March 2, 1962

electronics

A McGraw-Hill Publication 75 Cents

Photo at right

BATTERY OF LOUDSPEAKERS

Drives exponential horn for tests, p 48

INSPECTING TV RATINGS

Flying-spot scans film records, p 31

TELEMETRY BEACON

Uses transistor self-reactance, p 35

PRACTICAL PARAMP

For 5,000-Mc tropo scatter system, p 38

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A McGraw-Hill Publication *75 Cents*

W. W. MacDONALD, Editor

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electronics

March 2, 1962 Volume 35 No. 9

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DEPARTMENTS

CROSSTALK

GOOD JOB, GLENN. We didn't get much work done Tuesday before last. Like most Americans, we kept an ear to the news broadcasts, following the final countdown, waiting out the three long orbits and that agonizingly slow twenty minutes for recovery from the sea.

Our congratulations to NASA for its iron-pants determination to wait until launch conditions were right, to the industry for building a system that worked well when the chips were down, and above all to Col John H. Glenn. Jr.

Certainly the Mercury program and system had its flaws, but they overshadow the event no more than a pebble on a pyramid. Mistakes are what people learn by. If the Mercury program was going to be flawless, NASA could have skipped it and gone directly on to Gemini and Apollo.

No program that has gone so far so fast could be flawless. It has gone fast, even if the U.S. did get a late start and we spectators become impatient.

We took time to leaf back through the many news articles and technical reports we have printed during the past several years on Mercury, and its predecessors and successors. As recently as early 1958, in those pre-NASA days, the government was still ruminating over the best way to get the space program organized. Contrast our special report, "The Challenge of Space," April 24, 1959, with "Missile and Space Electronics," published last November 17. The first was long on what might be done; the second was packed with information on what is being done and the hardware doing it.

Hardly a week goes by now without a new achievement being planned or consummated. What happened last week was one of the most magnificent—yet.

LUCKY US. We can go to the IRE International Convention three weeks hence and spend at least part of the time socializing with old friends from out of town. We can do this with a clear conscience because half our job will be done when we put our IRE Special Issue to bed next week.

The staff has spent the last month or so extracting information on what's new and inter-

esting in the technical papers and exhibits, plus some general information on how to find your way around.

We don't guarantee next week's issue will report everything worth seeing and hearing. There are bound to be a few last-minute surprises. Finding out about them will be the other half of our job. But the preview should save at least as much time as a pair of roller skates, leaving you more time for socializing, too.

THE FIVE W'S. One of our assistant editors finds a shortcoming in this week's article by A. C. Lewis Brown. Brown describes an A. C. Nielsen Co. machine that automatically processes reports on the habits of tv viewers.

It is a reporter's rule of thumb that a good story tells the "who, what, when, where and why." The editor ruefully comments that "why" is the only information the machine does not give. He is vociferously dissatisfied with tv program fare, thinks it a pity that what he usually finds on his tv screen matches neither the inside of the set, nor Nielsen's machine, in ingenuity.

After all the effort that engineers have put into designing a national network of visual communications channels, he says, programmers "sadly let the side down and give the lie to engineers being second to artists in public doing-good."

Oh, well. As somebody once said, you can't please everybody. We still think it is a good article on a good system.

COMMENT

Laser References

Please tell me how to reach three of the references in your recent laser series (p 39, Oct. 27, 1961; p 40, Nov. 3; p 81, Nov. 10; and p 64, Nov. 24).

I am particularly interested in the proceedings of the Second International Conference on Quantum Electronics, which was held on March 21, 1961, in Berkeley, California.

Apparently the Wescon Proceedings were not published this year and I am anxious to see the abstracts or to reach the authors in the symposium there.

The last item is L. M. Vallese on the generation of coherent light sources, presented at the International Congress of Electronics in Rome, June 19, 1961.

Editors Vogel and Dulberger are to be congratulated on an unusually fine series.

BLANTON C. WIGGIN
Advanced Instruments, Inc.
Newton Highlands, Massachusetts

Editor Vogel replies:

The proceedings of the Second International Conference on Quantum Electronics are in a book entitled "Advances in Quantum Electronics," edited by J. R. Singer and published by the Columbia University Press of New York on Dec. 18, 1961.

As for the WESCON Proceedings, write to WEMA (Western Electronic Manufacturers' Association), 1435 South La Cienega Boulevard, Los Angeles 35, California, for information on obtaining abstracts or papers presented at the 1961 WESCON.

For a copy of Dr. L. M. Vallese's paper, write to him at IT&T Federal Laboratories, 500 Washington Avenue, Nutley 10, New Jersey.

Parametric Amplifier

Can you supply reprints of the two articles referenced by Denes Roveti in his article, Diode Amplifier Has Ten-Gigohm Input Impedance (p 38, Dec. 22, 1961)? There seems to be a typographical error, as I am unable to locate these references in our libarary copies of ELECTRONICS.

W. A. PETERSON, JR.
Tektronix, Inc.
Beaverton, Oregon

Author Roveti replies:

The references quoted in my article should have read, *Communication and Electronics*, instead of ELECTRONICS.

Other references pertaining to this article may be of interest:

(1) James Jenkins, Voltage Sensitive Capacitors, *Electrical Manufacturing*, p. 83, Dec. 1954.

(2) Shaw and Jenkins, Nonlinear Capacitors for Dielectric Amplifiers, ELECTRONICS, p. 166, Oct. 1953.

(3) Walker and Smith, Noise Figure in Semiconductor Dielectric Amplifiers, *IRE National Convention Record*, Vol. 5, Part 3, p 14, 1957.

Another item about the parametric amplifier in my article: with some minor modifications, it can also be used as a d-c amplifier with input impedance levels of 10^{11} ohms and close to unity voltage gain. With feedback techniques, the input impedance of this amplifier on a-c and d-c can be further improved with axuiliary transistor circuits.

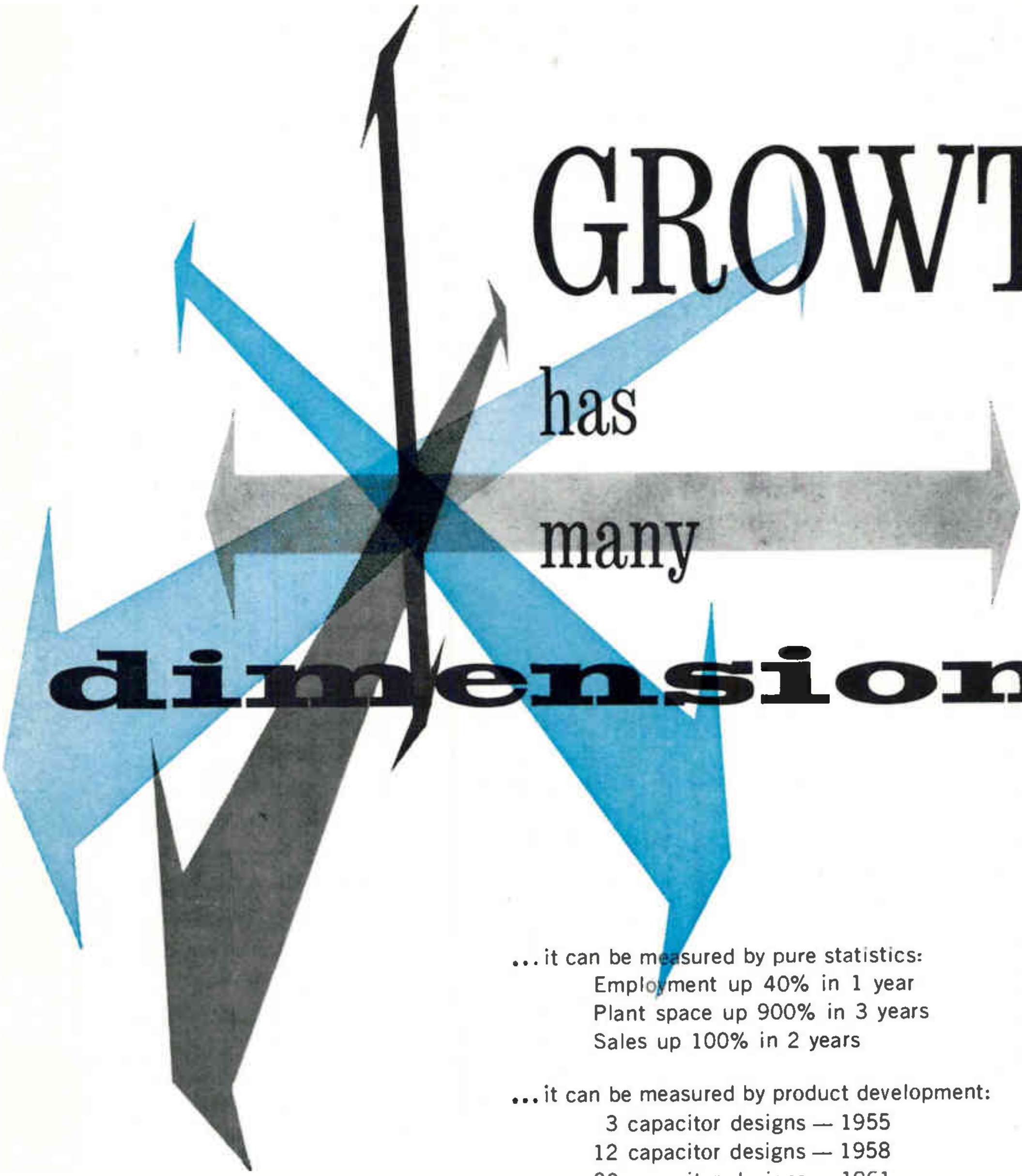
Since the article was written, the noise level of this parametric amplifier has been reduced considerably. We are now making unity voltage gain amplifiers with an input impedance of 10,000 megohms and an output impedance of 10 kilohms with a typical noise level of 50 microvolts (with input open, over a bandwidth of 3 cycles to 200 kilocycles). These units are operated from a 6.75-volt mercury battery with a one-milliamp drain. By lowering the input impedance, noise levels as low as 20 microvolts can be obtained with a 2,000-megohm input impedance.

DENES ROVETI
Denro Lab
Washington, D. C.

Laser Dangers

Please grant us permission to reproduce the article entitled Laser Dangers (p 27, Jan. 26). We are desirous of distributing this article to our field engineers.

C. M. E. HOFFMAN
Maryland Casualty Company
Baltimore, Maryland



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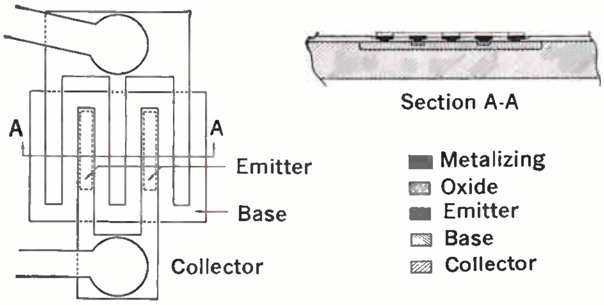

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RATINGS AND CHARACTERISTICS

			Min.	Max.	Units
V_{CBO}	Collector to Base Voltage			40 Volts	
V_{CEO}	Collector to Emitter Voltage			15 Volts	
V_{EBO}	Emitter to Base Voltage			4.5 Volts	
V_{CEO} (sust)	Collector to Emitter Voltage $I_C = 10$ mA (Pulsed), $I_B = 0$**		15		Volts
V_{CE} (sat)	Collector Saturation Voltage $I_C = 10$ mA, $I_B = 1.0$ mA			0.25	Volt
V_{BE} (sat)	Base Saturation Voltage $I_C = 10$ mA, $I_B = 1.0$ mA		0.7	0.85	Volt
h_{fe}	High Frequency Current Gain $I_C = 10$ mA, $V_{CE} = 10$ V, f = 100 mc		5.0		
C_{ob}	Output Capacitance $V_{CB} = 5.0$ V, $I_E = 0$			4.0	pf
C_{TE}	Open Circuit Input Capacitance $V_{EB} = 0.5$ V, $I_C = 0$			4.0	pf
h_{FE}	D.C. Pulse Current Gain $I_C = 10$ mA, $V_{CE} = 1.0$ V	2N2368 2N2369	20 40	60 120	
h_{FE}	D.C. Pulse Current Gain $I_C = 10$ mA, $V_{CE} = 1.0$ V, −55° C	2N2368 2N2369	10 20		
t_s	Charge Storage Time Constant $I_C = 10$ mA	2N2368 2N2369		10 13	nsec nsec
T_{on}	Turn on Time $I_C = 10$ mA	2N2368 2N2369		12 12	nsec nsec
T_{off}	Turn off Time $I_C = 10$ mA	2N2368 2N2369		15 15	nsec nsec

**Pulse Width = 300, μSec, Duty Cycle = 1%

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ELECTRONICS NEWSLETTER

Glenn Scores Point for Manual Controls

SPACE FLIGHT should be possible with less automation, Lt. Col. John H. Glenn, Jr., said at his press conference last Friday. He also saw a good prognosis for visual rendezvous in the ease with which he used retrorockets to manuever his Mercury capsule.

Glenn used manual controls for two orbits after his automatic stabilization and control system functioned improperly. At one point, he turned the Mercury capsule 180 deg to observe the illuminated particles, which appeared after each sunrise.

Meanwhile, Roger Pierce, technical director for Apollo deep space programs at Collins Radio, said Glenn's flight indicates that high-frequency radio gives satisfactory transmission over a very long distance.

H-f transmission was used from the upper layer of the ionosphere. There had been doubts whether this could be done without a direct line-of-sight. The results will help design telecommunications for Gemini, the two-man orbit, and Apollo.

Any specific recommendations for changes in the next orbital capsule will wait on analysis of telemetry data received from Glenn's capsule at 18 Mercury ground stations. Processing will take about two weeks.

Change in Resistance Is Basis for Memory

MEMISTOR memory element that permanently switches resistance 1,000:1 in nanoseconds when driven by a milliampere square wave in the 10-μsec range, is reported by Trionics Corp., Madison, Wis. In latest developed models, a 2 or 3-v pulse will switch from 1 megohom to 10 or 100 ohms.

Resistance states, considered as 1 and 0, can be nondestructively read out by an ohmmeter whose applied voltage is below the switching level. Trionics says elements are unaffected by 10,000-gauss fields, need no holding voltage and operate from −50 to 450 C. However, resistance ratios decrease with higher temperatures, becoming 10:1 at 250 C.

Element is formed with ceramic-type button of processed nickel oxide. These may be individually sealed in transistor can or fabricated in a matrix.

Paraplegic's Muscles Stimulated by Signals

MAIMONIDES HOSPITAL, Brooklyn, N. Y., is conducting experiments in the artifical stimulation of a paraplegic's muscles with programmed electrical signals.

Dr. Adrian Kantrowitz described the work to medical researchers at Brookhaven National Laboratory last week. He showed in a motion picture how a man, paralyzed from the waist down, stood up and sat down when signals were applied externally to leg muscles. Films also showed how electrodes implanted in a dog's leg made the leg perform walking motions.

Programs were prepared with an electromechanical simulator. Signals generated by potentiometers corresponding to flexor and extensor muscle actions at hip and knee joints were recorded on tape.

Recent report from Moscow indicates similar work is being done at a bioelectrostimulation laboratory in the Ukrainian Academy of Sciences, Kiev. Development of techniques to record "biocurrents" of a healthy donor are claimed. Expectations are the techniques may also be applied to heart and respiratory stimulation.

Goto Logic Makes Space Computer Resist Radiation

GUIDANCE AND CONTROL computer that can operate next to nuclear propulsion systems is being developed by IBM for Air Force. It uses Goto, or majority logic type circuits.

IBM says tests show that Goto circuits using only tunnel diodes and resistors tolerate steady-state radiation exceeding 10^{16} nvt and weapon burst radiation of 10^{7} rad/tissue per sec.

In Goto circuits, state is determined by the algebraic sum of input currents. Output voltages have the same polarity as the majority of input voltages.

The computer will have a 12,000-word memory, can carry out 70,000 operations a second, will weigh about 100 lb, occupy 2 cu ft and draw 150 w.

See 25-Percent Efficiency For Thermionic Converters

DEVELOPMENT model of a solar thermionic converter built for satellite communications power supplies operates at 13 percent efficiency, reports Thermo Electron Engineering Corp., Watham, Mass. A 200-w cesium generator has been made for the Air Force. A 135-w system being developed for Jet

USSR Ready to Invent Steller-Inertial Guidance

MOSCOW—Autonomous navigation system based on a combination of inertial and astronomical measurements is described in *Aviation and Cosmonautics* as the most reliable means of guiding a spaceship to the moon or planets.

The inertial system would act as a memory between astronomical fixes. The article goes on to say that development of a system able to take fixes and determine acceleration and speed is one of the "cardinal problems."

(See ELECTRONICS, p 95, Nov. 17, 1961)

Propulsion Lab weighs less than 8 oz, the company says. It expects fully-developed solar thermonic power systems to have lifetimes of a year or more, efficiencies to 25 percent and power levels of 100 w to 10 Kw. Isotope, nuclear reactor, gas and gasoline-fueled systems are in development, it was reported.

Voice and Teleprinter Transmitted Simultaneously

MARTIN MARIETTA says its Racep communications system will now transmit as many as 70 voice and teletypewriter messages at one time. Added capability is achieved by plugging in a single printed circuit card and printers. Data rate is 100 wpm.

Racep (Random Access and Correlation for Extended Performance) is a wideband radio system that breaks signals into microsecond pulses and combines them randomly for transmission. Receivers accept messages with a preassigned code and reconstruct the message. The system can have up to 700 subscribers. It is being tested by the Army and Air Force.

Vocoder Development Is Ordered by Air Force

TEXAS INSTRUMENTS has been awarded a $370,000 Air Force contract for development and manufacture of a full duplex digital vocoder system. It will be used for secure voice transmission at 1,200, 2,400 or 9,600 bits a second. The digital output of the system may be used as an input to automatic speech pattern recognition equipment being developed at Air Force Cambridge Research Laboratory. A voice-excited or hybrid technique makes voice quality in the 9,600-bit mode as good as toll telephone quality, TI says.

Sensitive Microphone Detects Earthquakes

GEOTECHNICAL CORP. is making a microphone which could presumably be used to detect nuclear blasts (p 9, Oct. 13, 1961, and p 28, Feb. 23, 1962). The company says it will detect small, low-frequency atmospheric pressure fluctuations caused by geomagnetic storms, tornadoes and earthquakes. It can detect barometric pressure anomalies as low as 0.03 dyne/cm^2 in a pass band of 1 to 0.025 cps. The transducer, which uses a metal diaphragm in a balanced barometric environment, is patterned after an NBS design. It is part of an f-m system for recording.

