing it.

Green ceramics. Meanwhile, screen printers are further refining hybrid circuit printing techniques, according to Sopru. One method that he predicts will catch on fast is automatic printing of film resistors and other passive-network parts on long, flexible tapes of green alumina ceramic. Green ceramic is ceramic that has been pressed, but not fired. The tapes look like strips of shiny, white cardboard.

At present, the passive networks are usually printed on individual, fired substrates that often vary in
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size and are not as smooth as the tapes. Sopru says the printers and other production machines can do a faster, more precise job when tapes are used. The tapes can run from the printer into a firing furnace. The only problem is that the resistor characteristics also depend on the firing temperature, so special inks are needed.

**Machine soldering.** Another method that is catching on, according to Sopru, is machine soldering of active-device leads into holes in the ceramic substrate instead of hand-soldering them to conductors on the top side of the substrate. The trick is to get the conductive inks into the holes so the solder will stay in the holes and form a good joint between the conductor and the lead. Solder won't wet bare ceramic.

This is being done, Sopru says, by having the screen printer form a little puddle of ink over the hole. Then a vacuum, drawn under the substrate, sucks the ink into the hole. The same method can be used to connect conductor patterns that have been printed on the top and underside of the board.

Resistors can be printed on the bottom of the substrate and devices such as packaged transistors can then be mounted on the top. This technique avoids the practice of bending the transistor leads under the substrate so that the lead ends can be soldered to a conductor pad near the hole.

**Medical electronics**

**Telltale hearts**

A device that in three minutes can detect heart defects in children has been developed by the Humetrics division of the Thiokol Chemical Corp. Called a PhonoCardioScan (PCS), the portable instrument can be operated by a nurse or technician.

The PCS was designed for school heart-test projects. Physicians stress that early detection of heart abnormalities improves chances of cure. When the PCS notes suspicious sounds, the youngster is sent to a doctor.

The PCS' logic circuits were designed, with the aid of a computer, to recognize the sounds characteristic of abnormal hearts. Heart sounds from many patients were recorded on tape and patients were also examined by cardiologists. The sounds were then analyzed for normal and abnormal patterns.

**How it hears.** The PCS picks up two types of heart information. Suction-cup electrodes register the electrical potential of the heart to time the heart sound within a cycle. A microphone, placed on four designated areas on a patient's chest, picks up sounds of contraction, expansion and valve motion.

Analog information from several cardiac cycles is examined beat by beat. The PCS registers on one digital counter the number of cycles examined and on another digital counter those cycles whose sound patterns are considered outside the normal, according to the information programmed. If more than 6 out of every 10 cycles are abnormal, the patient is sent on for further examination.

A second group of counters presents the PCS operator with additional information on every beat. If this data varies with the main counter's, the cycle can be thrown out and the process begun again.

**Industrial electronics**

**In the driver's seat**

No matter what they look like or how they operate, every function of the high-speed trains of the future will depend on electronics, according to a $515,000 survey for the
The only solid-state counters available? If any electronic counters can be considered all solid-state, they’re the Beckman 6100 Series. These 2.5, 25, and 50-mc counters use no vacuum tubes in any form—even the digital display is solid-state. This spells superior reliability and value backed by these unparalleled benefits: □ Electroluminescent display guaranteed against catastrophic failure for three years. □ More plug-ins—nine—for greater versatility. □ Plug-ins do not just add basic functions but expand and add capabilities (trigger controls and time interval function are available on basic counters). □ Plug-ins include frequency extenders to 3 gc, integrating DVM, mode expander/preset, and preamplifier. □ Active storage provides BCD output data during next sampling. □ All these benefits plus Mil ratings at no extra cost. □ Plus standard functions of frequency, period, multiple-period average, ratio, multiple-ratio average, time interval, and random count measurements; automatic decimal point positioning and unit of measurement display. Prices of basic instruments start at $1,960 and plug-ins from $440. For your best value in counting, ask your Beckman Berkeley representative for a demonstration of a truly solid-state electronic counter—the 6100 Series.
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Commerce Department, made by 
the Massachusetts Institute of 
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In fact, completely automatic 
electronic controls for high-speed 
ground transportation—200 to 300 
miles an hour—will have to be well 
on the way to development before 
any decisions on system design can 
be made, the study said.

The study pinpointed areas in 
which new research and develop­
ment efforts are needed. Congress 
has authorized a three-year, $900-
million program for high-speed 
ground transportation development, 
with about two-thirds of it for 
R&D.

Requirements for which elec­
tronic techniques have not been 
perfected, the study said, include: 
over-all computer control of the 
system; keeping of real-time tabs 
on each vehicle; speed control of 
each vehicle for safe headways and 
emergency stops; switching con­
trols to feed vehicles into the high­
speed guideway or to transfer pas­
senger-carrying capsules from one 
vessel to another without slowing; 
and a completely computerized sys­
tem for scheduling and for reserva­
tions, ticketing, billing and ac­
counting.

Choice question. Electronics may 
figure in choice of a power source 
and a decision on whether the 
high-speed vehicles should roll on 
steel or rubber wheels, skin on 
cushions of air, or float in magnetic 
suspension above the guideway.

A linear-induction motor—essen­
tially a rotary-principle motor with 
the guideway itself serving as the 
stationary energy-power source—
probably would be easiest to adapt 
to automatic control, the report 
said. Some developmental work has 
been done by the Westinghouse 
Electric Co. and the General Mo­
tors Research Laboratory at Santa 
Monica, Calif. And the use of sili­
ocn controlled rectifiers has made 
variable-frequency power supplies 
feasible at high-power levels, offer­
ing a possible means of acceler­
ation and deceleration. But linear­
induction motors are still largely 
theoretical, and the MIT study said 
extensive new research is needed 
into all potentially promising power 
systems.

Some groundwork is being done 
on automatic control systems. At 
least four companies are develop­
ing systems tailored to lower-speed, 
more conventional railroad and 
rapid-transit systems [Electronics, 
July 26, 1965, pp. 71-96]. They are 
the Westinghouse Air Brake Co., 
General Electric Co., Westinghouse 
Electric Co. and General Railway 
Signal Co. Some of their techniques 
may be adaptable upward, officials 
have said. But the demands of the 
high-speed system envisioned in 
the university study is expected to 
far exceed present-day control de­
vices.

Computer aided, "At the high 
speeds now encountered only in air 
transport," the report said, "there 
is overwhelming evidence to sug­
gest that . . . these command and 
decision functions must necessarily 
yield in large part to automation 
through computer control."

The MIT study recommended 
that a computer system be de­
veloped to handle not only reserva­
tions but also scheduling—putting 
new vehicles into service auto­
matically to meet increased de­
mand. This would require knowl­
dge of the position and of every 
vehicle in the system; and once such 
a process was started, it might 
eventually be possible to evolve 
completely free scheduling—add­
ing vehicles only when demand 
arose.

The study recommended estab­
ishment of a nonprofit research 
organization to coordinate R&D 
activities.

A high-speed ground transporta­
tion system could be constructed 
within 15 years, if intensive R&D 
efforts were begun now, the study 
said.

Instrumentation

Ultraviolet steel gauge
In steelmaking, one of the biggest 
causes of waste has been the in­
ability to measure accurately the 
width of the hot steel strip as it 
passes through the mill. Conven­
tional gauges are based on infrared
sensors; because the outer edge of the steel cools faster than the middle, it emits less infrared—sometimes too little to be picked up by the detector.

The Granite City Steel Co. of Granite City, Ill., says it has solved the problem by changing to ultraviolet measurement with a width gauge that provides its own light source. The noncontacting gauge, developed by Culton Industries, Inc., is just as accurate as conventional instruments—with error of only 1/10 inch per 80 inches of strip width—but is unaffected by temperature variations in the steel.

**Scanning.** As the steel passes over the ultraviolet light source, the gauge's scanning mechanism sweeps over the metal 20 times a second. Each time the scanner crosses an edge of steel strip, which is either blocking or unblocking the light behind the strip, the scanner generates narrow pulses defining the location of the edge. Filters screen out the infrared radiation. Simultaneously, a high-speed counter and a shaft-driven pulse generator convert the time between pulses into a digital quantity whose magnitude corresponds to the strip width.

The scanner consists of two optical systems, synchronized sequentially. The two scanners and the pulse counter are on a common shaft; this assures that the digitizing accuracy will be independent of any variations in the scanning speed. The width measurement is displayed digitally at a control console and compared with a preset width. This comparison generates an analog signal that can be used to control the mill. The scanning-and-display process takes 0.01 second.

This speed is important because the company receives orders for steel strip in a variety of widths, and any delay in adjustment of the width can result in expensive wastage.

**Easy to operate.** Besides reducing waste of time and steel, the ultraviolet gauge requires little maintenance and needs to be calibrated only once—when it is installed. That's because it has only one moving part, a rotating shaft that whirls

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**Revolutionary one-gun 9" portable color TV set developed by YAOU Electric Co., of Japan**

One of the big news stories in consumer electronics this year was Yaou's successful commercial production of its unique "colornet" color TV set. The all-solid-state system uses a line sequential system in combination with a 7-1/2" single-gun color tube, "colornetron," developed jointly by Yaou and Kobe Kogyo Co., Ltd. The result is an advanced TV color receiver with many attractive features:

1. single-gun color tube with post focusing system gives bright, natural color reproduction and makes adjustment and operation very easy
2. ingenious combination of three interval APC circuit, offset subcarrier demodulator, and storage counter circuit eliminates color drift
3. low switching frequency and full utilization of beam current results in stable performance and bright picture screen without "crawling"
4. low switching frequency drastically reduces interference from spurious radiation
5. phosphorescent materials are applied to the picture tube vertically, so color purity is not affected by terrestrial magnetism, and the set can be moved at will without necessitating readjustment
6. elimination of convergence circuit meant that servicing is no more difficult than for a black and white set
7. with post accelerating system, deflection power is very small and deflection yoke and other components the same as for black and white sets, so production cost of the set can be kept very low
8. all-transistorization (47 transistors, 25 diodes, 16 thermistors, and 3 high voltage rectifiers) keeps the set compact and lightweight
9. power consumption is only 30 watts (DC-20 watts)—1/10 that of a conventional vacuum tube color TV set
10. receiver can be operated on DC 12V battery

This revolutionary portable color TV set is only the latest example of the creative ingenuity built into every Yaou product. No wonder Yaou's electric and electronic consumer line has gained a reputation for quality and originality, along with reasonable prices.

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*Electronics | December 13, 1965*
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the two optical scanners' lenses at 1,200 revolutions a minute.

The gauge can also be checked to zero between strips. Conventional gauges have to be reset or recalibrated for each width, while production is interrupted.

The steel company declines to discuss savings, but Gulton says they should allow Granite City to amortize the machine's $60,000 cost in less than six months. The company already has decided to install an ultraviolet scanner at an automated mill under construction at Granite City.

Computers

Printing in patches

A computer program developed by Bell Telephone Laboratories uses a cathode-ray tube in printing, providing a fast way to set a page of type.

The program, still experimental, displays, on the face of the crt, lettering in any type font, or other designs or patterns.

An electron beam traces irregular patches on the screen. The patches are assembled into letters. To the eye the display appears only as an irregular dancing spot zig-zagging widely across the screen; but a camera using time-exposure produces negatives and pictures of the lettering. Negatives can be quickly converted to a printing plate.

Previous use. Cathode-ray tubes have previously been used in text displays, but only where printed output was not needed. And the displays have been limited to a relatively small number of characters of a single size and style. Two systems have been used; in one a short sequence of instruction for each individual letter directs the electron beam to trace the outline of that letter. In the other a mask or stencil with the letters cut out shapes the beam by passing it through the appropriate part of the stencil; the beam is then deflected to the proper point on the screen. Either
way, the display is limited to one particular shape of the letter generated by the instructions or cut into the stencil.

Present-day electronic typesetting techniques are generally limited to automatic hyphenation and justification (margin-straightening) using typesetting machines controlled by computer-generated paper tape.

**Simple to use.** To use the new technique, an operator types on a keyboard in much the same way as on a standard typewriter. The new program can display text in any alphabet, simply by assembling the patches in the proper order for the characters desired. The program can also display musical scores, line drawings, mathematical equations, or any other graphic output. With this technique, the "type" can be "set" for a printed page much faster than by any other method, and the printing plate then made from the photographic negative by conventional techniques.

Bell is working on clearer displays of more shapes, and on a special-purpose computer for operating the display. Eventually it may be possible for a reporter to file a news story, editors to edit it, and the printing plate to be made for it, without once writing it on paper.

**Avionics**

**The radar gap**

At 4:18 p.m. on Saturday, Trans World Airlines Flight 42 bound from San Francisco and Eastern Airlines' 3:30 shuttle from Boston were just two of almost a hundred blips on the radar scope in the air route control center at John F. Kennedy International Airport. The two blips were on a collision course, but nobody in the control center was concerned. According to the flight plans of the planes, they were separated in the air by 1,000 feet of altitude which doesn't show on the two-dimensional radar. At 4:20 p.m. the blips met; but one blip even-
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Moving from initial concept to final detailed specifications, Air Products design and engineering groups tailor their efforts to the individualized requirements of each customer.

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In each instance, Air Products operating capability gives an added measure of confidence that critical supply commitments will be met. In addition, the availability of highly skilled operating personnel meets the demands of increasingly automated equipment — with resultant maximization of plant efficiency.

Safety, a prime requisite in all phases of cryogenic technology, is a further by-product of the skills of Air Products operating specialists. Continuing feedback of information and data from each Air Products plant facility creates, in addition, a vast knowledge-reservoir drawn upon by all Company groups in fully satisfying customer needs.

PRODUCT DISTRIBUTION - Nerve center of Air Products distribution network is a computer-control center. Here, distribution specialists program each customer's product demand patterns, relate total requirements to plant production, and schedule rail and highway transports for optimal product distribution.

Though seemingly complex, this computer-controlled response has been refined to standard operating procedures that provide product availability when and where needed.

Economy, another vital aspect of Air Products distribution leadership, is underscored by the world's most modern fleets of tank-trucks, tank-trailers, and railway tank-cars, for the deliveries of bulk quantities of liquefied gases. Cylinder trucks and tube trailers distribute gaseous products.

Operating from Air Products nationwide network of production plants and distribution centers, these rolling fleets make on-time, every-time deliveries to meet your every industrial gas requirement.

MAKES THE DIFFERENCE
GASES IN TONNAGE QUANTITIES: Air Products — pioneer of the on-site concept of industrial gas production — builds a cryogenic production facility at or near the customer's location... economically supplies gases in tonnage volumes via direct pipeline.

GASES IN BULK QUANTITIES: Small to medium volume demand for industrial and medical gases is most economically supplied by bulk liquid deliveries to storage units installed on your property by Air Products. Liquid content is automatically vaporized and drawn off as a gas when needed. In addition, tube-trailers provide bulk deliveries of gaseous product.

GASES IN CYLINDER QUANTITIES: To customers requiring gases in cylinder quantities, Air Products means assurance of full-line product selection. Nationwide fleets of cylinder trucks and trailers speed deliveries of these gases from Air Products production plants and distribution centers. Added value: An Air Products analysis of your gas applications, and programming your most economical supply pattern.

RARE GASES: Deliveries of argon, neon, krypton and xenon — in the quantities and purities you require—are backed by the famed Air Products service that helps customers select and apply gases most efficiently and economically.

ANNEALING GASES: Air Products has adapted its on-site production leadership to the tonnage-volume supply of hydrogen and ultrahigh purity nitrogen gas mixtures that protect and improve the quality and versatility of steel and other metals.

SPECIALTY GASES: Air Products proprietary techniques in gas blending — plus the industry's most advanced quality control program — underscore a line of more than 100 specialty gas products including: research gases, gas mixtures, calibration gas standards, doping gases, zero gases, biomedical gases, and industrial and forming gas atmospheres.
The war in Vietnam has ruined President Johnson's efforts to hold this fiscal year's spending below $100 billion. Government outlays in fiscal 1966, ending next June 30, will be $5 billion to $7 billion higher than the $99.7 billion total originally projected. The President is likely to seek as much extra spending as possible in the current year, through supplementary appropriations, to take some of the inevitable pressure off what is shaping up as an enormously tight budget for fiscal 1967.

Military spending alone for fiscal 1966 will climb between $3 billion and $4 billion from the $49 billion that was estimated last January.

The big question now is the size of the additional buildup that Johnson will announce in January when he makes his requests for spending for 1967.

Unofficial expectations are that, for 1967, military costs will climb yet another $3 billion to $4 billion, to $55 billion. Minimal additional increases in what is being called a "lean" and "disciplined" budget should push the over-all total to a record $110 billion.

So 1967 will not be a year for initiating programs.

It is increasingly likely, for instance, that the government will back away again from a clear-cut commitment to build and deploy the Nike X antimissile missile defense system. President Johnson and Defense Secretary Robert S. McNamara must reach a decision soon in drawing up a new defense budget for submission to Congress next month.

But the rising cost of the Vietnam war and the inflationary potential of increasing government spending generally are known to be causing Johnson serious concern. These two problems are strong arguments against approval for production of Nike X now, particularly since there is such controversy both inside and outside the government on the need for the system.

The expectation is that production will be postponed for another year, or that only a modest start will be made so as not to constitute a firm commitment to eventually build the entire system. McNamara has long indicated doubts about how effective Nike X would be against a Soviet attack and about the high cost—$20 billion—for such a defense. But he has shown considerable interest in a more modest version, costing $6 billion to $10 billion, for protection against a Communist Chinese missile threat.

Now, however, approval of even this less-ambitious system appears doubtful because of the budgetary climate. As a reflection of this, Nike X advocates have begun to talk up a still more limited possibility—a pinpoint defense system to protect the United States' intercontinental missile sites. The problem is the high cost of tooling up to achieve such limited production.

Similarly, the National Aeronautics and Space Administration's budget for fiscal 1967 will be held tightly to programs already under way. That is the word coming out of conferences now being held by NASA and the Bureau of the Budget. NASA wants a $5.6-billion budget for fiscal
1967. The Budget Bureau wants to hold it to $5.1 billion.

NASA has planned to start a round of post-Apollo programs in fiscal 1967 as funding for current programs begins to taper off. This is contingent, however, on the agency's keeping its over-all budget at the $5.3-billion level, at which it has been running for the past couple of years. Now, NASA sources say they are not sure whether the White House will approve any of the new programs. NASA has definitely been told that there will be no across-the-board long-range money; funds must be earmarked for specific projects to stand a chance of approval.

The major program NASA wants to start next year is Project Voyager, to land unmanned instrument packages on Mars by 1971. The estimated cost is $1.5 billion. Congress authorized $48 million this year for study purposes, but hasn't officially approved the program in its entirety. Such approval would require $150 million to $200 million more in next year's budget. NASA also wants to move forward on programs to extend Project Apollo, whose goal is to land men on the moon by 1970. The space agency won't know for two to three weeks which of these will be approved, if any.

Whether NASA's budget for fiscal 1967 dips slightly below this year's level or not, spending during fiscal 1967 will hold at about $5.6 billion, about the same as this year's because spending lags behind new appropriations and contract-letting.

The attention of government specialists in handling scientific and technical information is beginning to turn to the need for information on projects that are still under way; earlier efforts concentrated on completed projects.

The Federal Clearinghouse for Scientific and Technical Information will begin publication early next year of a catalog of all current physical research, both basic and applied, supported by the government.

The listing, to be distributed to industry twice a month, will come out of the Smithsonian Institution's Science Information Exchange, which already has a catalog of about 12,000 projects.

For internal, research-management purposes, NASA is seeking proposals by Dec. 20 on an automated program-management and information system. The program will give NASA the ability to call any current research projects out of the system for a look or for meshing with other parts of the space program. NASA also has an agreement with the Defense Department under which the two agencies exchange reports of research projects.

Are the United States' scientific resources being "economically employed to achieve our vital national goals"? A research subcommittee of the powerful House Committee on Government Operations will begin hearings on that question in January.

The subcommittee's chairman, Henry S. Reuss (D., Wis.), agrees with Gov. Edmund G. Brown of California and Sen. Gaylord Nelson (D., Wis.) that a national effort might be justified, applying research-and-development techniques to water, sewerage, transportation, crime and civilian industrial technology.
Did you ever wish someone would combine the best cleaning features of fluorocarbon solvents and water detergents?

Someone did!
It's called FREON® T-WD 602.

FREON T-WD 602 solvent* is a clear, stable dispersion of water in FREON® TF that combines the cleaning power of water detergents with the unique properties of FREON fluorocarbon solvents. It cleans organic and inorganic soils at the same time...and cleans better than water detergents alone.

Here's why:

**Lower surface tension** — Water has a surface tension of 72 dynes per centimeter. With a detergent, this drops to approximately 30. But FREON T-WD 602 has a surface tension of only 19.5 dynes! It easily penetrates even the most microscopic pores and crevices to dissolve and wash away contaminants that water and detergents can never reach...and its high density floats particulate matter away.

**Quick drying** — A system using FREON T-WD 602 speeds up production. Parts come out clean, dry and ready to handle. No extra drying procedures are needed.

**Leaves no residue** — Parts cleaned in FREON T-WD 602 followed by a FREON TF vapor rinse dry without leaving any residue.

**Can be re-used** — You can renew the FREON T-WD 602 bath just by letting it settle, skimming off soils and replacing with an equal volume of water.

FREON T-WD 602 is ideal for cleaning complex assemblies where a combination of organic and inorganic soils exists. It is one of a group of "tailored" solvents for special cleaning problems based on FREON TF. For more information, mail the coupon.

*Process and composition patents applied for.

Du Pont Co., Room 3309-A
Wilmington, Delaware 19898

Please send complete information on
☐ FREON T-WD 602; ☐ the other FREON "tailored" solvents. I am interested in cleaning

Name________________Title________________
Company__________________________
Address____________________________

In Europe, mail to: Du Pont de Nemours International S.A., "Frees" Prod. Div., 81 route de l'Aire, Geneva, Switzerland

Electronics | December 13, 1965

Circle 53 on reader service card
THREE NEW RTV SILICONE RUBBER DEVELOPMENTS

RTV-7 foam for shock and vibration damping at extreme temperatures

RTV-7 foams to five times its original volume to provide mechanical support. Even at temperatures as low as -65°F or as high as 350°F, it retains the flexibility needed to absorb severe shock and vibration... assures continuous protection for electronic components and electrical apparatus.

Mixed with a curing agent, RTV-7 liquid silicone rubber foams and cures on the spot. In 10 minutes flat. Density can be varied to meet specific requirements.
Ultra-high strength RTV-630: slash it, flex it double...it never tears

By far the toughest two-part RTV silicone rubber ever developed, General Electric's RTV-630 has a tear strength of 100 psi — die B. That's more than twice the tear resistance of any other RTV.

Three physical properties comparable to those of heat cured rubber are the basis for RTV-630's uncommon toughness.

- Hardness measures 55-70 durometer.
- Tensile strength registers as high as 850 psi.
- Elongation ranges between 300% and 400%.

The overall strength and durability of General Electric's newest RTV are complemented by its superior reversion resistance. By its rapid curing time. And by its outstanding thick section cure capabilities.

Proven in Plastics Processing and Flexible Mold Applications

Already used for prototypes and in extended runs for plastic parts fabrication, RTV-630 has consistently demonstrated superior performance under rigorous production conditions.

In thermoforming reinforced plastic parts for space vehicles, RTV-630 was successfully used as a male punch die. Subjected to 5000 psi at 350°F, it has performed more than six times longer than previously used materials without any visible signs of fatigue or deterioration.

In multi-cavity molding of epoxy parts for electronic modules, RTV-630 molds lasted twice as long as molds made with conventional RTV's.

Now the toughest RTV in existence, RTV-630 also promises to be important in other applications. In potting and encapsulating. Molded functional parts. Pressure bag and matched die molding of reinforced plastics. Conveyor belts. And release coatings.

7 common properties of all G-E RTV silicone rubbers

- Extreme temperature resistance.
- Room temperature cures.
- Chemical resistance.
- Ozone, weather and age resistance.
- Strong bonds.
- Excellent dielectric.
- Minimum shrinkage.

Ready-to-use RTV-102 cartridge pack speeds production line sealing

No catalyst, no mixing, no priming needed. RTV-102 sealant is ready to go, ready to speed sealing jobs. Provides tough, flexible rubber seals for radio chassis, terminal connectors, other electrical and electronic applications. Ideal for hard-to-reach spots. Sets in minutes. Cures in hours. Won’t sag, shrink, crack, harden or peel.

General Electric's new cartridge pack comes with white (RTV-102) and translucent (RTV-108) compounds. In six and 12 ounce sizes for hand or air powered caulking guns.

For complete information on these newest G-E RTV compounds, ask your nearest distributor as listed, or write to Section N12167, Silicone Products Department, General Electric Company, Waterford, New York.

---

For complete information on these newest G-E RTV compounds, ask your nearest distributor as listed, or write to Section N12167, Silicone Products Department, General Electric Company, Waterford, New York.
Meet the most rigid design requirements

Circuit designers working to military standards of reliability will find that CLARE Military Type Relays are precise components of unusual flexibility, capable of long-life operation under a wide variety of contact loads. They offer the designer exactly the relays he needs—standard, extra sensitive, latching, miniaturized—with sensitivity ranging from 40 to 250 mw. All meet stringent requirements of shock, vibration and linear acceleration, in ambient temperatures ranging from -65°C to +125°C. Terminals are designed for 0.2” grid spacing. Terminal types include plug-in, solder hook, straight lead and formed lead. Mounting styles may be plain, side plate, stud or ear bracket. Relays are available with soldered or welded (W) cases.

**Versatile Contact Capability** • Gold-plated contact areas provide consistently low contact resistance. Bifurcated contacts, with high contact pressures and overtravel for proper wipe, provide reliable operation at high or low level.

**Long Mechanical Life** • Contacts and armature are only moving parts...obviating mechanical failure and assuring consistent trouble-free, long-life operation.

**High Sensitivity** • Consistently high sensitivity (while still maintaining wide contact gaps and high contact forces) is made possible by coils and magnetic parts of maximum size.

**CLARE Quality** • A continuous testing program, with feedback to product engineering, quality control, and production functions, results in standard production relays of constantly improving quality. It also provides reliability data of immediate value to the customer. CLARE Military Type Relays meet the rigid specifications of MIL-R-57570...plus the even more stringent requirements of the Claret Quality Assurance Program.

### Contact Arrangement

<table>
<thead>
<tr>
<th></th>
<th>F/FW</th>
<th>One-Coil LF</th>
<th>One-Coil LFW</th>
<th>Two-Coil LF</th>
<th>Two-Coil LFW</th>
<th>SF/SFW</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contact Rating—</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Level</strong></td>
<td>2.0 amp res @ 28 VDC, 125°C</td>
<td>100,000 miss-free operations monitored at every operation for a maximum drop of .5 mv.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Level</strong></td>
<td>10 µA @ 10 mv.</td>
<td>50 millionms max @ 6v, 100 ma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Before Life</strong></td>
<td>100 millionms max @ 6v, 100 ma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>After Life</strong></td>
<td>100 millionms max @ 6v, 100 ma</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Maximum Operate Time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(including bounce)</strong></td>
<td>5.0 ms</td>
<td>8.0 ms</td>
<td>6.0 ms</td>
<td>8.0 ms</td>
<td>5.0 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nominal Must-Operate</strong></td>
<td>250 mw</td>
<td>50 mw</td>
<td>100 mw (per coil)</td>
<td>40-200 mw (Note 1)</td>
<td>160 mw</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>6.3-110vdc</td>
<td>3.2-110vdc (continuous duty)</td>
<td>3.2-54vdc (continuous duty)</td>
<td>6.3-110vdc</td>
<td>5.0-48vdc</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating Voltage</strong></td>
<td>35-10,000 ohms</td>
<td>40-9100 ohms</td>
<td>15-4400 ohms (per coil)</td>
<td>35-10,000 ohms</td>
<td>40-3500 ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coil Resistance</strong></td>
<td>65 g</td>
<td>100 g</td>
<td>65 g</td>
<td>65 g</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ENVIRONMENTAL CAPABILITIES (Temperature Range: -65°C to +125°C)

<table>
<thead>
<tr>
<th>Shock (¾ sine wave 11 ±1 ms pulse)</th>
<th>65 g</th>
<th>100 g</th>
<th>65 g</th>
<th>65 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>.125” double amplitude or 20 g (Note 2)</td>
<td>.250” double amplitude or 20 g (Note 2)</td>
<td>.125” double amplitude or 15 g (Note 2)</td>
<td>.250” double amplitude or 20 g (Note 2)</td>
</tr>
<tr>
<td>Linear Acceleration</td>
<td>100 g</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. SF and SFW Relays are available in four ranges of sensitivity—40-60 mw, 61-80 mw, 81-120 mw, 121-200 mw.
2. Whichever is less and depending on mounting style.
3. 100,000 miss-free operations monitored at every operation for a maximum drop of 10% of source voltage.
RELAYS

...with a wide range of relay types built for 100,000 miss-free operations!

F/FW* STANDARD
Non-polarized • Single-side stable • Single coil operation
High speed relays with operate and release time of 5 ms max. Operate at a power of 250 mw approx. Have mean mechanical life of 50,000,000 operations at 30 cps. Dimensions of Type F soldered enclosure are: .800" wide, .396" deep and .875" high. FW (welded) enclosures are .900" high.

SF/SFW* SENSITIVE
Non-polarized • Single-side stable • Single coil operation
High-sensitivity versions of F/FW relays. Identical in dimensions, similar in construction but capable of operating as low as 40 mw. Four models available with varying operating sensitivities (see Note 1, Table of Electrical Characteristics).

LF/LFW* LATCHING
Polarized • Bi-stable • Single or double coil operation
Magnetic latching relays. Dimensions identical to Type F/FW relays. Two permanent magnets incorporated in the dynamically balanced armature provide latching forces to hold contacts in either stable position. One-coil relays operate at approximately 50 mw, two-coil at approximately 100 mw per coil.

HF MINIATURIZED
Non-polarized • Single-side stable • Single coil operation
Half-size relays with same dimensions as F/FW relays except height (.410" max.). With standard 26.5 vdc coil, has resistance of 1250 ohms, must-operate sensitivity of 160 mw and power requirement of 560 mw at nominal voltage. Also available with special 26.5 vdc coil, resistance of 700 ohms, must-operate sensitivity of 290 mw and power requirement of 1000 mw.

For complete information contact your nearest CLARE Sales Engineer

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(What a climate for selling!)

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Model 1107/1108  Signal Generators
3.80-11.0 GC
+3 dbm to −127 dbm
(+10 dbm uncalibrated)

Model 1205  Source
0.95-2.40 GC
Varies from 50 to 320 mw depending on frequency.

Model 1206  Source
1.95-4.20 GC
Varies from 50 to 230 mw depending on frequency.

Model 1207/1208  Sources
3.80-11.0 GC
Varies from 25 to 200 mw depending on frequency.

Model 1509/1510  Doubler
10.0-21.0 GC
0 dbm to −100 dbm; max. input 200 mw; conversion loss < 18 db.

Model 1001  Modulator
Sufficient level to modulate all modular-generators and sources.
Pulse, Square Wave & Sawtooth FM.
Pulse width: 0.2-10 µsec.
Repetition rate: 10 to 10,000 pps.
Sync delay: 0 and 2-2,000 µsec.

Model 3815  Phase-Lock Frequency Stabilizer
Stabilization of any oscillator—BWO, VTM, or Reflex Klystron, up to 12.4 GC.
MTA molded electrolytics outperform many metal case capacitors

The MTA is a different kind of aluminum electrolytic. Its plastic case is molded in one piece around the capacitor element. Its price is exceptionally attractive. And its performance and quality beat card-board and plastic case miniatures, and even many metal case models. It's already being used by leading manufacturers of entertainment and commercial electronic equipment. Here are some results of evaluation testing done recently.

Low temperature stability is good for a miniature aluminum capacitor. Capacity retention, even at $-30^\circ C$, is more than ample for most uses.

High temperature tests at $65^\circ C$ and at $85^\circ C$, show that DC leakage, dissipation factor and capacitance stability are comparable with much higher priced units. DC leakage of polar models is less than 0.03 micro-ampere per mfd-volt.

Long-term reliability tests indicate that the MTA may set a new standard of value in its class. At $85^\circ C$, there hasn't been a single failure of any kind in 1 million piece-hours of life test. At $65^\circ C$, there has been only one failure in $2\frac{1}{2}$ million piece-hours.

Miniature 5-Watt Control

Only $\frac{3}{4}$" in diameter, this Mallory wire-wound control is rated 5 watts at $35^\circ C$ ambient... can be derated linearly to zero watts at $105^\circ C$.

Resistance range is 1 to 25,000 ohms for non-linear tapers. Non-linear tapers can be supplied on order, with resistance range depending on taper.

Two styles are available: VW, with $\frac{3}{8}$" bushing and $\frac{1}{4}$" shaft; and SC, with $\frac{1}{2}$" bushing and $\frac{1}{4}$" shaft. Can also be supplied in military types as QVW and QSC. Special mounting arrangements can be provided to your specifications.

MOL Film Resistors rated full wattage at $70^\circ C$

We are now rating MOL metal oxide film resistors for full wattage at $70^\circ C$ ambient. Even at this new higher temperature, these resistors maintain the superior stability which has made them the choice of all major television manufacturers.

In a typical load-life test at $70^\circ C$, $125\%$ of rated load was applied on a cycle of 15 minutes on and 15 minutes off. After 200 hours, resistance change of 7-watt MOL resistors averaged less than $5\%$.

The MOL line has superior stability on all counts. Temperature coefficient is only $\pm 250$ PPM/°C. Humidity tests at 95% R.H. for 100 hours at no load showed less than 0.04% change in resistance.

A wide range of resistance values is available in 2, 3, 4, 5 and 7 watt sizes.
"Zero defects" program produces high-reliability Certified Mercury Cells

MTPH tantalum capacitors record zero failures in 3,700,000 test hours

For battery applications where maximum reliability is required, such as implanted heart pacemakers, we are producing Certified Mercury Cells in a special, completely separate manufacturing facility. The Certified Cell line, unique in battery manufacturing, uses the most advanced methods of screening and quality control to assure "zero defects" output. Of the many thousands of cells produced on this line, there has not yet been a single report of premature failure. As a result of the Certified Cell program, the mean life of cells used in heart pacers has been increased by about 50%.

All manufacturing operations are performed by trained technicians. Every component... anode and cathode pellets, containers, seals... is individually tested and pre-selected and only those which come within tight limits of optimum specification values are used. Fall-outs are discarded and not re-worked.

Complete physical and electrical tests are made on each cell during and after assembly. Complete test data are kept in permanent record for each production lot. Each shipment is individually certified to have been produced to the highest level of quality that is possible under the present state of the art.

A broad range of Mallory Mercury Cells can be supplied under the Certified Cell program.
spectrum analysis

with your TEKTRONIX oscilloscope

provides phase lock and 100 MHz dispersion

---

These new spectrum analyzer plug-in units can be used in all Tektronix oscilloscopes that accept letter-series plug-ins. They provide a rapid and accurate method for display and analysis of energy distribution over a wide range of frequencies. Type 1L10 with similar features covering frequency range from 1 MHz to 36 MHz also available.

---

phase lock — Permits stable displays at 1 kHz/cm dispersion by locking the frequency of the RF local oscillator to the internal 1-MHz crystal-controlled reference, or to an external standard frequency.

calibrated dispersion — Screen width calibrated from 1 kHz/cm to 10 MHz/cm in 1-2-5 sequence permits direct readings of displayed frequencies. For ease of operation, resolution is coupled to dispersion and varies from 1 kHz to 100 kHz. Can be uncoupled for optimized displays.

display flatness — ±1 dB over 100 MHz dispersion.

recorder output — A front-panel connector provides a dc-coupled analog output of the spectral display for chart recorders or other uses.

---

<table>
<thead>
<tr>
<th>other characteristics</th>
<th>Type 1L20</th>
<th>Type 1L30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>10 MHz — 4.2 GHz</td>
<td>925 MHz — 10.5 GHz</td>
</tr>
<tr>
<td>Minimum Sensitivity</td>
<td>110 — 90 (-dBm)</td>
<td>105 — 75 (-dBm)</td>
</tr>
<tr>
<td>Incidental FM</td>
<td>With Phase Lock, less than 300 Hz on fundamental.</td>
<td></td>
</tr>
<tr>
<td>Dial Accuracy</td>
<td>±(2 MHz ± 1% of rf input frequency)</td>
<td></td>
</tr>
<tr>
<td>IF Attenuation</td>
<td>51 dB ± 0.1 dB/dB in 1-dB steps</td>
<td></td>
</tr>
<tr>
<td>IF Gain</td>
<td>50 dB, variable</td>
<td></td>
</tr>
<tr>
<td>Display</td>
<td>Log, linear, square law, video</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>$1995.00</td>
<td>$1995.00</td>
</tr>
</tbody>
</table>

Type 3L10 for Tektronix 560-Series Oscilloscopes provides 1 MHz to 36 MHz spectrum analysis capability. U.S. Sales Prices, f.o.b. Beaverton, Oregon

For more information or a demonstration, call your Tektronix field engineer.

Tektronix, Inc.
Lodex*, General Electric's new permanent-magnet material, can be formed economically into the precise shape and size for your application.

Expensive form grinding or high-temperature treating are eliminated because this material is pressed into its final shape.

Lodex magnetic material consists of elongated single-domain particles dispersed in a lead matrix. This makes it possible to produce magnet shapes to extremely close physical tolerances and to maintain close magnetic uniformity.

Lodex magnetic material is already being used in many products:
- **Battery-powered Motors**—provides the stator field flux for truly portable appliances such as automatic movie cameras or electric toothbrushes.
- **Hearing Aids**—is contributing to miniaturization of newer hearing aids by providing a force field for diaphragm movement in a compact package.
- **Precision Meters**—provides uniform magnetic fields in the air gap, making it especially suited for core meters.
- **Reed Switches**—provides highly uniform magnetic performance with high-density packaging.

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**Questions and Answers, PNP.**

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Technical Articles

Off-the-shelf integrated circuits for versatile and accurate timer: page 70

More and more engineers are finding that it is cheaper to use off-the-shelf integrated circuits, particularly if the equipment is digital, than discrete components. In a precision timer for space applications, IC's saved time and money and made the finished product more reliable.

Special Report: Japanese technology

The new push for technical leadership: page 77

The Japanese are not content with following U.S. technology. Today, most companies are stressing research, even though they still depend heavily on government laboratories and universities for basic studies.

When you're second, you try harder: page 81

In one decade, Japan's semiconductor industry has become the world's second largest. But quantity is not its only accomplishment. The Japanese have developed some unusual devices and interesting ways to use semiconductors in circuits.

Japan seeks its own route to improved IC techniques: page 90

Though the integrated circuit work started only 18 months ago, the Japanese have made great strides to catch up with U.S. technology. After developing digital devices for computers, they shifted emphasis to linear units because there is greater potential in the products most important to Japanese electronics producers.

Bidding for world leadership in solid state microwave: page 99

With the densest microwave network in the world, the Japanese have much to gain by going to solid state systems. Every city in Japan has a skyline of microwave antennas. For our cover, we zeroed in on one, with Tokyo as a background.

After a lull, numerical control is enjoying new popularity: page 106

Sales in numerical control doubled this year. There's a preference for less expensive, point-to-point systems. Finding applications is more important than designing systems.

Manual process control makes way for computers: page 110

Worried by rising labor costs, many Japanese are looking to computer control to run plants in steel, chemical, petroleum, paper, cement and electric industries. Two concepts are direct digital control and integrated hierarchies.

Coming December 27

- First European electronics market report
- More on error control in communications
- Processing radar optical signals
Solid State

Off-the-shelf integrated circuits for versatile and accurate timer

Monolithic diode transistor logic circuit chosen to meet stringent requirements for airplane and spacecraft applications

By Alvin A. Lampell

Airborne Instruments Laboratory,
Division of Cutler-Hammer, Inc., Deer Park, N.Y.

As the availability of digital integrated circuits increases, engineers rely less on custom-made circuits. They are learning how to fit off-the-shelf IC's to system requirements. As a result, they are saving time and money.

For example, the engineers at Airborne Instruments Laboratory faced the problem of designing an accurate and versatile spacecraft timer that met stringent requirements. They chose IC's and the timer met the requirements with high reliability.

The primary goal of the laboratory, a division of Cutler-Hammer, Inc., was to develop a preprogrammed source of delays ranging from 2 seconds to 10 minutes or more. But the specifications also called for a minimum accuracy of repeatability of 99% (the time delay obtained with a specific dial setting should be repeated within 1% if the setting is changed, then reset) and a maximum variation of 5% for delays up to 60 seconds for temperatures ranging from -20°C through +70°C. With these requirements in mind, the engineers were required to cull carefully the available commercial IC's.

Signetics circuit used

The unit finally selected was a monolithic diode transistor logic circuit, the SE124G, manufactured by Signetics Corporation. The SE124G, a flip-flop circuit, is packaged in a ten-lead flat-pack, approximately ¼-inch square and ⅛-inch thick.

The timer circuit, comprising three SE124G integrated circuits and 22 discrete components, is on page 71. As shown by the dotted lines, one or two of the integrated circuits can be eliminated if a narrower range of time delays is acceptable. Additional IC's provide longer delays. For example, four IC's provide delays up to 20 minutes; five provide delays up to 40 minutes. Adding IC's to the basic 3-IC system also increases the time span over which variations from temperature changes can be held to 5%. With 4 IC's, the limit is 2 minutes; with 5 IC's, it's doubled.

In one application, the timer IC's, the signal-processing input circuitry and the signal-receiving output circuit are housed in a single module shown on page 71. Most of the equipment's IC cases (each ¼-inch square by ⅛-inch thick) are stacked and welded to form a cordwood assembly for compactness. The module is potted with an alumina-filled epoxy to improve its ability to withstand shock, and to assure improved temperature distribution through the entire unit. Only about one-third of the space in the module is occupied by the timer IC's and their associated discrete components. The timer unit measures 1¾-inch square by 1-inch high, but because of a 1-inch potentiometer protrusion, the total depth is 2¾ inches. The photograph on page 71 shows a small module, within the larger module, which contains timer IC's plus other IC's not associated with timing. A second small module, also within the larger module but not visible in the photo, contains other non-timing IC's.

The author

Alvin A. Lampell is in the special projects section of Airborne Instruments Laboratory's space systems department. He joined Airborne in 1959.
Interaction circuit module

Timer package also includes components and integrated circuits not associated with the timing function. The timer circuitry occupies only one-third of the package.

Operation of the timing circuit shown below starts with a negative-going pulse (pulse changing from +4 volts to slightly-above-ground voltage) applied at the input designated “set.” This sets all three of the flip-flop integrated-circuits to zero. The base of Q1, an n-p-n transistor, becomes more negative, Q1 turns off and D4 is back biased.

A constant charging current is supplied to C1 by the constant-current generator circuit consisting of Q2, R3, R6, D5 (1N643) and R7 (resistor R1 is a 1,000-ohm potentiometer). As a result, the voltage across C1 increases linearly with time until the voltage at the emitter of Q3, the unijunction transistor, is sufficient to turn it on. The rate at which C1 is positively charged is determined by the setting of the potentiometer, R7. As the potentiometer arm is moved toward the +24-volt-connection point, the voltage on the base of Q2 increases, the charging rate decreases, and the delay increases.

After C1 has been sufficiently charged, Q3 is triggered and C1 is rapidly discharged through R5, R6 and the emitter-to-base-one junction of Q3. Transistor Q4 is turned on by the conducting unijunction transistor and supplies a pulse to IC2, changing its flip-flop setting from the zero to the one state.

As the discharge current from Q1 flows through Q3, as Q3 decreases, Q3 drops out of conduction. Capacitor C1 starts to charge again and the entire cycle is repeated.

For a delay system with n IC’s in the feedback network, 2^n charging cycles are required to obtain the desired delay interval. In this case, two integrated circuits are being used, therefore C1 must be charged and discharged four times before C1 turns on, ending the delay period.

At the end of the second charging cycle, the pulse supplied by Q4 changes the IC2 flip-flop circuit from one to the zero state and the IC1 flip-flop circuit goes from the zero to the one state. At the end of the third cycle, IC2 changes from the zero to the one state. Finally, at the end of the fourth cycle, the pulse supplied by Q4 changes both IC1 and IC3 from the one to the zero state, causing IC1 to change from the zero to the one state, and thereby turning on Q1. The conducting Q1, in turn, clamps C1 to ground.