Film Memories' Cost Cut to 4 Bits a Bit

BURROUGHS announced this week that it is producing 3,072-bit, thin-film memory planes costing 50 cents a bit, a price reduction of 100 percent. The planes will store 128 24-bit words. Techniques are essentially an extension of those previously reported (p 39, March 3, 1961).

Orbiting Solar Observatory Uses Its Spin as Gyroscope

NASA SAID last week that "within a week or so" it would launch the first Orbiting Solar Observatory. It has a wheel-shaped section rotating at 30 rpm to act as a gyro and provide comparative data on radiation from the sun and the rest of the sky. Connected to the wheel is a stabilized, contrarotating, fan-shaped section with experiments that will continually point at the sun.

There are 13 experiments in all, five in the fan and eight in the wheel (ELECTRONICS, p 102, Nov. 17, 1961). The wheel also contains data storage, command, telemetry and battery compartments. Gas jets and a photodetector-servo system are used for attitude control. OSO has a six-month life, will be followed by other OSO's to study the sun for at least one solar-cycle. Funding in 1962 is $4.2 million.

OSO (S-16) is a refined and enlarged cousin of S-15, which spun but did not lock on the sun (p 32, April 14, 1961). The attitude system is like one developed for sun-pointing rocket experiments (p 43, Dec. 23, 1961) by Ball Brothers and AFCRL. Ball Brothers is prime contractor for OSO.

In Brief . . .

VOICE OF AMERICA is planning three more overseas radio transmitters as part of its $50 million expansion program.

TOSHIBA plans to export to the U. S. this spring a 15-tube, 10-inch portable tv costing under $130.

SYLVANIA has a $47,000 contract from Air Force for feasibility and design studies of high-speed digital computers for flight training simulators.

FEASIBILITY of using tunnel emission in thin-film, transistor-like devices is to be determined by Electro-Optical Systems under $89,056 Air Force contract.

OTHER R&D awards include $3.9 million to Raytheon for further work on Project Arpat; $236,000 to Microwave Associates for microwave semiconductor devices; $100,000 to Clausner Technology, for gas masers and magnetometer temperature sensor.

GRANGER ASSOCIATES has a $883,000 Army order for ionospheric sounder and other h-f gear.

SPACE AND MISSILE GSE contracts include $1.5 million to Radiation, Inc., for telemetry antenna systems; $800,000 to Miratel for tv monitors; $368,195 to American Concertone for miniature tape recorder; $301,000 to Dynatronics for pcm telemetry playback station. Rohr has a fourth NASA order for an 85-ft antenna.

EITEL-MCCULLOUGH is supplying $600,000 in high-power klystrons for Air Force troposcatter systems.

WEATHER BUREAU is installing 55 Alden facsimile recorders for cloud analysis at airports with AN/QMC-13 rotating beam ceilometers.

ARGONNE National Lab has ordered a digital computer from Advanced Scientific Instruments.

MARTIN, Denver, is installing two Titan telemetry checkout systems made by Telemetrics, Inc.

PM ELECTRONICS has acquired assets of California Instruments Corp.

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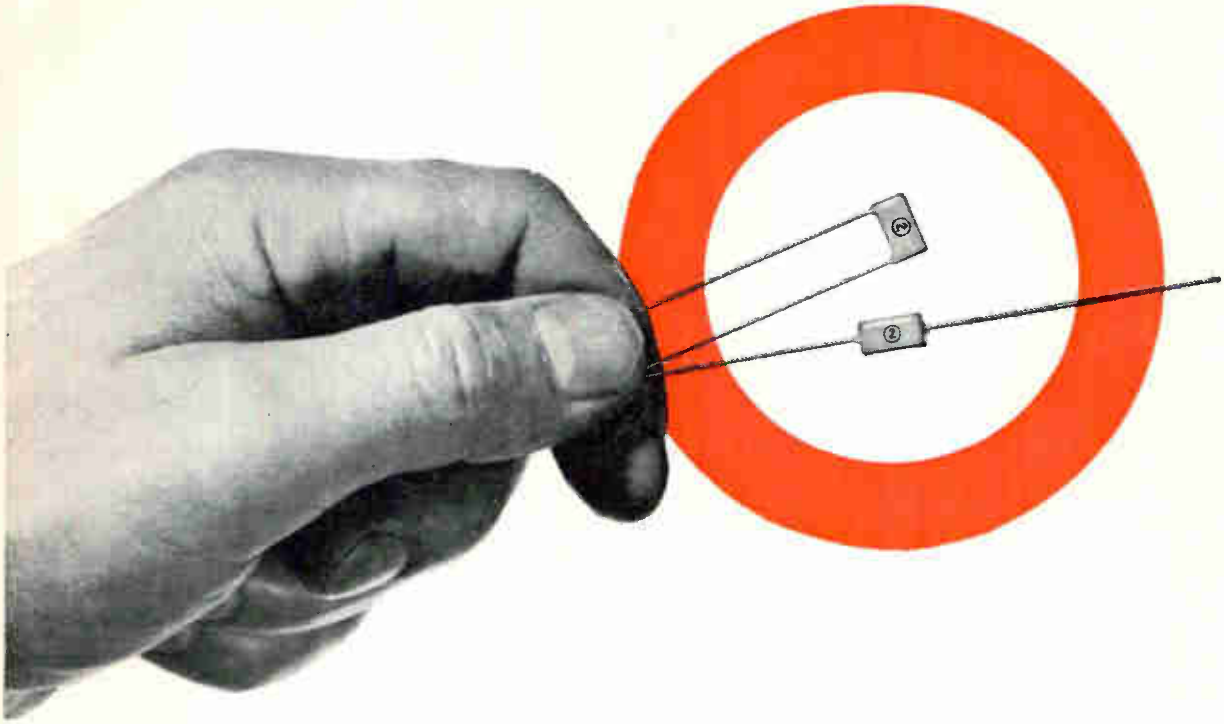

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CIRCLE 11 ON READER SERVICE CARD

WASHINGTON OUTLOOK

INDUSTRY GROUP OPPOSES TV BILL

EIA'S OPPOSITION to S.2109, the FCC-sponsored bill requiring production of only all-channel uhf-vhf tv receivers (p 12, Feb. 23), was delivered to the Senate Communications Subcommittee last week.

L. M. Sandwick, staff director of EIA's consumer products division, claimed the bill would penalize set manufacturers and consumers with "dubious" results. Buyers would have to pay an average of $30 more a set, plus antenna costs. Set sales might plunge as much as 14 percent.

The industry will produce all the uhf-equipped sets the public wants, Sandwick said. Shortage of buyers caused uhf set output to drop to a new low, 370,000 last year, against 1.5 million in 1953, he said.

Sandwick cited examples to indicate that uhf station failures were not due to lack of uhf receivers but to programming and other difficulties. Among examples were a uhf station that couldn't compete with vhf network programs, uhf stations that succeeded with network programs, and one that made the grade through "salesmanship" and vigorous competition with vhf programs in the same area.

As an alternative to legislation, he offered the industry's voluntary cooperation in promoting uhf and in solving technical problems. The bill, he protested, could lead to further FCC regulation of set design and might logically be extended to a requirement for f-m in all radio sets.

FEDERAL PAY TO JUMP UP

GOVERNMENT SALARIES under President Kennedy's proposed new scales would range up to $28,000—almost $10,000 more than top government scientists and engineers get now. Increases would be most significant in top and near-top levels, where turnover is greatest now. The four top pay grades ($15,030, $16,295, $17,570 and $18,500) are 20 to 50 percent below comparable private levels.

Proposed increases range from $6,000 to $6,500 by 1965, plus two new top classifications which would add another $3,500 to potential top annual pay. Object is to attract more trained men into government service.

TARIFF HEARINGS NEXT MONTH

ELECTRONICS INDUSTRY interest in the trade expansion bill will probably focus on the "zero list." The President could reduce to zero the tariffs on all product categories on the list. Products go on the list if the U.S. and European Common Market Countries control 80 percent of world trade.

Computers, for example, will likely be among electronic products on the list. The administration maintains that if Americans and Europeans drop computer tariffs, U.S. manufacturers would be faced with increased imports, but exporters of some lines would have a field day.

Key to the President's trading authority is what base year is selected for exports and imports. The year chosen could put as many as 50 products and categories on or off the list. This question will probably be cleared up after the House Ways and Means Committee begins hearing March 12.

MISSILE HIRING HEALTHY

LATEST LABOR DEPARTMENT survey shows employment in aircraft and missile plants rose 3.4 percent in the year ending August, 1961. Employment totaled 982,400. Moderate increases were expected through this February. Employment was up 9.9 percent in the missiles sector of the aircraft industry and up nine percent among missile producers in the electrical machinery (including electronics), ordnance and other industry groups. Missile contractors in industries other than aircraft were expected to account for three-fourths of the additional hiring through this February.

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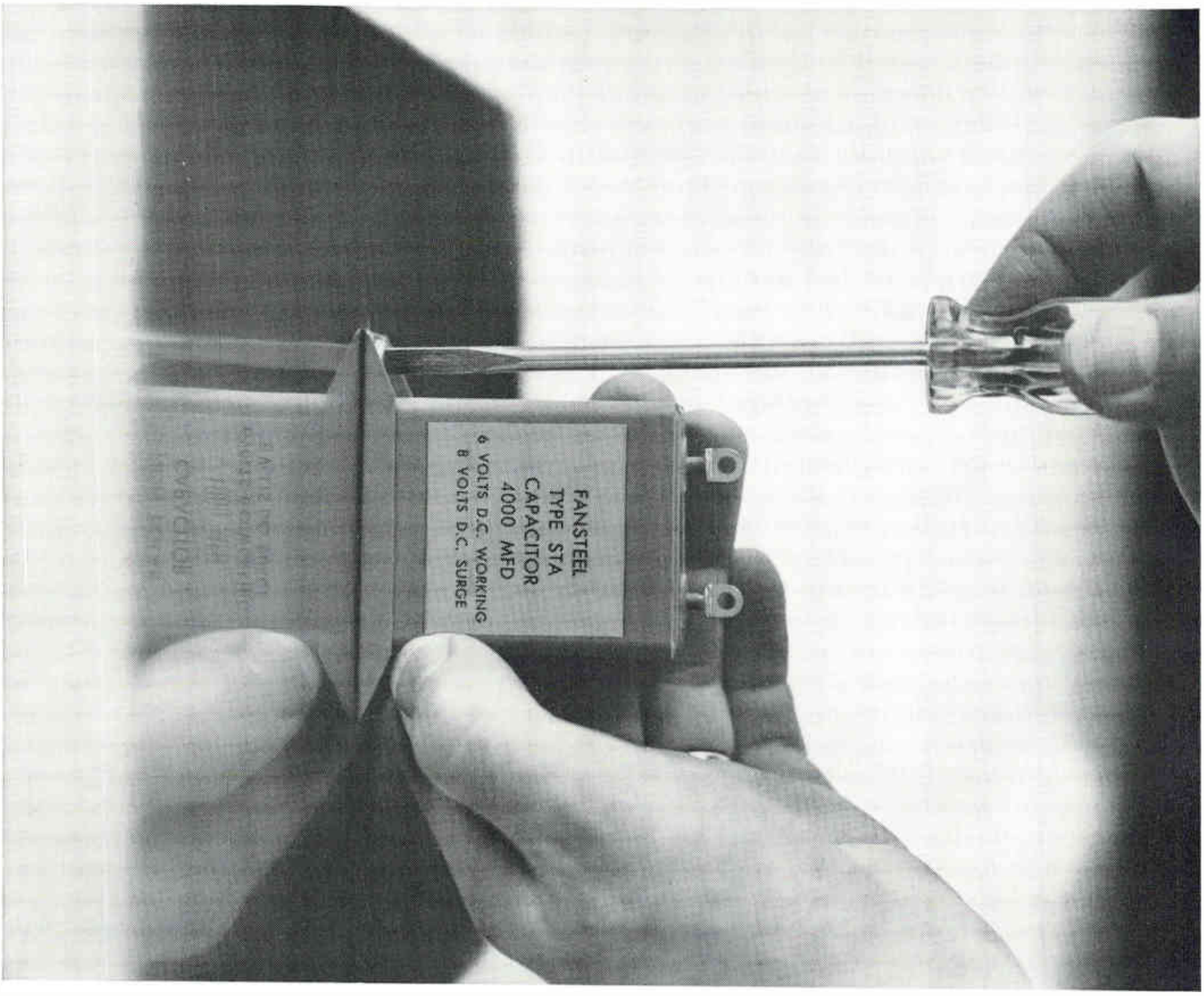
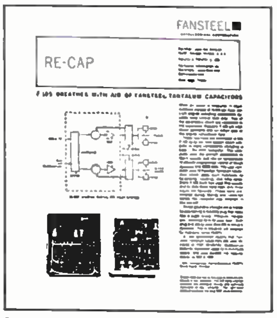
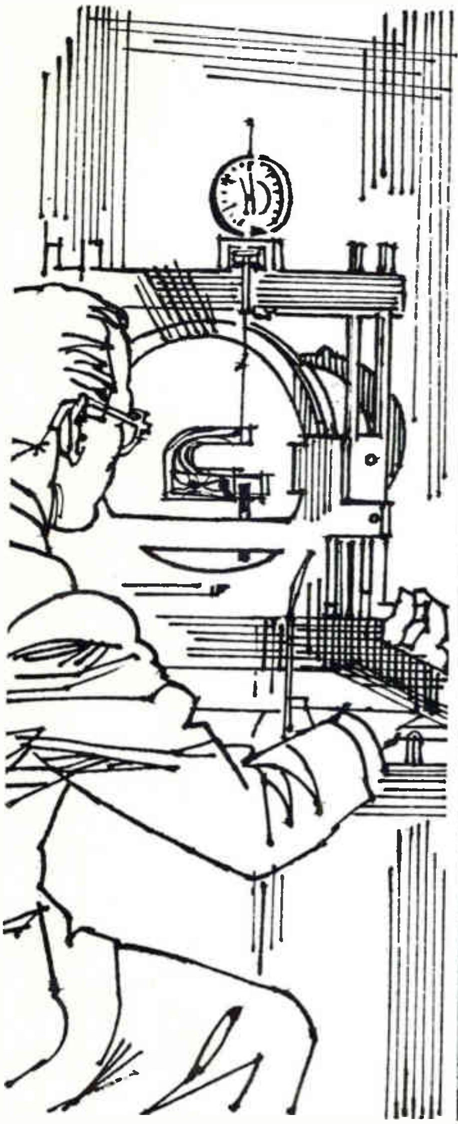
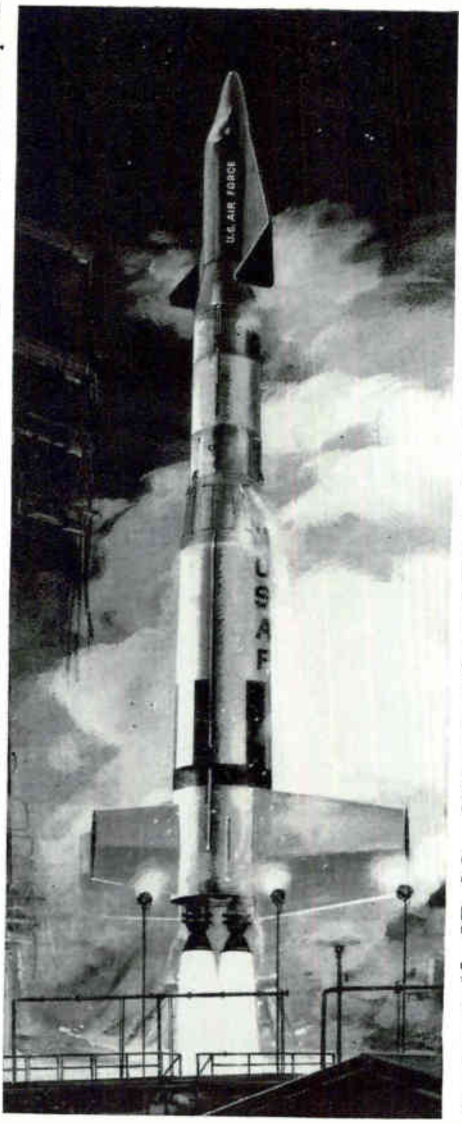


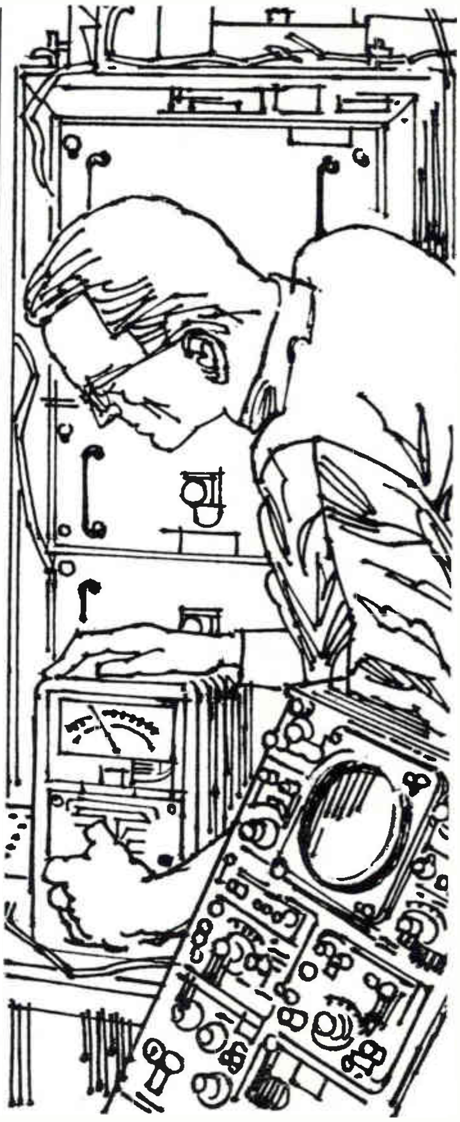
New high-capacitance STA's, a recent Fansteel Development, deliver up to 4000 μf in a single package. A dozen standard 330 μf solid tantalum capacitors are replaced with one compact 4000 μf unit—and you require only two connections instead of twenty-four! High-capacitance solid tantalum capacitors are supplied in units from 300 to 4000 μf polar, and 150 to 2000 μf non-polar. Solid or wet, general purpose, high capacity, straight sided, polar, non-polar, feed-thru, military—whatever your tantalum capacitor requirements, Fansteel offers a complete range of sizes and types. Reliability ratings start at 0.003% per 1000 hrs. @ 85° rated voltage for standard production tantalum capacitors. For complete specifications, write the Rectifier-Capacitor Division, North Chicago, Illinois.



Latest rectifier and capacitor developments and applications are offered bi-monthly in Fansteel's Re-Cap. To receive, write Publications Department, Fansteel Metallurgical Corporation, North Chicago, Illinois.







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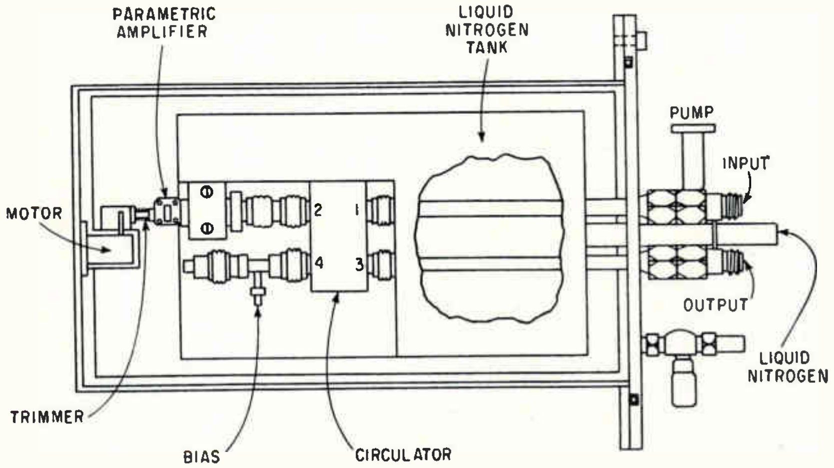
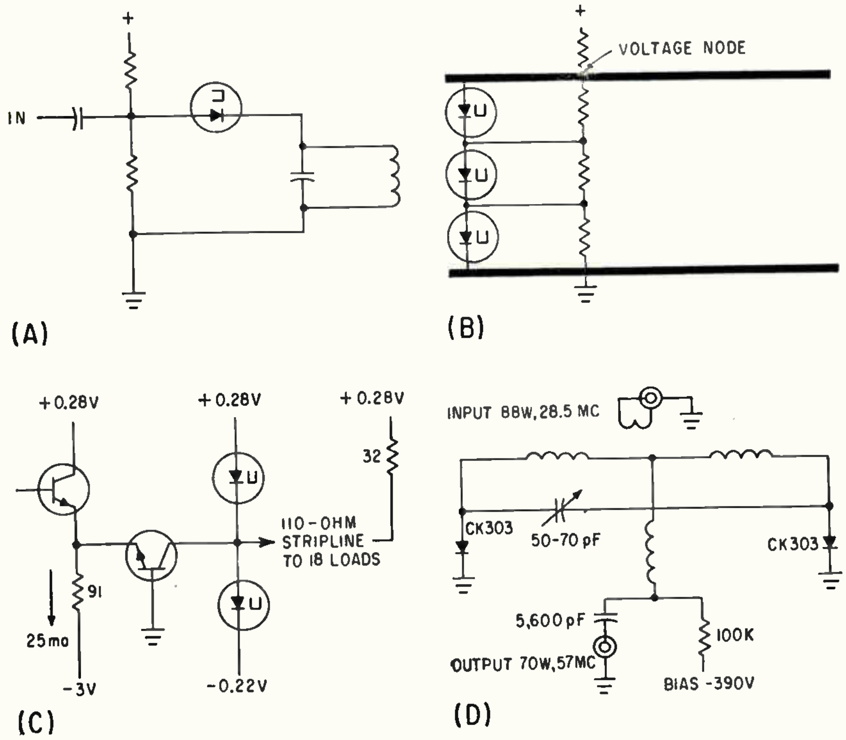
Circuit Designers Improve Practical

Low-noise amplifiers and microwave power sources using solid-state masers, tunnel diodes and varactors are featured at Solid-State Circuits Conference



Bell Labs' one-port parametric amplifier uses motor-controlled trimmers to compensate for diode impedance changes. It has an extremely low noise figure



Tunnel diode harmonic generator has operated to 15th harmonic (A). Also from Plessey is the 10-mw, 1-Gc oscillator (B). IBM's tunnel diode power driver passes 5-nsec pulse (C). Symmetrical high-power doubler was designed by R. P. Rafuse, of MIT (D)

By SAMUEL WEBER
Senior Editor
MICHAEL F. WOLFF
Senior Associate Editor
LAURENCE D. SHERGALIS
Associate Editor

PHILADELPHIA—Marked progress in masers and parametric amplifiers, the possibility of cryotron linear amplifiers, advances in microwave power sources and other circuit and component improvements were reported at the Solid-State Circuits Conference late last month.

During a session on low-noise amplification, F. Arams and B. Peyton, of Airborne Instruments, described a solid-state maser that requires a pump frequency only slightly higher than the signal frequency. It uses four-level operation with push-pull pumping.

The prototype has a signal frequency around 40 Gc, a pump frequency of 43 Gc and applied field of 700 oersteds. Stable operation has been obtained over large ranges in the K_a band. Tuning range can be varied with orientation of the active crystal, chromium-doped titania at a temperature of 4.2 K. Arams and Peyton expect the technique will be applicable at frequency of 150 Gc or higher.

M. Uenohara, of Bell Telephone Labs, reported a nondegenerate parametric amplifier believed to have the lowest-noise performance—0.9 db system noise figure—yet achieved. It has motor-controlled trimmers (see sketch) to compensate for impedance changes in the diode. The diode is a gallium arsenide, point-contact varactor.

Operating frequency is 6 Gc, pump frequency 23 Gc, and pump power 5 mw. A dewar which keeps the amplifier from contacting the liquid nitrogen is used for refrigeration.

Thin-film cryotrons, long experimental computer switches, were

Applications of Solid-State Devices

proposed as small signal, high-frequency, linear amplifiers, by N. D. Richards, of Mullard Research Labs. Experiments indicate low-noise cryotron amplifiers may have considerable utility.

Bandwidth-gain squared products around 200 Mc may be obtainable from present cryotrons. Richards thinks this figure can be raised to several Gc with new techniques and materials. One problem to be overcome is the low impedance (on the order of 10^{-3} ohm) of such devices, which must be matched to 50 ohms in practical applications.

Microwave Power Sources

Two major solid-state devices, varactors and tunnel diodes, were discussed by a panel on microwave power sources.

F. Sterzer, of RCA, disclosed that $\frac{1}{4}$-mw power has been achieved with tunnel diodes at about 10 Gc. He also discussed a unit that gives an output of 1 mw over its tuning range of 350 Mc to 1 Gc. In contrast, varactors employed as harmonic generators give 2-w outputs at 2 Gc and 1-w at 10 Gc.

Although tunnel diode output is low at microwave frequencies, inherent stability makes the devices suitable for local oscillator service; D-c to r-f efficiency is high (30 percent compared to a few percent for harmonic generators) and they are easily tuned over a wide range.

Tunnel-diode development is aimed at increasing the basic output limit. Tunnel-diode oscillators at X band are possible, the panelists said, but they are limited by shot-noise problems. At X band, noise level is around 6 db because of the device's series resistance.

In a session on tunnel-diode applications, P. M. Thompson, of the Plessey Co., cited uses such as specialized computer logic circuits (hybrid counters and shift registers), computer stores and level detectors, as well as microwave sources.

Tunnel diodes are good microwave power sources, he said, because they can be used in harmonic generators with gain, the oscillators lock well and power output can be obtained with multiple tunnel-diode circuits (see diagrams).

Thompson feels tunnel diodes make good superregenerative receivers. They have the right type of negative resistance and the frequency is not sensitive to bias changes. He said several 1-Gc receivers gave performance close to that predicted by theory.

D. W. Murphy, of IBM, described a tunnel-diode power driver (see diagram) designed to pass a 5-nsec pulse while preserving its waveshape. The driver's rise time is less than 1 nsec and its dissipation is approximately 80 mw. The circuit family has been used in designing a computer that could process two 64-bit words with eight adds, three multiplies and one divide at 5 Mc.

A semiconductor switching assembly capable of providing switching for a modulator producing more than 300 Kw was reported by F. A. Gateka and M. L. Embree, of Bell Telephone Labs. An assembly of 20 *pnpn* transistors switched from 8 Kv (off) to 80 amp in 125 nsec. Two in series switched 16 Kv.

P. R. Low, of Stanford, described a two-core magnetic adaptive component that could serve as an analog memory for an adaptive logic system. It takes about 10 msec to change gain from normalized +1 to −1, which could probably be speeded up by a factor of 100. A 50-mv r-f input gives 5 mv per turn on the output.

What's Ahead for Optical Masers?

By THOMAS MAGUIRE
New England Editor

AS POTENTIAL APPLICATIONS of the optical maser multiply, some of the hard-core engineering problems are also coming into focus, says Charles H. Townes, a maser pioneer now provost of MIT.

In a Lincoln Laboratory Decennial Lecture at MIT, Townes cited the need for more information about variations in atmospheric optical properties affecting maser communications. To work in atmosphere, a carefully controlled optical system will have to operate under conditions of high power, hot lenses and hot mirror surfaces.

Townes pointed out that acoustic vibrations in a normal environment can cause frequency vibrations of tens of Kc—or one part in 10^{10}—which could be troublesome in some of the precision applications now contemplated. Townes plans to tackle this problem with tests in a super-quiet laboratory.

A great deal of engineering will be needed also, said Townes, to take advantage, in space communications and radar applications, of the optical maser's directivity and super-intensity focusing.

Extensive work on doppler effects at optical wavelengths is required. Optical masers promise to achieve interference patterns at distances of thousands of miles. But it is not yet clear whether remote detection of these patterns will have important applications.

Changes in doppler shifts will be important if interstellar and interplanetary communications are explored, such as the Ozma-type experiments proposed by Townes and R. N. Schwartz. (*Nature*, p 205, Apr. 15, 1961). They point out that another civilization might be trying to communicate with the earth by optical or infrared masers.

With maser techniques, signals between planets one light year apart could be detected by the human eye, says Townes. Telescopes could be used to signal between planets 10 light years apart.

Monochromaticity, or frequency purity, of optical masers will make them extremely valuable as oscillators. Townes said the hydrogen maser under development at Harvard by Ramsey promises to be the most precise clock ever devised—accurate to one part in 10^{13}.

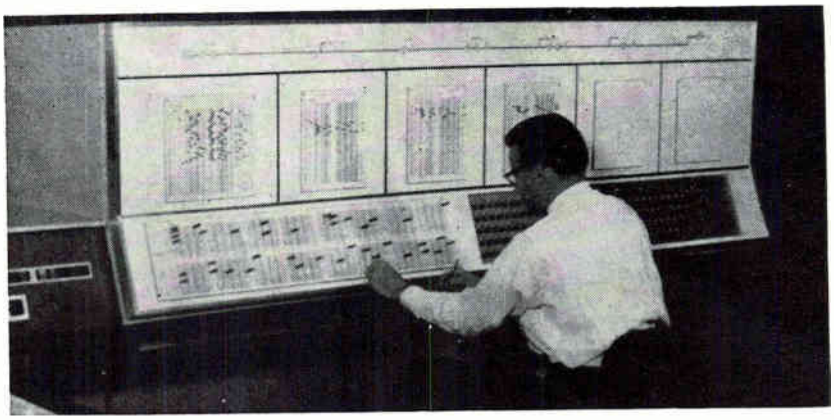
Townes also added an historical footnote. "We still don't have a good oscillator in the No Man's Land between 300 Gc and 3,000 Gc." Searching for such an oscillator led to masers and lasers, but the hunt still goes on in the region between microwave and infrared.

Among fields yet to be explored, Townes cited molecular resonance at the other end of the spectrum—very high intensity acoustic oscillations that might someday make possible a maser-like device.

The optical technology gradually being built around the maser, Towne said, includes amplification and oscillation techniques, antenna properties of lenses, frequency multiplication, heterodyning, and information on attenuation properties. Two maser beams, he pointed out, can be put through the same photocell and a difference frequency produced as modulation.

Other applications he thought interesting include:

- Communications: Optical masers can dispel the bandwidth problem. The entire radio-microwave range is equivalent to only 0.1 percent of the bandwidth available in the optical frequency range. Work is now underway on methods of powering an optical maser by solar radiation alone.
- Measuring distance and time: Possible measurement of the frequency of oscillation of light may eventually result in the velocity of light being made the standard of time.
- Surface measurements: Surface accuracies of large radiotelescopes will be measurable within one wavelength of light, a precision not yet reached in such antennas.
- Energy intensity: At focus point, the optical maser can concentrate 100 million volts per cm. It may be used for evaporating refractory materials, producing nonlinear effects on materials, etching, chemically pure welding, microsurgery, microscopy and perhaps precise control of machinery in factories by optical beams.
- Power transmission: Ten Kw could be beamed to a spot of 6-in. diameter 1,000 miles away. Light pressure could possibly be used to position or maneuver satellites.



Simulator operator sets up pipeline information on pinboards. Results of dry run are displayed by multichannel recorder at left

Two Pipeline Systems Bow

PIPELINE OPERATORS were offered two systems last month. One is an analog simulator that helps dispatchers schedule shipments. The other is a solid-state digital supervisory system.

The simulator, introduced by General Precision, evaluates in a few minutes shipment schedules and pump operations for periods up to two weeks in advance. Electrical circuits simulate pipe, pumping stations and other pipeline parts.

Products and pipeline parameters are set up in a pinboard. Flow rates and other data outputs are recorded on strip charts.

The digital supervisory control and telemetering system was announced by Transitel International Corp, of Paramus, N. J. One of its features is a digital setpoint capability which allows direct transmission of manual or computer-fed numeric commands to an unattended remote facility.

Control instructions are sent to remote stations after message loops have been selected and verified. Telemetering can be selective, continuous, monitor alarm limits, or automatically engage associated control functions. One alarm bank will scan up to 400 points at 10 Kc. Eight basic circuits comprise 90 percent of the system.

Lasers' Future: Bright or Cloudy?

PHILADELPHIA—Optimistic reports on the future of optical masers clashed with cautious reservations at a panel discussion on lasers at the Solid-State Circuits Conference.

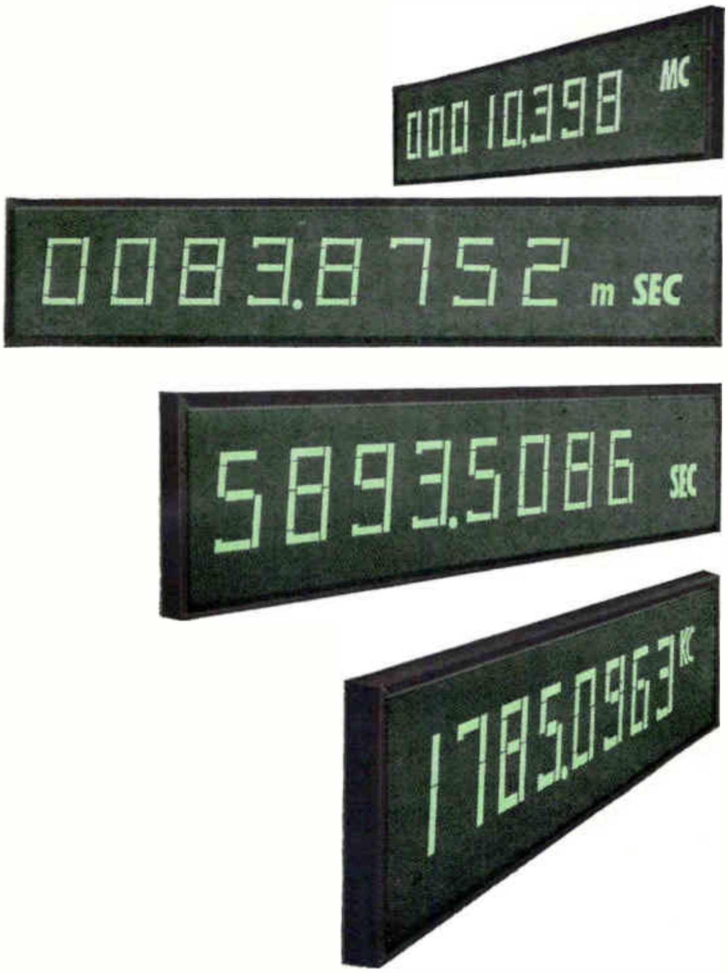
H. Scharfman, of Raytheon, predicted mounting power outputs. Outputs would be raised from 20 to 30 joules now to somewhere between 100 and 1,000 joules by the end of the year, he said. Efficiency would double, to two percent.

Outputs will later be raised to the 1,000 to 10,000-joule range, he thought. After that, though, a substantial improvement in technical knowledge will be needed to break through to higher outputs.

M. L. Stitch, of Hughes, remarked that "remarkable advances" in output of optical ranging equipment had been achieved since he reported one delivering over 600 Kw, six months ago. Stitch declined to reveal the new figure.

The note of caution was injected by P. Franken, of the University of Michigan. He said it has not yet been determined whether the laser is a major development. It can make a unique and lasting contribution, particularly in research, he said, but he now foresees small application in industry.

Scharfman argued that lasers should be regarded as something completely new and unique, with ramifications still unrealized. A. E. Siegman, of Stanford, felt the laser has an important future in the generation of millimeter waves with down-conversion techniques.



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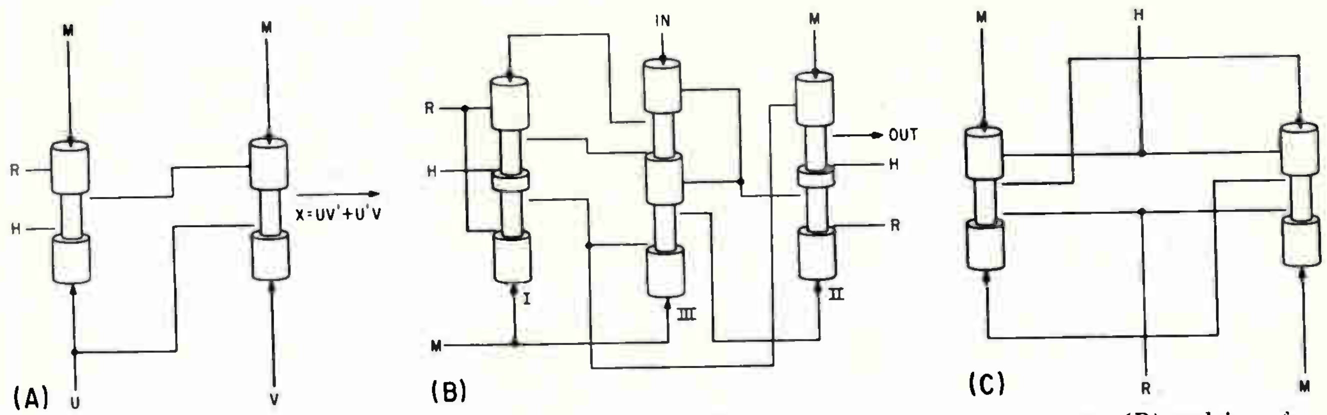


This is how fluid logic can be used in an exclusive-or stage (A), binary counter scale-of-two stage (B) and in a free-running multivibrator (C)

Propose Fluid Logic Space Computers

By HAROLD C. HOOD
Pacific Coast Editor

SUNNYVALE, CALIF.—Computer scientists from throughout the Free World gathered here this week for what was believed to be the first symposium on the application of switching theory to space technology. It was jointly sponsored by Air Force Systems Command and Office of Aerospace Research with Lockheed Missile and Space Co.