An expression for the current supplied to charge capacitor C1 can be derived by examining the base circuitry for Q2 which is in the diagram on page 73. Once this current is known, the time required to charge C1 can be determined. The portion of the circuit to be replaced by a Thévenin equivalent circuit is inside the box formed by the broken lines. The same circuitry is shown in the center diagram where the Thévenin equivalent circuit is represented by Rm.'

The Thévenin equivalent resistance, Rm, is actually three resistances, R10, R11, and R15 in
parallel. The expression for $R_{eq}$ is

$$R_{eq} = \frac{R_x (R_p - R_z)}{R_p} \left( \frac{R_z}{R_p} + \frac{1}{R_h} \right) \quad (1)$$

where $R_p$ = total potentiometer resistance, and $R_z$ = resistance between potentiometer and the +12-volt supply.

Because $R_x (R_p - R_z)/R_p$ is equal to or less than 500 ohms and $R_p$ is much larger than $R_x$ (in this case 10,000 ohms) equation 1 reduces to

$$R_{eq} = \frac{R_x (R_p - R_z)}{R_p} \quad (2)$$

Using nodal analysis, the Thévenin equivalent voltage for the portion of the circuit contained within the broken lines on page 73 is:

$$V_{eq} = \left[ \frac{(24 - 12)R_x}{R_p} + 12 - V_F \right] 10000$$

where $V_F$ is the forward voltage drop of diode $D_5$.

Using the same approximations that led to equation 2, equation 3 reduces to

$$V_{eq} = \frac{(24 - 12)R_x}{R_p} + 12 - V_F \quad (3)$$

The equivalent circuit on page 73 represents the charging circuit for capacitor $C_1$. The current flowing in this circuit is the emitter current of transistor $Q_2$.

$$I_e = \frac{24 - V_{BE} - V_{eq}}{R_5} \quad (5)$$

where $V_{BE} = Q_2$ base-to-emitter voltage and $\beta = Q_2$ current gain.

For the 2N2605, $\beta$ is typically equal to or greater than 50 at a temperature of 25°C and a collector current of 10 microamperes.

Because $R_5$ is much greater than $R_{eq}/\beta$, equation 5 can be rewritten as

$$I_e = \frac{24 - V_{BE} - V_{eq}}{R_5} \quad (6)$$

From equations 4 and 6

$$I_e = \frac{24 - V_{BE} - \left( \frac{(24 - 12)R_x}{R_p} + 12 - V_F \right)}{R_5} \quad (7)$$

Since $V_{BE}$ and $V_F$ are approximately equal throughout the entire operating temperature range, they effectively cancel. Eliminating $V_F$ and $V_{eq}$, and substituting $R_5 = 40,000$ ohms, $I_e = I_a/\alpha$, and $V_p$ equal to (12 $R_x/R_p$) - 12 in equation 7 yields

$$I_e = \frac{24 - \left( \frac{12R_x}{R_p} - 12 \right)}{40,000 \alpha} = \frac{24 - \frac{V_p}{R_p}}{40,000 \alpha} \quad (10)$$

where $I_a$ is the collector current of $Q_2$ and also the charging current for $C_1$, $\alpha$ is the $Q_2$ current gain in a common-base circuit, $V_p$ is substituted in the equation solely to make the equation easier to handle. The subscript $P$ denotes that $V_p$ is a function of the potentiometer setting.

The circuit is designed so when $Q_2$ conducts, capacitor $C_1$ charges until its top electrode reaches a voltage which is sufficient to trigger $Q_3$, the unijunction transistor. The charging current is the output of the constant-current generator, given in equation 8.

### The charging circuit

A simplified representation of the charging circuit is on page 73. The voltage across the capacitor is given by the expression

$$V_C = \frac{1}{C} \int_{t=0}^{t=E(t)/V_{PP}} \frac{dE(t)}{E(t)} \quad (9)$$

Solving equation 9 yields

$$I_{d}/C_1 = E_r(t) - E_r(0^+)^{0} \quad (10)$$

where $E_r(t)$ is the voltage across $C_1$ after a time $t$ and $E_r(0^+)$ is the voltage initially across $C_1$.

The initial voltage across $C_1$ is

$$E_r(0^+) = V_{D4} + V_{CE(SAT)} + I_aR_4 \quad (11)$$

where $V_{D4}$ is the voltage across $D_4$ and $V_{CE(SAT)}$ is the saturation voltage for $Q_1$.

Since the maximum value of $I_a$ is only about 0.3 milliamperes, the $I_aR_4$ product will be no more than 0.03. This is small enough to permit dropping the $I_aR_4$ component from equation 11. Therefore, the expression for $E_r(0^+)$ is simplified to

$$E_r(0^+) = V_{D4} + V_{CE(SAT)} \quad (12)$$

### Unijunction transistor

The voltage required to turn on the unijunction transistor is given by

$$V_{PP} = V_{BBT} + V_D \quad (13)$$

The following definitions apply to the equations given above:

- $V_{PP}$ = peak-point (turn-on voltage)
- $V_{BBT}$ = total base supply voltage
- $\eta$ = intrinsic standoff ratio (ratio is constant with temperature and $V_{BB}$ variations)
- $V_D$ = forward voltage drop for unijunction diode.

The current that flows in the charging circuit of $C_1$ must be greater than the peak-point current (the current at which the unijunction transistor is triggered). It must also be less than the sustaining current so the unijunction transistor will turn off after it is triggered. In this circuit, $I_a$ should be greater than 20 microamperes—the peak-point current (the current at which the unijunction transistor is triggered). It must also be less than the sustaining current so the unijunction transistor will turn off after it is triggered. In this circuit, $I_a$ should be greater than 20 microamperes—the peak-point current for $Q_3$—but less than 8 milliamperes, the sustaining current.

The unijunction-transistor portion of the timing system is also depicted in the circuit on page 73. This is the arrangement to be used if one integrated circuit is employed. For longer delays, $D_6$ and $R_6$ are added to the circuit to provide a reliable reference voltage to which $C_1$ discharges.
To provide an expression for delay time, equation 10 can be rewritten
\[ t = \frac{[E_c(t) - E_c(t^+)]}{I_c} \]  
(14)
Since the voltage across \( C_1 \) is equal to \( V_{op} \) when \( Q_2 \) fires, \( V_{op} = E_c(t) \). Therefore, from equation 13,
\[ E_c(t) = V_{BB} + V_D \]  
From equations 8 and 12
\[ t = \frac{(V_{BB} + V_D) - (V_{DA} + V_{CE(SAT)})C_1(40,000\alpha)}{24 - V_p} \]  
(15)

The unijunction diode voltage drop, \( V_{dp} \), is approximately equal to the sum of \( V_{DA} \) and \( V_{CE(SAT)} \). Equation 15 reduces to
\[ t = \frac{V_{BB} V_D}{V_S - V_P} K_\alpha \]  
(16)
where \( K_\alpha = 40,000C_1 \) and \( V_s \) = supply voltage.

Using partial derivatives to account for the variations due to changes in \( V_S, V_{BB}, a \) and \( V_P \)
\[ \Delta t = K_1 \left[ \frac{\alpha_o}{V_{Sa} - V_{Ps}} \right] \Delta V_{BB} + \frac{V_{BB} V_P}{V_{Sa} - V_{Ps}} \Delta a - \frac{V_{BB} \alpha}{(V_{Sa} - V_{Ps})^2} \Delta V_{Sa} - \Delta V_P \]  
(17)
where the subscript 0 indicates time \( t_0 \).

A 60-microfarad capacitor was chosen for \( C_1 \); this value is adequate for the time delay range required. The capacitor exhibited a positive linear temperature coefficient between -55 to +85°C. A slight improvement in the accuracy of the timer can be obtained if the 40,000-ohm resistor \( R_t \) has a negative temperature coefficient to offset the effects of temperature changes on \( C_1 \).

The value of \( a \) for \( Q_2 \) varies with temperature and is typically from 0.995 through 0.98. The value of the standoff ratio \( \eta \) for \( Q_3 \) is typically between 0.62 and 0.75.

If the +24-volt and +12-volt power supplies have 1-percent variations and \( a \) varies by 0.015, \( t \) will vary by about ±5 percent.

Separate +4-volt and -2-volt sources are required to bias the integrated circuits. The circuits could be operated with applied voltages of +4 volts and ground, however the units would then be less immune to noise. If a slight increase in package size is permissible, the +4-volt supply may be obtained from the +12-volt supply by means of a zener diode. This would not affect the timer accuracy.

There is a practical limit to the maximum time delay obtainable with the basic circuit (excluding \( I_{C2} \) and \( I_{C3} \)). Repeatability also decreases rapidly as the leakage currents of \( C_1 \) and \( D_4 \) approach the level of the charging current \( I_c \).

Components with low-leakage characteristics should be selected for \( C_1 \) and \( D_4 \). In this application, an RL series capacitor, made by International Telephone and Telegraph Corp., with a d-c leakage current of 0.4 microamperes at 25°C and 1.2 microamperes at 125°C was selected for \( C_1 \). For \( D_4 \), a FD300 diode made by the Fairchild Semiconductor Division of the Fairchild Camera & Instrument Corp. was selected. The FD300 has a leakage current of only three microamperes at 150°C with a reverse voltage of 125 volts. To further minimize the effect of the leakage currents, the timing system should be designed for a minimum value of charging current.

Resistors \( R_4 \) and \( R_8 \) protect transistors \( Q_1 \) and \( Q_3 \), respectively, from current surges; \( R_9 \) limits the base current of \( Q_4 \) to a safe value. Variable resistor, \( R_7 \), is a ten-turn clock-face potentiometer, model number 3600, manufactured by Bourns, Inc. If the space requirement had been more critical, the Bourns model 330, a microminiature potentiometer, could have been used. In this case, some repeatability accuracy would be sacrificed.

The timer system has been employed in several airborne applications and has provided the 99% repeatability desired. In one application, it has been slightly modified to generate linear sweeps for display.
Circuit design

Designer's casebook

Modified decade counter eliminates components

By Phil Ward
Texas Instruments, Inc., Dallas, Tex.

Because the binary-coded decimal counter shown below has no capacitively coupled feedback circuits, it increases the operating speed of the circuit. By using a simple wiring change and adding a single diode, D_5, the circuit returns to its initial state at the count of 10 rather than 16. The modifications are shown by the heavy lines.

The wiring change involves breaking the trigger input lines on stage 4 and connecting side A to the 2_0 output of stage 1, and side B to the 2_2 output of stage 3. Negative-going trigger pulses from stage 1 do not affect stage 4 until it has been flipped by a negative-going pulse from stage 3.

Stage 4 is flipped for the first time at the count of eight, and causes the counter to hold the binary number 1000. In this count, stage 4 has the 1 output. The ninth pulse forces the 2_0 output of stage 1 to go positive and makes the counter read 1001. Therefore the circuit operates as an ordinary binary counter up to and including the count of nine. While the circuit is holding the count of nine, the 1 output of the fourth stage, through diode D_5, reverse-biases the trigger gate of stage 2 so that it will reject the next pulse from stage 1. How-

Decimal counter operates at the maximum repetition rate of the flip-flop stages. Heavy lines in the schematic indicate the changes that have been made in the basic circuit.
ever, the tenth pulse still forces the output of stage 1 to reset to 0, and this negative pulse resets stage 4. The outputs of stage 1 to 4 now read 0000 and the binary-coded decimal cycle begins again.

This method of advancing the count reduces the number of circuit components. It also permits the binary-coded decimal counter to operate at the maximum repetition rate of the basic flip-flop and its trigger circuit. Decade counters which use capacitively coupled feedback require time delays to allow the feedback pulses to advance the count properly and to permit transient counter states to subside. This circuit uses no feedback pulses so no transient counter states occur. The only critical requirement is that the collector load resistors, R1, be small compared to the trigger circuit resistors, R2.

### Tunnel-diode sensor protects regulator from short circuit

By Jack Takesuye

**Short-circuit protection**, excellent regulation and fast response to changing load conditions are provided by the series regulator shown below. With an input voltage ranging from 30 to 40 volts d-c, the output at a full load of 3 amperes will be held to within 99.05% of 28 volts. With an input voltage of 35 volts, and a load current varied from 0 through 3 amperes, the output voltage will be maintained within 99.85% of 28 volts. When switching from half-load to full-load, the response time—the time for the output voltage to return to within 10% of its initial value—will be less than 4 microseconds.

The basic circuit, at the right in the schematic, is subject to short-circuit overload. Under normal conditions, output voltage is regulated by the series pass-transistor, Q1. The drive for Q1 is obtained by sampling the output voltage of the regulator with the voltage divider R1, R2 and R3. This sampled output is fed to the base of Q1 through the 2N2042 tunnel diode D1. The output of the tunnel diode is then fed to the base of Q2 which biases Q1 to the output voltage level.

The basic circuit includes an overload protection circuit to protect the series pass-transistor, Q1, against damage from short-circuited loads. The network does not increase the response time under varying load conditions.

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**Regulator includes** an overload circuit—to protect the series pass-transistor, Q1, against damage from short-circuited loads—and a delaying network to prevent oscillations when connected to a capacitive load. The network does not increase the response time under varying load conditions.
voltage is compared to the reference voltage provided by the zener diode \( D_1 \). The difference between the two voltages is amplified and drives \( Q_1 \) to minimize the difference. If the output terminals are short-circuited, \( Q_1 \) is driven fully on in an attempt to maintain constant output voltage.

Under these conditions, \( Q_1 \) will operate at maximum collector-to-emitter voltage and collector current, and can be damaged from excessive heating or secondary breakdown. If secondary breakdown does occur, \( Q_1 \) cannot be protected by fusing because transistor failure may occur in a few microseconds; the fuses will not open quickly enough.

To protect \( Q_1 \) from damage, an overload-sensing circuit consisting of tunnel diode \( D_4 \) and transistor \( Q_H \), is used to trigger a monostable multivibrator, which removes the drive from \( Q_1 \). This turns off the regulator circuit until the multivibrator resets. If the overload still exists, the regulator is again turned off. This type of protection would be adequate for resistive loads, but for large capacitive loads, the surge current charging the capacitor also would cause the overload protective circuit to turn the regulator off. If the capacitor is discharged by a shunt load, the overload would trigger again after the regulator turned on. This could result in a low-frequency oscillation. To eliminate this problem, the drive to the series pass-transistor can be applied slowly, minimizing the surge current. However, a simple RC-delaying network would degrade the response time (full to half load) of the regulator.

To apply drive to the series pass-transistor and maintain good response time of the regulator, the delaying network is added to the circuit. The voltage to drive \( Q_1 \) builds up slowly because \( C_1 \) must be charged through \( R_4 \) and \( R_5 \). This results in a slow-rising voltage at the collector of \( Q_3 \) and minimizes the surge current when the regulator is turned on. Once the capacitor \( C_1 \) is charged, diode \( D_2 \) is back biased and decouples the delaying network from the regulator circuit; therefore, no loss in response time is noticed from full-load to half-load steps.

Potentiometer \( R_4 \) in the overload protection circuit is adjusted to turn off the regulator when the load current exceeds 3.5 amperes. This keeps the load line within the safe limit of the operating characteristics of the series pass-transistor, \( Q_1 \).

The overload problem in series-regulator voltage supplies can be solved by many unique circuits. Various factors such as cost, reliability and performance determine the type of overload protection that should be used. The protective circuitry in this design increases the reliability of the series-regulator supply without degrading its performance capabilities.

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**Isolating transistor improves one-shot**

By Jozek Kalisz

Institute of Nuclear Research, Warsaw, Poland

Several improvements in one-shot multivibrator performance are obtained by adding transistor \( Q_1 \), as in the circuit at the right. The triggering circuit is isolated from the timing circuit, allowing the duration of the output pulse to be fully independent of the input pulse amplitude. In the conventional triggering method, shown by the components in the dotted lines, a 50% change in pulse duration may occur as trigger amplitude is varied from one through eight volts.

Another improvement is that the minimum triggering voltage is reduced from 0.25 to 0.1 volts. Furthermore, the circuit provides increased input impedance while reducing recovery time. Fast recovery is obtained by allowing \( C_1 \) to discharge through the low-impedance, base-to-emitter path that appears when \( Q_1 \) and \( Q_2 \) conduct. Isolating the trigger input from the timing-circuit \( R_2 C_2 \) also reduces the variation in output pulse width caused by temperature, because \( R_2 \) and temperature-sensitive diode \( D_1 \) no longer shunt \( R_2 \).

Except for the addition of transistor \( Q_1 \), the circuit has the same number of components as a standard one-shot multivibrator.
Japanese technology

The new push for technical leadership

No longer content with improving on U.S. developments, Japanese engineers are now stressing research. One reason is the increased cost of labor.

By Lewis H. Young
Editor

In 1960, when this magazine last took an in-depth look at electronics in Japan [Electronics, May 17, 1960, pp. 53 to 100], we found an industry built almost entirely on cheap labor. Research was meager. The principal products were low-priced transistors, components and radios. The best customers were bargain stores.

Today's vibrant Japanese industry is growing as rapidly as any in that country. High-speed production lines spew forth television sets, radios and tape recorders, and workers apply the private brand names of American electronics manufacturers as well as such American retail giants as Sears, Roebuck and Co. and Montgomery Ward & Co. Silicon transistors are slowly appearing, and engineers are installing facilities to produce integrated circuits.

But the biggest change is the new accent on research. At company after company, engineers talk about developing new concepts, rather than improving on American technology. Money, long scarce, is beginning to arrive from surprising places: The Bell Tele-
phone Laboratories, for instance, is financing work at the University of Tokyo on time-division electronic switching for telephone exchanges.

**A glamor industry**

Electronics' importance to the Japanese economy is far greater than one would guess from its annual sales of $2.5 billion to $3.0 billion. The technology offers Japan everything she needs in order to attain her national goals:

- Economic growth. The electronics industry is expanding nearly 15% a year, and that's just a start. With relatively little capital necessary, compared with steel or chemicals, electronics companies are springing up all over the country and existing concerns are constantly adding facilities.
- Exports. Despite a year-long recession, exports of semiconductors, components, radios, television sets, tape recorders and microwave equipment continue to climb, bolstering the country's balance of international payments. Record sales have been reported by the Sony Corp., which exports 63% of its production; also by the Nippon Electric Co., and Sanyo Electric Co., other big exporters.
- Long-range potential. Although the United States is Japan's best customer, with Western Europe a poor second, the new countries of Africa and Asia have gargantuan appetites for communications equipment and consumer products, which are Japanese specialties. These countries still lack money to buy such goods, but the Japanese are confident that they have the inside track for the time when the demand materializes. Japan has already sold solid state microwave equipment to Pakistan, Indonesia and India, and maintains good relations with many of these new countries.
- Prestige. Because electronics is an advanced technology, the Japanese think it can help them attain the reputation of being an advanced country. After shutting themselves off from the rest of the world for nearly 300 years, until 1850, the Japanese became known as copiers when they rushed to catch up. The desire to be considered advanced—which approaches the dimensions of an obsession in some quarters—is one reason the Japanese grasp any new technological idea that comes along, even if they see no immediate application or benefit. An example is the way Japanese companies plunged into color television in 1960—and, in many cases, were burned.
- Productivity. Electronics technology offers the capability of developing the automatic control equipment necessary to keep Japanese industries competitive with those in other parts of the world.

**Tough nut to crack**

"To compete in world markets, Japan will have to become a highly automated, high-efficiency producer," says Masahiro Shimizu, president of Hokushin Electric Works, Ltd., a producer of instruments, process controllers and computers for automation. Shimizu and other progressive executives recognize the nutcracker in which Japan's electronics industry is being squeezed.

From the south—Taiwan and Hong Kong—comes the threat of cheap labor—the same asset that Japan once used against the United States. From the east comes pressure by the superior technology of the United States. But the Japanese figure to be a tough nut to crack.

Salaries in Japan have risen sharply in the past five years—about 10% a year, with a 13% jump in 1965. A production worker starts at nearly $168 a month if you add fringe benefits; that's hardly competitive with the $15 a month paid in Taiwan or $30 a month in Hong Kong. And these increases will probably continue.

Electronics technology in the United States is still superior to Japan's, but the Japanese have been able to shorten development schedules by using the results of U.S. experiments and omitting the procedure that U.S. engineers had found to be unproductive. Evaluating the current status of Japanese electronics, Ichiro Isaka, chief engineer of the Electronic Industry Association of Japan, says: "In consumer products, Japan is number one in the world because of its high production rates and low costs. Our microwave equipment competes on even terms with U.S. products. But we are way behind in the study of integrated circuits."

Being second to the U.S. in technology is more than a matter of embarrassment to the Japanese. It is expensive, because Japanese companies must pay royalties to the U.S. owners of patents the Japanese want to use.

Fujitsu, Ltd., is an exception because it will not sign a licensing agreement with a foreign company. This producer of computers, numerical control for machine tools, components and semiconductors prefers to develop its own devices and procedures even though it may enter a market late as a result. More typical, however, is the Nippon Electric Co., which has a long list of licensing arrangements: with Honeywell Inc., for data-processing equipment; with the International Telephone and Telegraph Corp. for communications equipment; with the Western Electric Co. for telephone equipment; with Varian Associates for microwave tubes and linear accelerators; and with the Fairchild Instrument & Camera Co. and General Electric Co. for semiconductor processes.

An American who has lived in Japan for many
years noted another change recently. He said: "When I first came to Japan in 1954, Japanese consumer products were made badly. The only saving grace was that you could get them repaired. Today, Japanese appliances are beautifully made, but when something goes wrong there's nobody to fix them." Most good servicemen have given up repair work for employment in factories where they work shorter hours and earn more pay.

But clearly the biggest change is the new accent on research. One of the greatest incentives to this approach is the desire to become independent of U.S. patents.

**More development than research**

The biggest deterrent to effective research in Japan is management's inability to evaluate the importance of such studies. Sanai Mito, managing director of the Central Research Laboratory at the Hayakawa Electric Co., explains: "Now companies realize how important research is, but we are just half-way. Management is too hasty. Though they claim they understand research, they want quick results. To get quick results you have to go into development work, not research."

As a result, the accomplishments of Japanese laboratories are heavier on development than on research. At Matsushita, Tetsujiro Nakao, senior managing director, puts the case strongly: "Development is important, but if we ignore fundamental research we will be in trouble." Yet the Central Research Laboratory recently completed the design of a home video tape recorder, a project more akin to an engineering department than a research facility. Nakao says his company spends about 3.8% of sales income on research and development; last year's sales totaled about $616 million. "At least 15% of the total R&D budget is earmarked for basic research," he added proudly.

The growth of research facilities and the formation of new ones in the past five years, clearly shows Japan's intent. The list of expanded facilities and new ones is imposing:

- Just four years ago Hayakawa, which manufactures Sharp-brand tv sets, tape recorders and other consumer products, organized its first central research laboratory, even though the company itself started in 1923.
- Sanyo Electric Co., another appliance maker, officially recognized the importance of research when it chartered a central laboratory in December, 1961, after a small group had operated as a technical department for three years at the company's headquarters. The laboratory staff has increased to 230 people and is expected to expand to 300 as the proper personnel is found.
- The central research laboratory at Hitachi, Ltd., has increased from 600 to 1,400 people over the past five years—and is still growing. The present goal is a staff of 1,500.
- In 1960, the research facility at Mitsubishi Electric had 600 to 700 employees; today the number is 1,500.

Even though Japanese companies have increased their expenditures for R&D dramatically, there is still a serious shortage of funds for that purpose. The Japanese recognize that they must compete with the United States and bewail the giant appropriations for military and space research in America. By contrast, Japan's space program is budgeted around $7 million for 1965—and that is nearly double last year's figure.

To stretch R&D funds, the government and companies have evolved practices designed to minimize duplication of effort. A lot of fundamental research is performed at government laboratories, and the results are available to all companies.

When word of a truly significant development reaches Japan, the first research is likely to be done at a government laboratory. In 1955, development of numerical control for machine tools started at the Government Mechanical Laboratory near Tokyo. The first Japanese-designed computer was built in prototype at the Electrotechnical laboratory.

Many microwave developments started at the Electrical Communications Laboratory of the Nippon Telegraph and Telephone Public Corp., which the government owns. Much broadcasting equipment has been designed at the research laboratories of Nippon Hoso Kyokai, the government-controlled Japan Broadcasting Co.

When developments are completed at a government laboratory the results are given or sold to Japanese electronics companies. Almost every Japanese computer company owes its technical start in data processing to the development of the Mark IV computer, the first machine built at the government's Electrotechnical laboratory. A few months ago, the Electrical Communications Laboratory gave the solid state design for a 15-gigacycle microwave repeater, which had been designed and tested at the laboratory, to the Nippon Electric Co. to manufacture for the telephone company.

When a government lab charges a royalty, the fee is often microscopic. Toshiba paid only $1,500 for the design of a two-tube color camera, developed by the research laboratory of the Japan Broad-
casting Co., for televising the Olympics held in Tokyo last autumn. The payment included technical help in starting production.

Universities also help the Japanese to get more research per dollar. Although government professors are prohibited from receiving payment for outside activities, many faculty members secretly ignore the ban and work for private companies as consultants, buttressing the technical effort.

There is a legal way to use the universities too; it's called a kenkyusei, or research student. A company can send a graduate engineer to a university for one or two years to perform research under university supervision and take some courses. The cost is $800 per year plus the student's full salary. This year, Tokyo University registered about 30 kenkyusei.

One complaint heard often about Japanese educational practices is that too much money is spent on elementary and secondary schools and not enough on colleges and universities. Japan can boast of a literacy rate of nearly 100%, even though the language is exceedingly complex with nearly 2,500 characters (compared with English's 26).

In contrast, Japan's colleges have unattractive, rundown physical plants that are overflowing with students. Even in new facilities, such as those built to replace the bombed-out electrical engineering building at Osaka University, the structures are stark and unadorned, with unpainted concrete walls on the inside.

Changes in research

Because the facilities are so bad, most of the research carried out at universities is theoretical, requiring a minimum of equipment. At the University of Tokyo, for example, sitting in a ramshackle frame building, Prof. Takashi Isobe studies correlation techniques and pattern recognition. His most recent work has been to develop a new method of measuring the dynamic characteristics of a control system.

Across the campus, in a slightly sturdier building, Prof. Jin-Ichi Nagumo studies self-organizing systems and learning machines, and develops simple devices for medical electronics, such as a direct-coupled pacemaker.

But conditions are changing. More money for experimental equipment is becoming available. Some of it comes from surprising places. The Bell Telephone Laboratories, for example, is financing work on time-division electronic switching at the University of Tokyo. Money is coming from Japanese companies too, as more of them are sending their R&D staffs back to college to keep up with American technology, because so many faculty members have gone to the United States for graduate study.

Despite Japanese efforts to husband their research resources, there is still plenty of duplication. The reason is that Japanese companies tend to play follow-the-leader. Half a dozen companies, for instance, are striving to develop continuous-wave Gunn-effect oscillators for microwave applications. Also, after word spread that the aggressive Sony Corp. was building an electronic calculator, two appliance makers—the Hayakawa Electric Co. and the Yaou Electric Co.—rushed the development of similar calculators too.

The greatest research effort is going into integrated circuits and electronic switching for telephone exchanges. Still, a catalog of other Japanese research is impressive.

At the Nippon Electric Co., which many Japanese credit with conducting the best industrial research in Japan, projects range from computer developments to quantum electronics.

The NEAC L-2 computer, built at Nippon Electric's Central Research Laboratory, is the basis of the company's new model 500 commercial machine. It has a 10-megacycle clock rate and three memories: wire, core, and a read-only "eddycard" memory made of square holes in a copper plastic sandwich. In the experimental machine, Nippon Electric has built an index register of 15 words with tunnel diode circuitry to increase speed. The machine's add and subtract time is 0.5 microsecond, with fixed-point arithmetic and 1.4 microseconds with floating point; times for multiplication are 1.9 to 7.7 microseconds for fixed point and 2.4 to 7 microseconds for floating point.

Most of Nippon Electric's work with integrated circuits (see p. 90 for a survey of all integrated-circuit work in Japan) is being done at the company's semiconductor division. But the lab is trying to develop integrated circuits—double NOR logic units—for delta-modulation communication equipment.

In another project, a researcher at NEC has studied voice analysis and built a machine that accepts numbers, given orally, for dialing a telephone.

One of the Mitsubishi Electric Corp.'s top-priority research projects is the development of three-dimensional radar for Japan's defense agency. Says one Mitsubishi engineer: "It's the only development we can give the U.S."

Details are classified, and the company says only that the system uses a phased-array antenna. If it works, and the tests should be completed by next summer, Mitsubishi's system will be the most accurate radar in the world and have the longest range.

Matsushita's Wireless Research Laboratory has almost as many projects under way as the company's Central Research Laboratory. Its emphasis is on new materials and components. About a year away from commercial use is a cubic boride material for the recording heads of tape recorders. Its hardness is 1,000 on a Vickers scale, compared with 600 for ceramic materials; its permeability at 100 cycles per second is 3,000, far better than the 1,600 of ordinary head materials. Its one flaw is a higher coercive force than that found in conventional materials, so present work is aimed at reducing this force, the company says.

Closer to production is a cadmium-sulfide p-n
junction for photovoltaic cells. This material is less expensive than silicon, which has been used the same way, but cadmium sulfide's efficiency when generating power is slightly lower. Current generated is 15 milliamperes per square centimeter at 0.4 volt with a load and 0.5 volt on open circuit.

At Sanyo's central laboratory, work on injection electroluminescence shows promise because Sanyo scientists see a potential for high efficiency and brightness in the single crystals of zinc telluride which they are using.

Despite the surge of recent research, Japan's greatest strength still lies in her ability to perform high-quality development of products based on American technology. Visitors from the United States continually find examples of ingenious engineering. Last month at one of Sanyo's laboratories, for example, an experimental silicon controlled rectifier was controlling a refrigerator's motor. Changing the frequency of electricity doubled the running speed of the 40-watt motor, producing the same cooling effect as with an 80-watt motor.

To assess the technical contribution of the electronics industry in Japan, the editors of Electronics have asked several Japanese experts to report on their specialties, emphasizing those developments which are peculiarly Japanese. From these reports, which appear on pages 81 to 112, an engineer can assess Japanese technology. Those segments of technology selected are:

1. Discrete semiconductor devices, which are essential ingredients in most products (see below).
2. Integrated circuits, because the Japanese are emphasizing linear devices and racing to catch up with the United States (p. 90).
3. Solid state microwave, because the Japanese have the densest networks in the world and boast that their equipment is as good as anybody's (p. 99).
4. Industrial electronics, because the Japanese are pushing hard for automation to offset rising labor costs. One report covers numerical control of machine tools (p. 106); the other, process control by computer (p. 110).

**Japanese technology**

*When you’re second, you try harder*

In one decade, Japan's semiconductor industry has become the world's second largest. Pioneering engineers, a variety of unusual devices, and breakthroughs in miniaturization techniques account for phenomenal growth.

By Takuya Kojima and Makoto Watanabe

Electrical Communications Laboratory, Nippon Telegraph and Telephone Public Corp., Tokyo

Large scale production of semiconductor devices is the nucleus of the Japanese electronics industry. More than 400 million transistors were produced last year, making Japan's semiconductor industry the second largest in the world, trailing only the United States. Yet quantity is not the industry's sole accomplishment. Japanese engineers have created some unusual devices such as the passivated mesa transistor, a bidirectional twin transistor, the Esaki diode, and a double-diffused npn transistor of unique structure.

All this has happened in the last decade. The dominant force behind such rapid growth has been Japan’s pioneering in the transistorizing of consumer products such as a-m and f-m radios, tape recorders and television sets, now small enough to be called microsets.

The structure of the Japanese industry helped too. All the makers of semiconductor devices in Japan—and the total number is less than 20—also manufacture consumer products, other electronic equipment or both. Because they are in the same company, information flows rapidly between device builders and equipment designers.

Most of the semiconductors made in Japan are germanium devices, and go into consumer prod-
thus increasing maximum frequency diffusion, NEC reduces base spreading resistance, Nippon Electric Co.'s multiple diffused base transistor (left) compared to a conventional planar transistor at right. By widening the base area with a second diffusion, NEC reduces base spreading resistance, thus increasing maximum frequency.

New consumer products, however, require better quality devices. Thus, the transistorization of large television reviewers, with screens up to 19 inches, demands high-frequency transistors and high-power devices. Communication and industrial equipment also needs special-purpose devices of high quality. Although silicon technology is new in Japan, its spread has been rapid and most semiconductor suppliers produce both germanium and silicon devices.

Challenge of higher frequencies

As in the United States, there is great pressure in Japan to produce higher-frequency devices. For example, television makers want transistors capable of operating up to 1,000 megacycles for ultrahigh-frequency receivers. For this application, Japanese suppliers offer both germanium and silicon devices.

To boost operating frequency, Japanese firms are trying either to minimize the base spreading resistance of their devices or to minimize the collector capacitance. The reasons become evident from the equation for maximum frequency of oscillation of a transistor:

\[ f_{mc} = \frac{1}{4\pi \sqrt{\frac{1}{r_{bb'}c_e \tau_{ce}}}} \]  

(1)

where \( r_{bb'} \) is the base spreading resistance, \( c_e \) is the collector capacitance and \( \tau_{ce} \) is the carrier transit time between emitter and collector. The base spreading resistance and collector capacitance degrade performance. Base spreading resistance not only decreases the power gain and output power but also degrades the noise figure.

To lower this resistance in silicon transistors, firms have introduced some novel device structures. For example, the Nippon Electric Co., Japan's biggest microwave equipment manufacturer, uses a multiple base diffusion process to add another area of impurities in the 2SC288, 2SC289, and 2SC272 devices (shown above). After the usual diffusion has formed a conventional base area, a second diffusion forms impurities just outside the emitter area, widening the base thickness and reducing the base spreading resistance. The \( r_{bb'}c_e \) product of the 2SC288 is only 3 picoseconds; the base resistance is less than \( \frac{1}{2} \) that of a conventional transistor.

NEC also achieves a low base spreading resistance with a second approach called emitter mesa structure and shown in the figure below. This structure reduces the drive-in effect in which impurities in the base region are driven toward the collector area, forming a small projection in the collector junction plane.

Though the effect is more pronounced in a silicon mesa transistor, where the impurity is gallium, than in a planar transistor where the impurity is boron, it becomes critical in any high-frequency transistor. That's because a high-frequency device has an extremely narrow base width which is a bottleneck in the base region between the area immediately beneath the emitter junction and the area outside the junction. The bottleneck causes an appreciable increase in the base resistance and disturbs the uniform carrier flow in the base area.

In the emitter mesa structure, a mesa formed by a vapor etching process prior to diffusion, offsets the drive-in effect. The height of the mesa is just enough to compensate for the depth of the projection that would be formed in the junction plane by the drive-in phenomenon. Thus an ideal flat junction structure results.

There is one other advantage of the emitter mesa structure: it eliminates unwanted parasitic capacitance and carrier injections around the vertical outside edge of the base. Although these can be ignored in an ordinary device, they are appreciable in a high-frequency transistor whose emitter width is 5 microns or less. The parasitic capacitance decreases the high-frequency amplification factor in the small-current region of the emitter; the excess carrier injection at the edge decreases the current amplification factor in the large-current region of the emitter. By using the emitter mesa structure, NEC increases the gain by 3 db throughout the range of emitter current and decreases noise by 0.5 db.

From the equation for the maximum frequency of oscillation of a transistor (above), it is clear that frequency can also be increased if collector capacitance is reduced. In the base mesa transistor, designed by NEC, the geometry lowers this characteristic. In the structure (p. 83), the base area is defined by a deposited layer of silicon dioxide. Since only a small region of the base is needed to make contact with the metallization of the electrode, the capacitance of the metallized portion to the collector is negligible. Such low collector capacitance makes the device well-suited for application in wideband-amplifiers—and especially in amplifiers with automatic gain control because
Building a base mesa transistor

**STARTING PROFILE**

**DEPOSIT SILICON DIOXIDE**

**SHAVE OFF TOP MESA**

**DIFFUSE BASE**

**DIFFUSE EMITTER**

**ATTACH ELECTRODES**

circuit capacitance changes less with changes in voltage stemming from the gain control.

It seems clear that all three techniques—multiple diffused base, emitter mesa, and base mesa—could be applied to one device, to produce even better transistors capable of handling higher frequencies.

At the Matsushita Electronics Corp., the semiconductor producer of the big Matsushita Industrial Electronics Co., another approach to reducing collector capacitance has been taken with extended base planar transistors. A highly doped area just beneath the extended base electrode shields the electrode from the collector. In the Matsushita 2SC562 series, the base-to-collector capacitance is as low as 0.15 picofarads.

Minimum base-to-collector capacitance eliminates several bothersome effects. By definition, in an extended base electrode device, a metallized contact to the base is extended along the silicon dioxide layer on top of the collector bulk semiconductor region for easier bonding of the base lead wire. If the device has an extremely small base area, the parasitic capacitance between the extended base electrode and the collector bulk semiconductor region is comparable to the capacitance of the intrinsic collector junction. Such a high capacitance makes it impossible either to increase the power gain of the transistor in ultra-high-frequency ranges or to stabilize transistor operation at lower frequencies where capacitance can cause feedback. In addition, if the intermediate frequency stage of an amplifier is equipped with automatic gain control, high capacitance causes the bandpass characteristics to change with the gain of the transistor.

Most of the high-frequency devices Matsushita has developed are going into television sets. The 2SC562 is used in the control stage of television i-f amplifiers with forward gain control. The 2SC563 goes into the output stage of i-f amplifiers. And the 2SC593, with a power gain of 20 db at 450 Mc and a cutoff frequency more than 1,500 Mc, is for uhf tuners.

Because silicon devices cost considerably more than germanium ones, there is still a lot of interest in germanium devices in Japan, even for high-frequency applications. Japanese engineers use mesa, planar and alloyed diffused types of germanium transistors in high-frequency applications. One example is the 2SA448, a double-diffused pnp transistor, shown on page 84, developed by the Sony Corp. The mesa surface is divided into two steps of equal area, separated by a space of only one micron. One step is the base contact metallization region; the other is the emitter contact metallization region.

Even though high precision is required in manufacturing, the fabrication of the 2SA448 is relatively simple. First, a coating of silicon dioxide is deposited uniformly over the entire face of a germanium wafer. Then gallium is deposited on the oxide coating and diffused through it to form the emitter layer of p+ material. Trenches in the SiO₂ are formed by a photolithographic process. The p+ material below these trenches is etched out to form deeps whose bottoms reach to the p—material. Then the SiO₂ layer is removed, leaving a surface of alternating p+ and p—stripes. At this point, the device is a p—wafer with parallel ribbons of p+ material along its upper surface.

In the next step, the base diffusion of n-type material takes place. A layer of n-type material forms at the base of the trenches and under the p+ ribbons because the diffusion constant of the n impurity is 1,000 times that of gallium which was the p+ impurity. But, because the quantity of n impurity is much smaller than that of gallium, the p+ region stays a p+ region. Aided by geometry, the n impurity extends further into the p—region at the bottom of the trenches than under the p+ region. Since the n layer under the p+ layer is the base region of the finished device and the n layer at the bottom of the deeps is the base lead attachment region, the finished transistor has a thin base and low base spreading resistance.

After the second diffusion, a shadow evaporation process forms the aluminum base and emitter con-
One micron or less separates the emitter electrode (top) and base electrode (bottom) of Sony's double diffused germanium pnp transistor. Used for high-frequency applications, it can be fabricated easily.

Power transistors

The considerable effort to produce high-frequency devices has not been duplicated with high-power units. Though many companies make power transistors, both silicon and germanium, most are conventionally designed.

Epitaxial or triple-diffused silicon power transistors are manufactured with capacities ranging from 10 to 150 watts—not exceptional when compared with devices made in the United States with power ratings up to 300 watts. Currently the 2SD137 made by Kobe Kogyo has the highest collector breakdown voltage of any device made in Japan: 300 volts. Recently, both Kobe Kogyo and Toshiba (Tokyo Shibaura Electric Co.) started manufacturing overlay transistors which have higher power capability in the high-frequency range.

In entertainment and industrial applications, alloy drift and diffused base germanium transistors are still used almost exclusively. In audio-frequency amplifiers, horizontal deflecting systems for tv picture tubes, and regulated power supplies, they have proven to be free of secondary breakdown. Many people wonder whether silicon will ever replace germanium for such applications.

The passivated mesa

Although the planar structure is clearly the most widely used for silicon transistors, it has one serious limitation: the breakdown voltage of the collector is low. After examining the probable causes of this limitation, Hitachi Ltd., has developed an improved passivated mesa transistor which has a better collector junction.

In Japan, as in the United States, the causes of collector breakdown in planar structure are not clear. Partially, it's caused by geometry: the electric field is concentrated at the corners of the diffused area. Some researchers believe that a large amount of impurities in the base region cause surface breakdown. The surface of the base has a greater concentration of impurities than the region adjacent to the horizontal collector junction because diffusion produces a graded layer with a higher concentration of impurities near the surface.

At other times, a poor silicon-silicon dioxide interface seems the cause. Or, if the silicon-silicon dioxide surfaces are separated by an n+ surface layer, breakdown can occur too.

Hitachi's new process produces a mesa structure that has a high collector breakdown voltage, low noise figure, small leakage current, and a high current amplification factor in the small current region.

The process is applied to a completed mesa transistor. After silicon dioxide is deposited on the transistor by the thermal decomposition of organic oxysilane, a thin film of lead is deposited onto the oxide layer. Finally, the device is exposed to high temperature so the lead and silicon dioxide can combine to form a protective glass whose composition is lead oxide and silicon dioxide.

Many kinds of transistors treated this way are available for entertainment and industrial applications. For example, the Hitachi 2SD190 is a silicon device with a BV, of 300 volts; the 2S280H is a twin transistor for low-level differential amplifiers and it has an excellent reliability record.

Hitachi claims the process can be applied to other semiconductor devices, too.

Beginning of field effect devices

Among Japanese engineers, the field effect transistor is still a novelty whose application is very limited. Only five companies supply them at pres-
ent: Toshiba, Hitachi, Fujitsu, Kobe Kogyo and Mitsubishi. Typical of these devices is the Toshiba 2SJ13, a p-channel junction FET with a transconductance of 3.5 milliohms. The Mitsubishi 3SK15 series is a depletion mode metal oxide semiconductor device for general purpose use. The Hitachi 3SK11 is a depletion mode n-channel MOS fabricated by a technique called field cooling process.

Depletion mode, enhancement mode and even nonuniform channel MOS devices can be made by the field cooling process. A small quantity of movable impurities, such as sodium ions, are impregnated in the silicon dioxide layer. An electric field applied between the gate and bulk crystal at high temperature causes the impurities to drift through the oxide layer, changing the surface potential of the silicon appreciably. When the surface channel has reached the desired conductance, the field is removed and the device is cooled, fixing the impurities in the oxide layer.

Making the Esaki diode

Unquestionably the best known Japanese semiconductor development is the Esaki or tunnel diode, invented by Leo Esaki at the Sony Corp. in 1957. After a resounding acceptance, particularly because of its apparent high speed, the tunnel diode turned into a big disappointment. One reason was the incorrect use of the device in circuits. It is a diode and cannot replace transistors or other multi-lead devices. But another reason was reliability. Initially, every manufacturer fabricated Esaki diodes by a conventional alloy-etching process. It produced a diode whose structure resembled a boulder balanced on a point, and the device was not very rugged.

In addition, performance requirements were in conflict with each other. For a high cutoff frequency, the junction diameter has to be about 5 microns or less; but for high reliability, the final junction diameter cannot be smaller than the initial junction diameter before etching. It turned out that a 5-micron diameter area—needed for high-frequency cutoff—was too small for lead attachment.

Because the Esaki diode was a truly Japanese development, Japanese companies continue to work with it. To build more reliable devices, some of them have switched to a mask technique. At Sony, where the device was developed, a process called the bridge technique was developed, using a combination of evaporated mask and etching methods.