Some two dozen papers were delivered in sessions on circuit logics, systems and new switching and storage devices. Emphasis was split between theoretical considerations and new hardware.

Uses of hydraulic switching devices in space-borne logic networks were outlined by A. P. Speiser, of IBM's Zurich Research Lab. Binary counters, OR gates, multivibrators and shift registers have been successfully tested, he said.

He described two types of systems, one using spool valves as switches and the other employing dynamic phenomena involving no moving or deformable solid parts. Both may be operated with liquid or gas. Systems could be used by themselves or combined with electronic systems. Speiser said speed and power requirements are about that of electrical relay circuits.

Fluid logic is highly insensitive to nuclear radiation. Another advantage in space applications, he said, is that fluid amplifiers built of ceramic and using gas could operate at temperatures of many hundred degrees Centigrade.

Speiser does not expect fluid logic to replace high-speed solid-state circuits. But, he pointed out, many computers use such circuits at speeds far below their potential. Fluid circuits would have a cost advantage here. Elements can be made inexpensively of molded plastic. Miniature fluid circuits are now being designed. The minimum practical bore of spool valves used is about 1 mm.

Speiser drew some analogies between operation of fluid and semiconductor devices in logic systems. Fluid inertia in power lines and connecting channels, for example, creates a problem akin to large electrical inductances.

Among other new devices devices described were an electron spin echo storage, by M. E. Browne, of Lockheed; nonlinear resonance switching elements, by J. C. Santesmasas, of the University of Madrid, and superconductive switches and storages, by A. E. Slade, of Arthur D. Little.

Eiichi Goto, of the University of Tokyo, surveyed majority, threshold and bilateral switching devices. He stressed the importance of complementing practical approaches to threshold logic with mathematical or idealistic approaches. Some of the most promising applications for this logic in the near future, he feels, are neuron-like or adaptive systems.

Practical approaches resulted in development of such computer components as parametrons, magnetic core switches and Esaki diode circuits. But, Goto said, if too much emphasis is placed on practical considerations, fruitful mathematical theories may not be fully developed.

D. G. Willis, of Lockheed, also discussed threshold switching theory. He said the meeting was organized to focus on theoretical problems. Digital design problems are compounded in space, he pointed out, and design engineers will be hard-pressed to keep hardware abreast of theoretical concepts that are developing.

The general chairman, Howard Aiken, of Harvard University, also stressed the importance of theory. He called it the basis for all digital computers. Without digital techniques utilizing discrete variable circuits, space exploration as we know it would be impossible, he said.

The main objective of the fast-growing field of digital network theory, according to W. H. Kautz, of Stanford Research Institute, is development of analysis and synthesis procedures for networks composed of digital elements. He feels development hangs on understanding how network terminal behavior is related to internal structure or wiring.

In a paper on totally sequential switching circuits, Kautz outlined relationships between the structure of the state graph, which exhibits network behavior, and network equations which describe internal structure. Prime justification for studying totally sequential networks, he said, is their theoretical value in developing analysis and synthesis techniques for families of sequential digital networks.

Sensors Seen as Boon To the Earth Sciences

THREE-DAY SYMPOSIUM on the applications of electronic sensors in the earth sciences was held two weeks ago at the University of Michigan's Institute of Science and Technology, under a tri-service contract administered by the Office of Naval Research.

It gave some 70 oceanographers, geologists, meteorologists, biologists, botanists and other specialists an opportunity to discuss sensors largely developed under military programs. Specific research programs will be proposed at a followup symposium in May.

Among suggested applications were measuring sea temperatures, determining water content of soils, assessing agricultural diseases. Sensors might also be used to count the different kinds of animals or plants in a large area, or predict earthquakes and volcanic eruptions.

A number of agricultural scientists thought that great economic benefits could come from rapid aerial surveys of crops (ELECTRONICS, p 7, Feb. 2).

The full gamut of remote sensors could be used, including radar, infrared and microwave detectors, aerial photography, gravimeters, and magnetometers. Aboard aircraft or satellites, they could rapidly survey large areas.

But first, it was pointed out, there is a fundamental problem to be solved. There has been little cataloguing of spectral characteristics of natural and man-made materials. The problem is made more complex by variations in meteorological environments.

Big Simulator Tests Space Probes

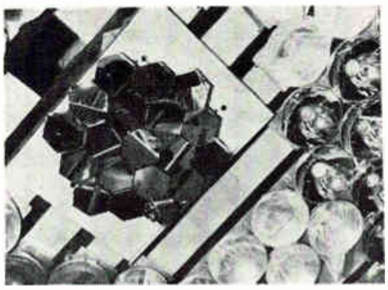
ENVIRONMENTAL simulator that cost $4 million is now being used by Jet Propulsion Laboratory to aid design of lunar and planetary probes JPL is developing for National Aeronautics and Space Administration. First to go in it, for a three-week period, is Mariner, a Venus probe.

Built by Consolidated Vacuum Corp., the simulator is 80 ft tall, has a chamber 47 ft high and 25 ft in diameter. The evacuation systems, comprising seven compressors, three blowers and 10 oil diffusion pumps, can produce a vacuum of 10^{-8} mm of mercury. Spacecraft performance is monitored by electrical connections through the chamber walls.

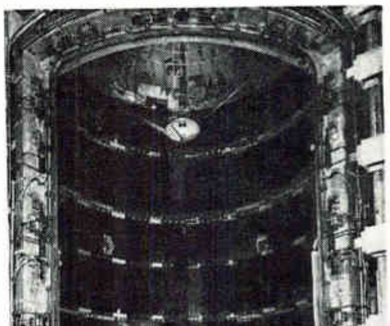
The optical system was designed by Bausch & Lomb to simulate solar intensity as close to the sun as Venus and as far as Mars. The optical sun is an array of 2.5-Kw, mercury-xenon arc lamps, each with a 16-ft reflector.

Light is reflected in zig-zag fashion by parabolic and hyperbolic mirrors into the chamber. In the chamber, the 3-ft beam is widened to 25 ft by a reflector consisting of hundreds of small stainless steel pebbles. Another parabolic mirror makes the beam almost parallel in the test plane.

Heat is prevented from radiating back from the chamber walls by an aluminum shroud made of 200 black plates cooled to −310 F.



Array of hexagonal mirrors directs light from 131 arc lamps into solar simulation system



Chamber interior is lined with refrigerated black plates to prevent heat radiation from walls

Four Computer Centers to Control Defense Network

DEPARTMENT OF DEFENSE will install a computer and electronic wall displays in each of its area communications control centers in Europe, Alaska, Hawaii and Colorado. The systems, designed to prevent delays in message routing and transmission, will give a detailed picture or printout of congestion or trouble in each area.

The Defense Communications System includes 6,300 circuits in 73 countries, the majority of long-haul point-to-point circuits used by military departments and DOD.

IBM Federal Systems division will equip the centers, which will use 1410 computers. IBM is also to train operators and turn the centers over to the Defense Communications Agency by March, 1963.

Electronic Systems Office Gets Another Commander

COMMAND of Air Force Electronic Systems Division, Hanscom Field, Bedford, Mass, was taken over last month by Brig. Gen. Charles H. Terhune, Jr. He succeeds Maj. Gen. Kenneth P. Bergquist, now chief of AF Communications Service, Scott Field, Ill. Air Force also announced Rome Air Development Center is now assigned administratively to Systems Command Headquarters, no longer part of the Hanscom complex. RADC mission remains the same, principally developer and purchaser of hardware for command and control systems designed and managed by ESD.

MEETINGS AHEAD

MISSILES & ROCKET TESTING SYMPOSIUM, Armed Forces Communications & Electronics Association; Coca Beach, Fla., Mar. 6-8.

QUALITY CONTROL CONFERENCE, MIDDLE ATLANTIC, Amer. Soc. for Quality Control; Statler-Hilton Hotel, Washington, D. C., Mar. 8-9.

IRON & STEEL INDUSTRY INSTRUMENTATION CONFERENCE, Instrument Soc. of America; Hotel Roosevelt, Pittsburgh, Pa., Mar. 14-16.

EXTRA-HIGH VOLTAGE COMMUNICATION, CONTROL & RELAYING, AIEE; Baker Hotel, Dallas, Texas, Mar. 14-16.

AUDIO ENGINEERING SPRING CONVENTION, Audio Engineering Soc.; Ambassador Hotel, Los Angeles, Mar. 19-26.

IRE INTERNATIONAL CONVENTION, Coliseum and Waldorf Astoria Hotel, New York City, Mar. 26-29.

QUALITY CONTROL CLINIC, Rochester Soc. for Q.C.; University of Rochester, Rochester, N. Y., Mar. 27.

ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS, AIEE, IAS, IRE, University of Rochester; at the University, Rochester, N. Y., Mar. 28-29.

SOUTHWEST IRE CONFERENCE AND SHOW; Rich Hotel, Houston, Texas, April 11-13.

PLASMA PHYSICS SYMPOSIUM, American Physical Society; Hilton Inn, Tarrytown, N. Y., April 13-14.

JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., May 1-3.

HUMAN FACTORS IN ELECTRONICS, PGHFE of IRE; Los Angeles, Calif., May 3-4.

ELECTRONIC COMPONENTS CONFERENCE, PGEC of IRE, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D. C., May 8-10

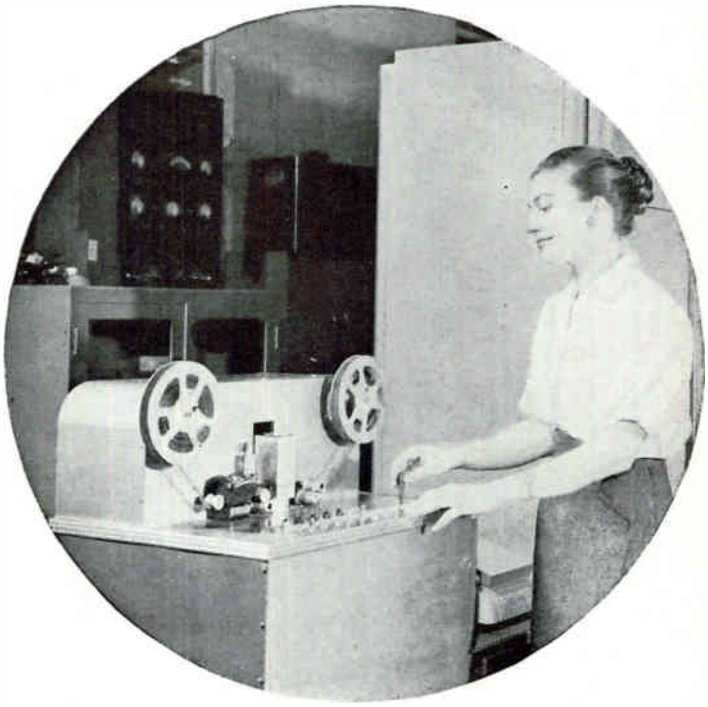
NATIONAL AEROSPACE ELECTRONICS CONFERENCE, PGANE of IRE; Biltmore Hotel, Dayton, Ohio, May 22-24.

SELF-ORGANIZING INFORMATION SYSTEMS CONFERENCE, Office of Naval Research, Armour Research Foundation, Museum of Science, and Industry, Chicago, May 22-24.

ADVANCE REPORT

ENGINEERING WRITING & SPEECH SYMPOSIUM, PGEWS of IRE: at Mayflower Hotel Washington D.C., Sept. 13-14. Five copies of titles (not more than 50 letters and spaces) and abstracts of papers (not more than 750 words) should be sent by Mar. 15 to: J. E. Durkovio, Program Chairman PGEWS, c/o ARINC, 1700 K Street, N.W., Washington 6, D.C. Papers should not have been presented elsewhere except at local meetings. Conference theme is "Engineering Writing and Speech An Art or a Science?" Suggested topics include: writing proposals that pay, better reading for better writing, visual communication, tutorial material, economics in writing and government regulations.

Flying Spot Inspects Tv Rating Records



Flying spot scanner provides light source for phototubes that read information on film in this system for obtaining tv ratings

Load switching controls phototube frequency response. Simultaneous switching of phototube load and intensity of spot in flying-spot scanner eliminates burning from quiescent spot and gives usable signal-to-noise ratio

By A. C. LEWIS BROWN
A. C. Nielsen Co.,
Evanston, Illinois

ONE SYSTEM for producing national tv ratings records minute by minute station tuning in a sample of homes on 16-mm microfilm. Described here is a machine designed for fast inspection of these records.

A previous article describes the general system.[1] A representative 16-mm film record is shown in Fig. 1A. A black minute mark is recorded by a synchronous motor for each elapsed minute. A day mark occurs each 6:00 a.m. under control of an electrically wound mechanical clock. Thus a home power outage, which interrupts the recording, can be compensated by using the known time of the mechanical-clock day mark. Power outage is indicated on the film after power returns by exposing all columns for three minutes. Viewing is recorded in five columns for each receiver as shown in Fig. 1A.

The inspection machine automatically finds the start of each film and reads the film at a rate of 700 recorded minutes per second without stopping. For each film minute, it scans the recorded information and makes logical entries into electronic accumulators. At each day mark or power outage, the accumulators read one line of characters to an output printer. This printed line shows the number of electrically recorded minutes since the previous day mark, whether a power outage occurred, plus indications of improper code patterns and of film faults.

The number of electrically recorded minutes between day marks must be $24 \times 60 = 1{,}440$ unless a power outage mark explains missing minutes. The clock times at beginning and ending of a power outage can be computed knowing the minute counts from and to the adjacent 6:00 a.m. day marks.

After inspecting a two-week film in about 30 seconds, the machine stops the film, prints totals of viewing for four receivers and then automatically searches for the beginning of the next record.

The output record for a four-day film is shown in Fig. 1B. The first interval is 720 minutes. The film was changed 12 hours after a day mark or at 6:00 p.m. Then there is a perfect day having a count of 1,440 minutes. During the next day a power outage occurs 280 minutes after the day mark, or at 10:40 a.m. Since the first count following the power outage shows 1,100 minutes, the power outage must have been an hour long, and must have ended at 11:40 a.m. The next day is a perfect one showing 1,440 minutes, but has an improper code pattern in receiver 1. The last interval, 240 minutes long, shows the film was changed about 10:00 a.m.

The film is read by phototubes with a flying-spot scanner as the light source (Fig. 2). Phototubes pass signals through a video amplifier that generates sequential signals to drive the serial input of a shift register. The shift register has a position for each film column, and stores all the information from one minute of film for 350 microseconds. During the storage interval, the shift register is interrogated by a set of enabling pulses that cause readout if any patterns of interest are present. Readout is in pulses that are stored in flip flops or counters for later printing. A time mark or power outage causes the readout selector to advance and read from the storage that has just filled. Meanwhile, a new storage accepts information being read while printing is completed.

The machine uses a 5ZP16 flying-spot scanner tube. A quiescent spot on the scanner tube is imaged by a lens system through the film onto the photocathode of a 931A multiplier phototube. Voltage output of this phototube is amplified and monitored by a Schmitt trigger circuit. When, due to film motion, a black minute mark interrupts the light path from cathode-ray tube to cell, the Schmitt trigger senses the voltage change to recognize the minute mark. When this happens the flying spot is swept from the minute mark column sequentially across all film columns. During this sweep, the phototube output will be pulsed dependent on the number and placement of black and white film columns.

A mechanical grating on the face of the flying-spot tube causes a gate phototube to generate a sequence of 21 gating pulses. These pulses define the center third of each film column, and occur whether or not the film column is exposed. By ANDing the gating pulses with the signal from the reading phototube, a series of digit and shift pulses is generated for input to the shift register. Thus, the shift register is continuously loaded and shifted in synchronism with the flying-spot image movement across the film. When the sweep is completed in 450 microseconds, the shift register is loaded with all of the information of one film minute.

The logic circuits that examine the shift-register contents are gated and output pulses for code combinations are produced. These output pulses are stored in flip-flops and counters for later printing. Meanwhile the flying spot has retraced to quiescent sensing, awaiting the next minute mark.

For the film speed of 700 minute marks per second, or about 1,400 microseconds per film minute, a sweep and shift-register loading time of 450 microseconds is used. If 21 film columns were alternately white and black, output pulses occur at a 50-Kc rate.

Measurements show that a 22,000-ohm phototube load is maximum to give good 50-Kc response. Sufficient light was obtainable from the moving spot to give good output signal-to-noise ratio. However, the light obtainable from a quiescent spot without screen burning was too low to give usable signal-to-noise ratio.

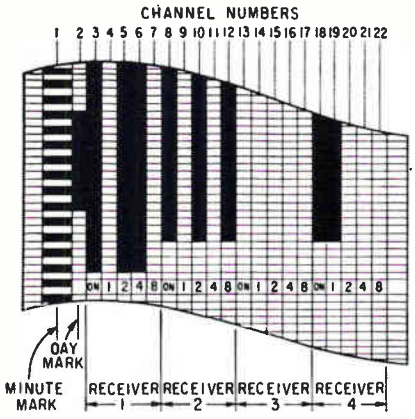
Because the required frequency response for the signal due to film motion (minute-mark sensing) is only about 2 Kc, switching is used to overcome burning. By switching the load of the reading phototube, its sensitivity and frequency response can be changed, and by simultaneously switching the spot intensity, the comparative system characteristics shown in the table are obtained. Since the spot intensity and phototube load resistor are simultaneously switched, the reading phototube voltage output remains constant for both minute sensing and sweep.

The circuit for phototube load switching is shown in Fig. 3A. Diode V_2 is normally conducting, holding V_1 at cutoff. The phototube sees a 470,000-ohm load resistor (R_1) that gives good sensitivity with poor frequency response. Circuits following the video amplifiers respond to the signal from the 931A phototube and trip the sweep when a black minute mark covers the quiescent spot. As soon as the sweep starts, a positive load switching waveform is applied to the cathode of V_2 to cut it off. Immediately, the photo currents developed by the 931A multiplier phototube effectively see a 22,000-ohm load by the connection of V_1. This lower load resistor gives the frequency response necessary to correctly reproduce the 50-Kc square wave generated by the read phototube as the spot traverses the film.