In the new Sony process, after a germanium slice...
In Sony's new method of fabricating tunnel diodes, a dot of alloy material bridges the trench between two metallized areas. The result is a more rugged device.

has been coated with silicon dioxide, a trench about 20 microns wide is cut in the oxide coating by photolithographic etching. Then two regions, 50 microns by 50 microns, on each side of the trench are metallized. An alloy dot bridges the two metallized areas over the trench, forming a junction at the bottom of the trench and ohmic contacts to the two metallized regions. A final etching process brings the diode to the desired characteristics of peak current and peak-to-valley current ratio.

In a diode made this way, the etched junction is only slightly smaller than the original junction. But the junction does not have to contribute to mechanical support; rather, the ohmic contact region supports the junction.

Besides being stronger, the new diode has better electrical characteristics. One which Sony produces has a cutoff frequency of 10 to 21 gigacycles, self resonant frequency of 14 to 22 gigacycles, and a capacitance-to-peak current ratio of 0.1 to 0.25 picofarads per milliampere.

**Other high-frequency diodes**

Because of Japan's interest in and use of solid state microwave, there has been a lot of activity in developing high-frequency diodes for communication systems. Among the first Japanese semiconductor developments was the Kita diode or silver-bonded diode developed at the Electrical Communications Laboratory of NTT, and now manufactured by Nippon Electric Co.

The Kita diode has outstanding characteristics when used as a parametric amplifier, up-converter or frequency multiplier at microwave frequencies. The reason is the small capacitance of the depletion layer, typically less than 0.5 picofarads, and a low series resistance, less than 10 ohms. Although the device was first developed in 1954, its greatest applications have appeared in the past two or three years. Now new ones are being discovered in high-speed switching, clamping and clipping.

Making the diode is relatively easy; the big difference is in the method of bonding. In a conventional diode gold wires are used. In the Kita device, the tip of a silver whisker, containing a small amount of gallium, contacts a bulk crystal which has been highly doped with n type germanium or silicon. Applying a large current pulse produces a very small area of p+ material on the crystal, completing the fabrication of the diode.

As an indication of Japanese activity producing a variety of diodes:
- Nippon Electric Co. produces high frequency zener diodes with low junction capacitance.
- Fujitsu Ltd., the Nippon Electric Co., and the Mitsubishi Electric Corp. make silicon diffused varactors for solid state microwave systems of 2, 4 and 6 Ge. The Mitsubishi MVE6006 can deliver an output of 3 watts at 4 Ge when used as a frequency tripler. That's the highest output at this frequency of any Japanese diode.
- The New Japan Radio Co., Ltd., Fujitsu Ltd., and the Sanyo Electric Co. make variable-capacitance diodes with a retrograded junction, a device which is also called a hyper-abrupt junction diode. These devices are used as a tuning element which covers a wide frequency range and as a modulator in f-m communications systems.
- Fujitsu Ltd., has also developed a new gallium-arsenide light emitting diode that throws a narrow beam of noncoherent light through a transparent window at the top of the mounting. It has been used in a micromanipulator which accurately positions tools driven by a pulse motor.

**Special purpose devices**

A look at some of the special purpose devices developed in Japan helps understand both the spread of Japan's semiconductor industry and its electronics industry.

One unusual device is the V-203, a bidirectional twin transistor, built by the Nippon Electric Co. for balanced modulators. A unique junction structure and a controlled epitaxial technique produces symmetrical characteristics (see circuit below).

Another device is a high-speed four-layer diode developed by Mitsubishi. A two-terminal silicon device, it has a breakover voltage of only 3 volts and
a switching time of 20 nanoseconds. Most probably application is in fast digital circuits.

And still another new device is the gate-turnoff silicon controlled rectifier produced by Toshiba. Labeled the MS392, it has a turnoff gain of 8; that is, a gate current of 500 milliamps can turn off a current of 4 amps.

**Power handling devices**

Although both power equipment manufacturers and transistor makers make power handling devices—silicon rectifiers, silicon controlled rectifiers, and silicon symmetrical switches (bidirectional four-layer diodes)—the development effort doesn’t begin to compare with that in the United States. In general, scr’s, for example, are expensive and are not yet used widely. Until recently, Japanese scr’s did not have the large current-carrying capacities of those available in the U. S. and Europe.

The situation is changing and some new devices supply the strongest evidence. A new scr developed by Nippon Electric Co. uses a silicon slice 1½ inches in diameter; it’s the biggest scr developed in Japan. Called the V-179, it has a mean forward current of 700 amps, repetitive peak reverse voltage of 2,350 volts, and a surge current rating of 9,000 amps.

One not so large is the CJ-021 built by Hitachi for ac-dc conversion in a 2,200 kilowatt electric locomotive. Ratings of this scr are: a peak reverse voltage of 1,200 volts and a mean forward current of 390 amps. Because so much of Japan’s extensive railroads net is electrified, there is likely to be an increased use of scr’s for conversion and speed control as the manufacturing volume increases and decreases the cost.

Hitachi has one other interesting scr, the CR-93VE, a small high speed device. It takes only 3 microseconds to turn on 1,000 amps, and 6 microseconds to turn off 10 amps. But it can handle 1,000 amps only for short surges.

Silicon symmetrical switches are a specialty of the Shindengen Electric Manufacturing Co. which makes several series of them. Its KXB series contains two terminal bidirectional switches with breakover voltages of 100 to 200 volts. The K17B-10 and K17B-20 have a rating of 150 amps, bidirectional rms current and the K5B can handle 12 amps.

Another supplier is Hitachi, whose FR-01 is a 5-layer switch with one control gate electrode. A control current, either positive or negative, of 100 milliamps can fire the switch in either direction, regulating an rms current of 16 amperes.

**High-voltage rectifiers**

Still a small part of the Japanese semiconductor industry is the manufacture of high-voltage rectifiers, capable of handling reverse voltages of 3,000 and 4,000 volts. The Hitachi HO3-DA has a peak reverse voltage of 3,000 volts and a rated mean forward current of 470 amps. A device made by the Sanken Electric Co. has a breakdown voltage exceeding 4,000 volts; mean forward current is 150...
milliamps and the forward voltage drop is only one volt when maximum forward current flows.

Shindengen makes an avalanche rectifier diode, the SSZ-50, with a reverse surge power rating of 2.5 kilowatts for 10 microsecond pulses. In the SSZ series, peak reverse voltages range from 400 to 1,200 volts; mean forward current is about 20 amps.

Any survey of the Japanese semiconductor industry would not be complete without mentioning several processing techniques which have been developed.

Many of the high voltage devices made in Japan receive a special surface treatment called ONV, which means oxidation by nitrogen dioxide vapor. The treatment, developed at the Electrical Communications Laboratory, consists of two processes: cleaning the silicon surface in an atmosphere of hydrogen fluoride and nitrogen dioxide; and oxidizing at a low temperature. Such treatment raises breakdown voltage, minimizes leakage current and steps up the surge power rating.

Though germanium devices far outnumber silicon devices produced by Japanese semiconductor makers, more research effort is being applied to silicon technology because it is newer. For example, the Oki Electric Co. has perfected a simple process for depositing polycrystal silicon.

The company has made a tiny diode with an upper ohmic contact formed by depositing polycrystal silicon. The polycrystal material is deposited in a window cut into oxide masking. During fabrication, it acts as an impurity source for diffusing the p-n junction beneath it, and afterwards as a protective coating and contact to the completed junction. This technique supplies a rigid, reliable contact that is simple; no ball or fancy contact structure is required as it is with many kinds of silicon diodes.

Another application of silicon polycrystal produces isolated silicon islands in integrated circuits.

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Some Japanese uses of semiconductor components

I. Switching the horizontal deflection of a TV tube

Two transistors connected in series are the essential components in a circuit (at right) designed to switch the horizontal deflection of a television tube. One has a relatively low breakdown voltage but switches at high speed; the other has a high breakdown voltage but sacrifices high frequency characteristics for a wide area of safe operation. The first has a grounded emitter, the second a grounded base connection.

To switch on the circuit, a signal is applied across the base and emitter of the first transistor, causing a base current to flow equivalent to

$$ I_B = \frac{E_2}{R_B} $$

If $I_B$ is large enough to turn on the second transistor, a deflection current flows equivalent to

$$ I_D = \frac{1}{L_D} (E_1 + E_2) \cdot t $$

where
- $I_D$ = yoke current in amperes
- $L_D$ = yoke inductance in microhenries
- $E_1$ and $E_2$ are power supply voltages in volts
- $t$ = time in microsecond after second transistor turns on

When an off signal is applied to the first transistor, the charge stored in the base of the second transistor flows through resistance $R_B$ until it disappears. Not until the stored charge completely disappears is the switching complete.

II. Esaki diodes in a PCM system

Possibly because the Esaki or tunnel diode was developed by a countryman, Japanese engineers have retained a fondness for it even though many U.S. engineers became disenchanted with the device a long time ago. Properly used, this high-speed device has some clear advantages. For example, the Nippon Telegraph and Telephone Public Corp. has just designed Esaki diodes into three switching circuits (see below and p. 89) for a 24-channel pulse code modulation communications system. By using this device, NTT not only reduced the size of the equipment, but decreased power consumption by nearly two-thirds, to 67 watts from 220 watts. The three are: a temporary memory, a pulse shaping circuit, and a voltage comparator.

The temporary memory is equivalent to a bistable flip-flop circuit. The pulse shaping circuit, like a Schmitt trigger, converts a sine-wave to a pulse train.

In the voltage comparator, when incoming signal exceeds a specified level, an output pulse of definite amplitude appears at the output.
in a process similar to Motorola's EPIC process—but simpler.

In Motorola's process, a silicon crystal is etched to a waffle-like pattern and then oxidized. Polycrystal is deposited over the waffle-like face; the bulk of the single crystal material is removed by grinding and lapping until the waffle-like projections are a group of oxide-isolated islands supported by polycrystal silicon.

In the Oki process, the starting material is a two-layer structure of thin silicon single crystal on a polycrystal bulk. In the etch that produces the waffle-like structure, the single crystal is cut down to the supporting polycrystal. The structure is then oxidized and polycrystal silicon deposited just as it is in the EPIC process. But the original polycrystal silicon is removed, leaving a group of oxide-insulated islands supported by polycrystal silicon. What makes this process simpler is that the polycrystal material is removed easily.

Pulse shaping circuit, like a Schmitt trigger, converts incoming sinewave signal to a pulse train.

III. Esaki diodes in a memory matrix

One attraction of the Esaki diode has always been its high speed. At the Electrical Communication Laboratory of NTT, engineers have used the tunnel diode to design a high speed memory matrix whose cycle time is under 50 nanoseconds.

The peak current through the diode is one milliamper and the capacitance connected in parallel with it is 50 picofarads. Thus a driving pulse with a rise time of 3 nanoseconds can deliver a readout pulse of 80 millivolts on the sense line. The capacitance in parallel to the diode matches the rise time of a memory cell with that of the driving pulse and stabilizes the operation against external noise.

Two silicon diodes and a load resistance form a load line (see circuit diagram below), which is connected between a bias line and a word line of the matrix.

In the static condition, the operating point is at one of two points on the voltage-current curve, depending on whether a zero or a one is being stored. When information is read out, a negative pulse or value $-V_1$ is impressed on the word line, causing a small noise to appear in the sense line. The size of this noise is large if a one is stored, small if a zero is stored.

A zero is written when a positive pulse is applied to the word line while a negative pulse is applied to the digit line.
Japan seeks its own route to improved IC techniques

Encouraged by the government, Japanese electronics companies, building on U.S. technology, are coordinating research, revising processing techniques and shifting their emphasis to linear circuits.

By Yasuo Tarui
Electrotechnical Laboratory
Ministry of International Trade and Industry

When integrated circuit activity started in Japan last year it followed almost exactly the pattern established by the United States. Initially, the biggest effort was to develop digital circuits for use in computers. This year, however, the emphasis has shifted to linear circuits because their potential seems more applicable to the products most important to Japanese industry—consumer, communications and industrial equipment.

The beginning of Japanese activity can be traced directly to the International Business Machine Corp.'s introduction of the System 360 series of computers, which incorporate hybrid integrated circuits. Because Japanese makers of general-purpose machines, six in all, have barely been holding their own with IBM, it was clear they had to have IC equipment if they were to continue to compete with any success. IBM has already installed more than 30% of all the computers in Japan. The move to integrated circuits was natural for the six Japanese computer companies because they also manufacture semiconductors.

By the autumn of 1965, Fujitsu Ltd., Hitachi Ltd. and the Nippon Electric Co., the big three of the Japanese computer industry, were ready with computers using integrated circuits (page 93).

Five other semiconductor companies have developed monolithic integrated circuits too. At present, in Japan as in the United States, diode-transistor logic is the most popular approach to computer design. Of the eight major producers, only the Sony Corp. and the Matsushita Electrical Industrial Corp., are not computer makers. But, it can be seen in the table on page 91 that not all the development work has been digital; a number of amplifiers have also been produced.

Government programs

The six computer companies are being helped and encouraged by the Japanese government. For example, the Ministry of International Trade and Industry (MITI) has made available about $80,000 in research grants to them for the development of special integrated circuits. Ostensibly, the grant is to cover half the direct costs of a project. In reality, the Ministry’s estimate is invariably low and the grant rarely covers more than one-third the cost of the research.

All the projects in this program (page 92) are scheduled to be completed by the spring of 1966. One advantage of coordinating research this way is to reduce duplication of effort. Thus one company works on the general register of a high-speed computer and another on a low-cost control memory. A third company is developing the arithmetic and control units for a desk-type calculator; a fourth, the arithmetic and control units for a small-sized computer; a fifth, the arithmetic unit of a high-speed computer; and the sixth, a read-only memory tester.

The research accomplished in each project will be

The author

Yasuo Tarui has worked with semiconductors ever since he joined the Electrotechnical Laboratory. Today he is a strong advocate of integrated circuits. In October, he received his Doctor of Engineering degree from the University of Tokyo for research on the measurement of transistor parameters.

Japanese technology
available to all the companies.

Producers are also being encouraged by the Microcircuit Technical Committee of the Japan Electronic Industry Development Association. Chairman of the committee is Noboru Takagi, a professor at the University of Tokyo; Tsuneo Momota of MITI's Electrotechnical Laboratory is the vice chairman. Because of their affiliations, they can disseminate technical information widely.

In September 1964, a new element was introduced into the Japanese integrated circuit picture when Kyodo Electronics Laboratory Inc., was formed by an American semiconductor specialist, Bernard Jacobs, and five Japanese component companies. Only Jacobs had any background in semiconductor production. The five are: Toko Inc., a maker of coils and other electronic components; the Nippon Chemical Condenser Co., electrolytic and nonelectrolytic capacitors; the Koden Electronics Co., radio direction finders and lorans systems; the Pioneer Electronics Corp., speakers and hi-fi components; and the Alps Electric Co., switches and television tuners.

Among integrated circuit producers in Japan, Kyodo is the only company that has not been producing transistors and other semiconductor devices. Last summer, it perfected its first product, a hybrid flip-flop that operates at a repetition rate of 25 megacycles. By 1966, it expects to offer a complete line of integrated circuits in Japan and the United States.

I. Examining Japanese products

Though many of the integrated circuits developed in Japan thus far closely resemble those available in the United States, there are some that are unusual. In addition, a lot of new processing techniques have been perfected, some to improve on U.S. technology and, some, frankly to avoid patents that cover procedures developed in the U.S. A closer examination of the unusual Japanese products show a decided bias for linear circuits.

**Negative feedback amplifier**

At the Nippon Electric Co. (NEC), a group of four engineers headed by Toshio Kurosawa has developed a negative feedback-type amplifier with a bandwidth of 10 megacycles. Some idea of potential applications can be deduced by the fact that two of the engineers are specialists on telephone carrier equipment; Kurosawa and the fourth engineer are semiconductor specialists.

In designing this amplifier, the NEC group recognized that absolute values of resistance are difficult to reproduce in an integrated circuit. But they capitalized on the fact that resistance ratios can be maintained because the geometry of elements on the same chip can be matched, even if absolute values of resistivity or depth of diffusion cannot be maintained. Thus, controlling the gain by the ratio of resistance produced their stable

---

**Integrated circuit manufacturers**

<table>
<thead>
<tr>
<th>Company</th>
<th>Digital circuits</th>
<th>Linear circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nippon Electric Co.</td>
<td></td>
<td>Low-level 3-stage amplifier for hearing aid</td>
</tr>
<tr>
<td></td>
<td>DTL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TTL</td>
<td>Low-level 2-stage direct-coupled amplifier (f = 2, 7 Mc)</td>
</tr>
<tr>
<td></td>
<td>CTL</td>
<td>3-stage direct-coupled wideband amplifier (f = 25 Mc)</td>
</tr>
<tr>
<td></td>
<td>MOS transistor gate</td>
<td>Feedback amplifier</td>
</tr>
<tr>
<td>Hitachi Ltd.</td>
<td></td>
<td>Separated collector Darlington amplifier</td>
</tr>
<tr>
<td></td>
<td>ECL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOS transistor gate 8-bit shift register</td>
<td></td>
</tr>
<tr>
<td>Fujitsu Ltd.</td>
<td>modified DCTL (resistors on SiO₂)</td>
<td>audio-frequency amplifier (thin film)</td>
</tr>
<tr>
<td></td>
<td>DTL</td>
<td>i-f amplifier</td>
</tr>
<tr>
<td></td>
<td>ECL</td>
<td></td>
</tr>
<tr>
<td>Mitsubishi Electric Corp.</td>
<td>TTL, DTL</td>
<td>2-stage direct-coupled wideband amplifier (f = 3 Mc)</td>
</tr>
<tr>
<td></td>
<td>Synchronizing signal-distributor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulse amplifier (resistors and capacitor on SiO₂)</td>
<td></td>
</tr>
<tr>
<td>Oki Electric Industry Co.</td>
<td>TTL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DTL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOS transistor gate flip-flop</td>
<td></td>
</tr>
<tr>
<td>Toshiba</td>
<td>DTL</td>
<td>a-f amplifier</td>
</tr>
<tr>
<td>Sony Corp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-stage direct-coupled wideband amplifier (f = 12 Mc)</td>
</tr>
<tr>
<td>Matsushita Electronics Corp.</td>
<td></td>
<td>i-f amplifier</td>
</tr>
<tr>
<td>(a joint venture of Matsushita Electric Industrial Co. and Philips Gloeilampenfabrieken, N.V., Netherlands)</td>
<td>Hearing aid (gain, 80 db)</td>
<td></td>
</tr>
</tbody>
</table>

**DTL—Diode transistor logic**

**TTL—Transistor transistor logic**

**CTL—Complementary transistor logic**

**ECL—Emitter coupled logic**

**MOS—Metal oxide semiconductor**

**DCTL—Direct coupled transistor logic**
Negative feedback amplifier (photo and circuit diagram) for possible telephone-carrier applications is produced by the Nippon Electric Co. Because it depends on ratios of resistance rather than absolute values, the amplifier is stable and its performance consistent.

constant-gain amplifier. The circuit diagram and a photo of the chip are above.

A series-parallel feedback circuit reduces power consumption by stabilizing the d-c bias setting at a low current and improves impedance matching. Low value resistances in the feedback circuit reduce random fluctuations in resistance.

Several IC amplifiers of this design showed consistent performance in tests. The gain of any one was within 0.3 decibel of the gain of any other amplifier. And the gain proved to be independent of temperature; since all the resistances change by the same percentage, the ratio of critical resistances in the feedback circuit does not change.

Examining the gain-frequency curves, nearly o-shaped, it is seen that there are two cutoff fre-

### Government-aided research projects...

<table>
<thead>
<tr>
<th>Company in charge</th>
<th>Equipment</th>
<th>Abbreviated specification (typical function)</th>
<th>Company in charge</th>
<th>Equipment</th>
<th>Abbreviated specification (typical function)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fujitsu Ltd.</strong></td>
<td>Arithmetic unit of high-speed computer</td>
<td>By CML—memory capacity; 512 words (18 bits+sign per word, 16 instructions) clock frequency of 8 Mc. (16 megacycle 2-phase) add time: 1 µsec</td>
<td><strong>Tokyo Shibaura Electric Co. (Toshiba)</strong></td>
<td>Processor of small-size computer (business machine)</td>
<td>By DTL—memory capacity of 8 words, each word consisting of 14 units of 5 bits each to give 13 decimal digits. add and subtract time: 3 millisec multiply and divide time: 100 to 300 millisec</td>
</tr>
<tr>
<td><strong>Nippon Electric Co.</strong></td>
<td>Low-cost control memory</td>
<td>By CTL, transistors and diodes—memory capacity 16 words with 18 bits per word access time: 250 nsec cycle time: 500 nsec nondestructive reading</td>
<td><strong>Oki Electric Industry Co.</strong></td>
<td>Arithmetic and control units of a simplified portable computer (desk-type calculator)</td>
<td>By thin-film integrated circuits augend subtrahend register: 10 digits multiplicand multiplier register: 9 digits multiplication register: 10 digits memory register: 2 registers of 10 digits each. Operable at room temperature and high humidity, compact size</td>
</tr>
<tr>
<td><strong>General register of a high-speed computer</strong></td>
<td>By CTL, transistors, and diodes—memory capacity 24 words with 32 bits per word access time: 50 nsec cycle time: 100 nsec nondestructive reading</td>
<td><strong>Hitachi Ltd.</strong></td>
<td>Read-only memory tester</td>
<td>By ECTL, transistors and diodes, read cycle: 40 nsec memory capacity: 512 words of 54 bits per word</td>
<td></td>
</tr>
</tbody>
</table>
Japanese computers with integrated circuits

<table>
<thead>
<tr>
<th>Computer</th>
<th>Nippon Electric Co.</th>
<th>Hitachi Ltd.</th>
<th>Fujitsu Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEAC 2200 series model 500</td>
<td>HITAC 8000 series model 8500</td>
<td>FACOM 230 series model 60</td>
</tr>
<tr>
<td>Word length</td>
<td>6 bits/character</td>
<td>32 bits/word</td>
<td>42 bits/word</td>
</tr>
<tr>
<td>Number of instructions</td>
<td>about 50 with variants</td>
<td>144</td>
<td>—</td>
</tr>
<tr>
<td>Main memory</td>
<td>wire</td>
<td>wire (scratch pad memory)</td>
<td>—</td>
</tr>
<tr>
<td>Capacity</td>
<td>33 k~524 k characters</td>
<td>66 k~524 k Bytes</td>
<td>128 k words</td>
</tr>
<tr>
<td>Cycle time</td>
<td>0.188 μs/character</td>
<td>0.84 μs/Bytes</td>
<td>0.92 μs/word</td>
</tr>
<tr>
<td>Operation speed*</td>
<td>decimal add (fixed)</td>
<td>9.9 μS (5+5 digits)</td>
<td>1.92 μS</td>
</tr>
<tr>
<td></td>
<td>decimal multiply (fixed)</td>
<td>110 μS (5+5 digits)</td>
<td>12.1 μS</td>
</tr>
<tr>
<td>Family of integrated circuit</td>
<td>CTL</td>
<td>ECTL</td>
<td>TTL</td>
</tr>
<tr>
<td>propagation delay</td>
<td>5 ns</td>
<td>20 ns/pair</td>
<td>10 to 15ns</td>
</tr>
<tr>
<td>Clock frequency</td>
<td>6 Mc</td>
<td>—</td>
<td>8.7 Mc</td>
</tr>
<tr>
<td>Serial or parallel</td>
<td>parallel</td>
<td>parallel</td>
<td>parallel</td>
</tr>
</tbody>
</table>

* Only representative values out of many available operations; comparison of operation speed appears to be for different conditions.

fquences when no feedback is applied—a cutoff frequency being a corner in the gain-frequency curve. The first is caused by the collector capacitance of the second transistor; the second by a combination of collector capacitance and the cutoff of the current amplification factor of the last stage.

When used as an audio amplifier, the circuit has these characteristics:

| Gain (600 ohm input and output impedances) | 36 db |
| Overload point | 17 dbm |
| Amplifier noise figure | 52 db at 1 kc |
| Gain-frequency characteristic | 0.15 db |
| between the range of 0.2 kc and 3.4 kc with reference to 0.00 db at 1 kc |

**Improved Darlington circuit**

Some of the disadvantages of a standard Darlington circuit have been eliminated in a linear integrated amplifier developed by Hitachi. In their modification of the Darlington circuit, useful to above 10 Mc, the Hitachi group has minimized input stray capacitance, output stray capacitance and collector capacitance. At the same time, it has tried to maximize amplification, f<sub>e</sub>, of the transistors and to keep the current amplification factor of the transistor in the last stage small.

With this design, the phenomenon known as the Miller effect is dissipated. In a conventional Darlington circuit, in which the collectors of all three transistors are connected, a very high capacitance—equal to the base-to-emitter capacitance multiplied by the gain—is reflected back to the input terminal. Because the Darlington circuit has a high impedance at low frequencies, the reflected capacitance (the Miller effect) reduces bandwidth greatly. In narrow-band amplifiers, the feedback capacitance also reduces gain and tends to cause instability. In addition, the Darlington circuit normally has a high collector-to-emitter threshold voltage so it cannot be switched when operated at low power supply voltages.

The large output-to-input feedback capacitance of the circuit (caused by the inclusion of the base-to-collector capacitance of the first transistor) produces the Miller effect. The Hitachi design eliminates that problem by a separate connection for one transistor. Hitachi’s separate-collector Darlington and the standard Darlington are compared on page 94.

In the manufacture of the Hitachi circuit, a three-step process produces a high concentration of boron in a smooth silicon dioxide surface. The process starts with the box diffusion of boron at 1,100° to 1,200° C for 20 minutes. A second diffusion is performed for seven and a half hours in wet oxygen at 1,200° C. In the third step, all silicon dioxide is removed and the diffusion repeated under the same conditions for an additional seven and a half hours.

For ohmic contacts and interconnections, the Hitachi researchers deposit a silver-aluminum layer. The silver layer is evaporated to a thickness of 50 to 100 angstroms while the surface temperature of the wafer is held to 500° C. The layer of aluminum is evaporated to a thickness of 5,000 angstroms while the surface temperature is maintained at 250° C. This procedure produces a very fine-grain evaporated layer which is bonded well to the substrate. The separate-collector Darlington circuit has been used in an intermediate-frequency amplifier (p. 94) and its gain-frequency characteristic measured at 455 kc. and at 10.7 Mc. Under the latter conditions, the gain-frequency curve is asymmetric, indicating a small amount of instability. The analysis on page 94 shows that stability can be improved by decreasing the feedback.
Using Hitachi’s modified Darlington circuit...

Separate-collector circuit is used in an i-f amplifier. No high capacitance is reflected back to the input with a Darlington configuration, and the circuit has greater bandwidths.

Conventional Darlington circuit (right) in which all three transistors have a common lead and Hitachi’s separate-collector circuit.

At 10.7 Mc, gain-frequency curve of i-f amplifier is asymmetric, indicating a small amount of instability. Feedback capacitance is too high.

 capacitance and increasing the cutoff frequency of the forward transconductance.

Synchronizing-signal distributor

Two chips make up a circuit that distributes a synchronizing signal to many cameras in a television studio. A group at the Mitsubishi Electric Corp. developed the circuit with help from Nippon Hosokiyokai, the Japan Broadcasting Corp. One chip is the input section; the other, the output (photographs of the chips and corresponding circuits are on p. 95).

In the input section there are terminals for a delay circuit, should one be needed. Following the delay circuit is an emitter-follower output stage with a Darlington connection for maximum input impedance. Diodes were added to speed up the circuit by extracting turn-off base current. An impedance of about 10 kilohms is measured at the input.

The output section also uses a Darlington connection in the output stage to obtain high d-c current gain.

When the two chips are connected in a signal-distributing circuit, the transient transfer characteristics are:

- Rise time: 20 to 30 nanoseconds
- Fall time: 40 to 60 nanoseconds
- Leading-edge propagation time: 70 to 90 nanoseconds
- Trailing-edge propagation time: 100 to 160 nanoseconds

These measurements were made with the delay line terminals shorted, at a pulse repetition frequency of 15.75 kc, pulse width of 5 msec, and input pulse height of −4 volts.

An 8-channel synchronizing-signal generator has been assembled with the two-chip circuit technique.

MOS shift register

Already producing metal-oxide-semiconductor transistors, Hitachi has extended its discrete-device fabrication techniques to build an 8-bit shift register on a single chip with MOS devices. Hitachi has already placed 96 MOS transistors and 32 MOS diodes on a chip 2 mm by 1.8 mm.

Another company experimenting with MOS integrated circuits for computer devices is the Nippon Electric Co. At its central research laboratory, NEC has built a very small-capacity MOS memory—8 MOS transistors on a chip packaged in a TO-5 can. NEC researchers are still a long way from their goal of 400 MOS transistors (or 100 bits of memory) on a single chip that would be capable of a 5- to 10-Mc clock rate. The first experimental units, 2 bits in a TO-5 can, have an access time of 50 nanoseconds; researchers want a cycle time of 100 to 200 nanoseconds.

Optoelectronic devices for logic

At the Semiconductor Research Institute of Tohoku University, in Sendai, investigators are
Developing optoelectronic integrated circuits to perform logic functions. Headed by Professor Junichi Nishizawa, the group has discovered that roughening two parallel faces of a gallium arsenide laser-diode prevents the light from leaving these faces and redirects it, thereby increasing the light output from the other two sides faces. Now, they are studying the interaction effects of a single crystal with two diodes, one with roughened surfaces.

In such an arrangement, the researchers have observed an interesting quenching of the light output in one direction. When a diode is biased with a current greater than its threshold current, the light emitted in one direction varies with changes in current through the other diode. By harnessing this dependency, the group expects to make a device capable of on-off logic.

Another research program at Sendai has produced an optoelectronic isolator with a 1.7 Ge cutoff frequency. The device consists of a gallium-arsenide laser diode and a silicon p-i-n photodiode. An electric signal is converted to light in the laser diode; the light is detected by the photodiode which acts as a transformer with good isolation.

From this research might come a direct current-to-gigacycle frequency isolator for optoelectronic logic, and a transformer with good isolation for integrated circuits.

In the experimental device, a 20-millivolt a-c signal of 1.5 Ge is superimposed on the 12-ampere-pulse current to the laser diode, which operates at liquid nitrogen temperatures. The pulse has a duration of 1 microsecond and a repetition frequency of 50 cycles per second. The output of the photodiode is detected with a local oscillator, whose frequency is 1.51 Ge, and then amplified.

The over-all current-transfer ratio is 13%, with an optical fiber between the laser diode and the photodiode. The cutoff frequency is limited by the photodiode now, but researchers believe that improved diodes will be available soon with cutoff frequencies of about 10 Ge.

II. New processing techniques

While most of their production techniques for integrated circuits are based on technology devel-
Roughening two parallel faces of a laser diode by sandblasting redirects the light to the other sides. Light transmitted in the Y direction by diode D, depends on current carried by diode D2, as shown by the curves.

Oki's improved method of isolation

1. Single crystal silicon.
2. Grow silicon epitaxially.
3. Oxide protection.
5. Cut windows in oxide.

*6. Etch out crystal.
7. Protect with oxide layer.
9. Remove polycrystal.

oped in the United States, in a number of cases the Japanese have made what are sometimes minor-sounding but important changes. One Japanese company, for example, has developed better methods of dielectric isolation.

Isolating the devices on an integrated circuit is essential. Of the two known methods, dielectric isolation is far superior to reversed-diode isolation. In the U.S., a method of fabricating dielectrically isolated integrated circuits was published in the Proceedings of the IEEE in January, 1965 by D.A. Maxwell, R.H. Beeson and D.F. Allison. Now Toshimichi Sakata and Mamoru Ikegami of the Oki Electric Co. have improved on the original U.S. method.

Though slight, the difference between the two processes is significant. To appreciate the difference, it is necessary to have a general understanding of the U.S. process. In it, mesa-like projections of polycrystalline silicon are formed on a substrate of single crystal silicon by photolithography; the surface of the silicon wafer is oxidized; polycrystalline silicon is deposited to fill in the valleys and cover the mesas; finally, the chip is flipped over and the original wafer is removed by grinding and polishing until only oxide-insulated islands supported by the deposited polycrystalline silicon remain. Removing the original wafer is difficult.

Oki's improved method is shown, step-by-step, below at left. Polycrystalline silicon is deposited for support before the photolithography process forms the mesas. During the formation of the mesas, all silicon between the mesas is removed. Then the procedure is the same as that in the American method: valleys are filled in and the mesas covered with a deposit of polycrystalline silicon.

When the first polycrystalline layer is removed, the silicon islands in which the semiconductor devices are fabricated are exposed.

Of significance in the improved method is the fact that silicon dioxide film separates the semiconductor islands from the polycrystalline layer that has to be removed. As a result, it is much easier to remove the layer than to remove the silicon single crystal which is contiguous with the islands.

Vapor selective etching

Sakata and Ikegami have also developed a method of selective etching capable of sharp resolution for some fabricating of dielectric isolation. With this procedure, it is possible to etch deeply in the vertical direction and minimize the etch in the horizontal direction without any etching of the silicon-dioxide passivation layer.

Windows are cut in the silicon-dioxide layer, using conventional photomasking and etching methods. Then a second silicon wafer is placed on top of the etched surface and the polycrystalline underside of the first wafer is heated to about 1,200° C in an atmosphere of hydrogen and hydrogen chloride (see top page 97).

Heating causes the silicon under the windows to
vaporize and deposit on the cooler wafer above them. In this way, silicon is etched in the vertical direction with high resolution. The amount of side etching necessary to finish the design is three to five times less than the amount required with conventional methods.

**Toshiba's preferential epitaxial growth**

Toshiba (Tokyo Shibaura Electric Co.) developed a method of forming n-type islands in p-type silicon substrate to make transistors and silicon controlled rectifiers [Electronics, April 5, 1965, p. 185]. Now the technique has been applied to integrated circuits so that, exclusive of regions masked by a layer of silicon oxide, silicon is grown epitaxially on substrates.

The process starts when the substrate is oxidized thermally. Next, windows are etched through the oxide film at the places where islands of n-type material are desired. Anhydrous hydrogen chloride, which does not attack the oxide film, etches moats into the substrate. The moats are filled epitaxially with n-type silicon single crystals into which planar structures are fabricated.

Experience shows the process works best when a buried n-type collector layer is formed. Toshiba's method cuts the time to fabricate isolation to about 30 minutes, an important reduction compared to the 10 to 30 hours required to produce islands of isolation by conventional diffusion processes.

A transistor built this way has a cutoff frequency above 130 megacycles; maximum collector voltage is 60 volts and maximum collector current is 500 milliamperes. At 100 ma, the current amplification is more than 20.

In diodes made this way, the p-n junction has reversed-bias characteristics, low leakage current and hard zener breakdown.

**Chromium-silicon thin-film resistors**

Trying to produce high resistivity for hybrid integrated circuits and thin-film circuits, Saburo Iikawa and Tatsuya Enomoto of the Mitsubishi Electric Corp. developed chromium-silicon resistors with resistance high enough to be used in communications receivers.

The thin film is evaporated from a tantalum boat containing a mixture of powders—60% (by weight) silicon and the rest chromium. Chemical analysis of the evaporated film shows a composition of 80% silicon and 20% chromium by weight.

Electrically, the sheet resistance can be controlled to values between 1,000 and 10,000 ohms per square. So far, Mitsubishi has used resistors made of films with a resistivity of 5,000 ohms per square; temperature coefficient has been minus 100 parts per million per degree centigrade.

To make terminations on the resistor, Mitsubishi
evaporates chromium and then a mixture of chromium and copper. The outer surface of the termination is pure copper.

These resistances are relatively stable. In one test, the resistance changed only 0.08% after a power dissipation of 2 milliwatts per square millimeter for 1,000 hours at 85 °C. After 3,000 hours of this test, change in resistance was still less than 1%.

The first use of these devices was in hybrid circuits for a portable transceiver used by railroad workers on the New Tokaido railway line. In these circuits, the chromium-silicon resistors supplied the high resistance; nickel-chromium films made up small resistance and tantalum oxide films were capacitors (see circuits at right).

**Tantalum photoetching**

Normally tantalum thin-film circuits cannot be deposited directly onto semiconductor chips because the silicon dioxide layer would be removed when the tantalum layer is etched. Ichiro Miwa and Takeo Nishimura at Hitachi developed a simple and accurate method of fabricating tantalum thin-film circuits and recently modified it for use on the oxidized silicon surface of other semiconductor materials.

The Hitachi researchers found that Kodak Photo-resist would protect the oxide coating long enough during the tantalum etching. Thus KPR is spread over the semiconductor material; then removed by photolithographic means wherever tantalum is to be applied.

Fabricating tantalum circuits by the Hitachi method depends on the selective etching of tantalum and tantalum oxide. Aqueous alkaline solutions will dissolve the oxide but not tantalum; acids will dissolve tantalum but not its oxide. Thus tantalum oxide is used as a mask when etching tantalum with acids.

A typical circuit would be made this way:

- After a tantalum film is deposited on an insulating substrate, its surface is electrolytically anodized until specific sheet resistivity is obtained.
- Kodak Photoresist is applied to the film. A photolithographic etch removes tantalum oxide and layers of tantalum from all places that are not to be used for resistors, capacitors or conductors. First, an alkaline solution dissolves the oxide layer; then an acid solution dissolves the exposed tantalum.
- The oxide layer covering conductors is then dissolved with an aqueous solution.
- A conductive film, which forms the conductors and counter electrodes for the capacitors, is deposited over the entire surface.
- A photolithographic process dissolves the unnecessary portions of the conductive film.

Though KPR is known to have inferior resistance to active etchants, it can protect the silicon dioxide film because the film is subjected to the active solutions for a very short time. There is a small variation in the time required to etch tantalum from different parts of the circuit. It is only during this variation period that KPR is required to protect the silicon dioxide film.
Japanese technology

Bidding for world leadership in solid state microwave gear

With problems uniquely suited to solution by microwave, the Japanese are making big advances in solid state equipment using such components as the tunnel diode, Kita diode, hyperabrupt diode and mesa transistor.

By Isao Someya
Electrical Communication Laboratory
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Japan has many of the problems that microwave is best-suited to solve—communications needs of a dense population (about half that of the United States squeezed into an area smaller than Montana), a combination of mountainous terrain and narrow streets that make coaxial cable difficult to install and maintain, and expensive and limited natural power. Japan also had an “advantage”—a chance to start fresh after 80% of its telephone service had been destroyed during World War II.

For these reasons, the country chose microwave and today has the densest system in the world. Japan’s first solid state microwave system went into operation in 1962, an 11-gigacycle system that connected television studios to telephone exchanges a short distance away. The system required only 10% as much power as would a comparable tube setup, and construction costs were halved. Because of these savings, Japan developed solid state systems and today boasts that her solid state microwave gear is as good as any in the world.

Although Japanese engineers borrow heavily from United States technology, they have made significant contributions in the microwave field, primarily with the application of Japanese-developed components such as the tunnel diode and the Kita diode. Since there are no military programs to prime the research pump in Japan, most of the development has been done at the Electrical Communication Laboratory of the government-owned Nippon Telegraph and Telephone Public Corporation. Its laboratory is comparable, in a modest way, to the Bell Telephone Laboratories. More recently, development work of this type has also been carried on in the research laboratories of a few private companies; the Nippon Electric Co., Fujitsu Ltd., Hitachi Ltd., Mitsubishi Electric Corp. and Toshiba (Tokyo Shibaura Electric Corp.).

Once a development is perfected, the Electrical Communication Laboratory (ECL) turns the design over to one or more manufacturers. The Japanese success in competing in the international market is evident in the sales of microwave equipment to the governments of Mexico, Taiwan, and Indonesia.

Solid state research in the microwave field in Japan can be traced to 1955 when the concept of the parametric amplifier was proposed independently at ECL. From this proposal came the development of variable capacitance diodes (varactors) and silver-bonded or Kita diodes. Mesa transistors with gain-bandwidth products of several hundred megacycles were developed in 1959. Today in Japan, parametric amplifiers are used mainly in over-the-horizon systems of medium capacity operated by private users such as railroads and utility companies. NTT has used these amplifiers in a 2-Gc over-the-horizon system that connects the southern island of Kyushu to Okinawa. And the applications...
Spreading microwave network
crowds the Japanese landscape

Japan owns the densest network of microwave links in the world; its five major islands are criss-crossed by microwave routes, as the map below shows. Around key cities such as Tokyo and Osaka, communication lines are so numerous that links interfere with each other. This year, when Japan’s telephone company found it had to increase capacity between Osaka and Nara, it installed a 15-Gc system because engineers feared interference from the 12 two-way, 11-Gc links between Osaka and Kyoto.

Because of this congestion, the Japanese are working hard to develop solid state microwave equipment with greater capacity.

Easily the biggest user of microwave in Japan is the Nippon Telegraph and Telephone Public Corporation (NTT)—a government-owned company. Other private users include the railroads—which include many independent lines—and public utilities, such as electric companies, gas producers and distributors, and water suppliers. Almost every railroad has its own private microwave link and so does every utility—a characteristic of big Japanese companies is to perform many services themselves.

Japan's dependence on microwave can be traced to the damage done in World War II when nearly 80% of the country’s telephone service was wiped out by bombings and fire. When rebuilding, the Japanese chose the newest type of communication and what for them was the most economical—microwave. Because of the mountainous terrain, installing microwave antennas and repeaters was far less expensive than laying coaxial cable. Japan National Railways, for example, puts relays on mountains to reflect beams into stations in valleys. Also, digging up the crowded and narrow streets in Japanese cities is expensive and far more trouble than the government believes it is worth. One characteristic of any Japanese city is the skyline of microwave antennas (see cover) that blossom like the chimney pots of another continent.

Communication explosion

In 1954, there were only 2.5 million telephones in Japan, which had a population of nearly 90 million people. Ten years later, Japan could boast 8.6 million telephones and 5.5 million subscriber lines. Today, the telephone company cannot fill 1.3 million applications for new telephones. The demand has risen sharply, despite imposing requirements for a new telephone. A new subscriber pays not only a connection fee of 300 yen (about 84 cents) and an equipment charge of 10,000 yen ($28), but he also must buy a debenture for 150,000 yen ($420). If the subscriber holds the bond for its full 10-year life, he earns 7.3% interest a year.

NTT has begun a four-year program to catch up with the demand for telephone service. By 1970 it expects to have 15 million phones on its line.

During the same period, television broadcasting has grown rapidly so that there are 350 local broadcasting stations scattered over the country. The Tokyo headquarters of the three networks, the government-owned Nippon Hoso Kyokai (Japan Broadcasting Co.) and two that are privately owned, originate programs which have to be carried throughout the island by microwave. In Tokyo, NTT has no cable connecting the network stations to telephone exchanges. Programs leave the station via microwave too, usually on an 11-Gc carrier aimed at the nearest telephone exchange.

Forced to higher frequencies

Although NTT has some local lines—2 Gc, 6 Gc, 11 Gc and 15 Gc—it's basic lines operate at 4 Gc. As traffic has filled these, the telephone company has been forced to higher frequencies. In 1961, a 6-Gc line was installed between Tokyo and Osaka, a distance of 350 miles, and 11-Gc lines were installed about the same time for short-haul traffic.

Private users of microwave operate at 2, 7, 8, and 13 Gc. They are mostly line-of-sight systems, and a few over-the-horizon systems, with a capacity ranging from 60 through 240 telephone channels. Since traffic volume on these private lines is generally small and there is no interference problem, most of them use passive relays with large metal reflectors. NTT, however, uses the most sophisticated equipment.

When NTT completed its first broadband 4-Gc system in 1954, the telephone company was the first in the world with a traveling wave tube in a commercially-operated repeater. In the United States, American Telephone and Tele-
graph completed a 4-Gc system earlier, but with triodes rather than twt's.

NTT's pioneering line, designated SF-B1, connected Tokyo and Osaka with 10 relay stations along the route. In each heterodyne repeater were two traveling wave tube stages to get the required power output. They heterodyned the received signal down to 70 Mc, amplified it, then heterodyned it up to the carrier frequency at which it would be transmitted. To avoid feedback, transmitter and receiver frequencies in one repeater varied by about 200 Mc.

Since that first system went into operation, three other 4-Gc systems have been developed. The latest, SF-B4, still uses vacuum tubes. It can carry color television transmission over a distance of 1,550 miles. Most of the radio frequency channels of the 4-Gc system now carry television signals. All four radio-frequency channels allotted to the 4-Gc band were being used by 1961, so NTT was forced to a 6-Gc system.

With the 6-Gc system, NTT can carry as many as 1,800 telephone channels, compared to only 960 in the 4-Gc line. The first system, the SF-U1, had a capacity of 1,300 telephone channels on each radio carrier. In 1964, an improved 6-Gc system, the SF-U2, was installed between Tokyo and Osaka with a capacity of 1,800 telephone channels.

For local networks where there is no demand for television transmission, NTT has a 2-Gc line with a bandwidth of only 150 Mc. The system uses lighthouse tubes with an output of about 5 watts. By the end of 1965, however, an improved solid state 2-Gc system will be in service.

In NTT's second 11-Gc system, developed in 1962, the only tube is a klystron in each transmitter and receiver; everything else is solid state—transistors or diodes. The SF-T2 was designed for short-haul telephone circuits. Its predecessor, SF-T1, was primarily for branching or entrance microwave systems, connecting to a 4-Gc or 6-Gc system. Both were intended for short-distance transmission, because rain severely attenuates 11-Gc signals.

In its complex and diverse system, NTT uses two kinds of repeater: the heterodyne type for long-distance transmission and the baseband type for short distances with few relay stations, so that any distortion buildup will be held to a minimum.

If the microwave system has a lot of branching, NTT uses a baseband system because it is easier to insert or remove groups of channels on a baseband signal. If the signal has to pass through many repeaters, however, the repeated detection and remodulation introduces distortion, so long-range systems use the heterodyne repeater. Also, there generally is no branching on a long-range system.

In the baseband repeater, the output of the i-f amplifier is detected to produce a signal which is a replica of the multi-channel baseband signal fed into the first relay signal. This baseband signal modulates the repeater's transmitter as it sends the signal over the next relay span. Such a signal covers a range of frequencies from the audio range to about 5 Mc for a 1,200-channel repeater—maximum frequency is equal to the number of channels times the 4,000-cycle bandwidth per channel.

Five companies supply most of the microwave equipment used in Japan: the Nippon Electric Co., Fujitsu, Ltd., Hitachi, Ltd., Toshiba (Tokyo Shibaura Electric Corp.) and Mitsubishi Electric Corp.

This year, Japan's spreading microwave network ran into serious trouble when the height limitation on buildings was raised. Previously, fear of earthquakes has kept buildings under 10 stories. Now some networks have been cut off by new skyscrapers in Tokyo and Osaka. The problem is so serious that it may force NTT to install coaxial cable to replace microwave systems. Because new buildings have blocked microwave stations—best publicized was the blocking of Japan National Railways headquarters in Tokyo—the Japanese Diet subsequently passed a law allowing a microwave user to stop construction of a new building for as long as five years if the construction cuts off a microwave system.
New baseband repeater for solid state 2-Gc system. Transmitter-frequency mixer (color) supplies 300-mw output.

are increasing as the microwave networks grow.

Last March, NTT tested a new all-solid state 2-Gc system. First units of this UF-B4 system are being installed now, and are scheduled to be operating before the end of the year. Designed for short telephone circuits where branching is frequent, the UF-B4 generally uses a baseband repeater (see block diagram above) but can also use a heterodyne repeater for long-distance systems.

One of the most interesting parts of the repeater is the transmitter-frequency mixer, which supplies the 300-milliwatt output of the transmitter. A local oscillator of the frequency-multiplier type delivers about one watt to the mixer. In the transmitter converter, a 70 Mc carrier that has been frequency-modulated by the baseband signal is heterodyned against the transmitter's local oscillator to produce the transmitter output signal. Power loss of about 5 decibels in the transmitter mixer accounts for the difference between the one-watt frequency-multiplier output and the 300-milliwatt transmitter output.

As a baseband system, the modulator is connected to the last i-f amplifier, which supplies the 300-milliwatt output of the transmitter. A local oscillator of the frequency-multiplier type delivers about one watt to the mixer. In the transmitter converter, a 70 Mc carrier that has been frequency-modulated by the baseband signal is heterodyned against the transmitter's local oscillator to produce the transmitter output signal. Power loss of about 5 decibels in the transmitter mixer accounts for the difference between the one-watt frequency-multiplier output and the 300-milliwatt transmitter output.

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At present, the laboratory considers only the parametric amplifier, operating at room temperature, and tunnel-diode amplifiers practical for broadband microwave systems. Maser and parametric amplifiers, which operate at the temperature of liquid helium, are so expensive and difficult to maintain that NTT considers them unsuitable for first-stage amplifiers of broadband systems.

So far in NTT's networks, parametric amplifiers have been used commercially only in the over-the-horizon system between Kyushu and Okinawa. The amplifiers are placed in the front ends of the receiver for this link's two operating bands: 900 Mc for television and 2-Gc for multichannel telephone transmission.

A similar amplifier has been designed for a 4 Gc broadband system (see figure next page) that can handle 960 telephone channels. The d-c biasing voltage, which is applied to the varactor diode, is fed through the circulator and polyiron non-reflecting termination. Coaxial lines are tuned by inserting dielectric plungers.

Pump power for the amplifier, 10 to 20 milliwatts at 12 Gc, is supplied by a tripler which multiplies the output of the transmitter local oscillator. As pump power changes, variations in gain characteristics of the amplifier are small (see p. 103). Because of the design, automatic control of the pump power is unnecessary; this simplification is made possible primarily by the characteristics of the device: an optimum self-bias voltage for the diodes and suitable detuning of the resonance circuit. These characteristics eliminate variations in the bandpass characteristics.

In 1963, research started on an 11-Gc parametric amplifier built with silver-bonded diodes. These diodes are a unique Japanese development, devised by Shoichiro Kita at ECL in 1955. Many types of these devices are now made in Japan for parametric amplifiers, microwave switches, transmitter converters for repeaters and i-f limiters. Because of its Kita diodes, the 11-Gc amplifier had a very low noise figure: 3 db measured for sideband reception at room temperature and 0.7 db at 85°.

The other low-noise amplifier favored by the
Japanese is a tunnel-diode type. This amplifier is not suitable for systems operating with relatively high input lines, because its saturation level is low. This restriction can be removed if tunnel diodes with high negative conductance are chosen.

For example, in the receiver of a 4-Gc broadband system, a tunnel-diode amplifier has a noise figure only slightly worse than a parametric amplifier. But it has one big advantage: it can amplify microwaves without requiring pump power.

**Frequency multipliers**

When the Japanese became acquainted with variable capacitance diodes or varactors, they began using them in frequency multipliers.

NTT uses such a frequency multiplier as a local oscillator when the required output power of the oscillator is low and the frequency is 6 Gc or less. Under these operating conditions, the solid state multiplier has a higher efficiency (defined as the ratio of microwave output to the d-c power input) than the conventional klystron oscillator. In addition, NTT has found that the longer life of a diode and the elimination of complicated automatic frequency control circuits simplify maintenance. In the SF-U2 system—NTT's second-generation 6-Gc system—only the local oscillator is solid state. Its output is only 20 dBm (20 db above 1 milliwatt or 100 milliwatts). But in the newest 6-Gc system, the SF-U3—scheduled for field test in 1966 and for installation in 1967—all vacuum tubes are replaced by transistors.

The local oscillator in this new system (see block diagram p. 104) has a crystal oscillator, transistor amplifiers and multipliers. Operating at a frequency between 55 and 59 Mc, the crystal oscillator is an overtone type.

The input to the frequency multiplier has a frequency-modulated noise component. Because its frequency deviation is multiplied by a factor of 108, parasitic oscillations have to be suppressed and noise reduced in the crystal oscillator and power amplifiers that follow. To reduce undesired harmonics and noise, a narrow bandpass filter—composed of two stages of cavity resonators operating in the H_{021} mode—has been inserted in the output of the multiplier. The loaded Q of the filter is about 8000 and its insertion loss is about 2 db.

ECL also has developed a new frequency multiplier for the new all-solid state 4-Gc system. In this multiplier, the overtone crystal oscillates at 114 Mc. This signal is amplified to about 30 watts before two tripler stages increase the frequency to 1,025 Mc.

The last two multiplier stages are doublers. They are made with a special varactor diode, the ECL 1242, which has an output of 2.5 watts at 4 Gc (see table p. 105 for its characteristics). Thus, the power range of the multiplier varies from an input of 30 watts at 114 Mc to an output of 2.5 watts at 4.1 Gc.

Improvements in solid state i-f amplifiers have made it possible to design better solid state repeaters. A solid state i-f amplifier was used first in 1961 in the first-generation 11-Gc system. Its bandwidth was large enough to amplify 600 telephone channels. Better transistors and transistor circuitry boosted this capability to 1,500 telephone channels and such an amplifier is now in production. ECL also has almost completed work on an

**Low noise parametric amplifier**

When pump power changes, variation of gain in parametric amplifier for 4-Gc system is small.

- Variable: Gain
  - Parametric amplifier: 15 dB
  - Tunnel diode amplifier: 15 dB
- Variable: Band-width
  - Parametric amplifier: 60 Mc (0.2 dB down)
  - Tunnel diode amplifier: 200 Mc (0.4 dB down)
- Variable: Noise figure
  - Parametric amplifier: 2.5 dB
  - Tunnel diode amplifier: 4.8 dB
- Variable: Diode
  - Parametric amplifier: MS-4104
  - Tunnel diode amplifier: MA-4604A
Frequency modulator (top), with four abrupt junction diodes (shown in color) in tuning circuit has linear output. Linearity, bottom, is within 1% over range of 70 Mc ±8 MHz.

An improved amplifier that can handle 2,700 telephone channels—more than quadrupling capacity in 4 years.

A key performance characteristic is output voltage. The output voltage of the i-f amplifier, designed for the repeater of the new solid state 4-Gc system, is 90 volts into a load of 500 ohms in parallel with 10 picofarads. This is a desirable performance for a heterodyne-type repeater, which requires a large i-f amplifier output supplied to the transmitter frequency mixer. In addition, a large i-f input decreases the microwave loss between the input of the local oscillator and the output of the transmitter frequency mixer. The new i-f amplifier has a frequency characteristic which deviates less than 0.2 db at 70 Mc + 10 Mc.

Another component that has made an important contribution to microwave technology in Japan is the hyperabrupt junction diode, which has made possible solid state frequency modulators.

The useful characteristic of a hyperabrupt junction diode is the value of n in the equation for junction capacitance:

\[ C_j = \frac{C_k}{(\phi - V)^n} \]

where

- \( C_j \) = junction capacity
- \( C_k \) = a constant
- \( V \) = bias voltage supplied to diode
- \( \phi \) = contact potential

Usually, \( n \) is larger than \( \frac{1}{2} \) and sometimes is as large as 5 or 6.

Microwave repeater stations, like this one at Futago Yama, dot the hillslopes of the Japanese countryside. Inside the building is a heterodyne repeater.
Switching circuit with Kita diodes has transition time of 15 to 20 nanoseconds for break and 40 nanoseconds for restoration. That is more than adequate, even for high-speed data transmission of 1,000 to 2,000 bands for which a transition time of 40 microseconds is required.

If a diode with an n value of about 2 is placed in the tuning circuit of the modulating oscillator and its bias voltage is controlled by the input signal, its linearity is good enough so the oscillator can modulate a super multi-channel signal. Under these conditions, the variation of differential modulation is less than 1% in the range of 70 Mc ± 4 Mc. Sensitivity is more than 10 Mc per volt.

Also, when several diodes are connected in parallel and are given different bias voltages to compensate for the characteristics of each, linearity can be improved to cover a broader range of frequency deviation. One modulator designed this way used 4 hyperabrupt junction diodes (see figure p. 104) and its variation of differential modulation was less than 1% in the range of 70 Mc ± 8 Mc (see figure below circuit on p. 104).

### Solid state switching

Traditionally, the reed relay has been used for switching an r-f channel to a protection channel when there is equipment failure or severe fading. The transition time of these mechanical devices is 1 to 2 milliseconds. Since this time is barely satisfactory for the transmission of 50-band telegraphy, it is clearly unsatisfactory for high-speed data transmission. Therefore, ECL has developed a solid state unit, using Kita diodes, for the 11-Gc system and the unit can be used in the new 15 Gc system, too. The actual design goes back to 1959, even though it has been used only recently.

When such a switching circuit (see figure above) is used in the receiving side of a broadband telephone system, the distortion introduced by the diodes which are positively biased, must be kept small. The impedance ratio of reverse-biased diodes to positive-biased diodes determines the quantity of cross talk between switched channels.

The insertion loss of this circuit is less than 0.6 db. The transition time is about 15 to 20 nanoseconds for break, 40 nanoseconds for restoration. These times, which include the operation times of the driving circuits, are more than adequate because the transmission of high-speed (1,000 to 2,000 band) data requires a transition time of about 40 microseconds.

To extend solid state in microwave, researchers in Japan are concentrating on developing power transistors and varactor diodes that can handle the higher frequencies at higher powers. The biggest obstacle is not system design, but lack of understanding of the diffusion technology for producing such devices.
Japanese technology

After a lull, numerical control is enjoying new popularity

Activity peaked in 1960, then fell off. Now systems are being installed at a rate that is more than double earlier sales. The newest entry is a low-cost point-to-point system

Kazuto Togino
Government Mechanical Laboratory
Ministry of International Trade and Industry

It is a Japanese trait to embrace the newest in technology even if its application and benefit are not immediately obvious. That is one explanation of the enthusiastic acceptance of numerical control of machine tools in 1955. Development activity peaked in 1960 and then slumped sharply as interest waned. The recent resurgence of interest in numerical control is based, this time, on the economy that such systems can generate for the buyer.

The clearest picture of what's been happening can be gained by examining the sales figures for the two kinds of numerical control: so-called point-to-point systems in which the numerical input information moves a tool from one specified point to another by the shortest possible route; and continuous contouring, in which the numerical instructions direct the cutter to move along some predetermined path.

In 1964, 36 point-to-point systems were sold, almost three times the number sold in the five preceding years. That represents a sales volume of about $360,000. This year, sales are running nearly 120% ahead of last year. Japan's metalworking firms should buy 75 to 80 such systems, about $750,000 worth.

Sales of continuous-contouring systems are enjoying growth too. Last year, 21 systems were sold at a value somewhere near $1 million; 34 such systems had been sold in the previous five years. This year, sales are up 100% and control makers should deliver 40 or more systems, worth nearly $2 million.

Despite the rapid growth, numerical control remains a small business in Japan, probably well under $3 million for 1965. In fact, it is so small that one company, Fujitsu Ltd., dominates the field. Industry experts estimate that Fujitsu's share of the numerical control business ranges from a conservative guess of 70%, to the company's own claim of 90%.

Fujitsu's Japanese competitors are Nippon Electric Co., Toshiba (Tokyo Shibaura Electric Co.), Hitachi Ltd., Mitsubishi Electric Corp., and Yaskawa Electric Mfg. Co. But Fujitsu sees the stiffest competition coming from the United States. Several Pratt & Whitney Tape-O-Matic machine tools equipped with numerical point-to-point systems, have already been imported into Japan.

Even of more concern to Japanese producers is the current patent situation on numerically-controlled machines with automatic tool changers, like Kearney & Trecker's Milwaukee-Matic. Though a few machines of this type have been built in Japan (by Hitachi Ltd., Niigata Iron Works, and the Matsura Manufacturing Co.), many foreign patents now registered in Japan may block their future manufacture.

In many ways, the Japanese again have followed

The author

Since 1949, Kazuto Togino has been on the staff of the Government Mechanical Laboratory. An electrical engineer with an interest in machine tools, he designed the numerical control system for a large precision-boring machine. His Ph.D is from Tokyo University. Currently, as head of the Systems Research Section, he is studying automation systems for applications ranging from production to traffic control.
Small and compact, Fanuc 260 numerical control has an attractively low price—$6,500.

the lead of U.S. industry. There is an obvious preference for the less expensive point-to-point systems, just as there is in the U.S. In addition, Japanese control makers are concentrating more on finding new applications for numerical control and selling it than in engineering new systems—as are their American counterparts. New design plays a minute role these days.

**Fanuc 260**

Japan's newest system is Fujitsu's Fanuc 260 and it is responsible for the boom in point-to-point systems. Small, compact and low in price, selling for about $6,500—it is supposed to be able to do 80% of the ordinary machining operations. All transistorized, it was introduced last year and production began last spring.

The two major units in the Fanuc 260 are shown in the block diagram above: a control unit and one electrohydraulic pulse motor for each dimension. The motor serves two functions—it is a digital-to-analog converter and it supplies power to drive the tool in one dimension. A three-dimensional machine has three such motors.

The electrohydraulic pulse motor has been responsible for Fujitsu's strong patent and market position in Japan. When it is used in numerical control, no feedback system is required to measure where the tool is at any instant. Most numerical control systems require a position-measuring transducer and a feedback link to tell where the tool is before another numerical instruction can be followed.

Although Fujitsu's pulse motor, shown below, was invented in 1956, it is used in almost all Fujitsu's numerical control systems, and its operation is still interesting.

Operating through a gear train, an electric pulse motor drives a spool-type, four-way valve to run a hydraulic motor that is connected to the feed screw of a machine tool. The motor rotates 1.5° for each electric pulse it receives. Normally the gear ratio through which it drives and the pitch of the feed screw are selected so that the tool moves 0.01 mm
for each pulse fed into the motor by an oscillator.

The motor starts instantaneously at pulse rates up to 2,000 per second; its maximum continuous pulse rate is 6,000 per second. That means it can drive the feed of a machine tool as fast as 3,600 mm/min. On the driving end, motors are available with outputs ranging from 0.4 to 6 horsepower.

The output position of the fixed-displacement hydraulic motor is fed back mechanically through a special nut. In this way, the actuator output shaft continually follows the low-power pulse motor.

In the control unit there are five main subsystems: a punched-paper tape reader; a central command unit that carries out control functions and computing; a magnetic drive circuit to actuate the clamp magnetics of the pulse motors and the switching relays; a pulse motor drive circuit that excites and rotates the pulse motors; and a power supply.

At the start of operation, the input control circuit activates the paper tape reader (see figure above). Coded data from the tape is distributed by the decoder and stored either in a sign register, an alphabetic register, a feed register or a number register. Direction of the movement is in the sign register; which axis (x, y or z) is in the alphabet register; the speed of feed is in the feed register; and how far to move the feed is in the number

---

**Typical Fujitsu numerical control system** has no feedback circuit to report where the tool is. Feed information subsystem (in color) goes into a number register; each pulse from the oscillator empties one number from this register into a subtraction circuit, until a zero detecting circuit finds the register is empty.

---

**Truing of wheels** is manually controlled in wheel grinder used by Japan National Railways on new Tokaido line. But diameter of wheels on the same axles are matched by automatic grinding (controls shown in color). In the 75-ton wheel grinder, four identical systems grind eight wheels of a car.
register (shown as a five-unit device).

Data stored in the alphabet and sign register goes into the output circuit to direct the tool movement along the proper axis. Movement is along only one axis at a time. Meanwhile, data in the feed-rate register feeds a pulse oscillator in a distribution control circuit to regulate the frequency of the drive pulse to the electrohydraulic pulse motor.

The same distribution control circuit empties the number register into a subtraction circuit, one number at a time every time the oscillator produces a pulse—thus moving the feed screw. The content of the number register is continually checked by a zero-detecting circuit in the distribution control circuit. When the contents become zero, the pulse distribution stops.

Of the more than 100 numerical control systems sold in Japan, the most technically interesting are a fully automatic camshaft grinder and a railroad wheel grinder. The controls of both were supplied by Fujitsu.

Wheel grinders

Two punched-paper tapes run the Fanuc 260 control system of a camshaft grinder which produces automobile camshafts completely automatically. One tape contains the profile of the cams; the other has sequence information to position each of the several cams on the shaft at the proper angle.

The numerical control positions the grinding wheel so it touches the cam profile at the point where the valve lifter is intended to touch. To do this, the wheel is raised in the $y$-direction while it is pushed forward in the $z$-direction (see below). Since the cam profile is determined by the cam rotational angle and the lift is a function of the cam angle, simultaneous control of three dimensions is required: $\theta$ (the cam angle), $y$ and $z$.

To program the machine, it’s necessary to plot a curve describing the position of the grinding wheel at every point. Then this curve is divided into many tiny straight lines. Next, numerical values describing each increment are punched into the cam profile tape.

On Japan’s new Tokaido railroad, the 125 mile-per-hour high-speed line between Tokyo and Osaka, the high speed wears grooves in the wheels. If the brakes are applied hard while the train is running at high speed, flat spots form on the wheels as they skid along the track. Only grinding can true the wheels back to their required shape and roundness because they are made of metal which has been heat treated to increase the hardness. To speed the wheel grinding operation and keep costs down, Japan National Railways has installed a grinder with numerical control (see bottom p. 108).

Though the wheel grinder is a 75-metric-ton machine that grinds eight wheels at a time, the fundamental principle of control is the same as that in the Fanuc 260 described previously. A separate Fujitsu electrohydraulic pulse motor feeds each grinding wheel. Gridding of the two wheels on the same axle (the eight wheels are on four separate axles) are synchronized, though machining front and rear axles of a truck is performed independently and is performed while the truck is still mounted on the coach.

Just as the electrohydraulic motor of the Fanuc 260 positioning system is run by pulses from an oscillator, so are the motors of the grinder. But there are two separate oscillators for each motor: one for fast traverse (moving the grinding wheel into position), and the other for feeding the grinding wheel as it cuts. The frequency that directs fast traverse can be changed at the control panel.

Truing of each wheel is performed by manually operated control. An operator feeds the grinders until the wheel in the worst shape on each axle has been trued. Then an automatic control takes over to match the wheels on each axis.

For matching, the right wheel of each axle is considered the standard. A sensor rolls over each wheel while a photoelectric coder connected to it generates pulses—1,000 for a complete revolution of the sensor. Signals from the coders on the right and left wheels are fed to a difference counter at the same time the coder on the right wheel feeds a preset counter. When the latter reaches 17,400, corresponding to two revolutions of a wheel whose diameter is the standard 870 mm, the count in the difference counter represents how much the wheels differ in diameter. If the difference is plus, the left grinding wheel is fed forward; if minus, the right wheel advances.

A low-cost binary display on the control panel tells the operator how much the diameters of each pair of wheels differ. From this information he can decide which grinding feed rate to use.

Now the railroad has one grinding machine in its yards outside Osaka. In November, the average speed on the run was increased to 103 miles per hour from 80, and wheel wear is expected to increase. JNR will need to set up another wheel grinder in its Tokyo yards and since the numerically controlled unit built by Kishou Seiko Kaisha Ltd. has worked so well, JNR will probably get another just like it!
Japanese technology

Manual process control makes way for computers

High labor costs, potential work force shortage, and expanding production encourage new technology

By Atsunobu Ichikawa
Professor, Tokyo Institute of Technology

Faced with sharply rising labor costs, a potential labor shortage and expanding production, Japanese industrialists are slowly replacing manual process control with control by computer.

Like many other technical innovations, the concept of computer control was borrowed by the Japanese from the United States. It was adopted after the first installation had been completed at the Texaco Co.'s Port Arthur (Tex.) refinery in 1958.

Today, computer control is moving in two directions in Japan: direct digital control and integrated control. Direct digital control, also borrowed from the U.S., was endorsed last month when Hokushin Electric Works Ltd. introduced a new low-cost DDC machine of Japanese design [Electronics, Nov. 29, 1965, p. 132].

At the other extreme, some Japanese companies are installing hierarchies of computers for integrated control. Nippon Kokan Kabushiki Kaisha, a big steel producer, will install 15 to 17 computers at its new Fukuyama works—now under construction—to control production, scheduling, management and processes in the plant. The machines will be used on three levels: off-line planning, off-line scheduling and process control.

The author

Atsunobu Ichikawa is a chemical engineer who has specialized in the dynamic response of processes and their control. He has a doctorate from the Tokyo Institute of Technology and has also attended Princeton University and Case Institute of Technology.

Since the Japanese first embraced computer control, 50 such systems have been installed at plants producing steel, petroleum, chemicals and electricity. Most of these machines were built to American designs. Of the nine supplying control computers, seven have licensing agreements with U.S. companies. Hitachi Ltd.’s HITAC 4010 is the RCA 3301 built under license. The Yamatake-Honeywell Keiki Co. is a joint venture that produces process control computer [though the Nippon Electric Co. produces Honeywell modified general-purpose computers]. And Mitsubishi TRW is a joint venture that used to build TRW process control computers until the Thompson-Ramo-Wooldridge Co. went out of the business. Now Mitsubishi executives are trying to decide what computer to use in its future control systems.

Only Hokushin and Fujitsu Ltd. have no ties to U.S. computer makers. Hokushin’s new DDC controller, an integrated circuit machine that costs about $20,000, was developed jointly with the Fischer & Porter Co., the U. S. instrument company. Toshiba’s first control computer, the Tosbac 3300, was Japanese designed. But Toshiba now has a licensing agreement with the General Electric Co. to build its process control computers.

Another new Japanese-designed process computer is Fujitsu’s Facom 270 series with three models: models 10 and 20 have discrete components; model 30 will have integrated circuits.

The biggest Japanese user of computers for control is the iron and steel industry. At least 15 machines are controlling basic oxygen converters, blast furnaces, and rolling mills. In the utility industry, 14 machines have been installed and 11 more are on order. Nearly all 25 are for monitoring operations, as opposed to control. Chemical and petroleum processors have installed more than 10
computers to control processes ranging from cement-making to the manufacture of ethylene and vinylchloride.

Because of the complexity of most processes, it is difficult to pin down all the savings resulting from computer control. For example, installing a computer in the control loop requires a better understanding of the process; this understanding often leads to better process equipment which improves the output of the plant. Integrated digital control, a large computer monitoring other computers which control processes, would seem to allow optimization on a large scale that would be impossible by manual control.

Although many of the computer control installations in Japan are duplicates of those in the United States, a few are unique because of differences in process or differences in computer philosophy.

Three such installations are control of a basic oxygen converter, automatic control of a cement kiln and sequential control of a batch fermentation process.

**Controlling the oxygen converter**

Making steel in a basic oxygen converter is one of the most significant improvements in metallurgy in a decade: it cuts the time to convert a batch of iron to steel from about 10 hours in an open hearth furnace to less than one hour. During the first part of the process, pure oxygen blows through molten steel, burning out impurities such as sulphur and phosphorous. During the last part or finishing portion, carefully calculated amounts of ferroalloys, carbonizing agents and other additives are injected to produce the quality of steel desired.

The critical part of the process is determining how long to blow oxygen through the melt, and what temperature to heat the steel at the end of the oxidizing. The computer makes both calculations and also predicts the proper amounts of additives to bring the steel to the desired mix.

In Japan, an oxygen converter was brought under real-time computer control for the first time in 1963. A HOC 300 computer, built by Hokushin Electric Works Ltd., controlled the process at the Kawasaki Works of Nippon Kokan Kabushiki Kaisha.

Because the mathematical model that relates the variables which might affect the process is so essential in computer control, it was designed first. The model was derived through an extensive theoretical and experimental study of the company's existing plants by an off-line computer. The model that evolved from this exhaustive study is

\[
y_{e.o} = y_{m.o} + \Delta y_{e.o-1} = y_{m.o} + f(u_1 v_0 - v_t)
\]

where

\[
u = \left\{ \sum_{1}^{h} (y_{m.n} - y_{m.o}) \right\}
\]

\[
v_0 = v[x_{01} x_{02} \ldots x_{0n}]
\]

\[
v_1 = v[x_{11} x_{12} \ldots x_{1n}]
\]

\[y_e = \text{control objective of variable } y
\]

\[y_m = \text{measured value of variable } y
\]

In this formula, certain key variables are established as control objectives and designated by the letter \(y\). Other variables which affect these objective variables are designated by \(x^1 \ldots x^n\). Thus, in this formula, the superscript is not a raising to the power, merely a way of describing the variables. The variables have a subscript which refers to a batch of material entered into the converter. Thus any variable with the subscript \(o\) refers to the charge currently in the converter; any other suffix \(i\) refers to the \(i\)th previous charge. The function \(v\) was derived theoretically and then refined by statistical analysis on actual data.

The computer determines the target value (or desired value) of a variable \(y_{o.o}\) from this mathematical model and from data measured and stored while previous charges of iron were being processed. Function \(u\) is a moving average of deviations from previous charges. The deviation represents the difference between the predicted value and the actual value. The term \((v_o - v_t)\) is an adjustment.

To control the oxygen converter, the computer receives data on 144 variables. Each time the computer recognizes a critical
input, which is related to each control equation, it examines the variables in the equation to see if they have been renewed and stored. If so, the computer resolves the equation. One such variable is the composition of the charge as measured by an X-ray instrument. In this way, succeeding computations have no errors introduced by earlier analysis.

At any time, an operator can ask to see variables needed to guide the steelmaking process, such as hot steel temperature and end-point temperature. A priority interrupt stops any computation and displays these variables on call.

The management of Nippon Kokan believes the installation has been a total success after two years of operation. The computer reached several control objectives with an accuracy far greater than that experienced when skilled operators ran an oxygen converter.

The company believes the computer control paid for itself within a year by saving 100 charges that would not have met specifications unless the control had intervened. In addition, the company says it is using smaller amounts of expensive ferroalloy material because the computer calculates the required amounts accurately.

### Making cement

There are two companies in Japan making cement under computer control. The installations of an RW-300 computer at the Kumagaya plant of the Chichibu Cement Co. and the TRW-330 machine at the Nanyo plant of the Tokuyama Soda Co. were joint efforts of Mitsubishi TRW and the plant involved. Although the computer is similar to that installed at the Riverside (Calif.) Cement Co., the approach is quite different.

Both the Riverside and the Japanese installations optimize by “hill climbing”—measuring variables, calculating output; then changing the variables to improve the output and repeating the calculation until an optimum point is reached. But the Japanese could not stabilize the kiln by feedback—the method used at the California installation—because they used a different process. Riverside mixed dry ingredients and roasted them in a short kiln about 330 feet long. The Japanese companies mix their ingredients as a slurry, then fed the stream into much longer kilns, nearly 500 feet long at Chichibu and more than 600 feet at Tokuyama. Because the Japanese kilns are so much longer, the roasting process requires far more heat than the U.S. method and has a time constant of four hours compared to one. The time constant is the number of hours between changing a variable and measuring the effect of that change.

If feedback stabilization is applied to the long Japanese kilns, the process tends to “hunt” and never stabilizes because the time constant is too long. Thus the Japanese applied a combination of feedforward and feedback in critical control loops (see p. 111). Because the technique requires additional memory, the Japanese computers had memories twice as large as the California installation—32,000 words compared to 16,000.

### Improving flavor

In Japan, as many restaurants and homes serve monosodium glutamate for seasoning as serve salt. Ajinomoto Co., Inc., a leading manufacturer of the seasoning, uses a type of direct digital control to set up the sequence for a fermentation process in a pilot plant at its Kawasaki works. The company soon will extend the sequence control to its production lines where it is now using a relay sequence control on some lines.

Ajinomoto’s fermentation process is a batch type reaction in which enzymes produce complex chemicals. It requires strict sequencing of operations. Before the process starts, steam is introduced in each part of the reactor to sterilize it. Then an enzyme strain is placed in a sterilized medium and air is fed to it under strict conditions. Improper manipulation of any one of many valves that regulate the process can produce harmful microbes or kill the useful ones.

When Ajinomoto decided to adopt computer control, the company concluded that none of the machines available was reliable enough to control its critical process. So Ajinomoto, working with Hitachi Ltd., developed a special computer—the Kodal 3061.

One interesting feature of the Kodal 3061 is the read-only memory that stores the fixed program. It has square magnetic cores, as the figure above shows. The cores are large and give high output voltage to reduce noise.

The program is stored on 64 boards; each has a capacity of 64 words of 24 bits. When the program is changed, excite wires are threaded manually inside and outside the cores. If the excite wire is outside, that core corresponds to a zero; if the wire is inside, it corresponds to one. Because the computer uses a fixed program memory, its cost—$25,000 to $30,000—is lower than if it had an ordinary core memory of equivalent size.

During the past six months, this computer has had a time availability of 99.90%.

Although engineers are enthusiastic about computer control, the current recession in Japan will prevent some prime users from automating—particularly steel and chemical plants, industries which suffer from overcapacity.
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**ELECTRICAL CHARACTERISTICS**

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<thead>
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<th>Parameter</th>
<th>3SK11</th>
<th>3SK12</th>
<th>3SK13</th>
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<td>$Y_f$</td>
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<td>$C_{iss}$</td>
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<tr>
<td>$R_{DSS(on)}$</td>
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<tr>
<td>$t_{on}$</td>
<td>$V_{DD}=6V$, $R_L=100\Omega$</td>
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<tr>
<td>$t_{off}$</td>
<td>$R_{GS}=50\Omega$</td>
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<td>$J_{DSS}$*</td>
<td>$V_{DS}=6V$, $I_{D}=0.5mA$, $f=1kHz$, $R_{G}=10M\Omega$</td>
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<td>$NF$</td>
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*Initial Drift*

**MAXIMUM RATINGS**

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<td>$V_{GSX}$</td>
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<td>$T_{ch}$</td>
<td>$\leq 150^\circ C$</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>$-55$ to $150^\circ C$</td>
</tr>
</tbody>
</table>

---

**3SK11**

ac amp.

**3SK12**

Switching

**3SK13**

dc amp.

This family utilizes a hermetically sealed four-lead package which is similar in shape to the JEDEC TO-18.
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<table>
<thead>
<tr>
<th>GME CATALOG NUMBER</th>
<th>COMPETITIVE EQUIVALENT</th>
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<td>SE101</td>
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<td>254G3</td>
<td>SE102</td>
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<td>254G6</td>
<td>SE105</td>
<td>6-Input Gate Expander</td>
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<td>254DA</td>
<td>SE106</td>
<td>Dual 5-Input Gate Expander</td>
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<td>264P</td>
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<td>3-Input Power Gate*</td>
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<td>SE116</td>
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<td>SE160</td>
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<td>263Q</td>
<td>SE181</td>
<td>Quadruple Inverter</td>
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<td>264T2</td>
<td>CS727</td>
<td>Triple 2-Input NAND/NOR Gate*</td>
</tr>
</tbody>
</table>

*Expandable
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An EE with six to ten years' experience (and maybe an advanced degree or two) has no business wasting his time on repetitive projects.

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2. Single control knob selects any of 32 ranges—less chance of incorrect settings and burnouts.

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† 630A same as 630 plus 1½% accuracy and mirror scale only $59.50

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- Hard soldered junctions eliminate thermal fatigue.
- Large emitter-base area puts an end to secondary breakdown.
- True monolithic construction stops runaway leakage.

<table>
<thead>
<tr>
<th></th>
<th>SINGLE ENDED</th>
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<td>200</td>
<td>10A</td>
<td>10A</td>
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</tbody>
</table>

And, of course, reliability is assured by the exclusive Westinghouse Lifetime Semiconductor Guarantee. For full information call your Westinghouse salesman or distributor, or write to the Westinghouse Semiconductor Division, Youngwood, Pennsylvania.

*Westinghouse warrants to the original purchaser that it will correct any defect or defects in workmanship, by repair or replacement f.o.b. factory, for any JEDEC-type silicon power semiconductor during the life of the equipment in which it is originally installed, provided said device is used within manufacturer's published ratings and applied in accordance with good engineering practice. This warranty is applicable to devices of the stated types shipped after March 9, 1964, until further notice. This warranty shall constitute a fulfillment of all Westinghouse liabilities in respect to said products. This warranty is in lieu of all other warranties expressed or implied. Westinghouse shall not be liable for any consequential damages.

You can be sure if it's Westinghouse
Now data systems designers can convert synchro or resolver signals to digital output with Fairchild’s new F-613 and F-615 microcircuit modules. Integrated circuitry gives these modules exceptional reliability, small size and low cost—ideal for airborne and ground support instrumentation as well as industrial controls and navigation systems. The block diagram below illustrates how the F-613 and F-615 combine to convert synchro or resolver voltages to digital output.

Add synchro conversion to your own data system. Building block construction permits the systems designer to add only the functions he needs to his existing system. For example, the F-613 module may be used with any suitable A-D converter.

Check these design features:
- Operating Temperature Range: 
  
  
  $-54^\circ C$ to $71^\circ C$

- Resolution: 13 Bits (when used with F-615 A-D Module)

- Accuracy: $+0.05\% \pm 1$ least significant bit (standard) higher on request

Designed to meet MIL-E-5400, Class 2

**DESCRIPTION OF OTHER TYPE MICROSERIES 600 MODULES**

- F-611-5 Microplexer, Basic 5-Channel Multiplexer
- F-612 Microstrobe, Sample and Hold
- F-614 Microadapter, AC-DC Adapter
- F-624 Microadapter, Digital-AC Adapter
- F-625 Microconverter, Basic Digital-DC Converter
- F-632 Microregulator, Reference Voltage
- F-633 Microregulator, Line Voltage
- F-634 Microadapter, Digital-Synchro Adapter

**F-613**

- Operating Temperature Range: 
  
  $-54^\circ C$ to $71^\circ C$

- Resolution: 13 Bits (when used with F-615 A-D Module)

- Accuracy: $+0.05\% \pm 1$ least significant bit (standard) higher on request

**F-615**

- Analog-Digital Converter

**F-613D**

- Non-Linear Corrector

**F-615 E**

- Synchro Input Expander

**F-613R**

- Strobe Generator

The F-613 is a single 250 cubic inch module consisting of: F-613A, F-613D, F-613E and F-613R. The F-615 A/D Converter Module is 125 cubic inches.
Probing the News

Space electronics

France joins the space age club

The successful launch of its first satellite was technically unimpressive but it became a membership card in the world's most exclusive organization

By Robert Farrell
Paris News Bureau

The 88-pound satellite that roared into orbit from its launch pad in the Algerian Sahara Nov. 26 was not a complete technical success, but it was a resounding political coup. It made France a member of one of the most exclusive and costly clubs in the world—the space age club. There are only two other members—the United States and the Soviet Union.

The A-1 satellite's main purpose—to test the French-developed, three-stage Diamant booster—was accomplished: the booster worked well. Transmission from the satellite, however, was almost a flop: one of the satellite's four antennas apparently was damaged during powered flight. This lack of transmission almost spoiled the second purpose of the launch—to test France's two satellite ground station networks, called Diane and Iris. Diane consists of tracking stations at the Hammaguir launch base in the Sahara and Pretoria, South Africa. Iris has telemetry and control stations at Hammaguir, Pretoria, Ouagadougou in West Africa, and in Beirut, Lebanon.

During the first orbit, neither Iris nor Diane picked up a signal. On the second pass, Hammaguir picked up a faint noise—enough to know the A-1 was in orbit. The equipment on board the satellite—for the most part silent—consists of a radar transponder and two transmitters; one is a beacon and the other is for telemetry. Batteries on board were supposed to keep the

Transmission from France's first satellite was late, weak and short-lived, but it proved that the Diamant booster worked—and well.
This new Precision product is a unique semi-flexible coaxial cable for low-loss RF transmission. Five linear splines of Teflon support the center conductor within a seamless aluminum or copper tube—achieving essentially an air-dielectric coaxial cable, light in weight and mechanically strong. Can be supplied with a jacket of vinyl or Teflon.

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Precision Adapters

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With this special adapter designed by Precision's engineers, Coaxitube can be terminated in standard UG connectors—with no deviation of electrical characteristics.

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France, however, does not intend to confine its space effort to national programs. It is participating in the European space launcher project by building the second stage of the Europa rocket. It is also working on a satellite program with NASA. The first one, designated FR-1, was scheduled to be launched Dec. 6 by a NASA Scout booster from Vandenberg Air Force Base, Calif.

The FR-1 satellite, designed and developed by CNES, is France's first scientific satellite. Scheduled to be launched into a near-polar orbit, the FR-1 was designed to measure the effects of the earth's magnetic field on very-low-frequency propagation. The experiment was to involve continuous radiation of signals from two ground stations, one in France and the other at Balboa, Panama. The satellite antenna system was to assist in tracking vlf signal propagation along the flight path and in measuring signal strength direction and signal-noise ratio.

Three more satellites will be launched from Hammaguir powered by Diamant boosters. In Janu-
ary, the 80-pound D-1 satellite will go up—the first French scientific satellite orbited by a French booster; later, the D-1B; and in mid-1967 the 175-pound D-1D.

After mid-1967, the French will shift their space shots to a new $60-million launch center now under development in French Guiana, in South America. This base, which will employ some 25,000 people, will not be completely finished until 1969 [Electronics Nov. 1, p. 159].

In all, the French have orbited one satellite and scheduled four more flights. In addition, the French hope to work out a new agreement with NSA for launching a meteorological satellite with a NASA booster sometime in 1967 to 1968.

III. Market

As might be expected, the bulk of the electronics business is handled by French electronics companies such as Compagnie Francaise Thomson-Houston and the Compagnie Generale de Telegraphie Sans Fil (CSF). One of the reasons for the French effort is to keep its companies proficient in advanced technology.

Initially, the French leaned on a U.S. supplier for such satellite components as silicon cells but now these items are being developed by Societe Anonyme de Telecommunications. U.S. companies are involved if they have French affiliates, such as the International Telephone and Telegraph Corp.'s wholly-owned subsidiary, Laboratoire Central des Telecommunications (LCT). They can also sell to France if they develop equipment so superior that the French have no recourse but to buy from the U.S.

When France moves its space activities to French Guiana, there may be more opportunity for U.S. business. Although CNES has already ordered its two big tracking radars from Thomson-Houston—similar to the Radio Corp. of America's AN/FPS-16 missile range standbys—two digital computers must still be purchased and two new telemetry stations must be outfitted.

France hopes the favorable location of the site for launching will attract many foreign users.
Hong Kong adds quality electronics to its bargain basement line

Growth comes from production of components, television parts, and better products at new American plants

By David Roads
McGraw-Hill World News

Hong Kong, for years a producer of cheap single-band transistor radios, is tuning into a wider electronics business wavelength. Pressed by the cheap sets of Taiwan and sparked by American interest, the old bargain-basement Colony is humming with talk of diversification, new markets, and improved and better-looking products. Though the growth rate this year will fall short of doubling—it has doubled annually for the past four years—businessmen are pleased that the increase will come as much from manufacture of more sophisticated products as from the inexpensive radios, which last year brought in $16 million.

The brightest news in Hong Kong has been the success of the component producers. At the Department of Commerce and Industry, assistant trade officer F. S. L. Young predicts exports of semiconductor devices will hit $7 million in 1965.

Businessmen are pleased, too, by the news that the United States has become its biggest electronics customer, picking up slack caused by a new United Kingdom surcharge of 15%.

I. Easy to read

United States companies moving to Hong Kong have gone there for several reasons. The Colony is one of the freest places in the world. Export and import licenses can be obtained in a matter of hours. It has British laws, written in English, making it easy for American executives to understand the few regulations the Colony imposes on manufacturers. And then there are the bargains in labor, components, and investment.

The Japanese transistor radio manufacturers, who preceded the Americans to Hong Kong by eight years, went there to bypass import quotas imposed by Commonwealth countries.

Among U.S. companies that have moved to Hong Kong are Arvin Industries, the Fairchild Semiconductor division of the Fairchild Camera & Instrument Co., the Oak Electronics Co., and the Ampex Corp. And rising smartly in the suburbs of Kowloon, a ferry ride across the bay from the island of Hong Kong, is the nearly com-
Fact No. 1. Carpenter offers you the widest selection of glass sealing alloys available today. This increases your opportunity to meet expansion characteristics more precisely. It strengthens the possibility of doing it with the most economical alloy... or one that is easier to fabricate.

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Growth ahead. Most component producers in Hong Kong can see only increasing business ahead. Many, like a subsidiary of the Sprague Electric Co. expect to supply a lot of parts to the Philco Corp.'s new television and radio plant in Taiwan, when it starts producing late in 1966.

The component men reflect the talk of radio assemblers in Hong Kong who now import almost all their components from Japan but who would like to buy them locally. A few small suppliers have already started producing such components as capacitors, coils, transformers, loudspeakers and printed circuit boards.

Although the assemblers have eyed the Fairchild operation in Hong Kong longingly, nobody is yet buying Fairchild's semiconductor devices. One reason is that Fairchild makes only silicon transistors and the assemblers use germanium. Said a radio executive, "Unless a silicon device is designed especially for a radio application its signal-to-noise ratio is bad."