So that the video amplifier circuits will see equal voltage waveforms during both load periods, the spot is intensified as soon as sweep starts. The circuit of Fig. 3B accomplishes spot intensification and also acts to hold spot intensity constant as it moves across the phos-

SYSTEM CHARACTERISTICS

FUNCTION	TIME DURATION	BRIGHTNESS	READING PHOTOTUBE LOAD RESISTOR	SENSITIVITY	FREQUENCY RESPONSE
MINUTE SENSING (SPOT QUIESCENT)	600μSEC TO INFINITY	LOW	470,000 OHMS	HIGH	LOW
SPOT SWEEP	450μSEC	HIGH	22,000 OHMS	LOW	HIGH



(A)

MINUTE COUNT	POWER OUTAGE	IMPROPER CODE PATTERN	FAULT
0 7 2 0	0	0	0
1 4 4 0	0	0	0
0 2 8 0	1	0	0
1 1 0 0	0	0	0
1 4 4 0	0	1	0
0 2 4 0	0	0	0

(B)

FIG. 1—Typical record (A) shows receiver 1 is on and tuned to station 6 (4 plus 2). Output record obtained from microfilm (B)

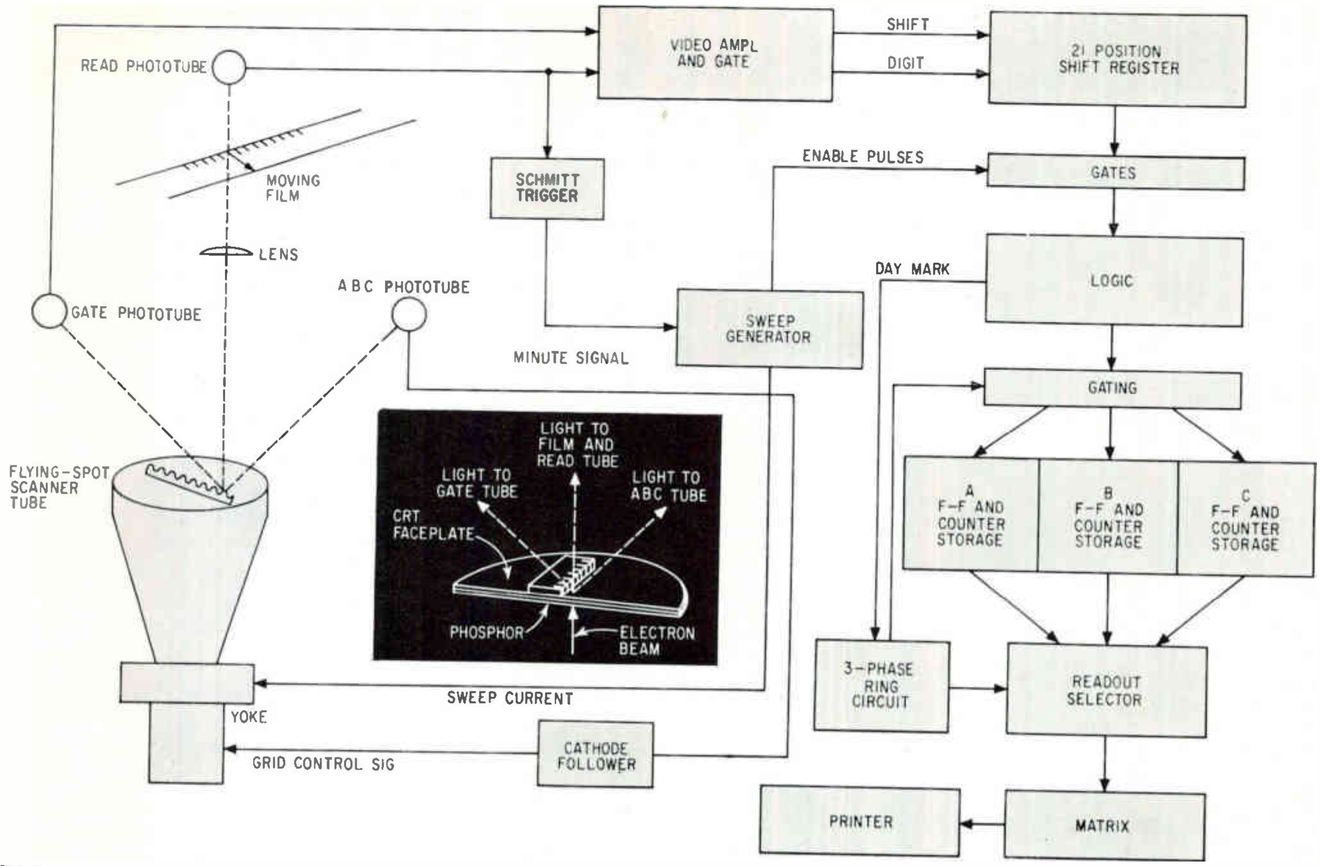


FIG. 2—Shaded area of system block diagram shows detailed cross section of crt face and grating

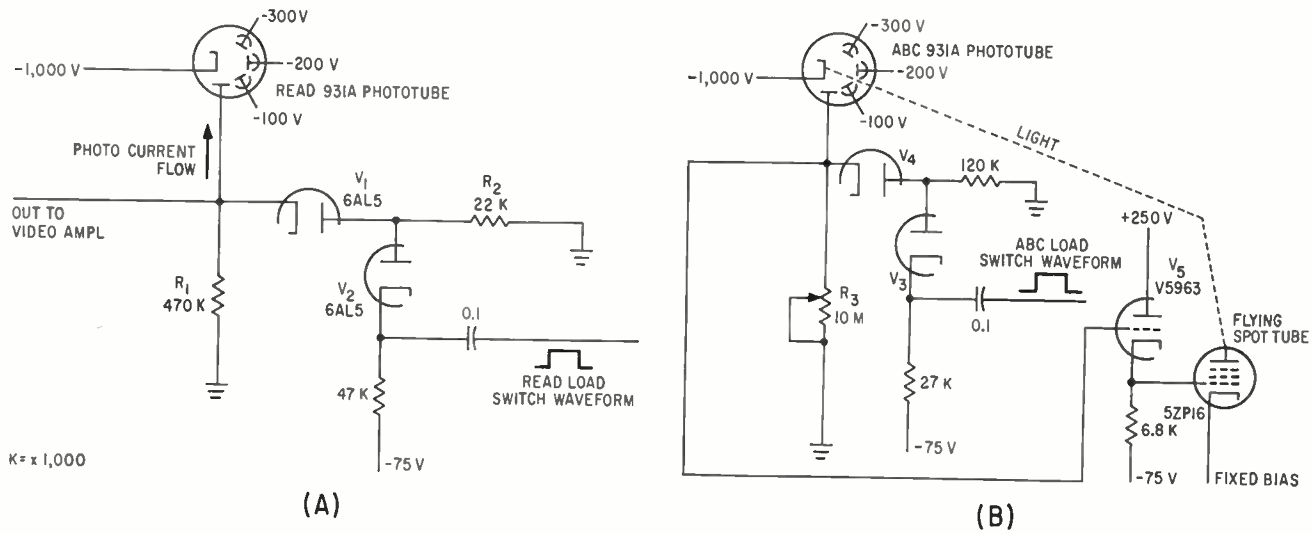


FIG. 3—Load switching circuit for read phototube (A) and abc phototube (B) are similar

phor. In this circuit a 931A phototube views the spot at all times without interruption by a lens system or film. While the spot is at rest the output signal of this automatic brightness control (abc) phototube is applied to a cathode follower. Output of the cathode follower determines the bias on the flying spot 5ZP16. This feedback loop compensates for any changes that occur in spot intensity.

Load switching similar to that employed for the read phototube is used for the abc phototube. While the spot is resting, the abc phototube sees only a 10-megohm load resistor since diode V_4 is cut off. This high value of load resistor develops a large negative voltage which biases the crt to prevent screen burning. As soon as a minute mark is sensed and the sweep starts, a load switching wave is applied to the cathode of V_3. This cuts off V_3 and allows V_4 to conduct. The abc phototube load is switched from 10-megohms to 120,000 ohms.

Since the phototube is a constant current generator this reduces the phototube output voltage, which acts through the feedback loop to cause the intensification of the spot.

By adjusting R_3, the increase in light intensity can be made to balance the decrease in read phototube sensitivity caused by going from a 470,000-ohm to a 22,000-ohm load. Thus, a usable signal is obtained from the read phototube both with the spot stopped and moving. In addition, good frequency response is provided when it is necessary while allowing relatively poor frequency response during the slow process of minute-mark sensing.

The video amplifier circuits are conventional and direct coupled. The supply voltages used by the video amplifier, cathode-ray tube and phototubes must be well regulated because of varying repetition rates. This is because film speeds anywhere from 0 to 700 minute marks per second must be accepted. Figure 4 shows how the read phototube and gate phototube signals are gated together to produce digit and shift pulses for the shift register.

Once the shift register is loaded, the sweep circuits issue commands for the logic to examine the stored pattern of the register. Diode gating circuits are used.

A printer capable of printing 3 lines of 11 digits each per second is used. Assuming that one line of printing could contain all the information for one film interval, in one third of a second approximately 500 minute marks or 8 film hours would be read. In this long film time that there might be occurrences of power outages and thus additional print orders.

Since the printer does not print instantaneously, unless the film is to be stopped more than one storage will be required to avoid loss of information. Since film stoppage is undesirable a minimum of 2 storage positions is required. The machine accumulates the first interval in storage *A* (see Fig. 2). At the end of the first interval, all storages are electronically switched to accumulate in *B* position. The selector circuits now read out from *A* to the printer. If the printer finishes its operation before the next print order, the *A* storage is available to take the next film information and contents of the *B* storage could be printed. However, if a print order occurs before printing of storage *A* is finished, the storage circuits switch to *C*.

Studies show that 3 storage positions would care for 95 percent of all encountered films. Accordingly, the machine is designed so that it normally progresses through *A*, *B* and *C* storage, both accumulating and printing. Two storages are normally in use while the third is held in reserve. Serial switching between storages is accomplished by the readout selector.

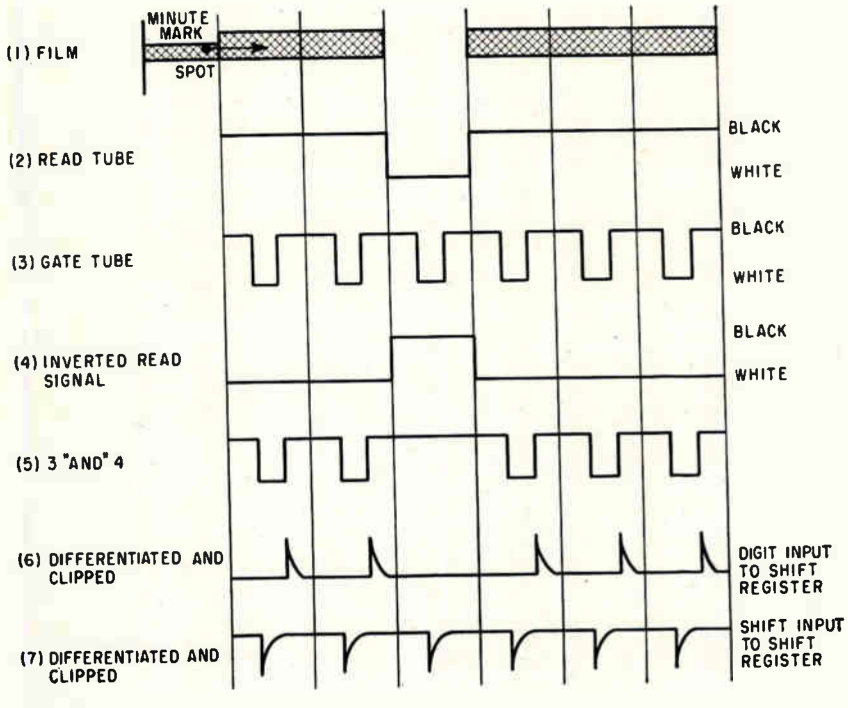


FIG. 4—Waveshapes for typical sequence of operation

When the film calls for more storage while a previous printing is still continuing, a lag cycle transfers control of the readout selector from the film to the printer. This means that as long as the printer is no more than two positions behind the accumulators, it will continue printing, and if possible, catch up. To provide additional time for the printer the film is automatically slowed whenever the machine goes into this lag cycle. If the printer falls more than two positions behind the accumulators, the film stops.

The readout selector of Fig. 2 uses a 30-level, 26-position switch. Four levels are used for control and the other 26 are sequentially switched to read out 26 binary variables from *A*, *B* or *C* storage. After switching, these binary voltages are fed to a matrix that drives a set of relays through amplifiers. Contact matrices operated by the relays convert the binary quantities for decimal input to the printer.

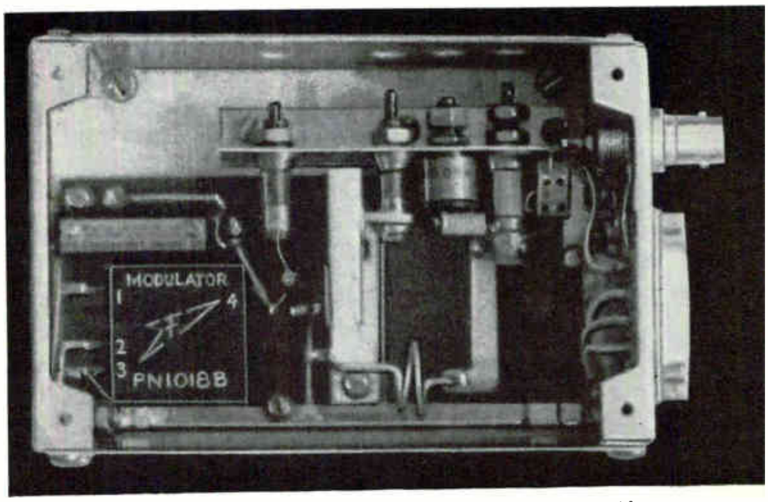
A binary counter circuit senses the end of the film. It compares mechanical motion of the film drive unit with the flying-spot sweeps. Film end is defined as film motion without sweep of the spot. The counter uses pulses from a generator on the film drive shaft as the count input. The counter tries to advance but is continually reset at each sweep occurrence. When the sweep no longer occurs the counter advances to a full count signaling the end.

At the film start, relay logic circuits advance the film until minute marks are sensed. As soon as minute mark sensing occurs the film is reversed and the end-of-film circuit looks for the end of minute marks. As soon as this is found, the film stops, all machine circuits are cleared and a start order issued. In automatic running of a number of films the machine begins to search for the start of the following film whenever the end of the previous film is sensed.

The author acknowledges the assistance of W. A. Marggraf particularly in designing the control circuits and in debugging the machine. Other contributions were made by D. W. Holbrook, C. Prisekin, J. Schweihs, A. Reszka, E. O. Ross, L. Scholten, R. L. Freeman and C. H. Currey.

Self-Reactance Modulation in TELEMETRY OSCILLATORS

Design formulas for predicting the frequency characteristics of vhf-uhf transistor oscillators using self-reactance modulation techniques



230-Mc pam/f-m telemetry beacon designed for self-reactance f-m principles

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SIMPLE frequency-modulation techniques for common-base transistor oscillators operating in the vhf-uhf range are of interest in the design of satellite telemetry beacons and similar equipment. This article considers the self-reactance frequency modulation of such oscillators. Although self-reactance modulation techniques have been known and used for some time in such circuits, the modulation chcaracteristics have been largely determined by experiment. Given here are analytic expressions for the modulation characteristics based on a new and more exact expression for the common-base parallel-output capacitance.

Consider the equivalent circuit of a drift transistor at vhf shown in Fig. 1. The capacitance at the output port is composed of the collector transition capacitance C_{ct} in parallel with the collector diffusion capacitance C_{cd}.

Experience has shown C_{cd} to be negligible at the frequencies and operating points of interest here. The parallel output capacitance C_{obp}, hereafter simply called C_{ob}, is then equal to the collector transition capacitance C_{ct}. Capacitance C_{ct} is a function of the externally impressed voltage across the collector depletion layer and the constant contact potential ϕ of the base-collector diode. Since $r_b' << r_c$ and $r_c' << r_c$, at d-c and low-to-medium frequencies such that $X(C_{ob}) >> r_c$ the voltage across the collector depletion layer is simply the collector-to-base voltage V_{cb}, with sufficient accuracy for this analysis.

The boundaries of the collector depletion layer adjust to a changed V_{cb} rapidly. For modulation frequencies in the usable range the adjustment of C_{ob} to a change in V_{cb} is essentially instantaneous, meaning that C_{ob} is a function only of the instantaneous value of V_{cb}.

Earlier analyses have derived the transition capacitance for planar diodes as a function of V. Where V is the absolute magnitude of the reverse bias voltage and $C(0)$ is the measured capacitance of the junction at zero bias, excluding the stray capacitance of the mounting arrangement

$$C(V) = C(0)\left[\frac{1}{1+\frac{V}{\phi}}\right]^n \quad (1)$$

$$C(V) \approx C(0)\, V^{-n} \quad (2)$$

The exponent n is $\frac{1}{3}$ for diodes having a linear impurity density gradient. Equation 2 is a more accurate approximation to Eq. 1 at high V for silicon junctions than for germanium ones, since ϕ for silicon is about 1.12; for germanium it is about 0.72 v. However, Eq. 2 may be used for simplicity without losing accuracy, due to the method of evaluation.

Experiment has verified that both Eq. 1 and 2 are not accurate enough descriptions of empirical data to be useful in the present design problem without modification. By artificially casting the experimental results in the form of Eq. 2, but allowing n to be a nonconstant function of V, this deviation from theory may be shown. Solving Eq. 2 for $n(V_{cb})$

$$n(V_{cb}) = \frac{\log C_{ob}(0) - \log C_{ob}(V_{cb})}{\log V_{cb}} \quad (3)$$

for $V_{cb} > 1$.

The resulting plot of $n(V_{cb})$ for a typical measurement of $C_{ob}(V_{cb})$, together with the graph of C_{ob} itself, is shown in Fig. 1. There is a region extending over almost all quiescent V_{cb}'s of interest in which $n(V_{cb})$ is approximately a linear function.

The deviation of C_{ob} from theory for both Eq. 1

and 2 appears to be due to several previously ignored factors: variation of the true impurity density function from a linear one along the axis of the junction as the depletion layer extends into both the nonlinearly doped base region and the constant-impurity-density collector region; skin effect at high frequencies (change of effective geometry with frequency); change of effective junction area with the position of the depletion layer boundaries due to a deviation from the cylindrical model for the junction; and variation of the effective dielectric constant of the depletion layer material due to variation in impurity density as the depletion layer boundaries extend. Exact theoretical consideration of these factors is in progress.

For the present, however, an empirically fitted curve will be used. The quiescent V_{cb} of the oscillator is chosen and $C_{ob}(V_{cb})$ is measured at zero bias and at reasonable intervals of perhaps 0.25 v around the quiescent voltage for about 1 v in each direction. Then $n(V_{cb})$ is plotted and fitted with a linear curve of the form

$$n(V_{cb}) = a + b\,V_{cb} \quad (4)$$

Then

$$C_{ob}(V_{cb}) = C_{ob}(0)\;V_{cb}^{-(a+bV_{cb})} \quad (5)$$

the accuracy of which depends solely upon the accuracy of measuring C_{ob} and the closeness of fit of the linear curve, since n was originally derived from Eq. 2. The reason for using $n(V_{cb})$ rather than the plot of $C_{ob}(V_{cb})$ directly is that since $n(V_{cb})$ is closely linear in many cases, the error in interpolation is less in using Eq. 5 in most cases.

For later derivations it will be convenient to express Eq. 5 as

$$C_{ob}(V_{cb}) = C_{ob}(0)\;e^{-[\ln V_{cb}(a+bV_{cb})]} \quad (6)$$

Consider the basic oscillator circuit of Fig. 2A. If a modulation current i_m is injected at the emitter, the presence of R_s causes the collector-to-base voltage to vary. This in turn varies the output capacitance, the tank resonant frequency, and ultimately the oscillation frequency.

In Fig. 2A, I_{eq} = 10 ma, V_{cbq} = 11.5 v, C_{obq} = 1.97 pf, C_1 = 3 pf total, h_{fbo} = 0.98, f_c = 200 Mc, and L_1 = 0.127 μh with three turns of No. 12 wire, inside diameter one-half inch, pitch 8 turns per inch. Transistor Q_1 is the unit whose $C_{ob}(V_{cb})$ curves are shown in Fig. 1. Capacitance C_1 includes stray capacitance. The L_2 and C_2 resonate at f_c. The Q of the loaded tuned input is not critical, but must sufficiently attenuate the 400-Mc harmonic. Coils L_1 and L_2 must be loosely coupled. The buffer output tank values will depend on the next stage.

Defining C_{obq} to be the output capacitance at the d-c quiescent voltage V_{cbq} (lumping the header capacitance with external circuit elements), and h_{fbo} as the common-base short-circuit current transfer ratio, constant over the modulation frequency band down to d-c, and evaluated at the operating point I_{eq}, V_{cbq}, then

$$\frac{d\,V_{cb}}{d\,i_m} = -\,R_s\,h_{fbo}, \text{ and} \quad (7)$$

$$\delta V_{cb} = v_{cb} \approx -\,i_m\,h_{fbo}\,R_s \quad (8)$$

Then taking $C_{ob}(V_{cb})$ to find the first derivative, evaluated at V_{cbq}

$$\left.\frac{d\,C_{ob}}{d\,V_{cb}}\right|_{V_{cbq}} = -\,C_{obq}\left[\frac{a}{V_{cbq}} + b\,(1 + \ln V_{cbq})\right] \quad (9)$$

Using a first-order Taylor polynomial in differential form

$$\delta\,C_{ob} \approx \delta\,V_{cb}\left.\frac{d\,C_{ob}}{d\,V_{cb}}\right|_{V_{cbq}} \quad (10)$$

This converges nicely to the differential of C_{ob} for small increments of V_{cb}, and V_{cbq} in the normal range,

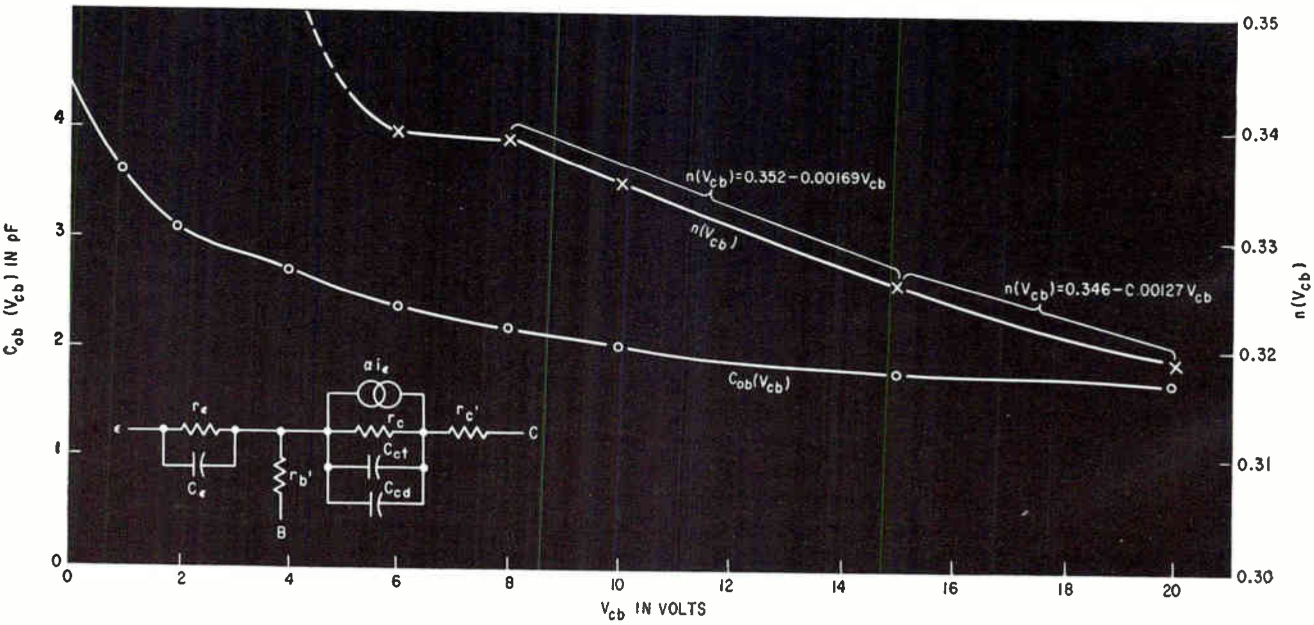

FIG. 1—Equivalent vhf circuit (inset); typical plot of $C_{ob}(V_{cb})$ and $n(V_{cb})$, based on 2N706 transistor, measured at 300 Mc in a transfer function bridge, and omitting the C_h header capacitance of 0.6 pf

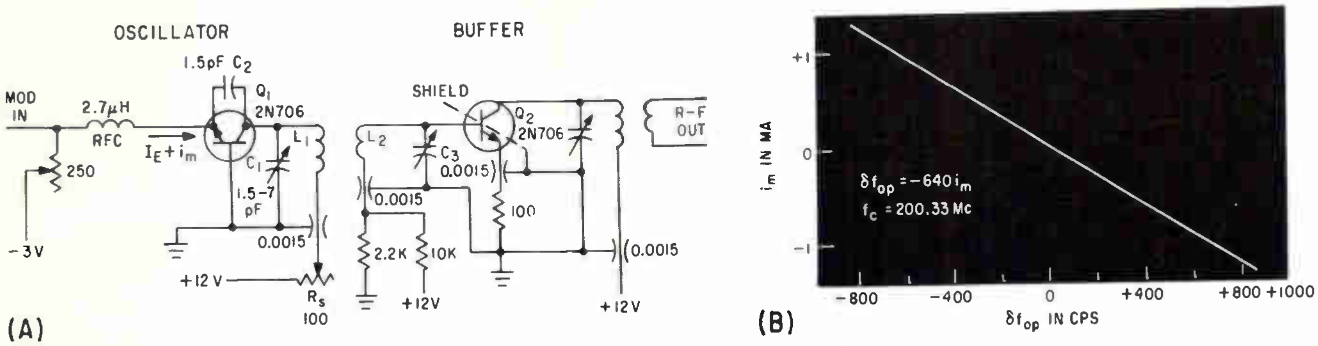

FIG. 2—Basic oscillator circuit (A) and its calculated modulation characteristic (B)

since $C_{ob}(V_{cb})$ has small curvature at V_{cb} greater than about 10 v, in general, meaning that higher-order derivatives are small.

Then, chaining backward to i_m,

$$\delta C_{ob} = (-i_m h_{fbo} R_s) \cdot \left.\frac{d C_{ob}}{d V_{cb}}\right|_{V_{cbq}}, \text{ or} \qquad (11)$$

$$\delta C_{ob} = i_m h_{fbo} R_s C_{obq}\left[\frac{a}{V_{cbq}} + b(1 + \ln V_{cbq})\right] \qquad (12)$$

Checking this result physically, it is seen that if i_m increases the total magnitude of the emitter current, the collector current increases, collector voltage V_{cb} decreases, and capacitance C_{ob} increases as expected. This is in fact the definition of the sign convention for i_m: if i_m tends to increase the absolute magnitude of total emitter current, i_m is positive; if i_m tends to decrease the emitter current magnitude, i_m is negative.

Examining the oscillator circuit, the frequency of oscillation of the circuit is nearly the resonant frequency of the tank. Thus the frequency of operation f_{op} is

$$f_{op} = \frac{1}{2\pi\sqrt{L_1(C_1 + C_{ob})}} \qquad (13)$$

Capacitor C_2 merely provides a feedback path to sustain oscillation. In some cases, the stray wiring and case capacitances between emitter and collector are sufficient alone. Now the deviation of f_{op} due to modulation is

$$\delta f_{op} = \frac{1}{2\pi\sqrt{L_1(C_1 + C_{obq} + \delta C_{ob})}} - f_c \qquad (14)$$

where f_c is the center frequency given by

$$f_c = \frac{1}{2\pi\sqrt{L_1(C_1 + C_{obq})}} \qquad (15)$$

This result for δf_{op} may then be used to generate curves of frequency shift versus modulation current for a given center frequency and $h_{fbo}R_s$ product (Fig. 2B). Note that in the equation for δC_{ob} (Eq. 12) nowhere does h_{fb} appear except in the product with R_s, thus allowing R_s to be adjusted to accommodate for differences in h_{fb} in a batch of transistors to be used for producing a group of identical oscillators. Actually, as Eq. 12 shows, the product $h_{fb}R_sC_{obq}$ is the pivotal quantity that allows adjusting of a group of oscillators to compensate for differences in all transistor parameters used in the design method. The constants in the equation for $n(V_{cb})$ can be expected to be nearly invariant over a batch of transistors of a given type.

Since the variation of C_{ob} encountered in normal modulation is of the order of 0.001 picofarad, careful electrostatic shielding of the entire oscillator is needed to ensure the oscillator is operated with stray capacitances the same as those present when center frequency was calibrated.

Thermal drift of the oscillator frequency will largely depend upon variation of h_{fb} with temperature when the I_{cbo} is small (as in planar mesas) compared with I_{eq} and when the total variation of I_{cbo} is small compared to $h_{fb}i_m$. One method of ensuring reasonable thermal stability is to use a small R_s and large i_m, but this leads to problems.

The best way of determining C_1 is by experiment, using the values of $C_{ob}(V_{cb})$ and L_1 known and the measurement of f_c for a given V_{cbq}. Capacitance C_1 includes all appropriate stray capacitances, the transistor header capacitance between base and collector leads, and any capacitance reflected into the tank by the load.

An analytic expression for residual a-m in the oscillator would require an accurate and general expression for oscillator efficiency as a function of operating point. Such a function is apparently not known at present. However, empirical curves for oscillator efficiency indicate that for usual cases the residual a-m should be small. However, if either R_s or the modulation current or both are unusually large, the modulation of the operating point may be sufficient to vary efficiency enough to cause problems with amplitude modulation.

The design analysis presented leads to accurate prediction of the frequency-modulation characteristics of a vhf-uhf transistor oscillator with low-to-medium frequency modulation current injected at the emitter. Methods for accommodating parameter differences in the transistors have been suggested. Residual amplitude modulation is very small in most cases.

The author expresses his appreciation to Robert L. Pritchard of Texas Instruments and Rainer Zuleeg of Hughes Semiconductor Division for helpful experimental data and theoretical discussions.

Parametric Amplifier

Design details of a production-type parametric amplifier for

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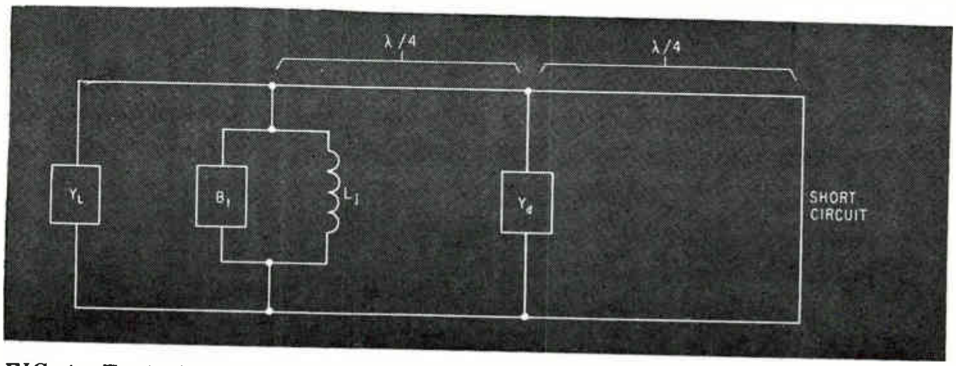


FIG. 1—Equivalent circuit of the final design of the parametric amplifier

PARAMETRIC AMPLIFIERS designed to improve performance of existing tropo scatter equipment must meet requirements for compatibility. Among the factors to be considered are: sufficient gain by the amplifier to overcome receiver noise, bandwidth, sufficient pump power for a dual diversity receiving system, amplifier isolation from the preselector and the antenna, and simplicity in operation and maintenance.

An amplifier to improve performance of a 4,400 to 5,000 Mc military tropo scatter communication set was developed under contract with the Air Force Rome Air Development Center. This article discusses the factors relating to the initial design concept through the laboratory phase and production of the final unit.

The requirement of compatibility with the receiver necessitated use of a noninverting amplifier, more commonly known as a reflection amplifier. This is a one-port negative-resistance device that relies on a circulator to separate the input and output. The system has a number of advantages over other types of parametric amplifiers. It provides better noise figures and permits fail-safe operation by allowing the signal to pass through the system with only the insertion loss of the circulator whenever the amplifier is off.

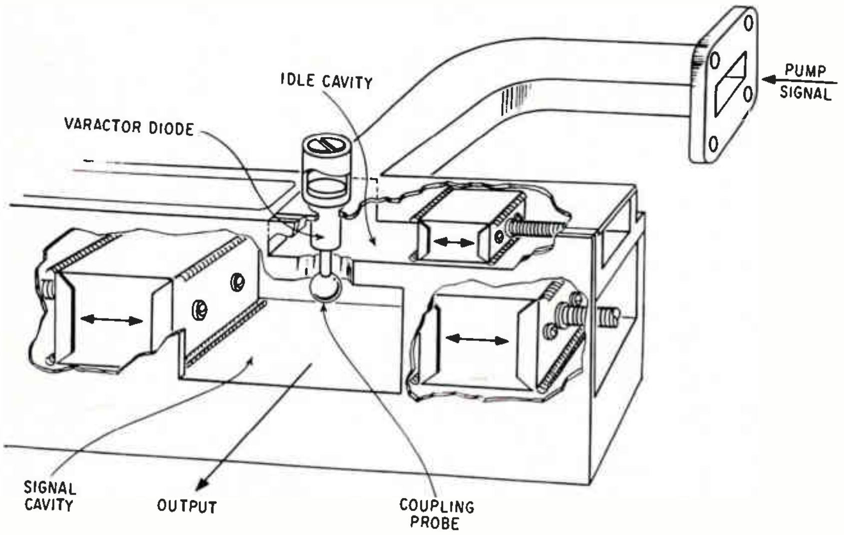


FIG. 2—Efficiency is increased by locating the varactor diode as close to the pump feed line as possible

The primary factors in developing the pump system were r-f, pump power requirements, power supply and theoretical attainable noise figure. A system using a pump frequency of 13.5 Gc was chosen over one operating at 25 Gc. The lower frequency system was chosen because diodes were available, tubes to operate in this range were available, and the power supply could be made small. Pump power requirement is only 600 v at 60 ma as compared to an estimated 1,500 v at 230 ma for the higher frequency unit.

The approximate expression for the noise figure of the reflection amplifier, assuming a lossless diode and near oscillatory pump power is

$$F = \left(1 + \frac{Q_E}{Q_I}\right)\left(1 + \frac{f_s}{f_i}\right)$$

where F = noise figure, Q_E = external Q of signal circuit, Q_I = internal Q of signal circuit, f_s = signal frequency, and f_i = idler frequency. Q_I may not be much larger than diode Q at signal frequency due to the large physical size of conventional diode cartridges and the necessity of obtain-

Improves Tropo-Scatter System

improving an existing beyond-the-horizon military communications set

ing large affective capacitance variation in the signal circuit.

Varactor Q is about 14, and is tightly coupled to the signal circuit, the internal Q of the cavity must be of the same order and the external Q close to unity for good noise figure. The amplifier design problem was that of achieving a series of extremely tight couplings, diode to signal cavity, diode to idler cavity, and signal cavity to line and maintaining these couplings over a large tuning range while simultaneously attempting to isolate tuning mechanisms functions. Knowledge of the fields in the immediate vicinity of the varactor was vague; the cartridge design is not directly controlled by the amplifier designer and the required Q's are so low that description of the signal cavity by conventional analysis by circuit theory of lumped equivalents is impractical. These factors increased the amount of laboratory work but use of a wideband sweep technique and a flexible test setup allowing measurements to be conducted without involved assembly and disassembly of waveguide components allowed rapid optimization of the great number of variables.

These experiments led to the building of two prototype models that were completely different in tuning. One was a waveguide cavity tuned by a capacitance plunger that was simple in construction but provided only 75 percent of the required tuning range due to the large change in field distribution as the plunger position was varied. The other, more complex in construction, was a short section of line, tuning being accomplished by varying its width. The amplifier may be represented by the equivalent circuit as shown in Fig. 1 and is the configuration used in the final design. In Fig. 1, Y_t is the input line characteristic, B_t is the tuning susceptance, L_j is the junction inductance, and Y_d is the diode admittance. Y_d can be resonated by adding susceptance at the junction. This makes the structure easily tuneable, since by varying the line section width and the susceptance, numerous impedance transformations of Z_d occur similar to those of E-H waveguide and triple stub coaxial tuners. The flexibility of this mechanism is the factor producing the required large external loadings.

The pump signal is introduced into the idler cavity by a waveguide beyond cutoff and pump power into the diode was accomplished more efficiently by locating the diode as close to the pump feed line as possible. The diode acts as an attenuator between the pump feed and reactive idler cavity reducing the effect of the idler cavity tuning on the pump circuit. The amplifier structure is represented in the outline drawing, Fig. 2.