II. Fallout easing

The other reason is price. Many
of Hong Kong's radio producers buy transistor fallouts from Japanese companies — devices that haven't met the semiconductor manufacturer's specifications. Even after sorting, the units cost only two or three cents a piece.

But this too is changing. E. P. Wethey, president of Transelectronics Ltd., has been studying the operation of other Hong Kong radio assemblers and he notes, "More and more companies are buying components against specifications instead of buying fallouts."

Still, radio production is the backbone of Hong Kong's electronics industry today. In 1964, the industry produced nearly 4 million sets, valued at $16 million. In the first seven months of 1965, 3 million sets were produced worth $9 million.

The decline in gross income from sales of radios — and a sharp reduction in average price to $3 a set this year from $4 a set last year — illustrates Hong Kong's chief problem. Competition from Taiwan has cut prices sharply, particularly for the pocket-sized, single-band radio, which has been Hong Kong's strength.

Less expensive. Because Taiwan labor is clearly cheaper [Electronics, Nov. 1, 1965, p. 114] many electronics companies in Hong Kong are now developing more sophisticated sets, 7- to 10-transistor units with several hands, a-m/f-m sets, and some shortwave units. And some of the firms are building handsomer, more attractive radios.

International Service Corp. Ltd., which started producing radios just four years ago and grew to nearly $2 million sales in 1964, felt the pinch so sharply, it was forced to take in contract work. For 1966, however, its president, George M. Baker plans some new products. One is a waterproof radio for yacht- ing enthusiasts and beach parties. Then, too, he'll be putting a line of multiple-band sets in teak cabinets instead of cheap plastic. Later he may add stereo receivers in teak cabinets. In addition he's adding production of f-m radio sets.

III. Gathered forces

Wireless Products Ltd., the second largest producer of radios in the Colony, fared better — enjoying

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For detailed information, write: Aerospace Electronics Division, Taber Instrument Corp., Section: 158, 107 Goudry St., N. Tonawanda, N. Y.
substantial increase in sales. Last month it moved to its own eight-story building from scattered lots in two buildings. In its new plant the company has the capacity to produce 150,000 radios a month. This year, its sales should approach $4 million. Only last month, the company chartered an airplane to fly 80,000 radios to Kayson’s International Ltd., an importer in Los Angeles, an indication of how good its business is.

The shipment indicated another change in Hong Kong electronics: the U.S. has become its biggest customer by far. As recently as 1963, the United Kingdom ranked as the biggest buyer when it imported 46.7% of Hong Kong’s electronics output; U.S. companies bought 36.6%.

This year, United Kingdom imports fell sharply because of a reduction in demand and the 15% surcharge imposed in March to protect the British pound sterling. In the first seven months of 1964, the U.K. bought 731,000 Hong Kong radios, worth $3.3 million. In the same period this year, the country imported only 457,000 sets at a value of $2.06 million. Meanwhile, from January through July, U.S. companies bought nearly 2 million sets, costing 86.1 million.

New markets. Obviously, Hong Kong radio producers would have been in serious trouble if some new markets had not developed, particularly in Canada, Southeast Asia, the Middle East and Africa.

With apparently dim prospects in hand, why did IT&T and Zenith pick Hong Kong for its new plant? Wethey, who surveyed many other locations including Portugal and Taiwan, lists a handful of advantages:

* Hong Kong is near a good source of components in Japan and a components industry is building up in the Colony. That’s important since the expense of components accounts for nearly three-fourths the cost of a radio.
* Export and import licenses can be obtained quickly. Wireless Products Ltd.’s president, A. I. Cappon, who has been in the radio-manufacturing business in the Far East for 12 years commented: “Hong Kong is the only place where you can build radios before lunch and have them on a boat before supper.”
* Its few laws are written in English.
* Labor is cheap. A female worker receives about $1 a day for the first three months, advancing to $1.13 per day eventually. Even though skilled technicians are in short supply, they earn only between $2.09 and $2.61 a day.

Local banks are the most generous in the world. “They’ll even lend you an umbrella,” quipped one executive. Hot money from all over Asia flows into them looking for investment opportunities.

IV. At their mercy

One advantage Transelectronics has over other Hong Kong producers is a built-in sales force. Zenith and IT&T will take all of its production. Other companies do business with the hundreds of buyers that flock to Hong Kong looking for bargains. Commerce Department’s Young explained, “We are at the mercy of buyers. We have to give them what they want.” What the bargain hunters want has led to some questionable practices. For example, because the buyers relate the price by the number of transistors in a set, a few manufacturers use transistors as diodes, just to boost the total. You can find single-band pocket transistor radios with anywhere from 6 to 12 transistors; sometimes as many as four of them with only two of their three leads connected.

To shake off such buyers, the In-

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341 Watertown Street/WOD 9-9590
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big little transistor will soon be on its way.

40-watt DC to DC converter gets an efficiency of
90 percent from the low saturation resistance of the
miniature Delco 2N3212.
International Service Corp. reorganized its sales staff. Explained president Baker, "We have to get away from the buyer who comes here seeking shirts, rattanware, plastic flowers and radios. We are setting up a chain of distributors who handle only electronics.

It's free. Because of Hong Kong's free enterprise system, its nearness to Communist China, and its flood of refugees, the electronics industry has a little of the aura of a television spy story. An entrepreneur can open business with only a $1,000 investment and one customer. At some plants, quality control consists of turning the finished radio on and off.

Officially, 25 factories have registered with the government to produce transistor radios in the Colony, 12 others are unregistered. Ten companies produce components and two others fabricate sub-assemblies such as television tuners and computer memory cores.

At Galli's, the fine old restaurant in the Peninsula Hotel, where electronics executives gather over stingers and curry, rumors make up most of the conversation. Fear of competition from Communist China, rising wages, shrinking component supplies are usual topics.

V. Tv on way?

One other rumor that created a lot of talk is that somebody is producing television sets in the Crown Colony. Until recently, the rumor was not taken seriously. Almost everybody agreed that Hong Kong had to produce something small and easy to ship. A television set seems too bulky for long-distance export. But now, at least two companies have pilot production started. One is an independent, N. Mings and Co., owned by J. K. Li, who fled from the China mainland nearly 10 years ago. The other is a joint venture of the Japanese Sanyo Electric Co. and Chinese interests.

Li is assembling Sylvania kits for sale in Malaysia and Indonesia. Sanyo is assembling the same set its parent builds in Japan.

George Baker, who also serves as president of the Hong Kong Radio and Electronics Association, says, "It is only a matter of time until Hong Kong makes miniature television sets and tape recorders."

Space electronics

Cleanliness is next . . . to Mars

When Voyager makes its trip it must be 'clean'. How to test sterilized components without recontaminating them is the big question at JPL

By Walter Barney

Los Angeles Regional Editor

The first earth creatures to land on Mars may be bacteria—but not if the National Aeronautics and Space Administration can help it. The Voyager capsule scheduled to land on the planet in 1971 will not get off the ground until NASA can offer odds of 10,000 to 1 that no living organism is on board. NASA's stakes are high—the scientific success of the whole Mars program depends on keeping the spacecraft "clean." The scientists must be sure that any bacteria encountered is indigenous to Mars and not imported from earth.

To achieve this state of purity, a large army of technicians at the California Institute of Technology's Jet Propulsion Laboratory, which is in charge of NASA's lunar and planetary programs, is devising means of sterilizing the spacecraft. Their problem is how to do it without damaging the electronic equipment. Ranger moon probes 3, 4 and 5 were sterilized—and all three missions failed.

Subsequent Rangers, launched without being sterilized, completed their missions successfully and crashed on the moon—bacteria and all. Since it is believed the moon has no bacteria of its own—at least on the surface—contaminating it doesn't matter. Mars, on the other hand, is believed to contain some form of life, thus making sterilization of the vehicle essential.

I. How to sterilize

There are several ways to destroy Voyager components, after sterilization, will be assembled in this bioclean room at JPL, one of the first in the U. S. to meet NASA's strict requirements.
µA711 Dual Comparator

as a Sense Amplifier

The µA711 is built around an entirely new approach to integrated linear circuits. It eliminates the tolerance problems encountered in designing sense amplifiers for coincident current memories. Using external precision resistors the threshold can be adjusted over a wide range almost independently of integrated circuit characteristics. Excellent threshold stability over the full military temperature range is inherent in this design approach. You can also use the µA711 as a dual sense amplifier for biax memories where the outputs are separated by the strobes.

Other applications include a double-ended limit detector as used in GO/NO-GO test equipment, or a window discriminator for nuclear pulse-height discriminators. Your distributor has the µA711 in stock, or write for complete data sheet and application information.

µA711 Features:

1. Independent strobing of both channels.
2. Outputs can be OR'ed directly.
3. Compatible with all popular integrated logic forms.
4. Guaranteed over full temperature range (−55°C to 125°C).
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- Large input voltage range ±5 volts
- Low power consumption 130mW
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There are three basic types of Superior disc cathodes. Each has its own advantages. All feature close control of the E-dimension (distance between top of cap and top of ceramic), flare at the shank opening to facilitate assembly, shadow groove in the ceramic to inhibit electrical leakage and are available in wide choice of both cap and shank materials. Available in 0.121", 0.100" and 0.090" outside diameter shanks. Ceramic diameters can be either 0.490" or 0.365", with either round or triangular center hole.

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In the full power design the emitter is separated from the ceramics by a shield which minimizes the conducting X-section from the shank to the ceramic. In the low power design, the slender shank, thermal shield and thin ceramic permit low heater power consumption and fast rise time. The shield also acts to eliminate leakage if sublimation takes place.

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Electronics | December 13, 1965

bacteria. Radiation and chemicals will do it partially, but only heat will kill all of them to produce real sterilization—the complete absence of life.

The staff at JPL is working toward the goal of a bacteria-free capsule in four steps:
- Hardware that can withstand the rigors of intense heat will be used; some components will have to be developed and all must undergo rigid testing.
- Before using heat, another sterilizing agent must eliminate as many bacteria as possible.
- The spacecraft will be sterilized by heat.
- After the heat treatment, recontamination must be prevented.

Heat resistant. Warren H. Lockyear of JPL is conducting a program to establish a list of electronic parts for Voyager that can withstand heat. Since NASA has not yet decided on the experiments Voyager will carry, the program concentrates on those parts likely to be widely used in any Voyager spacecraft.

In March, JPL will have completed testing about 5,000 heat-sterilized capacitors—consisting of 23 types. Already, Lockyear's program has shown that sterilized tantalum capacitors will not operate dependably for the 10,000 hours demanded of Mars equipment. Resistors and diodes have completed 4,000 hours of testing, and potentiometers 3,000 hours. Their acceptability can not, of course, be determined until the full 10,000 hours has been completed.

In the test, the parts must demonstrate ability to survive not only heat treatment at various temperatures and time cycles, but decontamination with chemicals—specifically ethylene tetraoxide (ETO), a gas used to reduce the number of organisms on the spacecraft before the final heat treatment.

Although ETO kills life wherever it finds it, it cannot penetrate all parts of a system. The gas is being considered for surface decontamination because Lockyear's studies indicate that ETO decontamination can reduce the number of organisms on board to 10⁸ before sterilization by heat.

Time and temperature. The heat treatment itself has two variables: time and temperature. Basically,
Travelling-wave tubes

During the past year, STC have added to their extensive range of travelling-wave tubes the new high performance types: W3/2G and the W3MQ Series. Magnetically screened versions of the W3MQ Series of low-noise packaged tubes have now been introduced. These may be operated efficiently in close proximity to one another or to extraneous ferro-magnetic materials. The new tubes can be supplied for wide-band operation, or for narrow-band operation with a lower noise factor. They can be fitted with coaxial or waveguide r.f. input and output connections, as specified by customers.

Abridged data for a selection of STC travelling-wave tubes are given in the adjacent table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency Gc/s</th>
<th>Max. Power Output</th>
<th>Gain dB</th>
<th>At output of Noise Factor dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>W3/2G</td>
<td>10·7 to 13·2*</td>
<td>12 W</td>
<td>43</td>
<td>5 W</td>
</tr>
<tr>
<td>W3MQ/1D</td>
<td>7·0 to 11·5</td>
<td>15 mW</td>
<td>38</td>
<td>Small Signal</td>
</tr>
<tr>
<td>W4/2G</td>
<td>7·0 to 8·5</td>
<td>15 W</td>
<td>45</td>
<td>5 W</td>
</tr>
<tr>
<td>W4/1G</td>
<td>7·0 to 7·8</td>
<td>11 W</td>
<td>40</td>
<td>5 W</td>
</tr>
<tr>
<td>W5/1G</td>
<td>5·85 to 7·2</td>
<td>11 W</td>
<td>38</td>
<td>5 W</td>
</tr>
<tr>
<td>W5/2G</td>
<td>5·85 to 7·2</td>
<td>25 W</td>
<td>42</td>
<td>10 W</td>
</tr>
<tr>
<td></td>
<td>7·2 to 8·2</td>
<td>18 W</td>
<td>42</td>
<td>7 W</td>
</tr>
<tr>
<td>W7/4G</td>
<td>3·6 to 5·0</td>
<td>12 W</td>
<td>49</td>
<td>6 W</td>
</tr>
<tr>
<td>W9/2E</td>
<td>2·5 to 4·1</td>
<td>10 mW</td>
<td>40</td>
<td>Small Signal</td>
</tr>
<tr>
<td>W9/3E</td>
<td>2·5 to 4·1</td>
<td>0·1 mW</td>
<td>15</td>
<td>Small Signal</td>
</tr>
<tr>
<td>W10/3E</td>
<td>2·7 to 3·7</td>
<td>3 mW</td>
<td>24</td>
<td>Small Signal</td>
</tr>
</tbody>
</table>

*With possible extension to 15 Gc/s. | Packaged tube. Magnetically screened.

USA enquiries to:
ITT Electron Tube Division,
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Other countries contact:
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\[
gm/2\pi C_{is} = 80 \text{ Mc} \quad gm/IG = 2 \times 10^7 \quad gm/I_D = 2
\]

In amplifier applications this means type 2N2967 will provide more gain at higher frequencies with less power supply drain and less transducer loading. Noise Figure is less than 1.5 dB at 100 cps. (Other types offer pinch-off voltage of 1.7 volts where power supply voltage is limited.)

For switching applications type 2N2966 offers \( R_{off}/R_{on} = 4.5 \times 10^7 \) and \( C_{DG} = 1.3 \text{ pf} \) maximum. In addition, pinchoff is controlled within the range of 4 to 6 volts. Thus spikes from the driving source are reduced and offset due to resistance effects are minimized.

These types are available from stock.

<table>
<thead>
<tr>
<th>Type</th>
<th>2N3966</th>
<th>2N3967</th>
</tr>
</thead>
<tbody>
<tr>
<td>( g_m )</td>
<td>1600-2400 µmhos</td>
<td></td>
</tr>
<tr>
<td>( R_{on} )</td>
<td>220 Ω</td>
<td></td>
</tr>
<tr>
<td>( C_{is} )</td>
<td>6.0 pf</td>
<td>5.0 pf</td>
</tr>
<tr>
<td>( C_{DG} )</td>
<td>1.3 pf</td>
<td>1.3 pf</td>
</tr>
<tr>
<td>( I_G )</td>
<td>0.1 nA</td>
<td>0.1 nA</td>
</tr>
<tr>
<td>( V_P )</td>
<td>4-6 V</td>
<td>2-5 V</td>
</tr>
</tbody>
</table>

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(612) 374-1969

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...the lower the temperature, the more time required for sterilization; the higher the temperature the more likely that reliability of the parts will be affected. There is some evidence, however, that prolonged heating at low temperatures is also damaging to parts, so low temperatures themselves would not be the answer to safe sterilization, even if the tedious procedure of prolonged heating were tolerable otherwise.

To establish thermal death-time curves, JPL borrowed a concept from the food canning industry, which has long used heat as a means of destroying bacteria. Canners have established a series of decimal reduction times, called "D values"; these are the times required to bring about a 90% reduction in the number of living cells. The D values vary for different organisms and different temperatures.

**II. Reliability factors**

Exactly what happens to an electronic component when it is heated is not completely known. Certain elements tend to boil off and settle elsewhere, as they would in a chemical solution. The heat causes a relaxation of the molecules and a change in the stress of the basic materials, producing a change in electrical characteristics. "Sterility and reliability are opposite sides of the same coin," says Gordon Kautz, who is in charge of JPL's sterilization program.

JPL's overriding preoccupation is that the Voyager capsule meet the sterility requirements. The lab would rather have a mission fail, than succeed and contaminate the planet. But the men responsible for the Voyager program at JPL do not want to be so conservative, that they will unnecessarily increase the difficulties and costs. In addition to developing hardware capable of withstanding the rigors of sterilization, JPL wants to learn more about sterilization techniques, with the idea of reducing those rigors.

Kautz's program had to take into account the equipment, procedures and controls needed to make sterile capsules, the monitoring and control of subassembly vendors, the ability to assess contamination during assembly and testing, the capability and control of the steril-
zation ovens, and the thermal lag characteristics of the assembled capsule.

The entire sterilization cycle is a series of type-approval and flight-acceptance tests. Type-approval tests are stiffer than those used for flight equipment, the environment being most severe at the lower stages of assembly. For type-approval, the entire system gets three cycles of 53 hours at 135°C; subsystems get six 60- to 70-hour cycles, and piece parts, six 96-hour cycles.

The same procedures are applied to decontaminate with ETO: flight acceptance consists of one 24-hour cycle at 40°C, while type-approval requires three 24-hour cycles at 50°C for systems, and six 24-hour cycles at 50°C for subsystems and piece parts. The type-approval tests are followed by careful testing to see how reliability has been affected.

### III. How to make a capsule

Testing of flight equipment poses a real dilemma for reliability engineers. After the most elaborate type-approval testing and flight-acceptance testing, there would still be the prospect of flying the space capsule itself without testing it after the heat treatment. The failure of the three Rangers points to the necessity of some sort of testing after sterilization.

It has been suggested to NASA that the capsule be tested after sterilization, and then given a second heat treatment. This, however, invites risk because heating a component a second time could be asking for trouble.

If the post-sterilization heating approach is accepted—NASA will eventually make the decision—the capsule will not require the expensive "superclean room" for assembly that would be needed if the capsule got only one heat treatment. After the two heat treatments, final assembly could be performed under less expensive conventional clean-room conditions.

JPL has proposed that subsystems be manufactured in a normal working environment having cleanliness standards consistent with the production of reliable space hardware. Detachable coupons—small hunks of material that pick up bacteria—would be attached to the

---

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Electronics | December 13, 1965

Circle 139 on reader service card
subsidiary, where they would remain until final assembly. They would then be removed and the amount of bacteria determined.

Completed subsystems would get flight-acceptance tests, including the ETO cycle and a dry heat cycle equal to the final sterilization cycle. Thus the equipment would be internally sterile and certified for assembly into the capsule.

The initial capsule assembly would also be in a normal working environment, but monitoring would be stricter, and personnel practices more rigid.

The completed capsule would be tested and then disassembled to the subsystem level; all surfaces would be decontaminated with ETO. That step marks the transition into the controlled bioclean environment in which final assembly would be performed.

Says Kautz: “This plan accomplishes the objective of enabling us to perform the more difficult phases of assembly and of all the environmental tests under reasonably normal working conditions. If environmental testing had to be performed under the bioclean conditions of final assembly, a manifold increase in time and cost would be incurred.” The superclean-room assembly, Kautz estimates, would double the cost of manufacture; the other method would add only 15% or 20% to the cost.

IV. A year’s work

While NASA deliberates on whether to use one or two heat treatments, JPL continues compiling the list of sterilizable piece parts and its work on the efficiency and effects of ethylene tetraoxide. This work must be finished by January, 1967. JPL is also trying to create better and more reliable techniques for the collection and evaluation of microbiological data.

One of the more vexing problems concerns the failure of a subsystem whose individual components may have survived heat sterilization. At a recent conference Wayne E. Arens of JPL described the failure of a tape recorder—heat had caused the tape to give off hydrochloric acid which combined with the magnesium frame to form crystals of magnesium chloride. These crystals caused a capstan failure after only five days of life testing. Additionally, the presence of some oxygen in the dry nitrogen atmosphere caused rust to form on some bearings.

American bacteria. NASA, of course, can only control bacteria that would emigrate from the United States. Although the Russians have announced that they are sterilizing their spacecraft at 105°C, some JPL scientists have expressed skepticism as to whether heat is being applied for the necessary 336 hours. If Zond 2, the Russian probe that failed at the time of Mariner 4’s spectacular success, hit Mars much of NASA’s work may be useless. Since speculation on that subject is fruitless, NASA and JPL will continue to work on a bacteria-free Voyager.
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Money available—with technical advice

Small-business investment companies have adopted a more cautious approach to borrowers in the electronics industry. Many offer engineering and scientific help along with business hints.

Like a once-scratched puppy eyeing the neighborhood alley cat, small-business investment companies are reacting more cautiously—but with continuing fascination—to advances from electronics concerns. The big change is an intensified interest by SBIC's in companies' technical problems. More and more of these investors retain scientists and engineers to help company engineers.

In 1961, the electronics industry received more than 20% of all SBIC loans. Today, four years and hundreds of bankruptcies later, the proportion has dropped below 10%, according to Stanley M. Rubel Jr., a Chicago financial consultant and publisher of an SBIC evaluation service. But with outstanding loans totaling $50 million to $60 million, SBIC's are still a major—and increasingly influential—source of funds for electronics companies.

The intensity of investor enthusiasm varies with experience and, to some extent, with geography. The president of a Chicago-based SBIC declares, "New electronics companies and those in related fields find it almost impossible to get financing in the Midwest." At the same time Meryn E. Doleman, vice president of the Bank of America in San Francisco and a specialist in electronics and aerospace industries, says, "SBIC interest is very high in electronics because a sound product and sound management can still compete successfully against heavy competition."

I. How they manage

The words "good management" are crucial. Many potential investors agree with James V. Sidell, president of Financial Investors of Boston, Inc., when he says: "Most management in electronics companies are rather artistic types, not business people. They are so involved in their theories that they can't or won't deal with business problems."

With increasing regularity, SBIC's try to assume some management role in companies in which they invest but avoid exercising direct control. "What we do exercise," says George Quist, president of an SBIC subsidiary of the Bank of America, "is the benefit of our business experience, and we keep ourselves available for consultation."

Shared ownership. In 1960, Narinder Kapany formed Optics Technology, Inc., in Palo Alto, Calif., to produce medical-electronics equipment, notably an ophthalmoscope laser for welding detached retinas. Kapany and his associates negotiated a $500,000 loan from a local SBIC, Draper, Gather and Anderson. The company was divided into three parts: 49% of the stock went to Kapany and his associates, 49% to the SBIC, and 2% was put in trust with the stipulation that if the company succeeded—as it has—Kapany's group would receive these shares and controlling interest.

Kapany and his group now hold 51% of the stock in a thriving company. Since that initial financing five years ago, Optics Technology has borrowed from three other concerns.

"We are highly pleased with our relationships with investors," says Kapany. "Investors have been able to understand the long-range goals of the company. They... offer business counsel when asked for it, but do not interfere with the management otherwise. Most of the decisions made at our board meetings have been unanimous."

Shared acumen. In September, 1964, Cybertronics, Inc., a New York company that leases data-processing equipment, borrowed $800,000 from the Small Business Investment Co. of New York. With the money came some business advice. During the ensuing 15 months, Cybertronics' sales have soared from $837,000 to more than $3 million, and the company has appointed a new vice president for finance—Donald Glickman, a former vice president of the investment company.

The Electronics Capital Corp. of San Diego, Calif., the biggest SBIC, has scientists and engineers on its board of directors; these men often help companies solve technical problems while other specialists concentrate on management and marketing. Electronics Capital's investments are almost entirely in scientific engineering companies.

The second-largest SBIC, the Boston Capital Corp., retains a technical consultant, Charles S. Draper, head of the department of aeronautics and astronautics at the Massachusetts Institute of Technology.

Shared responsibility. Despite the trend toward greater participation in the technical field, most SBIC's still make a point of avoiding giving advice about products. "I wouldn't know one black box from another," says Grogan Lord, president of the Texas Capital Corp. "We just attempt to be a financial partner."

One of Texas Capital's successful investments is in AirBorn Connectors, Inc., a Dallas producer of...
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precision-engineered electronic connectors. In 1961, the SBIC loaned $250,000 to AirBorn at 7% interest; Texas Capital also received an option to buy 60,000 shares of AirBorn’s common stock—about 23% of the outstanding shares. The strongest management influence exerted by Texas Capital was to try—unsuccessfully—to persuade AirBorn to make an acquisition.

In general, says Rubel, the SBIC specialist in Chicago, the SBIC “asks for a position on the board of directors, and from there provides counsel to the company in . . . financial administration or internal control. Some SBIC’s also provide general management or business consulting,” he adds.

II. Causes of caution

Why are investors so cautious in dealing with electronics companies? Besides the fact that many were burned in the years 1962 through 1964, there’s this basic reason: a big portion of SBIC loans go to new, unproven concerns that cannot raise money elsewhere. Such companies are high risks in any industry, and particularly so in an intensely competitive field such as electronics, where technology is increasing the tempo of obsolescence.

Some investors are veering away from new companies altogether. “We can’t evaluate a company right at its inception,” says B. J. Brooks, secretary of the Continental Capital Corp. of San Francisco, “because at that stage it has mostly engineering problems. We’re not electronics men, we’re businessmen.”

Continental Capital prefers to deal with a company that has been in business a year or two. “We no longer finance an idea, we finance growth,” says Brooks. He prefers that his investments go for such purposes as diversification, retooling, or stepping up of a promising research project.

The law. Yet it is the new, unproven companies for whom the Small Business Investment Act was written in 1958. Its chief sponsors, incidentally, were two senators who have risen to higher office: Lyndon B. Johnson of Texas and Hubert H. Humphrey of Minnesota.

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small businessmen who were unable to produce venture capital or to negotiate long-term loans. It permitted the establishment of small-business investment companies to advance funds—long-term loans or equity capital—to small companies which, because of the high risk, could not get money from usual sources.

To be eligible for a charter from the government’s Small Business Administration, an SBIC must raise a minimum of $300,000 on its own. Half of an SBIC’s operating capital may be borrowed from the SBA at 5¾% interest.

The law places few limits on an SBIC’s operation; the most important is a requirement for diversification—no more than 20% of its operating capital may be invested in one company. Loans are made for a minimum of five years and may run as long as 20 years. Interest rates usually are between 7⅝% and 10%.

An SBIC can—and often does—invest by purchasing stock in a company. But it cannot own a majority of the outstanding shares for long—usually the limit is 18 months.

Who is eligible for an SBIC loan? A small company, which the law defines as one whose assets are under $5 million, whose net worth does not exceed $2.5 million, and whose average net income after taxes for each of the preceding two years was not more than $250,000.

The gamble. Another cause of SBIC caution is the rapidly changing technology of electronics. Marvin A. Marder, president of Adams Street Capital, Inc., of Chicago, explains: “Before the small company can turn around with a new product it may be superseded” by an improvement.

Another drawback is the heavy government influence. “They depend to a great extent on sales...to the government,” says a Chicago SBIC official, “and the U.S. government is a somewhat unpredictable and capricious buyer.”

Still another problem is the traditionally short life-span of an electronic product. James W. Howard, president of Growth Capital, Inc., of Cleveland, explains: “One technological change, such as a shift from semiconductors to molecular...
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III. The bright side

Despite their wariness, SBIC’s have a lot to offer electronics companies. Perhaps the most attractive advantage is their ability to negotiate a tailor-made loan; most lending organizations are not that flexible. They also can offer business advice that young engineers often need.

An SBIC with strong interest in electronics may also bring a rich background to a new business. Stan Keller, controller of Data-pulse, Inc., of Inglewood, Calif., says Continental Capital of San Francisco provided valuable contacts with other segments of the electronics industry for his manufacturer of test equipment. “They are on the lookout for other companies with similar objectives,” he explains, and “this can be helpful, specifically in cases of possible merger or of acquisition of production rights.”

What they look for. One of the Midwest’s successful SBIC’s is the Vanguard Venture Capital Corp. of Chicago. Perhaps significantly, Vanguard’s president, Kenneth Arenberg, is an engineer.

“A balanced management team is the key,” he says. “We place a greater emphasis on the people involved than we do on a technical breakthrough.”

The president of an Atlanta SBIC, who asked that his company not be identified, recently discussed frankly the lessons of a brief career that “hasn’t been profitable” but that he believes is “on the right track at last.”

“In the first place,” he says, “we’ll never sponsor a brand-new company again. I’ll insist that they have at least three years of experience.”

Secondly, he will insist on business experience among top management.

And thirdly: “We’ll insist the firm set out on a course of carrying out one or two—and only one or two—well-defined projects.” Never again, he vows, will his company invest in an engineering company that has a dozen projects under way “with little hope of any of them ever reaching fruition.”
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<th>Resistive Carbon (MIL-R-22097B, Characteristic B)</th>
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<tr>
<td>MIL-SPEC STYLE RT10 Bourne TRIMPOT® Model 220</td>
<td>MIL-SPEC STYLE RT12 Bourne TRIMPOT® Model 224</td>
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<td>10Ω to 30K</td>
<td>10Ω to 100K</td>
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<td>MIL-SPEC STYLE RT11 Bourne TRIMPOT® Model 3010</td>
<td>MIL-SPEC STYLE RT22 Bourne TRIMPOT® Model 3250</td>
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<td>10Ω to 100K</td>
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<td>MIL-SPEC STYLE RT12 Bourne TRIMPOT® Model 3051</td>
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A test cavity that uses a magnetron has been specifically designed for the job of evaluating a production process using microwave heating.

This unit is an accurately instrumented and controlled microwave oven intended for laboratory use in applications where rapid reduction of moisture content by microwave heating is important. It will find application in laboratories in the food-processing, chemical, lumber, and textile industries. Other uses include the accelerated curing of glues, resins, and polymers; establishment of production processes where heating by microwave energy is to be employed; and chemical titration. It is claimed that any laboratory involved in processing research, as well as quality control and small-batch production, can use the system.

The test cavity and power pack are mounted in a common console. The PPS-2.5 power pack produces 2.5 kilowatts at 2,450 Mc, and power output is continuously variable from 500 watts to the 2.5-kw maximum rating. The unit is 31 1/2 inches high, 14 inches wide, and 28 inches deep, and operates on 220-volt a-c power. The PPS-2.5 power pack may also be supplied separately to allow coupling to special fixtures as required. Microwave power output is available through standard 3.40" x 1.70" (WR-340) waveguide.

The TCS-2.5 test cavity is of the multimode variety, and includes an integral scale for continuous monitoring of sample weight during processing. It can accept specimens with maximum dimensions of 24 x 18 x 16 inches. Specimens are placed on a balance pan which is the floor of the cavity. Weight, from 200 to 2,000 grams, is read from a meter below the cavity door.

Stable oscillator in a small package

Model 676 fixed-frequency, non-temperature-controlled oscillator offers a 4- to 25-Mc output in a 1/3-cu in. package.

Frequency stability is ±0.006% maximum from -55° to +90°C. Output is d-c coupled into a 100-pf load. Input is +10, +5 v d-c. The unit has a low silhouette form factor and is encapsulated in a low-density, high-strength semirigid foam. It is designed for 10 to 2,000 cps 20 g vibration, rfi per Mil-I-6181, environment per Mil-E-5400, and is suitable for in-flight missile applications.

Eimac division of Varian Associates, 301 Industrial Way, San Carlos, Calif. Circle 349 on reader service card.

**Specifications**

| A-c power required | 220 v at 20 amps |
| System dimensions | Combined units measure 31 1/2 x 28 x 42 1/2 in. |
| Total weight | 270 pounds |
| Price | $4,350 (excluding options) |
| Delivery | 90 days |

Monitor Products Co., 815 Fremont Ave., S. Pasadena, Calif. [350]
New Components and Hardware

Switch handles 5 amps, 200 volts

Raising the level at which current can be switched reliably has long been a goal of switch manufacturers. Now, the AB Svenska Elektronor, a subsidiary of the L. M. Ericsson Corp. in Sweden, claims to have increased the amount of switching current to 5 amps from the earlier maximum of 2 amps.

Dry reed switches have been used as relays in electronic computers, calculating machines and telephone exchanges. The dry reed switch—which can be operated either electromagnetically, or by a permanent magnet, or by a combination of the two—is enclosed in a gas-tight capsule; the magnetic field operates directly upon the reeds to ensure fast and reliable operation. However, the most serious limitation of the switch has been the amount of current it could safely pass.

Svenska tried standard electrophotodiode rhodium on the reeds and found that the contact resistance varied significantly with use, and from switch to switch. They tried diffusion gold; but found that the incidence of “contact stick” increased. Finally, to overcome these difficulties, they developed a proprietary technique of triple-plating rhodium on the reeds.

Not only has the amount of current the switch can handle been increased: the switch can handle a 200-volt inductive load—five times greater than before. At 50% of full load, the contact resistance varies only 1 ohm in 8 million operations. It also takes about 8 million operations before one failure (5 msec contact stick) occurs.

Svenska says that the switch, which will be sold only to the American market immediately, offers the manufacturer an off-the-shelf component that has higher reliability and lower cost than any other comparable unit available today. The reed relay will cost less than $5.50 in lots of 500,000 (comparable switches cost $2.00) and can be delivered 30 days after receipt of order.

Specifications

<table>
<thead>
<tr>
<th>Contact type</th>
<th>Spst—normally open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating time, approx.</td>
<td>1 msec</td>
</tr>
<tr>
<td>Operating rate, max.</td>
<td>350 cps</td>
</tr>
<tr>
<td>Initial contact resistance</td>
<td></td>
</tr>
<tr>
<td>Average value, below</td>
<td>25 milliohms</td>
</tr>
<tr>
<td>Maximum value</td>
<td>50 milliohms</td>
</tr>
<tr>
<td>Contact ratings</td>
<td></td>
</tr>
<tr>
<td>Switching current, max.</td>
<td>5 amps</td>
</tr>
<tr>
<td>Switching voltage, a-c/d-c max.</td>
<td>200 volts</td>
</tr>
<tr>
<td>Switching power, max.</td>
<td>100 va</td>
</tr>
<tr>
<td>Life expectancy, to first failure, (minimum)</td>
<td>500 x 10^6 operations</td>
</tr>
<tr>
<td>Pull-in</td>
<td>80-110 amper-turns</td>
</tr>
<tr>
<td>Drop-out</td>
<td>78.48 amper-turns</td>
</tr>
<tr>
<td>Breakdown voltage d-c</td>
<td>900 volts</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>100 ohms</td>
</tr>
<tr>
<td>Capacitances</td>
<td></td>
</tr>
<tr>
<td>Between reeds in air</td>
<td>0.5 pf</td>
</tr>
<tr>
<td>Between one reed and coil</td>
<td>1.2 pf</td>
</tr>
<tr>
<td>Vibration and shock, any direction</td>
<td>40g</td>
</tr>
<tr>
<td>Mounting position</td>
<td>Any</td>
</tr>
</tbody>
</table>

The Ericsson Corp., 100 Park Ave., New York 17, N.Y. [351]

Over/under-voltage metering relays

A family of solid-state over-voltage and under-voltage metering relays is announced. The relays combine a silicon, solid-state, operational amplifier and a reed contactor. The contacts will carry 15 watts a-c or...
Primary power requirements are 8 v a-c at 20 ma. Signal requirements to close contacts are 1 v, 1 ma ± 1%.

There are four types of relays available. Models 11A and 11B are latching relays, whose contacts will remain closed if the signal voltage approaches the operating point. Models 12A and 12B are on/off relays. The 11A and 12A will cause contact closure when the signal voltage exceeds 1 v. The 11B and 12B will cause contact closure when the signal voltage drops below 1 v. Signal voltage up to 500 v may be used with an appropriate external series resistor. The signal voltage may be d-c, rectified a-c, or rectangular pulses. With rectified a-c signals the relay will operate on the rms value; with rectangular pulses, on the peak value.

The relays are epoxy-encapsulated and are temperature-compensated from -20° to +70°C. They can be installed on p-c boards or standard chassis assemblies. Prices start at $15.45, single unit, with discount on quantity; delivery from stock. Sensitivities down to 10 μa are available on order.

Sensitak Instrument Corp., 531 Front St., Manchester, N.H., 03101. [352]

Hermetically sealed time delay switch

Model TDS-230 spst time delay switch is a solid-state, hermetically sealed package in a half crystal can. It is ideally suited for applications requiring high reliability and repeatability.

The unit is rated for 0.15 ampere continuous without heat sink. The use of an external timing resistor permits time delay ranges of 0.01 to 90 seconds with nominal ratios of 10:1 span within the range. Repeatability exceeds 1%. The switch is designed to meet ground and
"Special" Pulse Generators are made to order at TI. Modular construction allows assembly of the right building blocks to meet your requirements. Now, "specials" cost you no more, frequently cost less than conventional pulse generators.

For example, the 6613 is an economical general-purpose unit with PRF from 15 cps to 15 mc, priced at only $950. Another model, the 6325, is a ten-channel, word-bit programmable unit operating up to 25 mc. The single unit does the job of ten discrete generators, at half the cost, and fits in a cabinet 23 in. wide, 38 in. high, 18 in. deep.

TI Pulse Generators give you outstanding performance: PRF's to 100 mc, fast rise and fall times, variable pulse width and delay, variable rise and fall times, plus and minus outputs, pulse mixing, programmed and random word generation. You have your choice of portable or rack-mounting cases.

When you need special pulse generator performance, choose one of the thousands of standard pulse generator combinations from Texas Instruments. For more information, contact your nearest TI Authorized Representative or write to the Industrial Products Group in Houston.

New Components

space-borne environments and is protected against line transients and reverse polarity.
The unit price in quantities of 1 to 9 is $35 each and delivery can be made from stock to one week after receipt of order.
Temperature Systems, Inc., 1871 S. Orange Drive, Los Angeles 19, Calif. [353]

Tiny, glass-sealed high-megohm resistors

A new resistor line, series HR600, is now available in resistances from $10^8$ to $10^{14}$ ohms. This miniature, hermetically glass-sealed resistor (said to be smaller than any other manufactured) operates at voltages up to 1,000 v, temperatures up to $150^\circ$C. It is available in tolerances of 2%, 5%, and 10%, and offers good long-term stability.
The HR600 measures only 0.526 in. long x 0.110 in. in diameter.
Pyrofilm Resistor Co., 3 Saddle Road, Cedar Knolls, N.J. [354]

Feed-through seal has 37-pin connector

A low-cost, 37-pin electrical feed-through seal is announced for use in high-vacuum systems, test cham-
It is suited for quick electrical connections between instrumentation and the many types of electrical and electronics equipment to be energized while in vacuum or other atmospheres. The large number of identified pins, per feed-through, now makes it possible to provide wiring for numerous circuits economically.

The connector is mounted in a standard 2¾-in.-o.d. stainless-steel vacuum flange. The wire used on the connector is 20-gauge standard, polyvinyl-chloride insulated, glass-braid overlay. The external wires are prewired into the connector cap and number-coded. Inside wires, also provided, are fitted with individual connector contacts, and are also number-coded. The rating of each pin and wire is 7½ amps and 1000 v d-c, at sea level. The entire assembly is helium-leak-tight to \(5 \times 10^{-10}\) standard cc per sec.

The new feed-through, designated the model V4-137, is priced at $250.

Materials Research Corp., Orangeburg, N.Y., 10962.

The banana-type terminal socket illustrated is said to be the only one completely molded into high-temperature diallyl phthalate. The push-on-type banana jack offers high dielectric strength and low moisture absorption for critical test-equipment requirements. The jack is installed simply by drilling a 0.265-in.-diameter hole, and attaching the jack with a push-on fastener. There are no nuts or lock washers needed. A slight taper in the body facilitates installation. Over-all length is \(\frac{3}{4}\) in.

The socket is normally supplied for your choice of more than 10,534 TI converters, just select the input/output functions that meet your requirements. Then you get an A-D Converter composed of carefully engineered, field-proven functional modules that exactly fit your job... "made to order" from TI.

With Series 846 Converters, you'll get speed as high as 69,000 conversions/sec including built-in sample and hold. You'll get accuracy to 0.025% of full scale and high input impedance (100 megohms) for single-ended or differential units. And for low-level conversion, you get high common-mode rejection.

You can also have your choice of TI Multiplexers from 32 different models. Multiplexers can be furnished to accommodate 10 to 160 channels at sampling rates to 50,000 channels/sec. Four channel-select versions are offered: addressable, addressable/sequential, sequential or direct channel-select.

When you need an A-D Converter or Multiplexer, choose one of the "made to order" instruments from Texas Instruments. For more information, contact your nearest TI Authorized Representative or write directly to the Industrial Products Group in Houston.
New Components

Cadmium-plated: gold plating is also available. A complete range of colors is standard for coding. Prices range upward from 6½ cents each, depending on quantity. Mounting tools for hand or machine mounting are available.
Electronic Molding Corp., 38 Church St., Pawtucket, R.I., 02860. [356]

Time delay relays for industrial use

A series of highly accurate, solid-state time delay relays has been introduced for industrial application. The DDR series is available in a variety of enclosures and adjustable timing ranges from a fraction of a second to six minutes. Units can operate from a-c or d-c voltage sources.

The timer is designed to offer delay upon de-energization. Life expectancy is 10 million mechanical operations, with a repeat accuracy of ±2% and a reset time of 50 msec. Output contacts are dpdt and are rated for 10 amps resistive load.

Syracuse Electronics Corp., P.O. Box 566, Syracuse 1, N.Y. [357]

Thermal timing relays mount on p-c boards

Series JT thermal time-delay relays are designed for mounting on printed-circuit boards. Four pins
New F-111 uses 50 miles of wire jacketed with Kynar.*
Why? Primarily because KYNAR is tough. Its mechanical strength and abrasion resistance make it possible to use thinner jacketing without compromising performance. Result: savings in space...savings in weight amounting to several hundred pounds per plane. Wire jacketed with cross-linked KYNAR is described in MIL-W-81044.

If you have a problem with space, weight, cut-through, abrasion or temperature, consider using wire insulated and/or jacketed with KYNAR. For detailed information, write Pennsalt Chemicals Corporation, 3 Penn Center, Philadelphia, Pa. 19102.

Kynar...the fluoroplastic that’s tough! *Registered trademark of Pennsalt Chemicals Corporation for its vinylidene fluoride resin.
Supply Problem for Precision Metals got you stumped?

use Hamilton's theory of probability to solve it:

This is where complete production facilities count! Chances are Hamilton's capabilities are the answer... as they have been for hundreds of others... whether it's high strength, non-magnetic foil only 90 millionths of an inch thick... precision strip for contacts to work accurately at temperatures up to 1500° F... or permalloy sheets .006" thick with only a ± .0001" variation. The Precision Metals Division of Hamilton Watch has the unique precision production facilities to do the almost "impossible". What can you lose? Before you give up, ask us. Invest a postage stamp and ask for the brochure on Precision Metals. You will receive facts and information that you can use.

New Components

on the base of the relay serve as terminals and also attach the relay to the board. The units are fully compensated for ambient temperature variation and will operate in any plane. They are intended for use in communications equipment, industrial control, and other commercial applications.

Delay intervals from 2 seconds to 3 minutes are available and are factory set. Timing tolerance is ±15%. Heater voltages of 6.3, 28, 115, and 230 v are standard, and relays will operate interchangeably on a-c and d-c. Contacts are single-pole, single-throw, either normally open or normally closed. Contact rating for resistive loads is 5 amps to 125 v a-c; 3 amps to 250 v a-c; 1 amp to 32 v d-c. The enclosing case is of stainless steel and is approximately ¾ in. square and 2¼ in. long.

Price is $5 to $10, depending on time-delay range and quantity.

G-V Controls Inc., Okner Parkway, Liv­­ingston, N.J. [358]

Rotary switch has dual concentric shaft

A totally enclosed, explosion-proof microminiature rotary switch, series 2505, features a dual concentric shaft that permits one set of poles to be rotated independently of the other. Up to three decks maximum are available on the outer shaft with a total of eight decks over-all. The switch is available in combination of shorting and non-shorting decks.

The new series is built to exceed the requirements of MIL-S-3786B. Electrical rating carries 8 amps.
d is the dynamic response of a CELCO deflection yoke

It is 0.1% in 5 microseconds

Need a faster response for your display?