The system developed for control of frequency and pump signal level is shown in the block diagram, Fig. 3. Frequency control is accomplished by an equal-arm system that provides a large pull-in range thus allowing operating personnel to operate the pump system without test equipment. The amount of reflector voltage controlled is limited so that the klystron always operates on the desired mode and corrective mechanical tuning is accomplished in

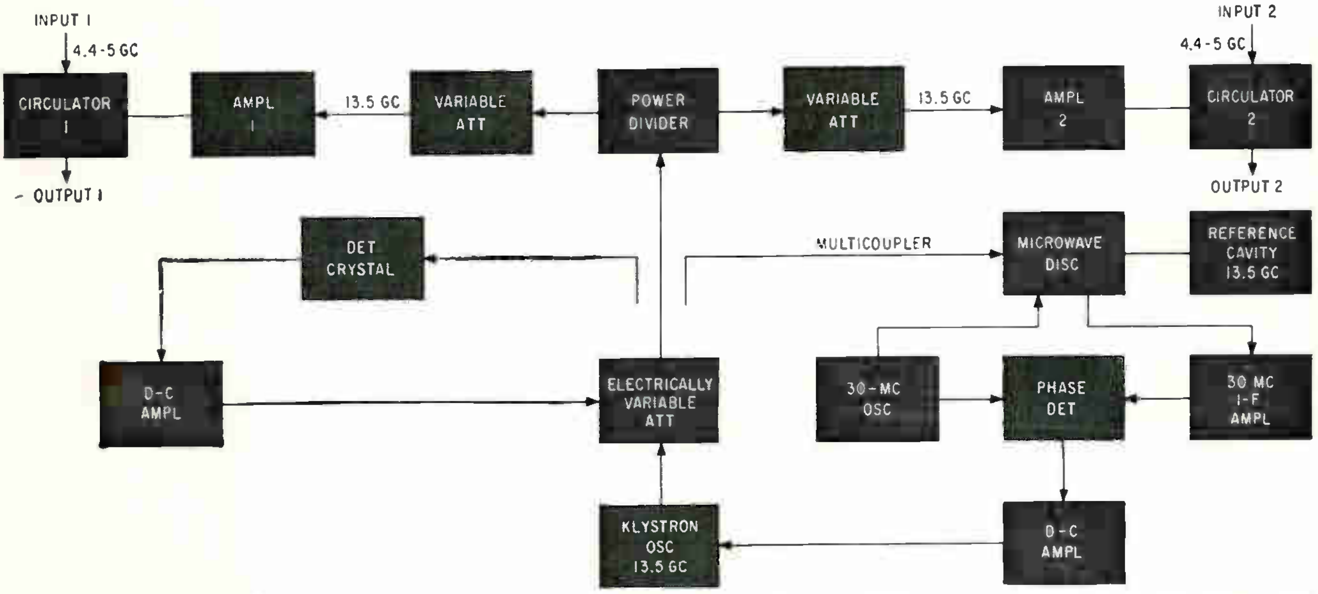


FIG. 3—Frequency control system at right controls the amount of reflector voltage to the klystron; pump signal level control at left operates the variable attenuator

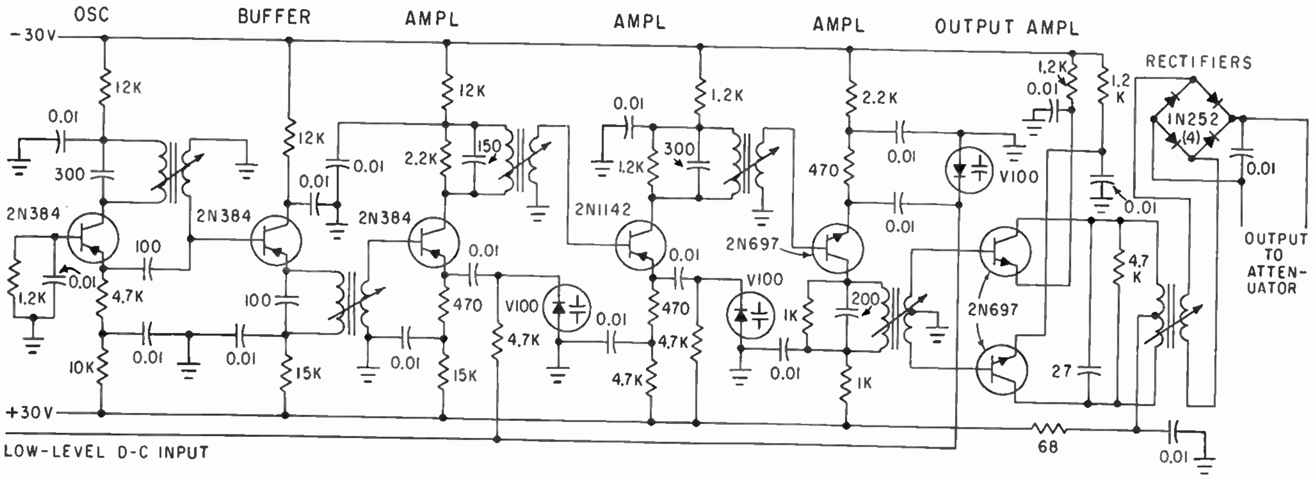


FIG. 4—Low level d-c from the detector modulates the high frequency from the oscillator to give stable d-c to operate the attenuator

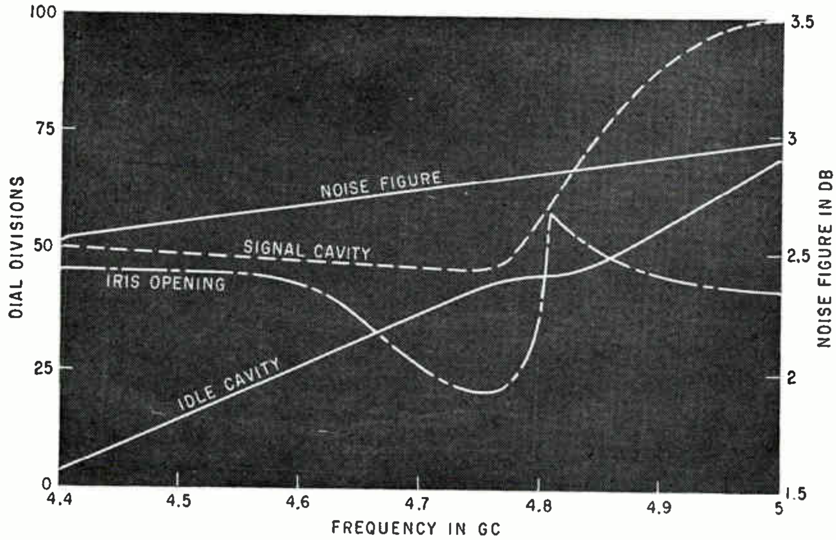


FIG. 5—Effect of amplifier adjustments on frequency and noise figure

a straight forward approach. A meter provides indication of whether the frequency is high or low. The afc feedback loop required high gain to lock with the desired accuracy and stability. This was accomplished by placing most of the gain in the i-f amplifier followed by relatively low-gain d-c amplifier. The reference frequency is obtained by a resonant cavity constructed from invar material which was then mounted in a relatively simple temperature controlled oven.

The automatic level-control system consists of a detector crystal driving a d-c amplifier which in turn drives a ferrite variable attenuator. At room temperature an initial attenuation is placed in the system; then as klystron output drops due to thermal detuning over temperature extremes, the system is able to maintain constant amplitude of output over the entire klystron mode by removing attenuation.

The control system circuit was solid-state, using transistors and varicaps, mounted on plug-in printed boards. The major problem in the design was achievement of stable operation over the required temperature range, minus 26 C to plus 70 C, and a circuit was developed especially to attain this stability. This consisted of modulating a relatively high-frequency signal by the low-level dc obtained by rectification of the high-frequency loop signal, amplifying and again rectifying to magnify the small d-c voltage. This circuit, Fig. 4 was called a magnified d-c amplifier.

Lack of proper means of specifying varactor diode parameters arose as a major problem during the engineering development phase. Specifications on the basis of Q or cut-off frequency proved inadequate. Grading diodes on the basis of performance in an amplifier, allowed analysis of diode parameters to discover roots of the performance variations. Diode Q, C_o, C_{min}, C operating, operating bias, and d-c leakage had to be restricted to achieve reproducible results.

Much of the early development was done using the Microwave Associates 460 series diodes. As the program progressed, type 450 HR diodes became available. They were evaluated and it was found that by obtaining diodes within specified C_o range, excellent and consistent results were obtained. The amplifier is provided with easily read precalibrated dials for adjustment of the signal cavity, idle cavity and the iris coupling. Frequency change and adjustment is accomplished simply by setting the three dial readings for any desired frequency in the 4400 to 5000 Mc range, then increasing pump power for a specified increase of receiver thermal noise as indicated on a meter in the receiver. The variation of the iris, signal and idler adjustments plus the variation of noise figure over the frequency range is shown by Fig. 5. These curves show a relative insensitiveness of the iris and signal adjustment, and over a frequency shift of approximately 100 Mc, adjustment of the idler cavity only is required. The discontinuity at 4.8 Gc is due to diode self-resonance.

BIONICS

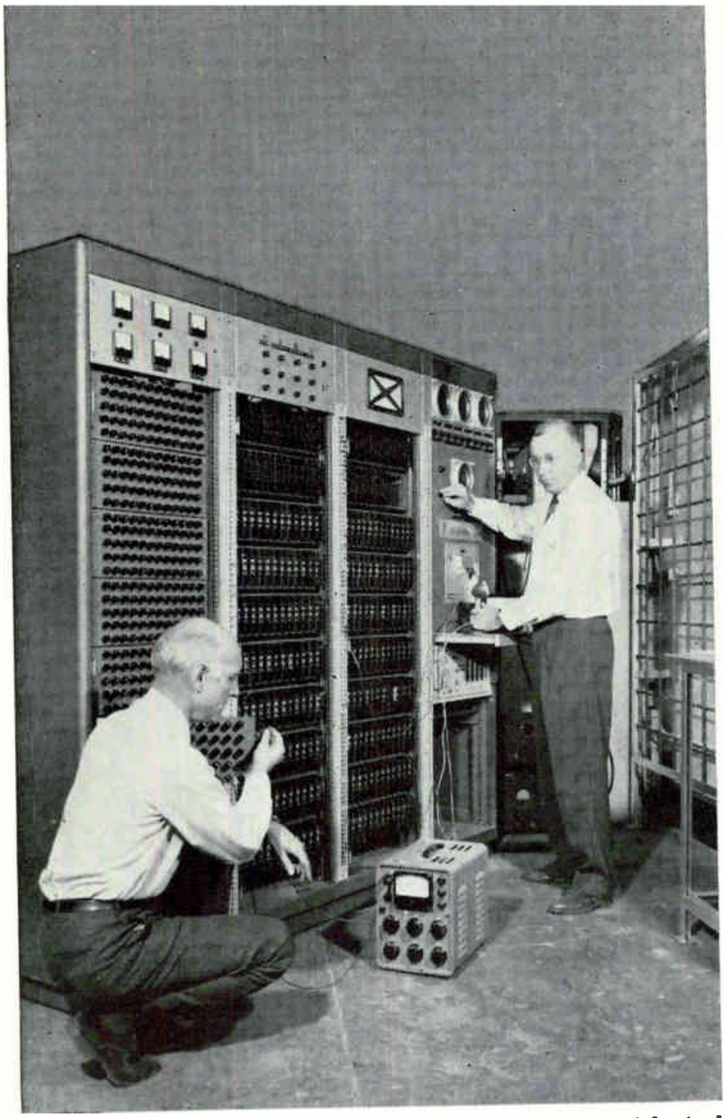
Part III:

Brain Models and

Neural Nets

Simulation of nervous functioning requires design of complex nets of neuron-like elements. Many approaches are being taken, but the difficult problems have only begun to be tackled

By NILO LINDGREN, Assistant Editor



Heinz von Foerster (left) and Murray Babcock of the Biological Computer Lab., University of Illinois, test the dynamic signal analyzer they developed based on property-filtering characteristics of human aural system

THE APPROACHES to understanding and to design of neural-like nets include build-up of neuron-like elements into physical networks; simulation of neural-like structures by computer; mathematical formulation of redundant nets of formal neurons; mathematical synthesis of neurophysiological functions; design of adaptive networks by inductive methods, then comparing their behavior with animal systems; and construction of randomly wired networks that are conditioned for memory and learning.

Such approaches differ in direction and intention as well as in method. One investigator develops nets of increasing complexity and aptitude to discover how the central nervous system is structured,[1] while another takes off from known biological facts about a neural subsystem and synthesizes a network that will perform useful tasks. One commentator remarks that the first investigator, Rosenblatt of Cornell Univ. and Cornell Aero Labs, has contributed more to the design of intelligent machines than he has to the understanding of neural nets.[2]

In psychological theory, emphasis has shifted from stimulus-response conditioning models to problem-solving models. Rosenblatt, for instance, sees the methodology of his perceptron studies merging with the heuristic program approach of A. Newell, J. C. Shaw, (Rand Corp.) and H. A. Simon (Carnegie Institute of Technology), whose General Problem Solver or GPS incorporates in a computer program means for soving problems, such as discovering proofs for theorems in logic. Simon concludes a present need is for programs to explain long-term memory.[3]

The problem of understanding both long and short-term memory and locating the residence of long-term memory traces in the brain are both unresolved, although a number of theories have some experimental support. These theories say that the residual effects of learning or memory traces are widely dispersed throughout the nervous tissue (distributed memory); that memory traces reside in the glial cells, which are found between cerebral neurons and outnumber them ten to one; that short-term memory may be based on reverberatory activity in nerve loops or in modification of neuron firing

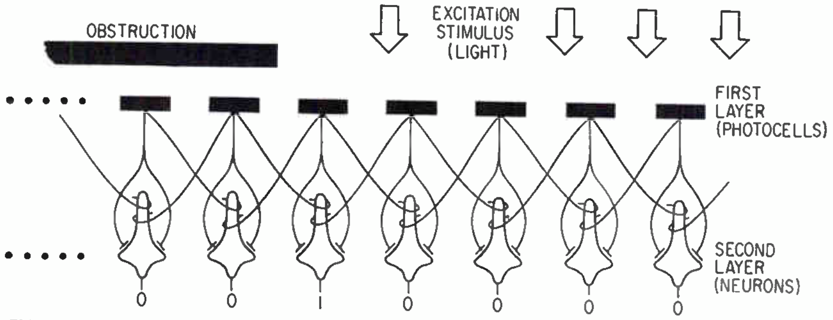


FIG. 1—Two-level array of active elements illustrating operation of an edge detector

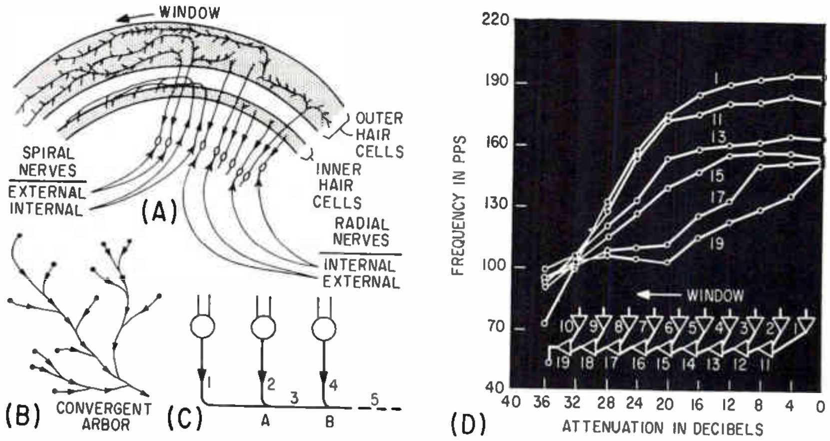


FIG. 2—Schematic of nerves in cochlea, which is spiral-like structure within the ear (A). Convergent tree in nervous system (B)—in divergent arbors, signals move in opposite direction to arrows. Interactions of signals in spiral nerves (see text) (C). Artificial spiral nerve (bottom) made of 19 electronic neurons, and resultant outputs (D)

threshold, etc.

Many other basic physiological questions are still open: how the organism exercises selective attention, how it sets itself to work toward a specific goal, how it makes choices, how it performs complex behavioral sequences and how it perceives.

There has been considerable controversy over whether the brain is highly prestructured in its functions. It is known that the sensory inputs to the brain are mapped in a precise, orderly fashion on the cerebral cortex—hearing is mapped according to pitch, touch according to body location, motor areas on the cortex are topologically similar to body muscle organization.

Whether the fine organization of the brain is highly structured is an open question. One view sees highly specific preorganization, another believes that the preorganization of the brain functions exists as biases and directional preferences, that the fine detail allows for a degree of randomness, which may be modified in learning. This latter view has led Rosenblatt and others of the perceptron approach to build brain mechanisms that start with randomly wired nets and then they introduce constraints one by one while observing results.[1]

In general, bionicists are working toward:[2] (1) understanding individual neurons including sensory neurons, motor neurons that transmit signals to muscles and glands and associative neurons that connect sensory and motor neurons; (2) understanding of neural nets and their relation to motivation and memory; (3) understanding the physiochemistry of attention and intelligence; (4) understanding the data processing throughout the nervous system; and (5) invention of a new mathematics to deal with unreliable elements and subjective probabilities.

Armour Research Foundation is doing mathematical studies on how concepts are formed and tied in with perception in man. These studies cover:[4] (1) how concepts are formed; (2) how perceptrons are randomized; (3) and design of a specific learning machine. It consists of a full retina based on sets of slides on which are deposited photosensitive material whose density changes on exposure to light. By a Pavlovian training procedure, the machine is taught to remember all the patterned slides it sees.

George Jacobi of ARF remarks, "We will be dealing with highly specialized learning machines for a long time."[4] Studies, by Scott Cameron and others at ARF, of the human perceptive system lead them to conclude that the human is highly specialized in the relations he perceives in his environment. Other workers have also stressed, in discussions of pattern recognition problems, that no pattern recognition scheme is universal. Reference to general-purpose pattern recognition devices may be misleading.

Another program has recently been announced by the Librascope div. of General Precision, under two contracts by the Air Force Office of Scientific Research. They are part of a five-year program of studies of intelligent machines and self-adaptive mechanisms. The program will cover hypothetical nerve nets, analogical simulation of neural behavior, relation of classical association psychology to data processing and digital computers, behavior of mutually inhibiting nerve nets and simulation of the lobster cardiac ganglia.

Rand Corp. reports that in addition to computer simulation of human problem solving and using computers to build and test theories in psychology, they are doing physiological modeling, attempting to make a mathematical model of the human external respiratory system and simulating neural nets. They are modeling the cortical neuron as closely as possible and are designing an artificial neural net that has learning properties.[5]

Heinz von Foerster and his colleagues at the Biological Computer Laboratory, University of Illinois are emphasizing, in their studies, methods of property filtration, taking as a basis the various kinds of property filtering found in living systems—such as in the frog's eye.