Use a DYNAYOKE®

Constantine Engineering Laboratories Company

YOKES FOCUS COILS DEFLECTION AMPLIFIERS
Four new proportional control ovens — 952 thru 955 Series — eliminates usual noise problems associated with thermostat controlled ovens. Temperature remains constant without deviations due to thermostat on-off cycling found in other devices. Models 952 and 953 are designed primarily for crystals and small components. The larger Models 954 and 955 are for large components, oscillators, etc. and can be supplied with 4, 7, or 9 pin internal sockets. Standard operating temperatures are 65°, 75° and 85°C ± 5°C. Other temperatures and closer tolerances are available. At constant ambient temperature oven stability is ±.025°C max.

Standard input voltage is 28VDC. Other voltages available on special order.

For detailed information request Bulletin 952-5 from your CTS Knights representative or from the main office.

New Components

A solenoid actuator has been developed that features compact size, low cost and versatile mounting. It is designed for push or pull operation and is available as a stock item for 6, 12, 24 or 48 volts. Size of the unit permits mounting side by side on 1/4-in. centers. Frame length is approximately 1/2 in.

The unit delivers 14-oz pull when closed and has a maximum stroke of 1/8 in. Low duty cycle coils deliver up to twice this force. The unit operates at very high speed due to its low inertia. Price of the model SP-25 ranges from 68 cents to $2.58 depending on quantity, features, etc.

Electro-Mechanisms, Inc., 5040 Sereno Dr., Temple City, Calif. [360]

Tiny capacitors are voltage variable

Voltage variable capacitors are being offered in a smaller-than-normal glass package. The Micro Caps feature high Q and high transconductance at high frequencies. A wide range of capacitances is available. Piv is 60 volts. The units are

Electro-Mechanisms, Inc., 5040 Sereno Dr., Temple City, Calif. [360]
No matter how big the ferrite piece, WHEN MECHANICAL AND ELECTRICAL SPECS ARE TIGHT... SPECIFY STACKPOLE

Stackpole makes them all:
- Toroids over 6.000" OD x .500" Long
- Cup Cores 2.500" OD x .960" O Hgt.
- Rods to 1.000" D x 2.812" Long
- Sleeves to 4.050" OD x 2.500" long
- Rectangular Solids of nearly 6" Length x 4.175" Width x .750" Thick.

But gross size isn't Stackpole's only claim to fame in ferrites. As one customer put it, "Your ferrite cores are more consistent from order to order than any of your competitors."

Over 30 grades. Isn't that what you're looking for?

Electronic COMPONENTS DIVISION
ST. MARYS, PENNSYLVANIA

Electronics | December 13, 1965
This is a new Optical Encoder.
It provides its own internal data storage.
It needs no amplifiers.
It's about two years ahead of the field.

This is a new Data Packet.
It tells about a breakthrough in encoder performance; explains the simplicity, high output signal, long life and storage capability of Datex's new Optical Encoders. It's yours for the asking.

New Components

especially designed for use in military field communications equipment, parametric amplifiers, frequency multipliers, and automatic frequency control. They are available in 5%, 10% or 20% tolerances, with both medium and high Q. Price ranges from $2.50 to $28 in 100 lots.
Easton Corp., 25 Locust St., Haverhill, Mass. [361]

Thin, rectangular cermet trimmer

Model 58 is a thin rectangular trimming potentiometer offered with either printed circuit pins or solder lugs. It is the industry’s only trimmer with a slim RJ12 style plastic housing and terminals staggered in RJ11 configuration. The unit is less than 0.200 in. thick and requires only two-thirds the board space of an RJ11 trimmer.
The pot features a cermet resistance element with essentially infinite resolution and standard resistances from 10 ohms to 2 megohms. Power rating is 1 watt at 85°C, and the total operating temperature range is −65° to 175°C. Price is $5.50.
Helipot division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. [362]

Solid-state switch handles high power

A solid-state switch now in production combines high power capability and broadband operation. Model DS-650 spst switch can handle up to 100 watts c-w power—average or peak—and operates in a frequency range from 100 to 600 Mc. Isolation

DATEX
GIANNINI CONTROLS CORPORATION
1307 S. MYRTLE AVE., MONROVIA, CALIF. 91017

Circle 168 on reader service card
In order to accommodate the 10,000-hour failure-rate level determination load life test (shown above) as well as the other special tests required by MIL-R-39008, Speer recently added 28,000 square feet of quality control and inspection facilities to its Bradford, Pennsylvania, resistor plant.

How to be sure that a resistor will shape up to MIL-R-39008

The problem, as we see it, is twofold. First: how can the resistor manufacturer be sure? And second: how can you, the purchaser, be sure?

First things first. The new MIL-R-39008 "Established Reliability" specification is a challenge to the manufacturer to achieve higher standards of accuracy and reliability than were required by the earlier MIL-R-11 military specs. Not only are the MIL-R-39008 tests more extensive and more exacting; they’re also decidedly more time-consuming. (Example? Up to 630 million unit test hours are required to extend qualification to the lowest of the new failure-rate levels. With MIL-R-11, failure-rate level determination was not even required.)

We at Speer had a sneaking suspicion that we possessed the broad background and the resistor know-how to achieve these new standards of accuracy and reliability. And now, at last, we’ve completed sufficient long-term life testing to determine that our 5-stripe resistors can indeed “shape up” to MIL-R-39008’s rugged military standards.

So far, so good. But how do we now assure you of our resistors’ Established Reliability? Five colorful stripes aren’t adequate assurance. Neither are glowing adjectives.

SPEER CARBON COMPANY
St. Marys, Pennsylvania
Speer Carbon Co. is a Division of Air Reduction Company, Inc.

☐ Arrange for me to receive reprints of “Component Comments.”

Name______________________________
Title______________________________
Company__________________________
Address____________________________
City______________________________
State________________ Zip__________

Our inductor capabilities are an open book

We have just discovered that our Jeffers Electronics Division is not a group to be trifled with.

In a recent issue of “Component Comments,” we presented a feature on “The Speer Resistor Handbook.” When our Jeffers associates got wind of this, they reminded us, a trifle tartly, that “The Jeffers Inductor Handbook” is equally fascinating.

And so it is. This colorful 16-page brochure takes you through the entire Jeffers inductor plant—from the automated manufacturing operation and the application engineering services to the Established Reliability Program and the comprehensive Quality Control & Inspection Program. (Did you know, for example, that there are continuous patrol checks at every manufacturing step?) You’ll also learn how our standard catalog inductors have performed under MIL-C-15305 test conditions.

As you can see, our Jeffers Division’s inductor capabilities are an open book. If you’d like a copy, just mail us the coupon.
A new recording concept
[AND HERE'S WHAT IT WILL DO]

THE AXIS PERFORMS AS
- A STRIP CHART
- X For X-Y
- T-Y (Sequencing Chart)
- PROGRAMMING CHART
- PROGRAMMABLE CHART
- PULSE CHART DRIVEN

THIS AXIS IS the highest quality servo available in any type multi-range potentiometric recorder today.

Dollar for dollar, this new OMNIGRAPHIC™ RECORDER will deliver more functions, more features and more conveniences than any other recorder... or any other two recorders on the market today. Examples: Continuous or automatic advance feed for recording on Z-fold continuous 8½” paper or on a 7” x 10” paper grid with perforations for easy tearing to 8½” x 11” file size; push button speed control provides 18 selections from 2”/sec. to .05”/hr., or a 144,000: 1 range; .15% accuracy; ½ sec. f.s. pen response; 20 voltage ranges; and infinite input resistance.

The OMNIGRAPHIC™ RECORDER is unique. It is a new concept in graphic recording. The cost is far less than you may imagine.

Mercury plunger relay is highly reliable

A mercury plunger relay measuring only 3 in. high x 1½ in. wide x 1½ in. deep is now available with quick-connect terminals. The Mini-Relay is rated to control loads up to 20 amps at 120 v a-c and it can safely handle 2,300 w of incandescent lamps.

Using liquid mercury-to-mercury contacts within a hermetically sealed shatter-proof tube, the Mini-Relay provides silent reliable operation. With no parts to wear out or stick or corrode, the unit permits millions of makes and breaks without service or repair.

The basic operating principle of a mercury plunger relay provides two separate pools of mercury,

New Components

at 100 Mc is typically greater than 42 db, at 500 Mc it is greater than 31 db.

The DS-650 will switch (10% to 90% points) at speeds as high as 200 nsec when used with a suitable driver. Insertion loss across the entire bandwidth is less than 0.5 db; on vswr is typically below 1.7; impedance is 50 ohms nominal. Size (excluding connectors) is 4.75 x 2.3 x 1.0 in. and weight is 15 oz. Standard connectors include type N female for r-f and type BNC for control unit.

Sanders Associates, Inc., 95 Canal St., Nashua, N.H. [363]
electrically isolated from each other. With the activation of the coil, a plunger is immersed in the lower pool, displacing the mercury upwards until it makes contact with the mercury in the upper pool, thus completing the circuit. Deactivation of the coil releases the plunger, allowing the mercury level to drop, breaking the circuit. The liquid contact surface is continuously renewed on each make, and arcing is kept to a minimum, assuring long life and trouble-free operation.

The MiniRelay is constructed with all terminals in the front for easy accessibility and simple installation.

Ebert Electronics, Floral Park, N.Y. [364]

Worm-gear-actuated adjustment pot

A 1/2-in.-square, worm-gear-actuated adjustment potentiometer has been developed for industrial and commercial uses. According to the maker, the wirewound model 3257 Trimit pot is the lowest-priced 1/2-in.-square unit available. Cost is $2.36 in 100-piece quantities.

The fact that it has only twelve parts contributes to the 3257's overall reliability yet keeps the cost low. Despite its price, the 3257 has features that allow it to be used in moderately rugged environments.

These features include an idling mechanism that prevents damage from forced adjustment at the end of wiper travel; a temperature range from -65° to +105°C; fused Silverweld termination, which eliminates the chief cause of potentiometer failure; and shock and vibration capabilities of 20 g and 10 g, 2000 cps, respectively.

Resistance range is 10 ohms to 20,000 ohms; resistance tolerance, ±10%; power rating, 0.25 w at 25°C; size, 1/2 x 1/2 x 0.22 in. Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. [366]

### GENERAL SPECIFICATIONS

- **CAPACITANCE:** Within tolerance @ 1 KC, 0.05 vrms max. and 25°C.
- **TEMPERATURE COEFFICIENT:** M-3—Z5R, Y5S, X5S, M-12, 16 and 25—Z5T, Y6T, X5U.
- **LIFE TEST:** 250 hours @ rated voltage and maximum temperature.
- **BODY INSULATION:** Durez phenolic—vacuum wax impregnated.
- **LEAD STYLES AVAILABLE:** Long leads—#22 AWG tinned copper and kinked lead plug-ins for printed wire circuits.

For their size RMC Magnacaps offer the ultimate in the development of capacitance with acceptable temperature stability. Considering their small size and their proven reliability you'll find that Magnacaps are very economical.

Type M3 and M12 "MAGNACAPS" offer an extremely high efficiency ratio and are recommended for applications with lower operating voltages. The M3 type is available with a capacitance range of .05 mf to 2.2 mf. M12 Magnacaps cover the range from .05 mf to 1.0 mf. Their use as emitter bypass components is particularly suggested, as they retain their proper impedance characteristics well into the radio frequency range.

M16 and M25 "MAGNACAPS" offer an economical general purpose component for wide application with a capacitance range of .01 mf to .22 mf. Their conservative design rating, and high value of insulation resistance (10 megohms at rated voltage) has made these units particularly popular in mobile or portable battery operated equipment.

For additional information, write on your letterhead.
Does this look like an answer to global problems of ignorance, disease and physical deprivation?

Not yet. But we're getting closer.

Behind this movement is a simple statistic with startling implications for all of us—If you count all the scientists and engineers since the beginning of recorded history, ninety percent are alive today!

We are now in the midst of the result—an incredible explosion of information from every corner of the globe. And somewhere within this explosion will be the ultimate answers to mankind's oldest, and newest problems.

The challenges are many. First, to understand the nature of this giant intellectual force. Then, to find the best way to collect it, classify it, store it...and distribute it appropriately and instantly to the people who need it.

In this light, you might consider today's Xerox products early and primitive steps along a difficult but fascinating path. You'd be right. Yet, has anyone taken these steps before us?

Your degree and background may be more appropriate to our advanced work than you imagined. We're as interested in talking with communication systems specialists as electromechanical designers, organic chemists as much as program analysts. This list is as broad as it is long. Maybe broader.

You'll find several specific (and urgent) openings outlined at the right. If they suggest a possible community of interest, send us your resume. An equal opportunity employer (M&F).

The Xerox 914 Copier revolutionized the office copying industry when it was introduced in 1959...and really started us on our way.

Less than 3 years later, the 813 further extended low-cost, quality office copying. One-seventh the volume of the 914, it does just about everything the 914 does except copy solid, 3-dimensional objects.

Another revolution. An electromechanical-chemical-optical device called the 2400 because it produces 2,400 copies per hour directly from an original document. No stencil or "master" of any kind. You press a button.

TOP PHOTO: LDX (Long Distance Xerography) scans, transmits and reproduces images over distances limited only by the transmission medium. Something like it may print the morning paper at your breakfast table some day, or help you manage a global business.

XEROX
Does this look like an answer to your career problems?

ELECTRONIC DEVELOPMENT ENGINEERS. Experimental design, fabrication, and testing of CRT displays, character generation, and control equipment. BSEE required with experience in electronic circuit design, solid state logic, display, communications and/or packaging.

ELECTRONIC ENGINEERS. To work in the development of peripheral equipment of data processing systems. BSEE required with design experience in the area of solid state digital data processing equipment in both systems and circuits.

INFORMATION SYSTEMS ENGINEERS. For system configuration study and synthesis leading to detailed specification of information storage and retrieval equipment, computer peripheral equipments, and data systems terminals. BSEE required with at least 5 years experience in design, development and/or systems in digital information processing equipment, communications, and/or microfilm systems.

DEVELOPMENT ENGINEERS. To work in Discrete and Integrated Circuit Packaging. BSEE with experience in such areas as standard circuit packaging, logic configurations, circuit selection for logic and linear applications, and component applications.

These positions are in Rochester, New York. Send resume, including salary history to Mr. John J. Foley, Xerox Corporation, Department EL-12, P.O. Box 1540, Rochester, N.Y. 14603.

New Semiconductors

Silicon transistors offer fast switching

Silicon annular npn transistors, types 2N3959 and 2N3960, are designed for high-speed nonsaturated switching applications.

New "narrow base profile" techniques permit base thicknesses on the order of only 0.1 micron in volume production transistors. Previously, base regions this thin could not be fabricated without prohibitive loss of yield. This production problem had limited gain-bandwidth (fT) to approximately 1,200 Mc with an adequate breakdown voltage rating. Using the narrow base profile, the 2N3960 offers a typical fT of 1,500 Mc combined with a collector-base breakdown voltage of 20 v minimum and a collector-emitter breakdown voltage of 12 v minimum.

Both the 2N3959 and 2N3960 feature gain-bandwidth products specified at collector current values of 5, 10, and 30 ma. Guaranteed minimum fT values at collector current of 10 ma are 1,300 Mc for the 2N3959 and 1,600 Mc for the 2N3960.

Input and output capacitance for both devices are 2.5 pf maximum. The collector-base time constant is 25 psec maximum for the 2N3959 and 40 psec maximum for the 2N3960, measured at collector current of 10 ma and collector-to-emitter voltage of 10 v d-c.

The high gain-bandwidth products, low capacitances and low base spreading resistances of these new devices provide exceptionally high speed in current mode logic circuits. In this type of circuitry, the transistors offer typical turn-on delay and rise time values of 2 nsec when measured at a collector current of 30 ma and an output voltage of 1 v.

Prices for the 2N3959 are $10.50 for 1 to 99, $7 for 100 to 999; for the 2N3960, $13.10 for 1 to 99, $8.75 for 100 to 999. Motorola Semiconductor Products, Inc., Box 955, Phoenix, Ariz., 85001.

Silicon rectifiers conserve space, cost

Axial-lead silicon rectifiers are being supplied with a forward current of 3 amps and a surge rating of 300 amps. The body is insulated. Replacing stud rectifiers mounted on heatsinks or metal stacks, the molded HIB type can be mounted on component boards, allowing space and cost savings.

The units are suitable for d-c motor controls, power tools, welding equipment, radio transmitters and battery chargers, as well as military power supplies requiring large forward currents and high surge currents. Price of the 800-piv units is $1.75 each for 1 to 99 pieces.


Silicon diode bridge rectifiers

A series of molded, single-phase, full-wave bridge rectifiers is comprised of hermetically sealed silicon diodes completely encapsulated in a ten-sided configuration that permits snap-on addition of heat sinks.

Available in current ratings of 6,
subminiature chopper
(actual size)

BIG SPACE FACTOR!

You'll always find room for this chopper—no matter how crowded you are for component space. And no matter what mounting you have, there's a style to fit it. All you need—for maximum precision and reliability—is 0.1 cubic inch. Bristol F Series Subminiature Chopper also gives you: complete shielding—welded construction—airborne environmental ratings—lowest noise level.

Write The Bristol Company, Aircraft Components Division, 152 Bristol Road, Waterbury, Conn. 06720. A subsidiary of American Chain & Cable Company, Inc.

AUTOMATIC CONTROLLING, RECORDING, LOGGING AND TELEMETERING INSTRUMENTS SUPERVISORY CONTROL SYSTEMS

New Semiconductors

10 and 12 amps in voltage ratings from 50 to 400 piv, the rectifiers feature a highly efficient heat sink for extra margin performance, when desired. The heat sink is offered separately for snap-on application to the 6- and 10-amp units, and is an integral part of the 12-amp units. Under fan cooling, 12-amp units operate at 15 amps.

Considering the volt/ampere rating, the bridge rectifiers are small in size, measuring only 1% in. across the top flat surface, and ½ in. high. With heat sink added, the diameter increases to 2½ in. Mounting is accomplished by means of one 8-32 screw through a hole in the center of the encapsulation. Since the rectifier is electrically insulated, it can be mounted directly to metal chassis.

All 15 devices in the series, and optional heat sinks, are available from stock, at prices ranging from $2 to $5 in production quantities.

Alpha Components Corp., 4222 Glencoe, Venice, Calif. [373]

Power transistor
in TO-46 package

A 2-amp silicon planar npn power transistor is being manufactured for military, industrial, and commercial applications. It will provide customers with the latest state-of-the-art construction for medium-power transistors. The new transistor can be used as power supplies for computers, medium-power amplifiers, compact lightweight airborne equipment, and medium-power switching applications.

Features include collector-to-base breakdown voltages from 60 to 180 v d-c; collector-to-emitter sustaining voltages from 40 to 120 v; gains from 50 minimum to 150 maximum and saturation voltage (collector to emitter) of 0.35 v maximum. The transistor has a thermal resistance of 25°C/watt and a dissipation of 4 w at 100°C case.

The family series are MHT5001 through MHT5005 and are priced from $5 to $10 at 100 quantity. Availability is from stock.

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. [374]
Objective:

To pierce the night and spot the enemy with a compact surveillance system.

Achieved by another American Optical development:

Wide-angle reconnaissance lens system smaller than a bread box.

Passive observation of terrain, under the cover of darkness, is essential for up-to-date intelligence. To accomplish this task, airborne systems further require minimum weight and space characteristics. Combining its recent innovations in fiber optics and optical design, American Optical produced the compact but powerful 136 Hytar lens system. Speed: f/0.8 (adjustable to f/16 for daytime operation); range: 7 ft. to infinity; field angle: 40°. The 8-lb., shock-resistant package can be tucked neatly into the underbelly of a helicopter or mounted in any tactical orientation.

Let American Optical contribute to the solution of your problem. For 132 years we have been advancing optical technology. Our capabilities include materials research, instrument development and production, and systems integration. For help with your optical problem, consult the leader in optics. Write American Optical Company, Space-Defense Division, Dept. 400, Southbridge, Massachusetts 01551.

Investigate these other AO products: 1) Custom Optics, 2) Aspheric Lens, 3) Sights, 4) Laser Glass, 5) Thin Film Coatings.
Yes, there is an a.c. Pot that gives you ±0.01% linearity and 20-ohm output impedance

A comparator that provides a rapid, economical method for the precise calibration of frequency sources has been developed by Parzen Research, Inc. The model 091 comparator was designed to work with standard frequency or period counters, extending their capabilities beyond their usual measurement range. Besides providing far greater resolution than a conventional frequency counter, the comparator simplifies frequency comparisons as contrasted with use of the standard frequency signals broadcast by the National Bureau of Standards.

According to the manufacturer, model 091 provides quick, unambiguous measurements in standard rooms, on production lines, and at field stations. It can be used to align the time bases of frequency counters and time code generators with primary standards, check the stability of frequency sources, and collect data on the long-term drift in input signals.

Parzen's multiple-input frequency comparator accepts any of 21 commonly used frequencies between 100 kilocycles and 10 megacycles on both the reference and unknown frequency input channels. No auxiliary equipment, switching, adjustments, or special connections are required to operate at the different frequencies, so the two input channels can be used interchangeably.

For each pair of input signals, the comparator generates two output signals. One, a train of fast-rise time pulses, corresponds to the error-expanded frequency of 1 Mc ± MΔf, where M is a multiplication factor referred to 1 Mc and Δf is the frequency difference between the converted input signals. This pulsed output is fed to a standard frequency counter for display. The difference MΔf can be expanded for greater resolution through a front-panel range switch. This changes the multiplication factor M by 10, 100, or 1,000.

The second signal, an audio-frequency output, corresponds to the term MΔf. With a period counter, it can be used for a high-resolution display of the amount of error. However, this output does not indicate which of the two signals is greater.

Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequencies</strong></td>
<td>100.0, 111.1, 125.0, 142.9, 166.7, 200.0, 250.0, 333.3, and 500.0 kc; 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, and 10.0 Mc.</td>
</tr>
<tr>
<td><strong>Input level</strong></td>
<td>0.25 to 3 volts rms.</td>
</tr>
<tr>
<td><strong>Frequency difference range</strong></td>
<td>100,000 to 10,000,000 Hz</td>
</tr>
<tr>
<td><strong>Output frequency range</strong></td>
<td>1 Mc ± 5 kc, where 5 kc is the range of the multiplied difference (MΔf) between the reference and unknown frequencies, which can be read directly in parts in 10⁻³.</td>
</tr>
<tr>
<td><strong>Resolution</strong> (with 1-Mc digital frequency counter)</td>
<td>± 1 part in 10⁻³ for 1 second count, ± 1 part in 10⁻⁴ for 10 second count, ± 1 part in 10⁻⁵ for 100 second count</td>
</tr>
<tr>
<td><strong>Frequency range (MΔf output)</strong></td>
<td>0 to 100 kHz</td>
</tr>
<tr>
<td><strong>Level (MΔf output)</strong></td>
<td>1 volt peak-to-peak</td>
</tr>
<tr>
<td><strong>Resolution (MΔf output)</strong></td>
<td>Better than ±1 part in 10⁻³ for 1 second and ±1 part in 10⁻⁴ for 1 period</td>
</tr>
</tbody>
</table>

New Instruments

Faster, clearer frequency comparisons
NEED 14-BIT A-TO-D CONVERSION AT 200 KC?
OR 8-BIT AT 1 MC? ADAGE HAS IT!

The high-speed, high-resolution VT13-AB and ultra high-speed VT7-AB are the latest additions to the Adage VOLDICON™ line of voltage digitizers. Based on a novel design combining techniques of successive approximation and parallel threshold decoding, the VT13-AB accomplishes a 14-bit analog-to-digital conversion in less than 4 microseconds. The 8-bit VT7-AB performs a complete conversion in under 800 nanoseconds.

And look at these other Adage data systems components!

Series VMX™ Multiplexers
100,000 samples per second
±.002% offset spread; .01% gain spread — no adjustments required
Systems-organized flexible programming

Sample-and-Hold Amplifier, Model SA3
Tracks within .01% in 10 µsec. for FS input step change
100 nanosec. aperture
100 µsec. recovery from 10X FS overloads

Operational Amplifier, Model OP3
Over 5 MC gain-bandwidth product
Approximately 100 pico-amps leakage current
Less than 30 µv offset drift

HZA™ Isolation Amplifiers
100,000 megohms input impedance
±150v input voltage range
1 part in 1,000,000 gain accuracy
Single-ended and differential with 120 db common mode rejection

Digital Logic
Designed for analog/digital system requirements
Compatible modules for digital control, decoding, formatting and interfacing

Other Voldicon models include:

VS Series A-to-D Converters
2 µsec. per bit conversion time
14-bit binary or 16-bit BCD
±.01% accuracy

D-to-A Converters
±150v output
±.01% accuracy
14-bit resolution

AC Signal Conditioners
.01% of final value achieved within 15 cycles of lowest frequency
±.05% accuracy

Next time, get a quote from Adage — for components or complete systems. We think you’ll like our prices, too. Call or write I. R. Schwartz, Vice President, 617 783-1100.

Adage, Inc. welcomes employment inquiries from professional engineers.

1079 Commonwealth Avenue, Boston, Massachusetts 02215

Electronics | December 13, 1965

Circle 177 on reader service card
New Wayne Kerr B201 Bridge

Designed for highly precise, simultaneous in-circuit measurement of capacitance and conductance over an extremely wide range—from 0.001pF—10,000pF and from 0.01µMho—100mMho—the B201 Bridge is invaluable for checking capacitors and components of printed circuits and/or encapsulated assemblies.

A four-figure digital readout provides excellent discrimination enabling the B201 to be used for the observance of minute changes in component values or alterations in the constants of lines, filters, aerials, equalizing circuits and a variety of passive 2-or 3-terminal networks. A built-in level control simplifies evaluation of semiconductors and other non-linear devices.

An all solid state design, the B201 is portable and completely self-contained with battery and rectifier unit housed internally.

SPECIFICATIONS

Measurement Ranges: 0.001pF—10,000pF; 0.01µMho—100mMho in six ranges.
Frequency Range: 100kc—1mc (plug-in Source and Detector units for 100kc or 1mc).
Accuracy: ±0.1% ± 1 minor division (4th significant figure).
Discrimination: ± 1 minor division or better.
Price: $1500. FOB Montclair, N.J.

B601 BRIDGE. For wide range, precise measurement of L.C.R.; transistor admittance, (with adaptor) from 15 kc—5 mc ± 1%.

Wide Frequency Range: 15 kc to 5 mc.
High Accuracy: ± 1% generally.
Extreme Versatility: Transformer Ratio-Arm circuit provides 2- and 3-terminal measurements balanced or unbalanced. Simultaneous display of R and X on separate dials.
Price: $800. FOB Montclair, N.J.

For literature and detailed specifications, write:

Wayne Kerr Corporation
18-C Frink St., Montclair, N.J. 07042 • Phone (201) 746-2438

Circle 178 on reader service card

World’s Most Accurate C/R Bridge

100kc—1 mc

0.1% ACCURACY

New Instruments

An a-c voltage standard now in production offers a basic output voltage accuracy within 0.05% and 7-day voltage stability within 0.01%. Model 601B provides a sinusoidal output at frequencies of 60, 400, and 1,000 cps; the frequency is accurate to within 1.0%. Output voltage from 1 v to 501 v is adjustable in 0.1-v steps, and between 0.1-v steps by a multiturn potentiometer having a 100-µv adjustment resolution. By using the 601B to drive a ratio transformer, output voltages lower than 1 v can be obtained.

Output harmonic distortion is less than 0.3%, and the noise and hum is less than 0.05% of setting. Line regulation is better than 0.01% for 10% a-c line-voltage change. Other design features in-
FOURTEEN 1.5-mc CHANNELS IN FOUR CUBIC FEET

Our new PC-500 Coax stands alone among compact field recorders, another working proof of Mincom's leadership in wideband instrumentation. Only twenty-four inches tall, this beautifully designed package contains the industry's highest performance per cubic foot—seven or fourteen 1.5-mc record channels, 14-inch reels, seven switchable speeds from 1 7/8 to 120 ips, two selectable reproduce-monitor channels. PC-500 is IRIG-compatible with all standard playback systems, including Mincom's TICOR II. Record on PC-500 with a 200-kc reference signal, on playback take advantage of TICOR II's unequalled ±0.5 μsec time base comparison between events. Solve your basic problems in multi-channel wideband field recording by writing for PC-500 specifications.
Three things make a good antenna system: design competency; fabrication proficiency; and economy—which is the sure result of integrating the electrical and the structural problems as a single responsibility of the TRYLON group.

New Instruments

- Include overload protection, and isolated and guarded output achieved with a case-within-a-case system of shielding.
- Output power capability up to 25 w enables the 601B to be used for many general-purpose applications, such as the calibration of low-impedance, dynamometer-type instruments. Other applications for which it is suited include gyro and servo system design and testing and evaluation of magnetic properties. It is a basic component in a-c/d-c calibration consoles. Price is $4,500; delivery from stock.
- Cohu Electronics, Inc., Box 623, San Diego, Calif., 92112. [382]

Multifunction timer has variable range

A multifunction timer now in production has a high visibility meter-type display. Said to complement cybernetically designed instrumentation and machinery, the model 179 series is available with continuously variable timing ranges from 6 seconds up to 60 hours. Settings can be made easily and accurately with a vernier thumb wheel.

The versatile unit may be used as either a delay timer, an interval timer, or a combination of both merely by varying the connections made at the easily accessible 9-point terminal board on the rear of the timer. Timing accuracy is 0.5% of full scale. Reset time is instantaneous. Model 179’s switching contacts are rated at 10 amps 125/250 v a-c.

Another feature is the unit’s one-
Shaft position pulse transducer

This rotary pulse generator produces two channels of quadrature signals, which may be used to produce up to 3,000 equidistant bidirectional pulses per shaft revolution. Use of high-impact-resistant polycarbonate housing increases ruggedness and reduces price.

The instrument is available with internal amplifier/shaper to produce amplified square waves in quadrature. Applications are in any system that measures or controls position or speed, including machine tools, tape recorders, process machinery, batch weighing, and material cut-off.

Price is $125 for the basic rotary pulse generator; $175 for the rotary pulse generator with amplifier.

Trump-Ross Industrial Controls, Inc., 265 Boston Road, N. Billerica, Mass., 01862. [384]

Pulse generator can be programed

A programmable 10-Mc, 10-v pulse generator, type R116, is primarily intended for application where a
TRANSISTORISED OSCILLOSCOPES
1Mc/s to 100 Mc/s

FOR LABORATORIES •

340 A
Cabinet (340 A) or Rack-Mounting (340 AR) model
The unit includes:
1 vertical amplifier
5 horizontal amplifier
1 calibrator 0.2 mV at 100 V at 1 Kc/s Accuracy: 2 %
1 delay line 120 nsec
1 cathode-ray tube
1 power supply
The unit can be equipped with:
1 set of plug-in vertical amplifier
P 110 and P 280 - Soon available; P 110 • DP 100

• PORTABLE

345 A
Vertical amplifier
Bandwidth: 0-9 Mc/s Deviation coefficient: 50 mV/div
Sweep system: free-running or triggered
Sweep coefficient: 1 div to 0.2 µsec/div
Magnifier X5: 0.04 µ sec/div
Cathode-ray tube Diameter: 7 cm - Acceleration voltage: 3.8 kV
Power requirements
Mains supply: 110-220 V - 50 to 400 cps
Power consumption: 2.25 A approx.

349 C
Vertical amplifier
Bandwidth: 0-50 Kc/s Deviation coefficient: 50 mV/div
Sweep system
Sweep coefficient: 10 nsec/div to 5 µsec/div
Triggering: automatic, internal + or - external sync.
Horizontal amplifier
Bandwidth: 0-50 Kc/s Deviation coefficient: 7 V/div
Cathode-ray tube Diameter: 7 cm
Power requirements
Mains supply: 110/220 V - 50 to 400 cps
Power consumption: 2.25 A approx.

BT 210
2 identical time-bases
5 sec/cm to 10 nsec/cm
As delaying sweep: Max delay: 100 sec
BT 110
one single time-base
0-100 Kc/s
100 µV/cm

P 110
0-10 Mc/s
1 mV/cm
P 1100
Bandwidth
0 - 100 Mc/s Rise-time 3.5 nsec
5 and 50 mV/cm
P 280
2 identical amplifiers
0 - 80 Mc/s Rise-time 4.5 nsec
5 and 50 mV/cm

OTHER PRODUCTS: GENERATORS, OSCILLOSCOPES CAMERAS....

RIBET-DESJARDINS
Measure and Control Department -13-17, rue Pèrier MONTROUGE/PARIS-TÉL: 253 24-40

New Instruments
variety of pulse amplitudes, polarities, shapes, and other parameters are required in rapid sequence, as in systems and production testing. All functions are programable; in addition, the unit can be operated from calibrated front-panel controls for applications that do not require external programing.

Calibrated and programable parameters include trigger source, period, delay or burst time, width, amplitude, mode, d-c offset, rise time, fall time, and polarity. Switch-range, as well as variable control, is programable for all functions.

Rise time and fall time range from 10 nsec to 110 µsec maximum, amplitude from 0.4 v to 10 v, width from 50 nsec to 550 µsec, delay or burst time from 50 nsec to 550 µsec, period from 100 nsec to 11 nsec, and d-c offset from +5 to -5 v, all continuously variable. Rise time and fall time are independently variable when on the same range.

Special programable operating modes include delayed single pulse that provides normal pulse output after the selected delay time; double pulse output for two pulses per pretrigger output, with one pulse delayed in time by a variable amount with respect to the other; burst output with a burst of output pulses for each applied external trigger; and gated output that provides pulse outputs for the duration of the applied gate.

Complete programing capability requires 21 bits and 7 analog lines. Characteristics of the type R116 make it suitable for semiconductor and general-purpose applications.

The pulse generator mounts in a standard 19-in. rack and measures 4½ in. high and 18½ in. deep. Net weight is approximately 23 lb. Price is $1,550; availability, approximately 60 days.

Tektronix, Inc., P.O. Box 500, Beaverton, Ore., 97005. [385]

Analog x-y plotter offers high stability
High stability and frequency response are credited to the Plotmatic model 800A, a new 11 x 17-
CONSIDER COLORADO . . . transportation gateway . . . East or West. North or South. Inter-State. Intra-State.

Air, rail, truck or bus, consider Colorado, the distribution center for a 13 state area. The state is served by 7 Class I railroads, on 3,671 miles of track within our borders. It’s served by 75 transcontinental truck lines, five of which are headquartered in the state. Four of the five are among the largest in the nation. Also, Colorado boasts the second busiest general aviation and the 12th busiest commercial airport in the nation, with 8 commercial airlines making 269 scheduled flights per day. Throughout the state there are a total of 36 public use and 80 civic airports to keep all Colorado in commuting distance of the nation.

If transportation is a consideration in your business, consider industrial Colorado for your expansion or relocation. Complete information is available from Dwight E. Neill, Director, Division of Commerce and Development, 15 State Services Building, Denver, Colorado.
Everyone's talking about
Delevan's

BROAD RANGE
OF SHIELDED
COILS
&
TRANSFORMERS

Here's why!
1 Only Delevan offers 12 mechanical designs from which to choose depending upon the environmental characteristics required to satisfy a specific need.
2 Standard RF and IF transformers offering similar electrical characteristics for all designs including standardized 30 MC, 10.7 MC and 455 KC, IF transformers. Also tunable units in RETMA values from .1 uh to 10 mH.
3 A wide pricing range from $5.00 for units used in high REL space programs to $1.00 for commercial applications.

The industry's widest selection

12 MECHANICAL DESIGNS

Delevan Electronics Corp.
Subsidiary of American Precision Industries Inc.
270 Quaker Road, East Aurora, N. Y. 14052

New Instruments

A portable, low-level vibration measuring system has been introduced. The model KA-9908A can be operated by unskilled personnel after only a few minutes' instruction. Voltage output terminals permit monitoring of vibration wave form on an oscilloscope or other auxiliary equipment. Charge amplifier construction maintains factory calibration with any cable length up to 250 ft.

The system is available with

In, analog x-y plotter. The all-transistor unit provides automatic plots of voltage/voltage or voltage/time functions, from a wide variety of d-c voltage inputs.

New servo-amplifier design gives the unit full-scale accuracies of 0.15% (both axes) and repeatability of 0.1%. Recording period is 1,500 sec, with a carriage sweep of 0.01 through 2.0 in. per sec. The 16 voltage ranges include 0.5 through 500 mv per in. and 1 through 50 V per in., with continuous vernier on all ranges. A constant input impedance of 1 meglomh is provided.

Other features include a new nonclog vacuum paper hold-down system, temperature-compensated zener reference circuit, easily replaceable ink cartridge, and maintenance-free, sealed, follow-up potentiometers. The Plotmatic 800A is available in either table or rack-mount models. Price for either model is $1,885; availability, 30 days after receipt of order.

Data Equipment Co., 2126 S. Lyon St., Santa Ana, Calif. [386]

Easy-to-operate unit measures vibration

SEMI-CONDUCTOR AUTOMATIC SELECTOR

MODEL TMS-101
TRANSISTOR AUTOMATIC SELECTOR SPECIFICATION

<table>
<thead>
<tr>
<th>Item</th>
<th>continuously variable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVCEO</td>
<td>20-50V 10-30mA</td>
</tr>
<tr>
<td>BYCEO</td>
<td>5-10V 10-30mA</td>
</tr>
<tr>
<td>LVCEO</td>
<td>10-40V 1-5 mA</td>
</tr>
<tr>
<td>hFE</td>
<td>10-200V 1-5 mA</td>
</tr>
</tbody>
</table>

accuracy stability
| <= 3% | = 3% |

REMARK.
BYCEO fixed in condition of 200 A > B, C > 205V
LVCEO fixed in condition of 100 A > B, C > 0V
hFE fixed in condition of 200 A > B, C > 10

EACH JUDGEMENT
BYCEO, BVCEO, LVCEO: Good when less than setting current value.
hFE: Bad except a.b.c in condition of 200 A > B, C > 10

TOTAL JUDGEMENT
9 combinations of good A, B, C and good a, b, c are: A, B, C, a, b, c. Accordingly, total of combination makes 10 classification with inferiority.

MODEL DMS-101
DIODE AUTOMATIC SELECTOR SPECIFICATION

<table>
<thead>
<tr>
<th>Item</th>
<th>continuously variable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>0-50V</td>
</tr>
<tr>
<td>VR</td>
<td>1.5-20V</td>
</tr>
<tr>
<td>VF1.2</td>
<td>250-20mA</td>
</tr>
<tr>
<td>VF1.4</td>
<td>1-10mA</td>
</tr>
</tbody>
</table>

stability accuracy
| <= 3% | = 3% |

JUDGEMENT
IR, VR: Good when more than setting current value.
VF1:4: Good when the difference between upper and lower limits of IR is within setting range.

OTHERS: DMS-102, TMS-102, 103, 104, 105, 106.

OMINATO ELECTRONICS CO., LTD.
Address: 10, Nishihabe-bachiman-cho, Minato-ku, Tokyo, Japan.
Tel. (431) 2762, 2733
Today, Hughes is one of the nation's most active aerospace/electronics firms. Projects include: F-111B PHOENIX Guided Missile System, TOW Anti-Tank Missile, SURVEYOR Lunar Spacecraft, SYNCOM, POLARIS, VATE, Hard Point Defense and others.

This vigor will assist the qualified engineers and scientists towards more and better opportunities for both professional and personal growth.

Many immediate openings exist. The engineers selected for these positions will be assigned to the following design tasks: the development of high power airborne radar transmitters, the design of which involves use of the most advanced components; the design of low noise radar receivers using parametric amplifiers; solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles, timing, control and display circuits for the Hughes COLIDAR (Coherent Light Detection and Ranging).

If you are interested and believe that you can contribute, make your appointment today.

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For immediate consideration, please airmail your resume to:
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Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 11, California

Creating a new world with electronics

Hughes
Hughes Aircraft Company
Aerospace Divisions
An equal opportunity employer.
U. S. citizenship required
CEI MADE THE BEST 1-2 GC FREQUENCY EXTENDER

NOW WE MAKE A BETTER ONE

The solid state FE-1-2A, CEI's latest YIG-tuned frequency extender, covers 1-2 gc in a single band, converting signals to a 160 me (or optional 21.4 me) IF compatible with other CEI equipments. Improvements over the earlier FE-1-2 include: more compact size (now just 3 1/2" tall); a spring steel tape dial for easier and ultra-precise tuning; plus other features ... at no increase in price.

R eliable and easy to operate, the FE-1-2A incorporates a four-section YIG preselector for low oscillator radiation and high image rejection. The preselector is tracked electronically throughout its range, thus avoiding complex mechanical drives.

For details on this and other CEI products, please write:

COMMUNICATION ELECTRONICS INCORPORATED
6006 Executive Boulevard, Rockville, Maryland 20852, Phone (301) 933-2800

Circle 302 on reader service card

New Instruments

sweep generators have wide tuning range

Models HS-80 and HS-85 sweep generators are high-power, wide-tuning-range units that provide more than 5 watts of leveled output over the frequency range of 200 Mc to 1 Gc. Each unit offers a choice of four modes of operation: swept r-f, modulated swept r-f, c-w, and modulated c-w.

Silicon transistors are used in all circuits except the high-voltage circuits, which use vacuum tubes. The elimination of vacuum tubes wherever possible has added to the reliability and useful life of the instruments, minimizing required maintenance. Both instruments contain a built-in attenuator, which enables the user to adjust the output signal from 4 to 85 db in 1-db steps and a vernier attenuator covering 0 to 4 db.

These units also have provisions for accepting up to six single-frequency or harmonic plug-in markers for accurate frequency identification. High-power sweep generators have wide applications in testing and aligning high-power,

For your vidicon, image orthicon and professional movie cameras, Cosmicar lenses are available in focal lengths from 12.5mm up to 1000mm.

New zoom lenses are now available.

ICHIZUKA OPTICAL CO., LTD.
2-368, SHIMOOCHI, SHINJUKU-KU, TOKYO CABLE ADDRESS: "MOVIEKINO TOKYO"
nonlinear circuitry such as varactor frequency multipliers and high-power transmitters. These instruments also provide sufficient power to drive a multiple test station system or an extremely lossy system.

Price per unit is $2,500; delivery, 30 days.
Texscan Corp., 51 S. Koweba Lane, Indianapolis, Ind. {[388]}

Temperature programer is self-contained

This temperature programer allows the generation of any arbitrary function of temperature without the use of cams or complicated curve followers. The TP-200 series uses a principle of electronic function generation said to be completely new to the field of temperature control. The desired temperature function is generated by use of a large number of straight line segments of varying slopes, controlled by function dials right on the face of the instrument. Any arbitrary temperature function can be approximated to any desired degree of accuracy by this technique.

The outstanding feature of the programer is that any new function can be programed in less than 5 minutes without the use of any external equipment or conversion charts. The function is set up right on the face of the instrument, using the built-in meter which reads directly in desired temperature. Programs may be started at any point or may be interrupted as desired. A front-panel drum dial indicates the progress of the program at all times. The program progress is synchronously governed, so that programs are exactly repeatable.

In addition to providing a means of programing temperature, the TP-200 will also provide built-in mon-
New Instruments

Measures frequency response from 0.001 to 1000 cps
- performs servo analysis automatically—with speed, accuracy and ease of operation never before achieved...
- provides results from 1 to 1½ cycles of test frequency .001 to 1 cps, 2 secs. from 1 to 1000 cps
- displays phase and amplitude on direct digital readout
- achieves 40 dB of noise and harmonic rejection
- accurate to 1% in amplitude and 1° phase
- carrier and dc operation
- has No drift adjustment
- high-speed, automatic operation
- self-check, self-calibrating
- all solid state, only 7"x17"x16" in size
- weighs just 38 lbs.
- and costs but $6840.00
- options for automatic operation, point-to-point, printout, etc.

Write for Bulletin DA410

Delay measuring set offers high accuracy

High order accuracy, compact construction and solid-state design throughout are major features of a new transmission delay measuring set. Accuracy of the model 460 delay set is ±5 µsec, and the total delay that can be measured unambiguously is 4 msec. The unit utilizes carrier frequencies variable from 500 cps to 50 kc. It is capable of both absolute and relative measurements. Readings are direct in milliseconds and the set is adaptable to either closed- or open-loop measurements.

The company explains that precision determination of electrical monitoring of the actual temperature conditions at the load. A 4½-in. panel meter provides a continuous visual indication of the actual temperature, while an edgewise meter monitors the deviations between the actual temperature and the desired program, and provides a visual alarm whenever the two differ. External recording of temperature programming is available as an optional accessory, as is an alarm amplifier that provides a relay closure for remote alarm whenever actual and programmed temperatures differ.

TP-200 programers may be used to program systems using mechanical or CO₂ refrigeration or thermoelectric cooling, in addition to standard oven or furnace heaters. Cabinet styles are available for either bench or surface mounting. Harrel, Inc., 16 Fitch St., E. Norwalk, Conn., 06855. [389]

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Tel. 201-567-9222 N.Y. Tel. 212-244-0695

Circle 303 on reader service card
delay is a critical parameter in telephone communications engineering. The compact model 460 transmitter and receiver units can be stacked together for local input-output, or separated for remote inputs and outputs. Each contains its own power supply for plug-in operation, on 115 V a-c.

The transmitter and receiver units together occupy a total of only 10 1/2 in. of panel space on a standard 19-in. rack. The new instrument is designed to provide for precision measurement of delay in transmission lines, filters, networks and other linear active or passive elements.

Acton Laboratories, Inc., 531 Main St., Acton, Mass. [390]

Cavitation meter has instant response

Cavitation can be regarded in general terms as the formation followed by a rapid collapse of small cavities into a liquid phase. It can be produced not only by intense acoustic fields, but also by other means, such as high-speed ship propellers, underwater sparks, heated wires, exploding capsules, rapidly rotating rods, venturi tubes, vibrating blades, etc. This would explain the interest in accurate cavitation intensity measurements.

A cavitation meter, model CVM-3a, has been developed which gives an instantaneous indication of the true amount of energy released during the cavitation of liquid media. It gives readings proportional to the amount of noise produced during bubble collapse after reduction of the transducer signal contribution.

Characteristics of this meter include: response time less than 1 second; extended frequency range (up to 600 kc); analog d-c output; light weight (9 lb); and compactness (8 1/4 x 9 1/2 x 12 1/4 in.). Each meter is calibrated with the carbon tetrachloride decomposition technique.

An important application will be the monitoring of cavitation intensity in ultrasonic baths during cleaning operation.

Macrosonics Corp., 1001 Roosevelt Ave., Carteret, N.J. [391]
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INDUSTRIAL ENGINEERING — These men will have a wide range of industrial engineering experience. They will be involved in standard data application, cost estimating, utilization studies, layout facilities planning, work measurement and cost reduction. (Cedar Rapids and Newport Beach)

INDUSTRIAL ENGINEERING, MECHANICAL ENGINEERING OR INDUSTRIAL MANAGEMENT GRADUATES — Experience in any of the following areas: manufacturing planning and methods, facilities planning, work measurement, cost reduction and control systems and procedures, tool and equipment design, computerized manufacturing techniques, quality engineering. (Dallas and Newport Beach)

FIELD SUPPORT ENGINEERS — Openings for field engineers with installation and check-out experience in one or more of the following: high density microwave systems, toll terminal equipments, cable and open wire multiplex monopulse tracking techniques, phase locked loop receivers, parametric amplifiers, Cassegrain feeds, tropospheric scatter systems, solid state data systems. Most openings are single status with minimum of one year at location. (Dallas)

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CRYSTAL FILTER ENGINEERS — To work in the challenging field of crystal filter development and/or crystal development. Minimum requirement B.S. degree but prefer M.S. or Ph.D. Two to four years minimum experience. (Newport Beach)

PRODUCTION ENGINEERS — These men should have a background in flight director systems, gyroscopic devices or general electronics manufacturing. This area involves final development, tooling up and development of processes required for manufacture of newly designed avionics products. (Cedar Rapids and Newport Beach)

ELECTRICAL ENGINEER (Test Equipment) — This supervisory position involves the application of advanced techniques in product testing. Background should include utilization of programmed tape control and real time computer control technology and automatic test stations. (Cedar Rapids and Newport Beach)

RF SYSTEMS ENGINEERS — B.S.E.E. with experience in RF Systems including receivers, transmitters, and antennas in the VHF-UHF frequency range. Of specific interest is experience in phase locked loop receivers, high power transmitters, tracking (monopulse) antenna systems, and tracking system analysis. (Dallas)
New Subassemblies and Systems

The power that won't fail

The 100-kw no-fail power system consists of (left to right) hydraulic motor, synchronous motor and alternator, and accumulators for hydraulic fluid, all in cabinet; diesel engine starter system, diesel engine and radiator.

Last month's massive power failure in the Northeast pointed up sharply the need for instantaneous backup power to prevent even momentary blackouts of such critical electronic equipment as computers, radar, data-transmission systems and aircraft landing aids. Coincidentally, the Fermont division of the Dynamics Corp. of America has announced a system that is specifically designed to provide just such backup power.

Fermont's electronically controlled "No-Fail" power system not only takes over automatically when commercial power fails, but also cuts in whenever frequency or voltage varies beyond preset tolerances.

Under normal operating conditions, the No-Fail power system operates as a buffer between the primary power source and the equipment to which it is supplying power. Commercial power drives a synchronous motor that is directly coupled to an alternator. The alternator supplies the equipment with power and closely regulates voltage and frequency.

When commercial power fails, or becomes irregular beyond tolerable limits, a solid-state frequency sensing device at the alternator's output activates a constant-speed servo-mechanism. The servo system keeps the rotor of the generator turning at a constant rate by releasing high-pressure hydraulic fluid at a controlled rate into a motor. The frequency-sensing device also starts up a diesel engine and, when it attains operating speed, the engine is automatically coupled to the motor-alternator shaft by an over-running clutch. Power for the alternator is then supplied by the diesel engine and the hydraulic motor shuts off.

While the system is operating on emergency diesel power, the moni-

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated power</td>
<td>10 kw to 250 kw with 0.8 PF (as specified)</td>
</tr>
<tr>
<td>Output</td>
<td>Any standard operating voltage and frequency, single or three phase</td>
</tr>
<tr>
<td>Voltage Regulation</td>
<td>± 1% from no-load to full load</td>
</tr>
<tr>
<td>Voltage transient</td>
<td>± 1/8% at constant load</td>
</tr>
<tr>
<td>Frequency regulation (Engine)</td>
<td>Isochronous, ± 1/8% at constant load</td>
</tr>
<tr>
<td>Frequency regulation (Transition from utility to engine power)</td>
<td>± 1/4 cycle</td>
</tr>
<tr>
<td>Frequency regulation (motor drive)</td>
<td>Synchronous with commercial power frequency</td>
</tr>
<tr>
<td>Price</td>
<td>Depends on size and other variables, ranges from $15,000 to $150,000</td>
</tr>
<tr>
<td>Delivery</td>
<td>From 90 to 180 days</td>
</tr>
</tbody>
</table>

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2-2 Komidorī Shibuya, Tokyo, Japan
Tel: (400) 8511

Circle 305 on reader service card

New Subassemblies

tor circuit in the control console continuously monitors the commercial power. When commercial power is found to be stable over an adjustable period (15-60 minutes), a synchronization circuit adjusts diesel engine speed, synchronizing it with the power frequency. The commercial power breaker is then closed and the diesel engine shuts off.

The No-Fail 100-kw unit (see picture) is 15¾ ft. long, 4 ft. deep, and 6 ft. high; weight is 8,800 lb.

Fermont Division, Dynamics Corp. of America, 141 North Ave., Bridgeport, Conn., 06606 [401]

Educational tv system fits tight budgets

A closed-circuit educational tv system recently introduced is priced within most school budgets. It uses modular components to allow developing the nucleus of a high-performance system that can be expanded as needs and funds allow.

A “starter” camera-monitor chain can be purchased for $1,500. This can be used for teacher training and for image magnification within a classroom.

A basic system costs approximately $11,000, compared with about ten times as much for the usual studio arrangement. The package includes two viewfinder cameras, another camera for use with film chains, microscopes and similar equipment, a projector, two monitors and all controls. Screen images are up to 2½ times clearer than home tv, according to the manufacturer.

Designed primarily for educational use, the new system meets all broadcast requirements and EIA
Engineers interested in developmental aviation have 3 ways to go at Lockheed-California.

Subsonic.

Supersonic.

Hypersonic.

Lockheed’s company speedometer spans speed regimes from 0 mph through Mach 12. And the opportunities for engineers interested in programs encompassing these regimes were never more diverse.

In subsonic airborne systems, Lockheed is taking a fresh look at basic problems. For example, it is deeply involved in STOL and V/STOL short-haul transports for mass travel between major cities. In addition, a Lockheed five passenger rigid rotor helicopter prototype is now flying. In the future: heavy-lift helicopters capable of transporting 24,000 or 40,000 pounds for 100 or 200 miles. And under parallel development—advanced rotary-wing craft able to stop, fold, or start blades in forward flight.

Lockheed’s supersonic efforts are also expanding. Its SST program alone is a major and growing endeavor. It reflects the unprecedented experience Lockheed engineers have gained in Mach 3, high altitude, titanium aircraft.

Manned hypersonic test and cruise vehicles, using the SCRAMJET approach, are under development at Lockheed. They point to the day when high priority passengers and cargo can travel at Mach 12 speeds to any place on earth.

A large number of engineering positions are now open in sub-, super-, and hypersonic speed efforts. For information concerning specific opportunities write: Mr. E. W. Des Lauriers, Professional Placement Manager, Dept. 1512, 2404 N. Hollywood Way, Burbank, California. An equal opportunity employer.

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New Subassemblies

RS-170 standards. Key components are two new viewfinder cameras
with horizontal resolution of either 650 or 800 lines. They are said to
be the first viewfinder cameras to use silicon transistors throughout
(both camera and viewfinder) for picture reliability and stability.
Silicon transistors are not affected by the temperature changes that
cause picture shrinkage, fading and blurring in conventional units. In­
put power changes of up to 30 v
and temperature variations of
125°F will not cause noticeable
picture degradation (change in size,
contrast or resolution).

Diamond Electronics, Lancaster, Ohio. [402]

Medium-power-load
servo repeater

Model 893A/CT-879A servo repeater makes up a medium-power,
high-accuracy synchro follower combination designed for a wide
variety of heavy-duty industrial
and military applications. The self­
contained, fully engineered pack­
age consists of a solid state a-c
servo amplifier that requires just a
117-v, 60-cps power supply, and
a mechanical gear train which in­
cludes a 10-w servo motor with in­
tegral a-c tachometer, precision
gearing and feedback control
transformer with coupled output
shaft.

No additional equipment is
needed for this fully integrated
servo system. Everything has been
included to provide a light-weight,
power-packed, long-life servo mod­
ule. The system follows 60 cps, 3­
wire synchro data and affords a
top unloaded output shaft speed
of 100 rpm max and a stall torque
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**Electro "NFB" Power Supply** ... one of the industry's lowest cost-per-watt-output, priced at only $250. Regulation: 13% at maximum output; 0-32 vdc up to 15 amperes; Low dc impedance: 0.3 ohms, no load to full load. (Rack model NFBR... $275.)

2. Need low ripple, high voltage: ... Electro has both for only $150.

**Electro "EFB"** ... a low cost power supply delivering up to 128 watts, with top-load ripple less than 0.1% at only $150. Low cost-per-watt-output. Two ranges, continuously variable 0-32 vdc up to 4 amperes; 0-16 vdc to 8 amperes. Regulation: 1.25 volts for each ampere of load current change between 0-4 amperes in 32 volt range; 1.0 volt for each ampere of load change between 0-8 amperes in 16 volt range. (Rack model EFBR... $175.)

3. Need others?

... 18 standard models, 6 to 500 vdc from $27.50 stocked at your electronic distributor; custom designs for O.E.M. and special applications.

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Circle 195 on reader service card
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"HOW FAST CAN I GET AEL VARACTORS?" A good question. AEL gives you speedy stock to two-week delivery every time.

"TELL ME MORE ABOUT AEL VARACTORS" Okay... read on...
- Types available... standard double ended cartridge and pill (or button) package.
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Meet the Miniature SLIDE REGULATOR from Matsunaga

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Small as a cigarette pack, these regulators are manufactured on an automated line. Quality is uniform from unit to unit, performance high and durable. Extensively used in copying machines, electric computers and other office machines. For detailed information please write today.

<table>
<thead>
<tr>
<th>25VA</th>
<th>0.5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>50V or 117V</td>
</tr>
<tr>
<td>Output</td>
<td>0~117V</td>
</tr>
</tbody>
</table>

MATSUNAGA
MANUFACTURING CO., LTD.
No. 7, 2-chome, Himonya, Meguro-ku, Tokyo

New Subassemblies

of 350 oz-in. Price of the servo repeater is approximately $980; delivery, 4 to 6 weeks.
Industrial Control Co., Central Ave. at Pinelawn, Farmingdale, N.Y. [403]

Nanosecond tapped delay line

A miniature, nanosecond delay line has been announced. The encapsulated unit has a total delay of 15 nsec with taps every nanosecond, and a rise time of less than 5 nsec.

Designed for printed circuit mounting, the delay line is available in three impedance values of 93 ohms, 200 ohms or 500 ohms.

With a size of only 1.5 x 0.5 x 0.25 in., the delay line is suitable for many computer applications where high-reliability delay elements are required.

Price in production quantities is under $8; delivery, from stock to 2 weeks.
Bel Fuse, Inc., 198 Van Vorst St., Jersey City, N.J. [404]

Multiplexers handle
8 to 128 channels

Series 970 solid-state multiplexers are designed to handle as few as 8 channels, as many as 128 channels. Eight switches are constructed on
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New Subassemblies

A single plug-in card module for channel expansion in groups of eight, to be added at any time. The versatile units will accept single-ended inputs, differential inputs or three-wire inputs consisting of a differential input and guard shield.

For single-ended operation, a high-input-impedance buffer amplifier is provided. Gain is adjustable from 1 to 20, so that input signals as low as ±500 mv full scale are amplified to ±10 v. at the output. With an internal impedance less than one ohm, the amplifier can deliver a full 10 ma to the multiplexer load.

For differential inputs, an input resistance of 100 megohms is maintained, and amplification is available external to the unit.

Stepping rate of the series 970 multiplexers is selectable from 0 to 20,000 channels per sec. Optional provisions are available for random channel selection from external signals, or sequential scanning by internal programing.

The entire multiplexer is packaged compactly in a standard 19-in. rack frame, occupying only 7 in. of vertical panel space. Included in the unit are decoder modules, a control module, a buffer amplifier (for single-ended operation), and a plug-in power supply. Input filters can be supplied on request.

Astrodata, Inc., 240 E. Palais Road, Anaheim, Calif. [405]

Solid-state laser is versatile

A solid-state laser system now on the market consists of a single cavity laser head and a matching 3,000-joule power supply.

The versatile LH5 laser head can be used with a wide variety
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HARDWARE... and more HARDWARE

You name it... we have it in stock... for instant delivery!

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New product:

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Rated power: 5W
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Circle 199 on reader service card 199
New Subassemblies

of straight flashlamps. The crystal holders can be adapted to accept crystals from ¼ in. to ½ in. in diameter and 1 ⅛ in. to 6 ½ in. in length. The holders can accommodate crystals with dielectric coatings, roof top prisms and other reflector techniques.

Although supplied with a ruby laser rod, the LH5 head can also be operated with crystals of neodymium in glass, calcium tungstate, calcium fluoride, and other laser materials.

Using the standard 2,000-joule lamp and LR3 ruby, the LH5 system delivers 10 joules at room temperature and 20 to 25 joules when cooled with liquid nitrogen.

The double open-ended design facilitates use of external mirrors, cavity lengthening and Q switching, all of which can be accomplished without modification to the laser head.

Designed particularly for use with the LH5 laser head, the LPS12 power supply operates from nominal 110 v lines (110-125 v, 60 cycle). Pulse-forming networks match the output pulse shape to the characteristics of the flashlamp in use. Output can be varied from 0 to 3,000 joules in a 1.5-nsec pulse length. When the laser is Q switched, the pulse length can be shortened to 0.8 msec. Charging time for 2,000 joules is 5 seconds.

Raytheon Co., Laser Advanced Development Center, 120 Second Ave., Waltham, Mass. [406]

Power supply has high input-output isolation

Silicon regulated d-c power supplies are available with high input-output isolation. The RW series offers
Servo components are not all alike, in spite of the fact that international standards dictate identical external appearance. The difference is in the component — reliability and life expectancy — two characteristics which depend solely on quality. The Nifegon trade-mark symbolizes precision servo components with built-in quality.

**SYNCHROS**
(for torque applications and servo system)
Sizes 11, 18 and 23 — 2", 3" and 5" respectively.

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New Subassemblies

a combination of excellent regulation and stability with less than 0.1 pf input to output capacitance. The units are designed for use in instrumentation, control systems, strain gages, and other d-c power uses where precision, stability, and isolation are critical parameters.

The supply is wired on an epoxy glass card that may be used in card racks or chassis-mounted. Over-all size is 4½ x 6½ x 1¾ in. Discrete voltages to 30 v d-c are available with ±5% adjustment by multiturn potentiometer. Output power is 4 watts. Regulation is 0.01% line, 0.05% load; ripple and noise, less than 1 mv peak-to-peak. Temperature coefficient is 0.005%/°F. Price for 1 to 9 is $89 each; availability, stock to four weeks. Scintillonics, Inc., Box 701, Fort Collins, Colo. [407]

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The transistorized version of the CF-T voltage-controllable, variable-bandwidth, active crystal filter requires lower power—only 13 v d-c at 10 ma. A two-stage filter provides improved skirt selectivity at the narrowest bandwidth and at the -90 db points. Ratio of widest pass band to narrowest pass band is greater than 40 to 1. Center frequency may be specified from 5 kc to 1 Mc. Bandwidth is adjusted by d-c or a-c control voltage.

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- High output power—20mW min.
- Long life—2,000 hours expected and one year warranted
- FM modulation at high repetition rate over full tuning range
- Easy AM modulation
- Low noise

<table>
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<tr>
<th>OKI Model</th>
<th>Freq. (Gc)</th>
<th>Power output (mW)</th>
<th>Delay line voltage (V)</th>
<th>Cathode current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* BA47F</td>
<td>43.5-51.5</td>
<td>30</td>
<td>3600 max.</td>
<td>33 max.</td>
</tr>
<tr>
<td>* BA50G</td>
<td>46.5-63.5</td>
<td>30</td>
<td>3600</td>
<td>40</td>
</tr>
<tr>
<td>* BA55B</td>
<td>51-59</td>
<td>20</td>
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<tr>
<td>* BA60C</td>
<td>55-65</td>
<td>20</td>
<td>3600</td>
<td>33</td>
</tr>
<tr>
<td>** BA47H</td>
<td>46.5-52</td>
<td>150</td>
<td>4000</td>
<td>65</td>
</tr>
<tr>
<td>** BA50H</td>
<td>48.5-54</td>
<td>150</td>
<td>4000</td>
<td>65</td>
</tr>
</tbody>
</table>

* Forced air cooled.
** Water cooled. Water cooling is required for operation at cathode current of over 30mA at typical operation.
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<table>
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<tr>
<th>For a Wide Range of Military Electronic and Electrical Uses</th>
<th>Natvar Coated Fiberglass Sleeveings</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose Extruded Vinyl Tubing</td>
<td>Natvar 241 MIL-I-631C, Type F, Form U, Grade A, Class I &amp; II, Category 1.</td>
</tr>
<tr>
<td>Natvar 261 MIL-I-631C, Type F, Form U, Grade A, Class I &amp; II, Category 1.</td>
<td></td>
</tr>
<tr>
<td>Natvar 302 MIL-I-7444B, Type I, II &amp; III, Range I, II &amp; III.</td>
<td></td>
</tr>
<tr>
<td>Natvar 363 MIL-I-22076.</td>
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</tr>
<tr>
<td>Natvar 400 U/L Approved for 105°C Continuous Operation.</td>
<td></td>
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<tr>
<td>Natvar 500 Specially Formulated for Use in Transformer Oil.</td>
<td></td>
</tr>
<tr>
<td>Vinyl</td>
<td>MIL-I-21557 (Grade A Only) and MIL-I-31908.</td>
</tr>
<tr>
<td>Isolastane (Polyurethane)</td>
<td>MIL-I-31908B.</td>
</tr>
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<td>Silicone Rubber</td>
<td>MIL-I-18057A (Grade A Only).</td>
</tr>
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New Subassemblies

bandwidth must be adjustable and controllable. Price for 1 to 4 pieces is $95 each.
Polyphase Instrument Co., Bridgeport, Pa. [408]

Miniature f-m tuner offers high stability

The FM-9 tuners are three-gang variable condenser models with three transistors mounted inside the package. Approximate dimensions are 2 1/2 in. wide x 2 1/4 in. deep x 2 in. high, excluding shaft extensions.

Power requirement is 12 v at 8 ma negative ground, with positive ground and other operating voltages available. Input impedance is 300 ohms balanced, 75 ohms unbalanced. Double-tuned i-f transformer works into a 60-ohm load output shunted by 55 pf.

Tuners can be customized to meet circuit requirements and chassis compatibility.
Oak Mfg. Co., Crystal Lake, Ill. [409]

Tiny 1-Mc oscillator is crystal-controlled

A 1-Mc, microminiature, crystal-controlled oscillator now being offered is believed to be the smallest available commercially. Model S2967, designed for printed-circuit-board mounting, is intended primarily for use in communication and navigation equipment.

The crystal, which is an integral part of the unit, is in a cold-welded holder. Cold welding, because it eliminates solder and attendant
flux and heat, permits substantial increases in the stability and reliability of crystals.

Specifications of the model S2967 are: aging, 3 parts in 10^8 per day; size, 0.75 x 1 x 0.562 in. Cost is less than $50 per unit in lots of 100 or more.

Reeves-Hoffman division of Dynamics Corp. of America, 400 W. North St., Carlisle, Pa., 17013. [410]

**Fifty-millisecond delay line**

Model 81-43 delay line is a 50-millisecond unit, which is adjustable from 48 to 51.75 msec in steps of 0.25 msec. It is designed for geophysical exploration devices. Bandwidth is 800 cps (down 3 db); amplitude response, ±1 db from 100 cps to 600 cps; phase response, ±0.25 msec from 100 cps to 600 cps; impedance, 5000 ohms; insertion loss, approximately 8 db; peak signal amplitude, 1 v rms, d-c test voltage, −200.

The unit is supplied in three cases (complete with carrying handles), each of which requires 17 x 10 x 5 in. Delay lines with similar specifications or multitapped units can be built to exact customer requirements.

ESC Electronics Corp., 534 Bergen Blvd., Palisades Park, N.J. [411]

**Instrumentation-type wide-band amplifier**

A solid-state differential amplifier is available with gain settings from 10 to 1,000. Type ADV-1 delivers an output of 100 ma at ±20 v. The unit is designed to amplify small signals from low-impedance sources.

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Circle 205 on reader service card
This unitized, dimensionally accurate, pure fused quartz envelope (coil), of rugged design, provides an excellent source for Xenon high intensity lighting or ultra-violet irradiation. The LAM-O-LUME can be supplied as a plain envelope or as a completed tube with electrodes and rare gas.

FOR XENON SERVICE, which provides light intensities brighter than the sun, for outdoor lighting, photography, etc., the unitized THERMAL AMERICAN LAM-O-LUME power supply comes complete with built-in capacitors and trigger circuit. Provides 600 joule output with operating range between 1000 and 1800 volts; delivers 35-50 lumens per watt second and a life of 10,000 flashes at rated input.

FOR ULTRA-VIOLET LIGHT SOURCE for irradiation, laboratory heat exchangers, laser pumping, etc., the LAM-O-LUME power supply is available with standard 400 watt average capacity.

Write for details.

New Subassemblies

sources, such as thermocouples and strain gauges. It is well suited to many instrumentation-system uses, for data acquisition, and for general laboratory use.

The ADV-1 has a self-contained power supply. Active components are reliable silicon devices used to achieve low drift, low noise and fast recovery from overloads. Other principal features are high gain accuracy and high common-mode rejection. Eight ADV-1 amplifiers, assembled in a rack adapter, can be mounted in a standard 19-in. rack, using only 5¼ in. of vertical panel space.

This amplifier will be available beginning in December. It is priced at $495.
Fairchild Instrumentation-West, 844 Charleston Road, Palo Alto, Calif. [412]

Breadboarding system can hold 33 modules

A breadboarding system has been developed that is fast and easy to use and accommodates up to 33 encapsulated plug-in circuit modules, each comprised of from one to four standard digital circuits. Faster, more positive plug-in is provided by means of longer floating power pins on the circuit modules. The system, known as Facilogic laboratory kit K6001, consists of a pre-wired bench cabinet, an 18-switch panel, a power supply, a complete set of patch cords, and 33 plug-in circuit modules.

All standard circuits are available, including NAND, NOR, AND, and OR logic. Blank modules are available for special circuits. Breadboard modules correspond directly to a complete line of encapsulated circuit modules and standard cards.

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which are available from stock. Thus, prototype systems and test equipment may be breadboarded, debugged, and later constructed of corresponding standard in-stock encapsulated circuit modules and cards, with significant savings in time and cost.

The FacLogic modular breadboarding system is available on a special free tryout leasing basis that provides a 30-day in-plant trial at no charge.

Roback Corp., 1525 Buck Road, Huntingdon Valley, Pa. [413]

Plug-in amplifier
is rated at 2.5 watts

A solid-state linear amplifier, model MA25C, is designed for multitone audio signaling systems. Its 2.5-watt rating is sufficient to drive 10 single-channel resonant reed decoders (RDI or MD2C) simultaneously.

Gain is adjustable from 0 to 47 dB. Input impedance is 600 ohms, balanced and isolated for direct connection to standard telephone lines. Minimum output load impedance is 200 ohms. With an input of 0.022 v rms per tone, minimum output is 5 v rms per tone.

Power required is 24 v d-c at a maximum of 350 ma. Operation is class B, so current drain is proportional to power output. The amplifier weighs only 10 oz and is available from stock at the following prices: 1-9, $69; 10-24, $61.50; production lots of 100-499, $54. Delivery, 4 to 6 weeks.

Branco Controls Division, Ledex, Inc., College and South Sts., Piqua, Ohio. [414]
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New Microwave

Antenna withstands reentry temperature

A fin-shaped beacon antenna, weighing only three ounces, can withstand the intense heat encountered when missiles and space vehicles reenter the atmosphere. The antenna, designated DM AQ4 by its developers, Dorne and Margolin, Inc., is capable of withstanding 800°F continuously and 1,200°F for five minutes.

The stainless-steel blade antenna is covered with an ablative material known as Imidite 1850, and has a stainless-steel base plate for mounting. Several antennas can be mounted around the circumference of a space vehicle to provide nearly spherical coverage; the number required for this purpose depends on the diameter of the vehicle. A vehicle whose diameter is 13.5 inches, for instance, needs only two antennas on opposite sides for spherical coverage. For such an arrangement, power-matched dividers must be connected to each antenna to maintain constant load.

The DM AQ4 is designed for C band, having a frequency range from 5,400 to 5,900 megacycles and a voltage standing wave ratio less than 2.0. For any 250-megacycle band within this range, however, vswr is less than 1.5.

At an altitude of 30,000 feet and a speed of mach 3, the antenna drag is 2.9 pounds. At 70,000 feet and the same speed, the drag decreases to 0.1 pound.

The antenna was developed for the GAR-9, an air-to-air missile, and meets both MIL-E-5400, general airborne electronic equipment specification, and MIL-E-5272C, environmental test specification.

Cost of the DM AQ4 is $625. Delivery is within 60 days.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna load impedance</td>
<td>50 ohms</td>
</tr>
<tr>
<td>Connector type</td>
<td>TNC</td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
</tr>
<tr>
<td>mounting base</td>
<td>3.38 x 1.5 inches</td>
</tr>
<tr>
<td>antenna height</td>
<td>0.60 inch</td>
</tr>
</tbody>
</table>

Dorne and Margolin, Inc., Westbury, N.Y. [421]

Crossguide couplers come in 48 models

Both unterminated and terminated crossguide directional couplers are offered in 48 standard models to provide 20, 30, or 40 db coupling over the frequency range of 2.60 to 40.0 Gc. Other coupling values are...
available on special order. The compact, light, and relatively inexpensive units feature excellent vswr coupling and directivity characteristics.

The unterminated crossguide coupler is used to sample incident and reflected power simultaneously. The crossguide coupler with the secondary arm terminated serves many applications where sampling of only incident power is required.

Minimum directivity of all models is 20 db with a coupling sensitivity of ±1.5 db maximum over the waveguide range. The vswr of any arm is 1.05 maximum.

Waveline, Inc., Caldwell, N.J. [422]

**Full-bandwidth waveguide isolators**

Nine new high-isolation, full-bandwidth waveguide isolators cover the frequency range from 3.95 to 26.5 Gc. Typically, model X910LI features 40 db isolation, 1.0 db insertion loss and vswr of 1.10 across the full X-band.

Units are designed for critical system and laboratory applications where higher than average isolation is required. Minimum length and volume are achieved by use of improved solid-state techniques.

E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. [423]

**Light-weight, Ku-band coaxial magnetrons**

Light-weight, coaxial magnetrons are announced for operation at Ku-band frequencies. The units—the QKH1302, 1325, and 1368—are designed for airborne radar applications requiring high efficiency, frequency stability, and small size. They will meet the most rigorous

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Exceptional opportunities on our technical staff for qualified scientists and engineers. An equal opportunity employer.
New Microwave

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The QKH1302 is tuned mechanically over the 16.6- to 17.1-Gc frequency range. The QKH1325 operates at a fixed frequency of 16.5 Gc, and the QKH1368 at a fixed frequency of 17.2 Gc. Peak output power for the QKH1325 is 65 kw; for the other two units, 35 kw.

The coaxial magnetrons have integral stabilizing cavities incorporated in the resonant structure of the tubes. This design is said to be responsible for lower push-pull figures, longer tube life, and higher reliability than in conventional magnetrons.

Microwave & Power Tube division, the Raytheon Co., Foundry Ave., Waltham, Mass. [424]

Millimeter-wave bwo delivers up to 1 watt

A line of backward-wave oscillators now available cover the millimeter frequency range from 44 Gc to 100 Gc, with a power output from 400 mw to 1 watt, over a wide bandwidth. They are available for either air or water cooling operations.

Model 50BW10 has a center frequency of 50 Gc and is electronically tunable from 46.8 to 54.35 Gc. The delay line voltage rating is 2,000 to 4,000 v d-c; delay line current, 60 ma d-c; anode voltage, 1,080 v d-c; Wehnelt voltage, −300 v d-c; anode current, −0.5 ma d-c; heater voltage, 6.3 v a-c; heater current, 1.0 amp a-c. The unit is priced at $3,100.

These bwo's are finding increased application in satellite ground stations, space communications, maser pumps and many other...
If you ever want your power sources to get off the ground, read on:

When it comes to power sources and frequency multipliers we are tempted to say: We offer more of what you go to solid state for—excellent stability, high reliability and high efficiency in remarkably small, lightweight packages.

Take our P8004 Ku-band power source. This gives you a 16.5 Ge output frequency with 6mw output power in just 25 cubic inches, weighing 22 oz. Stability is crystal-controlled as part of the high reliability and long-life design. Input power requirements are unusually low.

For telemetry systems, the P8003 S-band power source gives you 20mw output power at a 2.2Ge output frequency, in 12 cubic inches weighing 8.5 oz.

As an example of broad bandwidth and high efficiency, consider the P8405 VHF multiplier: x3 multiplication factor, 360 to 420 mc output frequency, for a 15% bandwidth and greater than 42% efficiency. 12 watts output power.

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Measuring Frequency?

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Now, for the first time, a Wavemeter capable of indicating frequency to 0.2% accuracy on a direct-reading dial is available at a price under $200. It's the new Telonic Model TWM.

50 Mhz to 4 Ghz

An absorption type meter, the instrument has a tuning range of 1 full octave covering all frequencies from 50 Mhz to 4 Ghz. Insertion loss is held to 0.5 db and VSWR at 1.5/1.

The TWM passes signals through a matched transmission line, the sample being absorbed by the cavity at resonance and causing a 2±1 db power dip in the line.

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Simple to use, the TWM has a pre-calibrated 5:1 vernier dial that needs no interpolation or extrapolation. The setting you make is the frequency you read. Considering convenience, accuracy, range and price, the TWM Wavemeter is a natural for every engineer who wants to be frequency-sure. Full specifications available on request.

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Model 380T provides fast temperature readout even in locations not previously accessible. Accuracy is ±1% of scale range.

An S-band, pulsed type Amplitron, the QKS1110, is rated for outputs up to 3.0 megawatts. When used with a modulator having proper load line characteristics, it covers its frequency range of 2.9 to 3.1 Gc without electrical or mechanical adjustment. Peak power ranges from 0.7 to 3.0 megawatts, while average power is 20 to 30 kilowatts. Pulse duration can be varied from 2 to 100 µsec.

Efficiency of the 115-lb, liquid-cooled tube is rated between 68% and 74%. The integral magnet tube employs waveguide with UG54A/U couplings for both input and output.

Raytheon Co., Microwave and Power Tube division, Waltham, Mass. [425]

New Microwave

Pulsed type amplitron delivers up to 3 Mw

Grid-pulsed twt designed for X-band

A 10-kw, grid-pulsed traveling-wave tube now available weighs 14 lb and measures 15.5 in. long. The air-cooled type ZM-3280 has 1. Preparing design drawings in tapes.
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MIAL 611
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MIAL 614
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MIAL 615
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11, Haramachi, Nishinokyo, Nakagyo-ku Kyoto, Japan.

NEW MICROWAVE

a gain of 40 db. Output exceeds 10 kw from 8.5 to 9.6 Gc. Typical operation is at 22.5 kv and 4.7 amps cathode current.

The twt is particularly designed to meet the stiff demands of airborne and tactical surface systems. For example, it has met a shock test of 80 g and a vibration of 10 g in accordance with Curve I of MIL-E-5400.

A liquid-cooled version, type ZM-3281, is also available.
General Electric Co., Schenectady, N.Y. [427]

Spdt diode switch
covers 2 to 6 Gc

Model SC-38 is a single-pole, double-throw diode switch that operates over the frequency band from 2 to 6 Gc with insertion loss averaging 1.5 db and isolation a minimum of 40 db. Switching speeds in the nanosecond range have been measured.

Applications of this switch include switching one receiver between two antennas. Delivery of model SC-38 can be made 30 days from receipt of order.
Hyletronics Corp., 185 Cambridge St., Burlington, Mass. [428]

Compact twt amplifier
features low noise

Model HL-701 is a traveling-wave-tube amplifier containing a solid-state power supply, and designed for the 2.0- to 4.0-Gc band. Size is 3½ x 5 x 15 in.; total weight is less than 11 lb; and power con-
DRAMATIC REDUCTION
formerly 77" h. x 33"w. x 33"d.
now only
29" x 17" x 17"
(5 KW Audio Power Amplifier)

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Output: 150V.
Voltage: 200V.
Voltage: 1,500V.
Type MFL.
Dipped Flat Shape.
Capacitance Range: 0.01 MFD to .1 MFD.
Voltage: 150V.
Type MFK.
Dipped Flat Shape.
Non-Inductive Construction.
Capacitance Range: 0.01 MFD to .1 MFD.
Voltage: 150V.
METALLIZED POLYESTER FILM CAPACITORS
Type FNX-H
Mylar Wrapped Semifinal
With Epoxy End Seal.
Capacitance Range: 1 MFD to 10 MFD.
Voltage: 500V.
SOLID TANTALUM CAPACITORS
Type TAS.
Sealed with Epoxy Resin.
Capacitance Range: 1 MFD to 232 MFD.
Voltage: 3V, 6V, 15V, 20V, 35V.
Type TAX.
MIL-C-28853A Formally Sealed.

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New Microwave

sumption is less than 22 watts. It is equipped with an advanced tube furnishing a noise figure as low as 10 dB, 1 w c-w power output, and a small signal gain of 35 dB. Similar units can be supplied with other tube's covering octave bandwidths up to 12.4 Gc.

Typical applications include electronic countermeasures, reconnaissance, augmenters and buffers. The unit may be supplied to meet MIL Spec requirements for parts, construction, and reliability. The compact configuration allows installation of multiple units in a very small space, with each unit covering a different octave across the microwave spectrum.

Availability is 45 days after receipt of order, and price in quantities of 1 to 5 is $4,950.

Huggins Laboratories, 999 E. Arques Ave., Sunnyvale, Calif. [429]

Reflex klystron uses low resonator voltage

The VA-300 reflex klystron oscillator requires only 100 volts for its resonator. It has been designed for reliable local oscillator or low-power transmitter service in microwave relay systems.

The tube produces an average output of 15 mw. It has an external cavity design that provides exceptional frequency stability in 300-Mc bands between 5.86 and 7.85 Gc. Modulation characteristics are excellent and free from anomalies. The output is routed through a fe-
Microwave amplifiers use tunnel diodes

Tunnel-diode amplifiers are announced for the television and communications industry at prices previously available only in large production quantities. Amplifiers are available with 10% bandwidth between 5.9 and 7.2 Gc, 15 db minimum gain and 5 db noise figure. They can be provided with type N coaxial connectors or CPR 137G waveguide flanges. The amplifiers utilize germanium tunnel diodes as the active elements. Prices for the coaxial units are $750 each; waveguide units are $850 each; delivery, 60 days.

International Microwave Corp., River Road, Cos Cob, Conn., 06807. [431]

YIG bandpass filters for S- to K-band use

A line of four yttrium iron garnet bandpass filters has been announced for S- to K-band operation. Models Y-1001, 2001, 4001, and 8001 are voltage tunable over their frequency ranges. Frequency range for the Y-1001 is 1 to 2 Gc; the Y-2001, 2 to 4 Gc; the Y-4001, 4 to 8 Gc; and the Y-8001, 8 to 12 Gc.

Shape factor is 30 to 3 for all units, and bandwidth is 20 Mc. The devices measure 6 x 2 x 2 in., weigh 8 to 10 oz, and have in-line connections.

MicroState Electronics Corp., 152 Floral Ave., Murray Hill, N.J. [432]
Garrett-AiResearch Ram Air Turbine Systems (RATS) give you auxiliary electrical power from 150 watts to 30 kw.Externally or internally stored RATS provide power on demand—full-time or intermittent loading—speed control within ±5% of the rated electrical frequency. Think RATS for reliable electrical power for countermeasures, communications, control, guidance, weapons systems, and other aircraft and missile needs. Operate over a broad environmental range. Low weight. Low drag. Backed by AiResearch single-source responsibility and service.

For design and application data on RATS for electrical, hydraulic, pneumatic, and mechanical power, write: AiResearch Manufacturing Company, 9851 Sepulveda Blvd., Los Angeles, California 90009.

An instrument that can make immediate, automatic contact with every part of a circuit-board assembly for testing purposes is being made by the McKee Automation Corp. It serves as a connector that allows test signals to be applied to any combination of contact points anywhere on the circuit board, so automatically programmed circuit analyzers can be used for step-by-step analysis of the assembly.

McKee originally designed this fixture for high-speed check-out of circuit boards of the Mark 46 torpedo system. Now the company will custom-build similar fixtures for checking out other types of boards.

The fixture shown has some 600 test probes. These are mounted in a movable plate in a plenum chamber made of transparent plastic. The contact ends of the probes extend through the chamber top. When air pressure in the chamber is increased by means of a solenoid valve that is actuated by a signal from the check-out system, the plate carrying the probes rises. This brings the probes in contact with the test board, which is mounted above the probes.

Each probe is spring-loaded to maintain contact pressure against test points of varying heights on the board.

The probes can be arranged in a special pattern for a specific board assembly, or they can be set to mate with contact points on a standard grid pattern. Center-to-center spacing between contact points can be as little as 0.1 inch.

Because the probes are spring-loaded, the same probe array could be used to test both unassembled and assembled boards. For example, the probes could contact plated-through-hole lands on the unassembled boards, for wiring-continuity tests. After assembly, the probes could contact the solder joints under the board for circuit tests.

McKee Automation Corp., 7315 Greenbush Ave., North Hollywood, Calif. [451]

Pocket wiring tool strips and cuts

Engineered to serve all circuit wiring functions except actual soldering, the Snip-N-Strip cuts jumper
The Boxer Fan fights failures by keeping components cool in these and many other systems and electronic enclosures.

Standard size rugged metal housing resists breakage to assure system reliability.

Long life. Air bearing model endures 20 to 30 years; sleeve bearing model some 5 years; stainless steel ball bearing model has life in between. Commercial and mil spec types available. Accepts many inputs. de to 400 cps, 28 to 230V models. Range of outputs. From 70 to 195 cfm, flip fan to reverse airflow direction.

Accessories. Screen and filter available in standard and slim-line (1/2 inch) types; also finger guards and cord sets. Available. Six widely used models are distributor stocked for immediate delivery. Sales reps throughout the US and in Canada.

IMC Magnetics Corp., only producer of the high-reliability fan used in the MINUTEMAN'S guidance computer, is the single-source specialist for air movers.

Circle 331 on reader service card

Circle 310 on reader service card
Production Equipment

Production equipment wires and component leads to measure length; strips insulation; and tails lead bends. It contains a retractable surgical-steel knife blade, and fits the pocket with a convenient clip.

The tool is constructed of tough lightweight glass-filled nylon plastic, and has, at one end, a trigger-actuated set of quadrilateral shear blades, which cut conductors cleanly without distorting stranded types. An adjusting setscrew on the trigger provides for partial closing of the shears for insulation stripping operations. A sliding scale on the side of the tool gives an accurate, quickly adjustable length gage, and can be locked in position by means of the pocket clip.

Both stripping and cutting operations can be performed from either direction. For cutting and preparing a quantity of jumper leads, the conductor is fed through the tool from the opposite end. Thus, when the tool is used to work on leads inside equipment, the cut ends and insulation scraps are contained inside the Snip-N-Strip instead of flying into inaccessible parts of the equipment.

At the opposite end of the Snip-N-Strip is mounted a latching carrier for interchangeable and replaceable scalpel blades of standard type. A receptacle beside the blade gives a convenient means of inserting component leads to produce neatly tailored bends and turns. The measuring rule, reversible in any of four directions and extensible at either end, is used for accurate measurement of component lead bends. List price is $9.95.

James Electronic Tool Co., P.O. Box 1482, Palo Alto, Calif. [452]

System controls resistor quality

A system has been developed that will permit automated manufacture of tantalum thin-film resistors. Initially, tantalum film is deposited on a glass substrate to obtain a resistance about 25% below the final value. The surface is then subjected to controlled anodization, which forms a layer of tantalum oxide, progressively increasing the effec-
Hand-operated machine makes bends in leads

A machine to produce precision bends in resistor, diode and other component leads is designed to fill the gap between the needle-nose plier and mass production-bending techniques. Model 100A Lead-bender is manually operated and produces uniform and accurate lead bends in a variety of configurations. Axial lead components as large as ½ in. in diameter can be accommodated by the machine without body damage or damage to the leads, while production rates of up to 600 per hour are possible.

Bends for 0.5-, 0.6-, 0.7- and 0.8-in. printed-circuit centers can be made with standard, easily interchangeable dies. Dies for Military-NASA type, commercial, and offset-double bends, as well as single bends for perpendicularly mounted components, are stock and considered standard. Custom bends for these and other hole spacings can be supplied to customer specification.

D. Vel Research Laboratories, Inc., 555 Bedford Road, Bedford Hills, New York, 10507. [454]
New 20 pg. Catalog makes it Easy to Select

the right Thermal or Magnetic Circuit Breakers

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Since IMP’s mission includes the measurement of fields, the system requires a power supply which generates no significant magnetic field. In response to this requirement, Space Craft designed and built a non-magnetic power converter. It converts DC to RF through a 1 Mc oscillator and demodulates back to DC at four output voltages. Voltage regulation is better than ± 0.05%.

Thus IMP takes its place among more than a score of power conversion contracts successfully completed or under way at Space Craft, Inc. These systems have combined conversion efficiencies as high as 86% with minimum weight, minimum volume and maximum reliability.

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SPACE CRAFT, INC.

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Circle 222 on reader service card

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Model MAK-655A

FEATURES:

- FREQ. RANGE: 20-20,000 c/s in 106 steps, 2-5-10 sequence, automatic (1 step per sec.) or manual selection. ■ LOW DISTORTION OSCILLATOR, with marker output, 30-dB output level control; automatic or manual. ■ DISTORTION METER: 0.3% - 30% f.s. in 5 ranges, input -60 to +20 dBm, overall, or 40-dBm range, automatic; recorder output, 0.4V max. X-axis 0.3V DC ■ APPLICATIONS: Audio distortion and response measurements, signal and noise level meter, etc.

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(Meguro Electronic Instrument Co., Ltd.)
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TEL: 731-7191 -7 Cables: MEGURODENPA TOKYO

Circle 336 on reader service card
New Books

Laser operation
Optical Masers
George Birnbaum

The principles of laser operation—in particular, the atomic processes associated with laser action and their relation to device configuration—are discussed in this book. The major topics are consistent with the building blocks of an optical maser: materials, pump and resonator. The three types of laser materials now in use—crystal, gas, and semiconductor—are described in separate chapters. Optical pumping is discussed in a brief chapter. Several introductory chapters cover the theory of maser operation, from both the steady-state and transient viewpoints. These chapters include derivations of the rate and gain equations and a comprehensive discussion of optical resonators. The final chapters discuss the radiation characteristics of the source, such as coherence and mode patterns, and a short review of laser applications in the fields of communications and spectroscopy. There is also a chapter treating nonlinear effects, using both the quantum picture of multiple photon absorption and the wave picture of harmonic generation.

But the quality of the treatment is uneven. This is not so much the fault of the author: Almost all the books written in a new multidiscipline field that is growing at an exceedingly fast rate have this shortcoming. As is often the case, the book excels in those areas where the author has contributed original research. This applies to the first few chapters. For instance, a chapter on spectral line shape is concise and to the point; in particular, the distinction made between homogeneous and inhomogenous broadening is very well done in terms of Lorentz and Gaussian distributions. The chapter on optical resonators is also good, with excellent photographs of radiation patterns for rectangular and circular modes. The chapter on multiple-photon processes is another asset because this material is not usually found in texts on optical masers. Furthermore, one of the chapter’s outstanding points is the clear distinction made between parametric interaction processes such as harmonic generation (which leaves the atomic system in its initial state) and Raman- or Stokes-type emission processes.

Other chapters fall below standard. An example: the chapters on output of optical maser radiation characteristics and optical maser applications. In the former, the important subject of spatial coherence, for all practical purposes, is ignored. There is either confusion in the author’s mind or poor exposition in pointing out the difference between coherence lengths parallel to and coherence lengths normal to the direction of propagation. It also appears that some of the material in this chapter was not thoroughly studied before it was incorporated in the book; the material on photon correlation contains entire lines taken verbatim from one of the quoted references. In the chapter on applications, the development is so sketchy that its usefulness is questionable.

In spite of its shortcomings, this book will be valuable to anyone engaged in laser research. Because it is written in the language of the atomic physicist, the book may be difficult for electronic or microwave engineers. But those concerned with applications and desiring greater understanding of the laser will find it a useful guide to appropriate papers in the technical literature.

Henri Hodari
National Engineering Science Co.
Pasadena, Calif.

Elementary network theory
Physical Networks
R. S. Sanford
Prentice-Hall, Inc., 516 pp., $12.95

Various types of linear one-dimensional physical systems are discussed at an undergraduate level. Using the concepts of “through” and “across” variables and the generalized definitions for basic network elements, this volume treats the network theory from a unified point of view. Besides electrical networks, other types of lumped-parameter linear systems are examined; these include mechanical, hydraulic, acoustical, and parametric interaction processes such as harmonic generation (which leaves the atomic system in its initial state) and Raman- or Stokes-type emission processes.

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New Books

The Chemistry of Diamond-Like Semiconductors N.A. Goryunova, Edited by J.C. Anderson, The M.I.T. Press, 236 pp., $10


Atomic and Space Physics, A.E.S. Greene, P.J. Wyatt, Addison-Wesley Publishing Co., 619 pp., $18.75

Computer Control & Industrial Processes, E.S. Savas, McGraw-Hill Book Co., 400 pp., $16

Industrial Management in the Atomic Age, A.L. Parsegian, Addison-Wesley Publishing Co., 374 pp., $10.75
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PZC-3107
A miniature slug type, cadmium sulfide, low voltage cell. Especially applicable to camera equipment. Hermetically sealed, moisture proof and long lived.

PZC-7103
Especially applicable to automatic relays and automatic switching equipment, this moisture proof cell is designed for a power application of approximately 0.3 W.

PZE-3101G
A glass sealed, slug type, selenic cadmium cell, designed for photoelectric measuring devices, control circuits, non-contact relays etc.

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Technical Abstracts

Small package, high power

High-performance experimental high-power triodes

By J.E. Beggs and N.T. Lavoo

General Electric Research and Development Center, Schenectady, N.Y.

A tenfold increase in plate current, transconductance, gain-bandwidth product and power output is provided by new experimental planar triodes developed for microwave frequencies. The increased performance capabilities over that of commercially available triodes of comparable size and weight result from design modifications utilizing new structural materials and improved tube assembly and processing techniques. The L-65/Y1430 triode—the smaller of the two tubes discussed in the paper—is approximately 1 1/4 ounces. The larger tube, the L-64/Y1498 triode, is 1 1/2 inch long by 1 1/2 inch in diameter.

The cathodes supply a current of 1 ampere, corresponding to an emission-current density of 1.6 amperes per square centimeter. Extremely rugged control-grid structures have fine detail, yet are capable of conducting the large displacement currents that flow during high-power operation of the tube. This combination results in exceptionally high transconductances on the order of 0.3 to 0.7 mhos, in small triodes that can provide an output of 1 kilowatt or more at 1 gigacycle and a few milliwatts at 20 Ge.

In the L65 tube, 50 watts of drive and a plate voltage of 2.1 kilovolts produce a continuous-wave power output of one kilowatt and a plate efficiency of 67%. The power gain is 13 decibels. By increasing the anode voltage, 1 kw of output power is obtained with 20 db gain at an efficiency of 41.5%. An output capacitance of only 4 picofarads together with the high transconductance permits a theoretical gain-bandwidth product of 12 Ge. When tested in a triple-tuned circuit centered at 1.3 Ge, a gain-bandwidth product of 7.45 Ge was measured. Under typical conditions the gain was 15.5 db and the three db bandwidth was 167 Mc.

The L64, is very similar in construction to the L65, but because of its larger size is capable of higher output power. At 1.3 Ge, it has been tested with an input pulse of 500 microseconds and a duty factor of 0.07. Under these long-pulse conditions, a gain-bandwidth product of two Ge was measured in a triple-tuned circuit. Typically the gain is 21 db and the three db bandwidth is 144 Mc. Under large-signal, broadband conditions, five-kw peak output power is obtained with a gain of 17 db and an efficiency of 33%.

Other construction features contributing to high performance of the triodes include a water-cooled molybdenum anode to permit high-power operation, close spacing between control grid and cathode to reduce electron transit time, and thoroughly degassed components and high vacuum within the tube.

Presented at the International Electronics Devices Meeting, Washington, October 20-22 1965

Logical design with IC's

Cobweb cellular arrays

Robert C. Minnick,

Stanford Research Institute,

Menlo Park, Calif.

Logical design with integrated circuits should produce the desired output with a minimum of interconnection — minimum component count is secondary.

The cobweb cellular array offers
a technique for logical design with integrated circuits improving on the previously reported cutpoint array. A cutpoint array is a rectangular group of cells, each with two inputs and two outputs and each capable of performing one of six logical functions plus the "1", "0" and flip-flop functions. Switches within the cells define the logical function; these switches may be phototubes, flip-flop circuits, or conductor breaks.

However, cutpoint arrays tend to require a large number of cells—though a minimum component count is not a concern, they often require connections from edge to edge of the same array through back-panel wiring. Often they do not have enough edge terminals for the required back-panel connections, and faulty cells in an array are not easily isolated.

The cobweb array is similar to the cutpoint array, but has more connections between cells on one substrate and more switches within the cells. The circuitry within the cell is the same, and the logical functions generated are the same. With the cobweb array there are 1½ to 3 times as many edge terminals for outside connections; and at the same time connections from edge to edge of the same array can be made equivalently through the greater complexity of the individual cells. A 3-bit adder can be built with 30 cobweb cells, but requires 49 cutpoint cells; the number of cobweb cells for a shift register is 2½, five greater than with cutpoints, but with a complete elimination of edge connections. And a typical generalized logic function drops from 36 cells to 18, with elimination of edge connections.

Faulty cutpoint cells, when found, can be removed from the array and replaced. This is not feasible with cobweb cells because of the complex design.

Presented at the Fall Joint Computer Conference, Las Vegas, Nov. 30-Dec. 2

Wideband amplifier
The reflex repeater, a direct r-f to r-f repeater

Although the reflex-amplifier concept has been known for many
years, it has not been used to any great degree. Applications, for the most part, have been limited to video or the low end of the very high frequency range. These early systems were designed for point-to-point relay of television, and were in ground-based installations only. Reflex amplifiers with traveling-wave tubes are now being designed; such systems have wide bandwidth, high gain, and multiple signal handling capability.

In the basic reflex system, an input signal at frequency $f_1$ is passed through a bandpass filter and amplified by a twt. On leaving the twt, the signal is routed through a second filter to the mixer for frequency translation. At the output of the mixer, either the upper or lower sideband is selected by filtering and the signal (now at frequency $f_2$) is fed back to the twt and amplified. The amplified signal is fed from the twt to the output of the mixer.

Other radio repeaters use a “back-to-back,” or heterodyne, configuration. With the back-to-back repeater, the received signal is first demodulated and then used to modulate a separate transmitter. With the heterodyne repeater, the received signal is translated to an intermediate frequency, amplified, and then again translated, this time to a radio frequency suitable for transmission. Both of these repeaters have been used in point-to-point systems and in satellite communication applications.

In his paper, the author discusses the merits of each repeater system and how a reflex repeater can provide wideband capability, increased reliability, system and component simplicity, duplex and multiple access capability, and flexible operation.

In a discussion of laboratory tests on a typical 7-Gc reflex repeater system, the writer tells how the operation of a reflex repeater is essentially that of a linear amplifier, and why the distortion products which result from this type of operation are extremely low.

Presented at the National Telemetering Conference, Houston, Tex., April 13-15
ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

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

Electronics QUALIFICATION FORM FOR POSITIONS AVAILABLE

NAME ...........................................
HOME ADDRESS ................................
CITY ...........................................
STATE ........................................
HOME TELEPHONE .............................

FIELDS OF EXPERIENCE (Please Check)

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Electronics | December 13, 1965
Investigate your career now in missile-defense radar; advanced sonar engineering at General Electric.

G.E.'s Heavy Military Electronics Dept.—whose capabilities include the design, development and fabrication of the world's largest and most advanced ASW and radar systems—announces long-term career openings for continuing contributions to large military contracts.

HMED offers you stability based on its broad capability for handling large programs and the experience that goes with front-rank performance on this decade's most advanced projects. Your growth is tied to that of a lean, highly professional engineering group backed by top-flight facilities—both within HMED and throughout General Electric.

At G.E., you'll be treated as a professional who's expected to handle well-defined, delegated responsibility. In most instances you'll deal directly with your customer's organization.

You will be given every opportunity to develop yourself professionally through continuing Company-taught courses and advanced tuition-paid study at nearby Syracuse University. And, in the course of your work, you'll have access to information developed by other G.E. facilities throughout the country.

WHY NOT MATCH YOUR EXPERIENCE AND CAREER DESIRES AGAINST THESE REQUIREMENTS?

SONAR: Advanced Sonar Engineers; Array Beamformer and Signal Processing Development Engineers; Digital Logic Engineers; Sonar Solid-state Circuit Design; Transducer Development; Solid-state Transmitter Development; Pattern Recognition Analysis; Adaptive Filtering Research; Display Development; Propagation Analysis; Sonar Subsystem Development.

RADAR: Monitor and Control Analysis Engineers; Digital Control Eqpt. Engineers; Microwave Component Design Engineers; Consultant, Circuit Design and Development; Instrumentation Circuit Engineers; ME's for Signal Processing Modules; Consultant, Array Radar Subsystem Requirements.

INVESTIGATE NOW! For full information, send a resume of your experience in confidence to J. L. Wool, Professional Placement, Heavy Military Electronics Dept., Section 122, General Electric Co., Court St., Syracuse, New York.

An Equal Opportunity Employer
FOR INFORMATION

about employment opportunities advertising contact the McGraw-Hill office nearest you

ATLANTA, 30309
1275 Peachtree St., N.E.
404-875-0523

BOSTON, 02116
607 Boylston St.
617-262-1160

CHICAGO, 60611
645 No. Michigan Avenue
312-664-5800

CLEVELAND, 44113
55 Public Square
216-781-7000

DALLAS, 75201
1800 Republic Nat'l. Bank Tower
214-747-9721

DENVER, 80202
1700 Broadway, Tower Bldg.
303-255-2981

DETROIT, 48226
856 Penobscot Building
313-962-1793

HOUSTON, 77002
2270 Humble Bldg.
713-224-8381

LOS ANGELES, 90017
1125 West Sixth Street
213-482-5450

NEW YORK, 10036
500 Fifth Avenue
212-971-3594

PHILADELPHIA, 19103
Six Penn Center Plaza
215-568-6161

PITTSBURGH, 15222
4 Gateway Center
412-391-1314

ST. LOUIS, 63105
7751 Coronelet Avenue
314-725-7285

SAN FRANCISCO, 94111
255 California Street
415-362-4600

2 REASONS WHY THERE'S MORE ENGINEERING OPPORTUNITY AT ECI

Where there's engineering excitement there's engineering opportunity. Two key indicators — prime contracts in progress and R&D work in progress — prove that exciting things are happening at Electronic Communications, Inc. ECI has generated these remarkable activity increases by building a solid, successful reputation in airborne systems, multiplexing, space instrumentation and other areas of military and aerospace communication. You can get aboard this upward trend immediately if you are qualified in:

RF ENGINEERING — aggressive new programs are now under way in the design and development of microminiature transmitters and receivers. Positions require at least a BS degree, with a minimum of three years experience, and sound knowledge of transmitter and/or receiver design theory.

SPACE INSTRUMENTATION PROJECT ENGINEERING — you'll need in-depth technical ability, plus six years experience in data handling, control, or analog instrumentation.

THIN-FILM CIRCUIT DESIGN — involving theory and application of thermodynamics, mechanics of materials and electronic component design in the development of microelectronic circuitry. BS or MS in EE or physics required.

SYSTEMS INTEGRATION — you must be thoroughly grounded in aircraft electrical systems and be familiar with interface problems involved in installation of airborne communications equipment. Prior systems integration or field installation experience is most desirable.

If you are qualified, send your resume, in confidence, to Duane Meyer, ECI, Box 12248E, St. Petersburg, Fla., or call him collect at (813) 347-1121.

(An equal opportunity employer.)

ELECTRONIC COMMUNICATIONS, INC.
ST. PETERSBURG, FLORIDA
Kaiser Aluminum
and Chemical Corporation

Philadelphia Naval Shipyard

Naval expansion offers you a career in ship and shore system design, research, development and evaluation.

Starting salaries up to $10,619 depending on experience.

Many exciting opportunities for engineers are being created by the expansion of the Philadelphia Naval Shipyard, the major facility for new ship construction on the East Coast, and expansion of the activities of the Office of Industrial Manager, Fourth Naval District. These are career Civil Service positions with regular salary increases and generous benefits including 15-26 days of vacation, 13 days of sick leave, 8 holidays, inexpensive health and life insurance, and an unusually liberal retirement plan.

Electrical and electronic engineers are offered a variety of challenging assignments in every phase of ship and system design ranging from electrical power and light to fire control, communications, radar, and instrumentation, etc. Also offered are laboratory assignments in research and development of stress, sound and vibration, measuring equipment and their application; assurance engineering and reliability engineering covering the field of shipbuilding systems and equipment; and development, design, instrumentation, and installation planning of electronic systems for U. S. Naval activities ashore.

Philadelphia and its suburbs offer housing accommodations for every taste. This historic city has museums, libraries, spacious parks, 27 colleges and universities, and is within an hour's drive of excellent ocean beaches and famous mountain resorts.

If you have a degree in engineering, send a resume or Standard Form 57 (available at any Post Office) to the Industrial Relations Office, Code 175-F.

Philadelphia Naval Shipyard
Philadelphia, Pennsylvania 19112

An Equal Opportunity Employer

Kaiser Aluminum
and Chemical Corporation

Ravenswood Works
Ravenswood, West Virginia

Permanent position in aluminum reduction plant Engineering Division. Responsible for major electrical engineering projects including design of new facilities and alterations to existing equipment. Must provide technical and administrative supervision for engineers and draftsmen.

Applicants must have the following minimum qualifications: B. S. in E. E. or 10 years experience in responsible engineering work, good working knowledge of high voltage AC power distribution (138 KV), metering, relay switching, etc. Adequate working knowledge of high voltage, high current rectifier stations including mercury arc and solid state rectifiers, DC bus systems, high current metering systems and safety requirements.

Minimum salary $12,000.

Salary commensurate with experience.

Location: Mid-Ohio Valley.

Excellent benefits including relocation assistance.

Send resume in complete confidence to Mr. Carl A. Dunlop

Kaiser Aluminum & Chemical Corporation
P. O. Box 98

Ravenswood, West Virginia

An equal opportunity employer

E. E.'s
for FEE-PAID Positions
WRITE US FIRST!

Use our confidential application for professional, individualized service. A complete national technical employment agency.

ATOMIC PERSONNEL, INC.

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Details in the forward section of the magazine for additional Employment Opportunities advertising.

RATES

DISPLAYED: The advertising rate is $52.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. Effective Jan. 1966. Rate is $60.00 per inch.

An advertising inch is measured \( \frac{3}{8} \)" vertically on a column—3 columns—30 inches to a page. Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. The above rate does not include payment. Discount of 10% if full payment is made in advance for 4 consecutive insertions. Not subject to Agency Commission.

Send new ads to:

Electronics
Closs. Adv. Div., P.O. Box 12, N.Y., N.Y., 10036

Kaiser Aluminum
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Ravenswood, West Virginia

Permanent position in aluminum reduction plant Engineering Division. Responsible for major electrical engineering projects including design of new facilities and alterations to existing equipment. Must provide technical and administrative supervision for engineers and draftsmen.

Applicants must have the following minimum qualifications: B. S. in E. E. or 10 years experience in responsible engineering work, good working knowledge of high voltage AC power distribution (138 KV), metering, relay switching, etc. Adequate working knowledge of high voltage, high current rectifier stations including mercury arc and solid state rectifiers, DC bus systems, high current metering systems and safety requirements.

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WRITE US FIRST!

Use our confidential application for professional, individualized service. A complete national technical employment agency.

ATOMIC PERSONNEL, INC.
**SEARCHLIGHT SECTION**

- Classified Advertising
- Business Opportunities
- Used or Surplus Equipment

**TEST EQUIPMENT**

For over 20 years specializing in top brands only. Write for our latest listing.

**ELECTRONIC SALES**

1413 Howard Street, Chicano, Illinois 60626
Telephone Rogers Park 4-8600

**CIRCLE 955 ON READER SERVICE CARD**

---

**REFERENCE BOOK**

"TRANSISTOR CIRCUIT ANALYSIS"—Joyce and Clarke

Presents the basic method of analysis involved in the understanding and design of junction transistor circuits. Includes 24 transistor circuits employed to a few easily interrelated ones. Write for free brochure. $1.27

Addison-Wesley, Reading, Mass. 01867

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**EQUIPMENT SALE**

H.P. TEC, G.R. ETC. Practically new Decode Boxes, Pulse Gen's, VTVN's, Audio Osc.—Counter's, etc. EASY-UP, INC.

2425 Bradley Road, Rockford, Ill. P. 877-5588

**CIRCLE 951 ON READER SERVICE CARD**

---

**SEARCHLIGHT Equipment Locating Service**

**No Cost or Obligation**

This service is designed to help you, the reader of SEARCHLIGHT SECTION, to locate used or rebuilt equipment not currently advertised.

**HOW TO USE:** Check the ads in this SEARCHLIGHT SECTION to see if what you want is advertised. If not, print clearly the specifications of the equipment and/or components wanted on the coupon below, or on your own letterhead.

**THIS IS A SERVICE TO OUR READERS. THIS PUBLICATION DOES NOT BUY, SELL OR STOCK EQUIPMENT OR MATERIALS OF ANY TYPE.** Your requirements will be brought promptly to the attention of the used equipment dealers advertising in this section. You will receive replies directly from them.

Obviously, the list of such advertisers is limited by comparison with the over 65,000 subscribers to electronics, all directly engaged in the electronics industry. A small 'EQUIPMENT WANTED' advertisement section, to locate used or rebuilt equipment not currently advertised, will handle up to 20 ft. dish. Supplied complete with control chassis. In stock—immediate delivery. Used world over by NASA, U.S.A.F., TYPE 89 H. SCR-394, NIK AEI mounts in stock plus several airborne trackers.

**SCR 584 AUTOMATIC TRACKING RADARS**


---

**PULSE MODULATORS**

**MIT MODEL 9 PULSER**

1 MEGAWATT—HARD TUBE

Output 25 kw 40 amp. Duty cycle. 0.02. Pulse lengths 25 to 250 microseconds. Output 3 to 30 kw. 1 microsecond. Uses 9546 thyatron. Input 1152 60 cycle AC. Mfr. GE. Complete with high voltage power supply.

**MIT MODEL 3 PULSER**


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**MICROWAVE SYSTEMS**

**E-4, FIRE CONTROL SYSTEM**


**C-BAND RADAR**

250 KW output. C-band, PPI indicator. Transmitter. 250 kw output, 3 cm, PPI indicator. Transmitter 20 kw output, 3 cm, PPI indicator. Transmitter.

**500 TO 2400MC RF P Que**

500 to 2400 MC C.W. Tunable. Transmitter. 10 to 50 Watts. Output. As new $475.

**500KW “AJ” BAND RADAR**

500 kw 1220-1350 mics. S. Atlantic microwave search range P.P.I. and A Scopes. MTI. thyratron mod. 5J26 magnetron. Complete system.

**5949 THYRATRON AGING RACK**

Comp. Chatham Electronics Console incl. 15 kw power supply & PPM's. $1600.

**PHILCO MICROWAVE LINKS**

200 mc. Microwave Link terminal bay. Repeaters in stock. New $1500 each or $2500 per pair.

---

**INFRARED SOURCES**

Collimated radiation simulator and transistorized temp. controller. Temp. range, 200-600 degrees C. Absolute Accuracy ±3 degrees C.

**3KW RCA PHONE & TELEX XMTR**

8-20 Mc. 30 automobile channels plus MO. Input 220 vac. 50/60 cycles.

**CIRCLE 992 ON READER SERVICE CARD**

---

**AUTOTRACK ANTENNA MOUNT**

760 degree azimuth, 210 degree elevation sweep with better than 1 mill. accuracy. Missile velocity scrambler and slowing rates amplifier and servos control. Will handle up to 20 ft. dish. Supplied complete with control chassis. In stock—immediate delivery. Used world over by NASA, U.S.A.F., TYPE MP-87 B. SCR-394, NIK AEI mounts in stock plus several airborne trackers.
New Literature


Tantalum capacitors. Transistor Electronics, Inc., West Road, Bennington, Vt., has released an engineering bulletin on its custom-made type CM tantalum capacitors. [462]

Materials technology. The Carborundum Co., Niagara Falls, N.Y. A semiannual publication, Advanced Materials Technology, features in its current issue silicon carbide whiskers, plus articles on high-temperature thermistors, graphite, Zirconium powders and ceramic bonding. [463]

Two-axis accelerometer. Kearfott Division, General Precision, Inc., Little Falls, N.J., offers a catalog data sheet on the model C70 2414001 inertial two-axis accelerometer. [464]

Microwave components. PRD Electronics, Inc., 1200 Prospect Ave., Westbury, N.Y., 11590, has available a two-page data sheet describing waveguide and coaxial microwave components. [465]


Silicon semiconductors. Raytheon Company, Components Division, 191 Spring St., Lexington, Mass. Key specifications for more than 500 silicon semiconductors are listed in a new condensed catalog. [467]

Analog computation. Electronic Associates, Inc., West Long Branch, N.J. A 12-page booklet describes the basic principles of analog computation and briefly explains how this versatile, problem-solving technique can be used to increase engineering efficiency. [468]

Nickel-cadmium batteries. Sonotone Corp., Elmsford, N.Y., 10523, has issued a four-page technical brochure, BA-125, on its line of sealed nickel-cadmium battery cells. [469]

Quartz pressure transducer. Kistler Instrument Corp., 8989 Sheridan Drive, Clarence, N.Y., 14031, has released bulletin 157465 describing a subminiature quartz pressure transducer, which contains an internal accelerometer that virtually eliminates vibration sensitivity. [470]

A-c motors and rotating devices. Rotating Components, Inc., 1560 Fifth Ave., Bay Shore, N.Y., offers a new catalog...
You Know A Great Deal About Electronic Equipment
And That's Why You Know Capacitors Are So Valuable

Nichicon provides you with the best from Japan because Nichicon has the experience built up from many years of research. One of our major customers abroad is R.C.A., The Magnavox Company. Nichicon products are mainly for overseas markets.

Main Products: Electrolytic, Ceramic, Tantalum, Plastic Film, Paper, MP and Mica Capacitors.

Nichicon Capacitor Ltd.
HEAD OFFICE: Nakagyo-ku, Kyoto, Japan
CABLE ADDRESS: CAPACITOR KYOTO

that includes, in addition to its line of fans, blowers and motors, the complete line of Sangamo precision motors. [471]

Test/measuring/control equipment. Industrial Instruments, Inc., 89 Commerce Road, Cedar Grove, N.J., 07009, has released a 42-page catalog dealing with equipment for test, measuring and control applications. [472]

Transmission measuring facility. Radio Engineering Laboratories, 29-01 Borden Ave., Long Island City, N.Y., 11101, has available a technical data sheet on its solid-state transmission measuring facility. [473]

Thermal writing recorder. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. A four-page bulletin describes a low-cost, portable, two-channel thermal writing recorder. [474]

Microphotography facility. HLC Engineering Co., Anderson & Roesch Sts., Oreland, Pa., 19075. A microphotography facility for low-cost, in-house production of microelectronic photomasks and similar photographic applications is described in a six-page technical bulletin. [475]

Linear motion potentiometers. Compu-ter Instruments Corp., 92 Madison Ave., Hempstead, N.Y. Catalog IMP263A presents the comprehensive range of the company's latest precision film potentiometers, including the new model 110 with stroke to 60 in. [476]

Microwave power measurement. Hewlett-Packard, 1501 Page Mill Road, Palo Alto, Calif., 94304. Application Note No. 64 is an 80-page, up-to-date reference on the subject of microwave power measurement. [477]

Power supplies. Elasco, Inc., 33 Simmons St., Boston, Mass. A 20-page catalog includes eight series of standard models and introduces 800 new power supplies. [478]

Slotted sections. PRD Electronics, Inc., 1200 Prospect Ave., Westbury, N.Y., 11590, has available a two-page data sheet describing waveguide and coaxial slotted sections for precision VSWR and impedance measurements. [479]

Video switching system. Cohu Electronics, Inc., Box 623, San Diego, Calif., 92112. The 9000 series video switching matrix system is described in technical data sheet 6-382. [480]

Piezoelectric data. Clevite Corp., Piezo-electric division, 232 Forbes Road, Bedford, Ohio. A comprehensive piezoelectric data book is available to electronic device, and system designers. [481]

Multiplex receiver. Dayton Electronic Products Co., 117 E. Helena St., Dayton, Ohio, 45404, has issued a data sheet on the S/6 logical solid-state multiplex receiver for the broadcast industry. [482]
WHAT ONE INSTRUMENT...

can be used to accurately test the frequency response of quartz crystals,
meeting the rigid requirements of stability, flatness, adjustability and frequency identification necessary for this precise operation?

can measure the dynamic impedance of a power supply at any frequency from 20 Hz to 3000 MHz, or at several frequencies in that range, providing an instantaneous oscilloscope presentation of the supply's impedance characteristics?

can provide complete frequency transmission characteristics of telephone or other transmission lines for equalizing operations, materially reducing testing time, supplying total frequency coverage, and eliminating correlation errors between first and last test readings?

What instrument that does all this can also determine filter passbands, compare input characteristics with phase/amplitude transmission, test relative inputs and outputs of an RF network, and perform many test functions in the lab or in production that by other methods took too much time and supplied incomplete data?

The answer is Telonic's **SM-2000 SWEEP GENERATOR**, a basic control unit that accepts 22 different plug-in oscillator heads covering 20 Hz to 3000 MHz in both wide and narrow frequency segments for a wide variety of applications. It is the most time-saving, versatile instrument you'll find on any test bench.

**MORE APPLICATIONS**

On request, Telonic will be glad to send you an Application File Folder covering all techniques mentioned here in detail, in addition to many other applications for swept frequency measurements. Your request also places your name automatically on our mailing list to receive further application notes for the file.

**Telonic INDUSTRIES INC.**

60 North First Avenue, Beech Grove, Indiana

Tel: (317) 787-3231 

TWX: 810-341-3202

International Leader in Swept Frequency Instrumentation, Representatives in all major cities in the U.S. and throughout the world.
Micron transistors

A research group at Telefunken AG in West Germany has apparently cracked open one of the barriers to the production of higher-frequency semiconductor devices. The barrier has been inaccuracy of dimensions at extremely small device sizes. Small transistors, diodes and integrated circuits can operate faster than big ones, but only if they are shaped precisely.

Telefunken has worked out a method called optical masking that is similar to the conventional photoetching process but about 10 times as accurate. Lines as narrow as 0.3 micron have been developed in etching resist, and lines 0.4 micron wide have been etched in silicon dioxide. The thinnest line achieved with other techniques is 0.1 or 0.2 mil, or about 2½ to 5 microns, according to Hans-Juergen Schuetze, head of the Telefunken research group. A micron is 0.000039 inch.

Windows. The Telefunken group projects directly onto the silicon wafer an optical image of the pattern to be etched—the windows through which silicon-device junctions and metal-film electrodes are formed.

Optical masking will soon be tried in the United States by the Microelectronics division of the Hughes Aircraft Co., under a development contract with the United States Air Force. Rainer Zuleeg, a native of Germany who heads device research at Hughes, received a preview of the technique last summer at the Telefunken laboratories in Ulm, while on a visit to Germany. With the masks, Zuleeg hopes to make multichannel field-effect transistors (FET’s) that will operate at one gigacycle per second. Zuleeg’s group previously had developed a 100-channel FET that operated at 300 megacycles per second [Electronics, Nov. 30, 1964, p. 46]. He now plans to shrink the channel structure, use 1,000 channels and thus boost frequency.

As a favor to Schuetze and his coworker, K. E. Hennings, at the recent Electron Devices Meeting in Washington, Zuleeg read a paper they had written about their method.

High-speed logic. Schuetze says high-speed, nanowatt logic circuits and high-capacity semiconductor memories can be made more economically by optical masking. Telefunken will be producing IC’s with the technique in about a year, according to Richard Epple, head of device development at the company’s plant in Heilbronn. Schuetze also anticipates applications in microwave transistors and micro-wave diodes.

Noncontact lenses. The usual method, contact masking, has inherent resolution problems, Schuetze says. First, light shining through the mask is diffracted, undermining the developed resist. Also, the mask and substrate cannot be aligned accurately.

Projecting the masking image through lenses above the substrate eliminates the diffraction problem. The two images are aligned by re-magnifying the substrate image so that it appears to be in the same plane as the masking image.

Mike or camera. For patterns that are small but extremely precise, Telefunken projects the masking image through a microscope objective (lens) called a planop-chromate. For larger patterns but lower precision, high-resolution camera lenses are used. Carl Zeiss of Oberkochen helped to develop the lenses.

With an objective, lines 0.3 micron wide can be developed in resist over an area 0.2 millimeter square, or 0.6 micron over 0.5 mm square, or 1 micron over 2 mm square.

Camera lenses produce 3-micron lines over a 20-mm square area. Schuetze thinks the camera lenses will prove most popular because they give a better ratio of image area to resolution, and can be used for large etching patterns. He hopes to obtain 1-micron lines over a 1-inch square area, with lenses being developed.

Step and repeat. An inch square is big enough to cover most of a silicon wafer. Usually, many devices—1,000 or more transistors, for example—will be made in a wafer. This requires repetitive patterns, such as the contact masks now made on photographic film by step-and-repeat cameras.

Repetitive images can be prepared for the camera-lens method in the same way. Repetitive images can be developed on the silicon wafer with the microscope method. Line width is 1 micron over a 1-inch square when the repeating is done mechanically. Schuetze thinks he can cut this to 0.5 micron if the masking images have a resolution of 0.3 micron and if the repeater is guided electronically.

Such precise masks must be...
made of thin-metal film on glass. The metal is etched with patterns that are reduced from large artwork and developed in very thin layers of resist on the metal film.

**Fallen Starfighters**

The pride of the new Luftwaffe—but clearly not its joy—is the F-104 Starfighter, 500 of which have been built in Germany under license from the Lockheed Aircraft Corp. Last month the Luftwaffe's 10th birthday was marred by the grounding of all Starfighters following three crashes in a week and 22 so far this year. Each plane will be thoroughly tested before it is allowed back into the air.

Unlike a previous controversy, this one has not implicated the plane's electronic systems, which account for more than half of the $1.75-million cost of each aircraft. This time, critics—such as the influential newspaper Die Welt—are calling for more electronics in the form of more advanced, automatic testing gear.

**A complex plane.** The hassle last year centered on the inertial guidance system, the LN-3, made by Litton Industries, Inc. This time, it is charged that the Luftwaffe's ground maintenance and testing procedures and equipment are inadequate to keep the complex Starfighter in good operating order.

The German Air Force might be less sensitive to such attacks were the accident rate the same in the air forces of other members of the North Atlantic Treaty Organization. But only 4 of 130 Starfighters in the Dutch Air Force have crashed, 2 of Belgium's 100 and none of Denmark's 29.

**Computer push**

Siemens & Halske AG, West Germany's biggest electronics company, plans a $125-million push to expand its puny—6% to 7%—share of the domestic computer market.

The first step will be creation of a $10-million computer-development center in Munich; then $5 million will be spent to expand Siemens' manufacturing plants in that city. Most of the rest will be spent on development, production and distribution.

The International Business Machines Corp. is estimated to have installed 70% of the computers in use in West Germany. Another United States company, the Remington Rand Corp., is a poorn second with 7% to 8%.

**Link with RCA.** The German company has sold fifty 4004-model computers, which it manufactures and sells under a cross-licensing agreement with the Radio Corp. of America. The 4004 is Siemens' name for the RCA Spectra 70.

Siemens plans to increase the share of domestically produced components for the 4004 computer—to 70% from 30%.

**Canada**

**Electronic quiz**

The trouble with intelligence tests is that many psychologists disagree on the definition of intelligence. Furthermore, some test results are affected by differences in the subjects' reading ability, cultural experience and emotional state.

An Ottawa psychologist, John P. Ertl, thinks he may be on the way to an electronic solution. His system requires no overt response, dealing as it does directly with the subject's brain. But Ertl cautions: "We are not measuring IQ (intelligence quotient) as such, but rather the neurological efficiency on which all intelligence depends."

**Timing the waves.** Ertl's system is based on the fact that when the brain reacts to any stimulus, it emits electrical signals. It is further dependent on two hypotheses: that a specific point in each wave train represents information-processing activity in the brain, and that the speed with which these information-processing signals follow the stimulus is proportional to that vague attribute called intelligence.

With financial support from the Ontario Mental Health Foundation, Ertl has worked out a way to stimulate the brain and measure the brain's response time. He has compared his electronically derived cores with those obtained on standard IQ tests and found a 0.8 correlation; 1.0 is perfect correlation.

**Light stimulus.** The subject is stimulated by flashing a bright light in his eyes. These flashes occur at random, but average about one every three seconds. The brain signals are picked up by an electrode on the subject's head.

One technical problem was to select the weak signals—about 50 microvolts—from a noisy background. Ertl's system picks out and amplifies the information-processing signals with the help of an Enhancatron—a device made by the Nuclear Data Co., that samples such waves at as many as 1,024 points and enters these measurements in its memory. The Enhancatron extracts weak signals from backgrounds of nonfilterable random electrical noise by an electronic overaging technique.

After 100 measurements, the enhancatron displays the waveshape—representing the average of these measurements—on an oscilloscope. From the display, the operator can measure the interval between the stimulus and the information-processing signal.

One of this system's major potentials is still to be demonstrated. Ertl hopes it will provide a valuable way to detect mental retardation earlier than is now possible.

**Great Britain**

**Stop and go**

London bobbies will soon have a couple of computers helping them try to unsnarl that city's traffic. Late next year the British Ministry of Transport will test a closed-loop control system in a six-square-mile section of London that copes with a quarter of a million cars a day.

If the $1.4-million experiment is successful, computerized traffic control will be extended to other
parts of the city. The electronic hardware, $560,000 worth, is being supplied by the Plessey Co. Besides computers, the equipment includes data-transmission gear, control and display units, detectors and traffic lights.

**Self governing.** The London system will be a closed-loop feedback control; that is, the flow of vehicles will be determined automatically, based on traffic conditions. Other systems—for example in Munich and Los Angeles—compare traffic flow with a series of preset computer programs and select the most appropriate program.

London's vehicle-actuated controls will be subject to override by a computer in the central office and by manual controls.

**Double check.** The system will have two computers, one in the central processor, the other in a data-scanner unit. The scanner will collect information from vehicle detectors and rearrange it into a format intelligible to the central processor. Either computer will be able to check the other.

The computers will be along the lines of Plessey's XL type of digital machine. About 100 of these are being used in air-traffic control. Each computer has a 24-bit 4,096-word core memory, expandable to 65,536 words. The core store's cycle time is about 2.5 microseconds. Magnetic-drum backing stores will compile data for traffic analysis and for storing programs.

Traffic detectors will be pneumatic and inductive loops. The pneumatic detectors—rubber tubes embedded in the road surface will measure the vehicles speed; the inductive loops, installed under the road surface, will sense the passage of vehicles and the backing up of traffic.

**Outstations.** At each traffic light a "data outstation" will convert data received from the central processor into an output that will control traffic-light switches. The outstation will also scan the condition of traffic lights and transmit the information to the central control office. The outstations, made with integrated circuits for high reliability, will be housed in weatherproof cabinets adjacent to the curb.

Television cameras installed at major intersections will allow the traffic picture to be monitored on screens at the central office. There will also be a wall-map display of the area showing whether each light is red or green.

Should the line with the central office be broken, as in a partial power failure, the lights will be able to operate independently.

**Japan**

**Printer catching up**

Fast computers have at least one built-in problem: they outrun their printing units. One way to reduce computer waiting time is to write the output on tape, to be printed later; but this still results in some delay.

Now the Tokyo Shibaura Electric Co. (Toshiba) has developed an electrostatic printer that operates as fast as most Japanese digital computers. The printer, built at Toshiba's Central Research Laboratory, grinds out information at 152 lines a second, with 130 characters to a line; that's almost 20,000 characters a second. Tsutomu Honma, leader of the development group, says the speed has been increased experimentally to 250 lines a second.

In the United States, Stromberg-Carlson's 4020 is believed to be the fastest electrostatic printer. Made by the Stromberg-Carlson division of the General Dynamics Corp., the 4020 prints 3,600 lines a minute. But the company also manufactures a microfilm printer that produces as many as 20,000 lines a minute.

**In quintuplicate.** Toshiba has another advantage over other electrostatic printers: it can make as many as five copies, each as sharp as the original. Other printers of this type make only one copy. The Toshiba unit can print more than 100 different characters, a bigger variety at a faster speed than one developed by Hitachi, Ltd. [Electronics, March 22, p. 157] because it loses no time bringing a rotating type-wheel into position.

For each of the 130 character positions on a horizontal line, the Toshiba printer has five stylus electrodes. Opposite this row of 650 electrodes are 130 counter electrodes; between the two rows of electrodes travels a web of paper that has been coated to retain
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electrostatic charges. The paper passes through the printer at 2.3 feet per second, and seven voltage pulses are applied between selected styluses and counter electrodes as the paper advances the 2.7-millimeter height of each symbol, producing the equivalent of a matrix five dots wide and seven dots high. The characters are formed from a pattern within this 35-dot matrix. Each character is 1.8 millimeters wide, and there is a 1.35-millimeter space between lines.

The limit. The paper is charged electrically at points corresponding to the energized styluses. After charging, the paper is developed with toner powder in the conventional manner, but not fixed. Toner from the coated paper is transferred, under pressure, to as many as five webs of ordinary paper to produce up to five copies. The print-out paper is fixed with heat, then cut into page-size sheets and stacked. The speed of cutting is the ultimate limit of the printer’s overall speed, Honma says.

Page forms can be printed if desired, although they are not fitted to the experimental printer. Ability to use ordinary paper for the final print-out holds down the cost. The intermediate print-out, on coated paper, is not fixed, and the paper can be reused until it falls apart.

The printer is still experimental. It will not be connected to a computer before spring, Toshiba says. Meanwhile the company will continue to improve it, simulating a computer’s output by using electrical signals. Toshiba, besides spending its own money, is aided by a research grant from the Japanese Ministry of International Trade and Industry.

NATO’s annual ministerial meeting blame faulty project definition.

NATO knows what it wants technically, but bidders say the goals are impossible under the organization’s price limits.

Bidders complain that Nadge was defined several years ago, with no subsequent provision for increasing costs. One says: “Nadge marks the first time such a vast international undertaking has been attempted on a fixed-cost basis.”

Three choices. Details of the disagreement between bidders and NATO have not been disclosed, but sources close to the competition agree that the organization will have to make one of three moves:

- Relax the technical requirements demanded from bidders.
- Increase the ceiling beyond $280 million.
- Kill the Nadge program.

The three competing consortiums are led by the International Telephone and Telegraph Corp., Westinghouse Electric Corp. and Hughes Aircraft Co.

Czechoslovakia

Eyes west

The small countries of Eastern Europe constitute a growing market for automatic air-traffic control systems, says Zdenek Zacek of the Czech transport ministry.

His own country ranks second only to the United States in air traffic, Zacek told an aeronautics symposium last month in Washington. With 13 major airports crammed into a country about the size of Louisiana, Czechoslovakia claims to have the highest air-traffic density in Europe.

Automation by ’72. Eleven of these airports are being equipped for all-weather landing systems, Zacek says, and the Czech government is studying automation of air-traffic control. By 1968 the manufacture of hardware is expected to begin in Czechoslovakia, he says, and in 1972 he expects an automated system to be in operation.

Most of the radar systems, both
primary and secondary, are being made in Czechoslovakia, but those for the automated system will probably be imported, he adds. The Czech air ministry, and those of other countries in the Soviet bloc, will look to the West for these and for computers, Zacek predicts.

Soviet systems. Why won’t the Czechs buy this equipment from the Soviet Union? Zacek says the Russian equipment available does not meet Czech specifications. The Soviet Union is known to have installed improved gear in recent years for ground control at its own civilian airports, but nothing that could be called automatic beyond the usual air-route radio channels. But little is known about Soviet aviation equipment because it all comes under military secrecy. Aeroflot, the national airline is a branch of the Soviet air force which, in turn, is part of the Red Army.

Around the world

Great Britain. A two-year study of ways to apply pneumatic fluid logic to digital control systems has won support from the British Science Research Council. The research will be conducted at Birmingham University. A principal goal is the development of simple digital feedback servomechanisms for controlling machine tools.

Soviet Union. The Russians have transmitted Secam color-television programs from Moscow to Paris via their Molnya-1 communications satellite. The experimental broadcast arrived in Paris strong and clear. The Russians also have promised to do something about the high prices of color-tv sets in the Soviet Union.

Sweden. The Swedish Post Office Board says it will invest about $40 million over the next seven years to “automate” postal service. Mail-sorting machines, probably of West German manufacture, will be tested, the agency says, and electronic accounting machines will handle postal savings and money orders. Parcels will be sorted semi-automatically.

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