The U. of I. work has resulted in an object counter, called Numa-rete, a retinal device that counts, using a sequential method of interrogation, as many as 40 separate objects in 0.2 second. It is not confused by intricate shapes or by objects appearing in holes in other objects.[6] They have also developed a topological counter that is based on a parallel technique.[7]

Their information-processing networks rely chiefly on layers of active elements that perform mathematical or logical operations on input stimuli.[8] Figure 1 shows a two-level array of elements. The first layer is an extensive array of photocells, the second of neurons that carry out logical operations. Loops about the stems of the neurons indicate inhibitory inputs (-1), and T connections to the sides of the neurons indicate excitatory inputs $(+1)$. A neuron in the second layer shows no response as long as the two neighbors of its overlying photocell are both stimulated. For uniform lighting over the photocell array, there is no output. However, the edge of an obstruction will be detected since the photocell under the obstruction provides no inhibition to its neighboring photocell exposed to the light. This photocell thus has an output $(+1)$ that indicates the edge. By extensions of such strategies, it is possible to perform complex operations on various kinds of inputs.

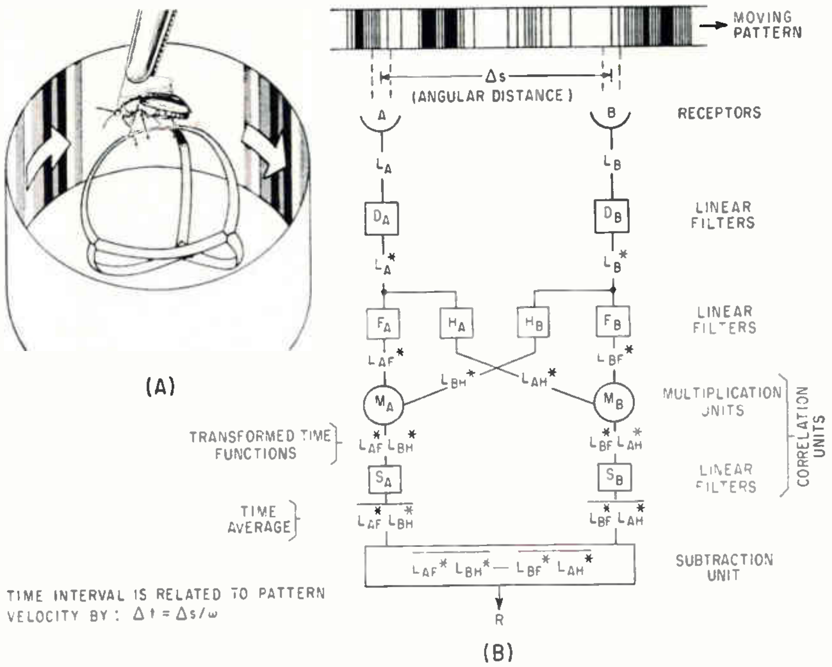


FIG. 3—Beetle and Y-globe maze used in experiments on optomotor responses (A), and mathematical model of stimulus reaction relations in a bettle's central nervous system

Most recently, von Foerster and M. Babcock have developed a dynamic signal analyzer (photo) that, through banks of filters, analyzes the frequencies in an aural spectrum, and reproduces the action of the ear. The analyzer depends on a double differentiation of sound inputs. This artificial ear exhibits extremely sharp frequency discriminations, recalling the resonance theory by Helmholtz, which assumes that the transverse fibers of the basilar membrane act as tiny resonators, each tuned to a different frequency.

Using neuromimes, Harmon and van Bergeijk at Bell Labs have turned up functions that suggest explanations for hearing phenomena and nerve responses of the skin.

In the cochlea of the inner ear there are four groups of nerve fibers, of which the least is known about the external spiral fibers which cross what is called the arch of Corti (Fig. 2A), and connect to external hair cells. These external hair cells respond through the basilar membrane to pressure changes from sounds impinging on the ear and form part of a convergent neural arbor (Fig. 2B). Impulses stimulated in these nerves conduct inwards towards the brain (afferent innervation). The function of this spiral innervation is unknown, but because of their length (these external spiral nerves cover a quarter to a third of a cochlear turn), there has been speculation about their role in preprocessing aural information.

A neuron is refractory for a short time after it fires. Observing Fig. 2C, it is seen that if a hair cell triggers branch 1, the spike will travel down 1, into 3, 5, 7. As the pulse travels along the nerve, it leaves the nerve and the junctions (A, B, C) refractory. If an impulse has also been triggered in branch 2, it will be stopped at the A junction. For low firing rates and randomly distributed firing, few pulses are blocked; as firing rate goes up the probability of blockage goes up. With high stimulus on the ear, and with much agitation of the nerve hairs, fewer pulses are transmitted towards the central nervous system.

An artificial spiral nerve was made with 19 neuromimes (Fig. 2D); this chain was connected to an electrical analog of the cochlea, which was excited with a one-Kc sine wave. The outputs (see Fig. 2D) from neurons in the chain show that the slopes of the plots of sine-wave attenuation in db against neuromime output in pps decrease as the chains grow longer. Thus, a long chain of neurons can cover a much larger dynamic range than a single neuron can cover.

There is some physiological evidence to support this view; psychophysical studies of the effect of varying density of innervation in the skin, by von Bekésy, show similar results in dynamic range. Although it is not certain that this model explains the spiral nerve function, it shows how electronic modeling of neural events give rise to viewpoints that may prove fruitful.

Unusual experimental studies by Werner Reichardt on how a beetle (Chlorophanus) responds to moving periodic patterns has led to a mathematical model of the beetle's perception processes. The model allows predictions of how the beetle moves his whole body in response to light stimulus.[9]

The beetle is glued to a stand that holds him suspended inside a hollow cylinder composed of vertical dark and light stripes of various patterns, and he is given a Y-maze globe which he carries (see Fig.

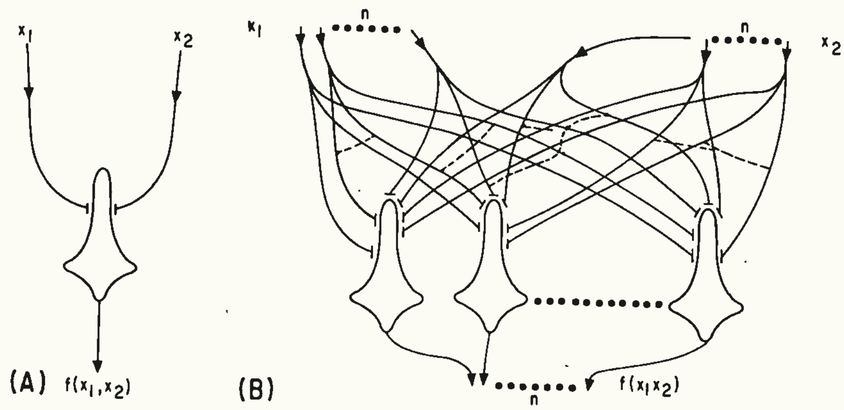


FIG. 4—Single-line automata (A), and multiple-line automata (B), by which redundancy is introduced into network to provide reliability

3A). When the beetle tries to walk he remains motionless, but carries the maze so that every few steps he confronts a Y junction, and must turn one way or another. As the cylinder of dark and light stripes rotates about him, he chooses his turns on the maze in response to the changing optical stimulation. His ratio of choices is a sensitive measure of his turning tendencies. By using several concentric cylinders and narrow light slits, so that single facets (ommatidia) of the beetle's eye were stimulated and checked for reactions, Reichardt was able to build up a mathematical model that could be used to predict the beetle's responses to other patterns.

The model (Fig. 3B), consists of just two light-sensitive receptors, *A* and *B*, representing adjacent ommatidia, which transform the space and time dependent processes of the optical surroundings into time functions L_A, L_B, which are linearly transformed by units *D*, *F* and *H*. The multiplier (*M*) and low-pass filter (*S*) process the transformed time functions to time averages. These are subtracted to provide the output the controls the motor output of the beetle. This model is the basis for an aircraft ground-speed indicator.

The thresholds of all neurons can be changed in the same direction by caffeine and alcohol to the extent that every neuron computes some wrong function of its input. Yet the overall biological network still operates. These networks operate between two physiological entremes—from coma, when neuron thresholds are extremely high, to convulsion, when thresholds are so low the neurons fire continuously.[10]

Consideration of such nets, which von Neumann called circuits logically stable under common shift of threshold, has led Warren S. McCulloch and his group in Neurophysiology at the Research Lab. of Electronics, MIT, into the mathematical construction of redundant nets of formal neurons that are logically stable even when the component neurons and their connections are unreliable.

A formal neuron is defined as an all-or-none threshold device with many input lines and one output line. Each line can be in one of two possible states, on or off. A finite unit of time elapses between consecutive states. Input lines in the on state excite the formal neuron with a strength + 1 or −1, and in the off state with a strength 0. If the algebraic sum of the excitation of the input lines equals or exceeds a given value, the threshold θ, the formal neuron fires, giving rise to the on state of its output line. Such a formal neuron is capable of logical computation.[11]

Although early work on these nets has dealt with performing simple logical functions, McCulloch's group would like eventually to study more complex phenomena such as learning.[12]

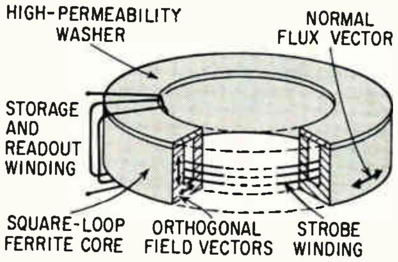


FIG. 5—Cutaway shows design of perceptron memory component called Mind

Various disturbances to the neurons and to the nets composed of them have been studied, including failures in the input and output lines to individual neurons, fluctuations of signal strength and variations in neuron firing threshold.

Various types of redundancy have been considered to produce networks that will operate reliably. Says McCulloch, "It is only out of redundancy that one can buy security."[13] One way to introduce redundancy into the nets is by a bundling technique in which single-line automata are replaced by multiple-line automata, as shown in Fig. 4A and 4B. Bundles of lines in Fig. 4B carry the same amount of information as individual lines in Fig. 4A. More sophisticated schemes have recently been under consideration. McCulloch distinguishes redundancy of coding, redundancy of channels, redundancy of calculation and redundancy of potential command.

Computer simulations of neuron-like nets that show promising relationships to electrophysiological findings are being carried out by Belmont Farley at Lincoln Laboratory, MIT, on Lincoln's TX-2 digital computer.[14] Associated physiological studies may be made by Charles Molnar, of Air Force CRC and the Communications Biophysics Group at MIT. Computer simulations are interesting, since the analysis of the behavior of large numbers of interacting neurons appears impossible at this time.

Farley's nets are composed of 1,296 elements, in 36 × 36 array. Each element possesses many of the characteristics of biological neurons: both spatial and temporal summation of excitation, analog and digital qualities, definite thresholds, refractory periods when threshold rises to infinity, holds and then decays exponentially to normal threshold.

Connections between these neurons can be given any desired probability distribution. Both tightly coupled and loosely coupled nets have been studied, the first tending to produce well-defined wave fronts, the second tending to oscillate diffusely.

The number of connections to the

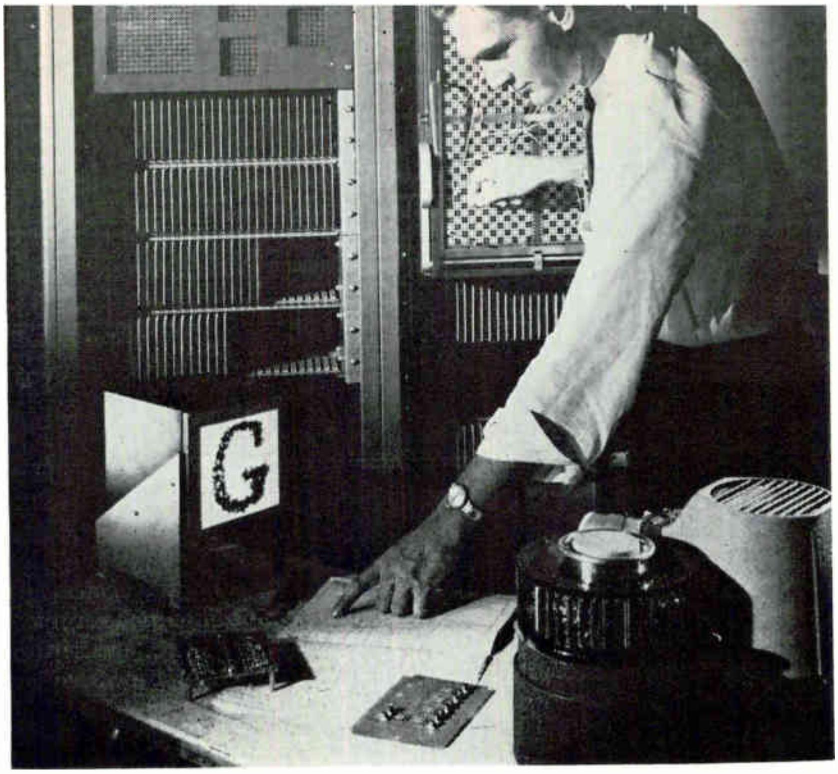


FIG. 6—Testing Aeronutronic general-purpose learning system with alphabetic character input. System uses 200 Mind components

various elements can be varied, and all element parameters can be changed to study their effects. Oscillations in these nets have been set up by stimulus to small groups of elements, and have also been driven by repeated stimuli. Study of these large nets has revealed simple oscillations, amplitude-modulated burst-like rhythmic activity as well as irregular waves of all kinds, especially in loosely coupled nets. These are suggestive of so-called slow-wave phenomena. Farley suggests that these slow-wave phenomena may arise chiefly from dendritic interactions. He stresses, however, that these suggestions are open to question and must be pursued experimentally.

One of the most popular approaches to learning machines has been the perceptron (ELECTRONICS, July 22, 1960, p 56). This approach, originated by Frank Rosenblatt in 1957, has grown to such an extent that a perceptron symposium was held in Washington in December to consider recent progress. At least 21 companies have constructed some form of perceptron.[2]

Rosenblatt stresses that a perceptron is a brain model, not an invention for pattern recognition.[1] However, opponents generally attack the lack of physiological evidence in support of this view.

Despite such controversies, perceptrons may find many applications. They may be trained to detect targets of military interest in aerial photographs, diagnose medical symptoms and recognize events in a bubble chamber. At the December conference, Rosenblatt reported that an audio perceptron is being built, under ONR sponsorship, that will learn to recognize spoken words and develop a vocabulary of several hundred words. Called Tobermory, it will be completed within a year.

One of the many companies engaged in perceptron work is Aeronutronic, a div. of Ford Motor Co. They report that their work has taken the form of mechanizing basic biological learning models with low-cost, high-speed hardware. One component they have developed is called mind (magnetic integrator, neuron duplicator), shown in Fig. 5. It is a magnetic element whose flux can be changed in approximately 50 discrete steps, having nondestructive readout, and suitable for perceptron-type memory elements. Two systems have been built using these components. The first is equivalent to a single-neuron model. The second is equivalent to 32 neurons. It contains about 200 mind components and was completed late last year.[15]

This perceptron shown in Fig. 6, will test a variety of neural-net learning processes. Both systems were sponsored by ONR and Rome Air Dev. Center. Aeronutronic expects that its present program in new computing concepts will overcome component-cost limitations that presently confront builders of neural-model recognition systems.

Another machine that operates by networks of adaptive elements,[16] employing associative storage and retrieval methods, is the Madaline, designed by Bernard Widrow and Marcian Hoff, Jr. of Stanford Electronics Labs. Madaline is being used to investigate learning and various types of memories. Interest in this type of adaptive system has also been expressed by Westinghouse, which has recently instituted a bionics program.

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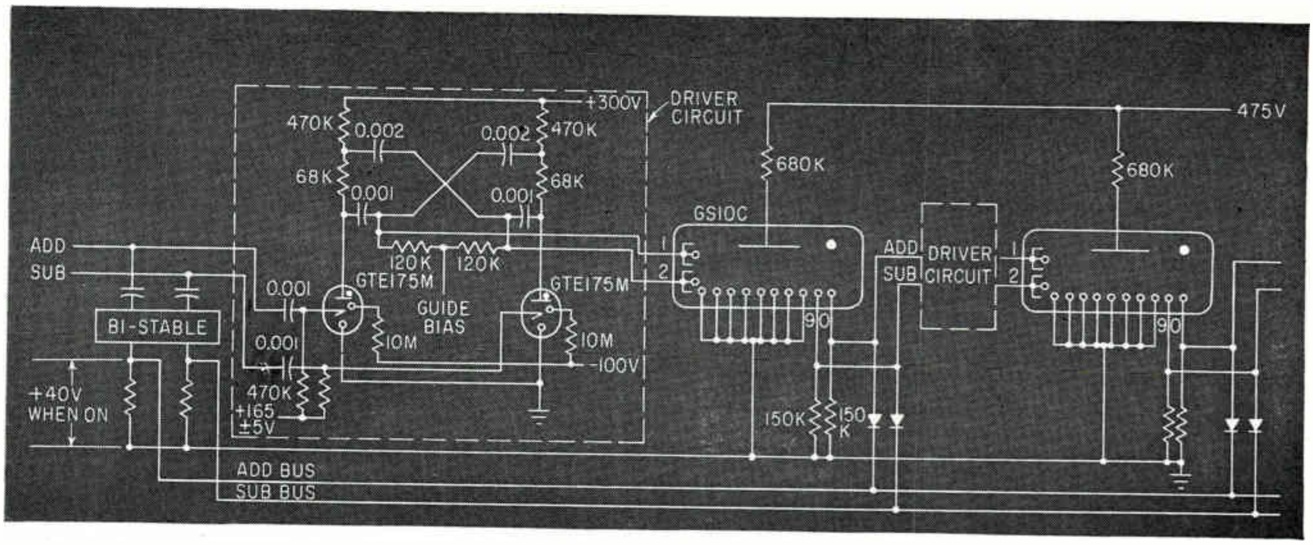


Bidirectional counter accepts 25-v, 100-μsec duration pulses at a maximum frequency of approximately 300 pps

Reversible Decade Counter

Multidecade counter uses one sign-determining signal to handle rapid reversal of count direction in this simplified circuit

By L. C. BURNETT
Eteloc Ltd., Beeston, Nottingham, England

COMPLEXITY in conventional counter circuits arises from the requirement to produce an add carry when the count changes from 9 to 0, but not for a 1 to 0 change, and similarly a subtract carry must be generated by a 0 to 9 change, but not by 8 to 9. Each decade stage is normally equipped with memory and coincidence circuits to give the required performance.

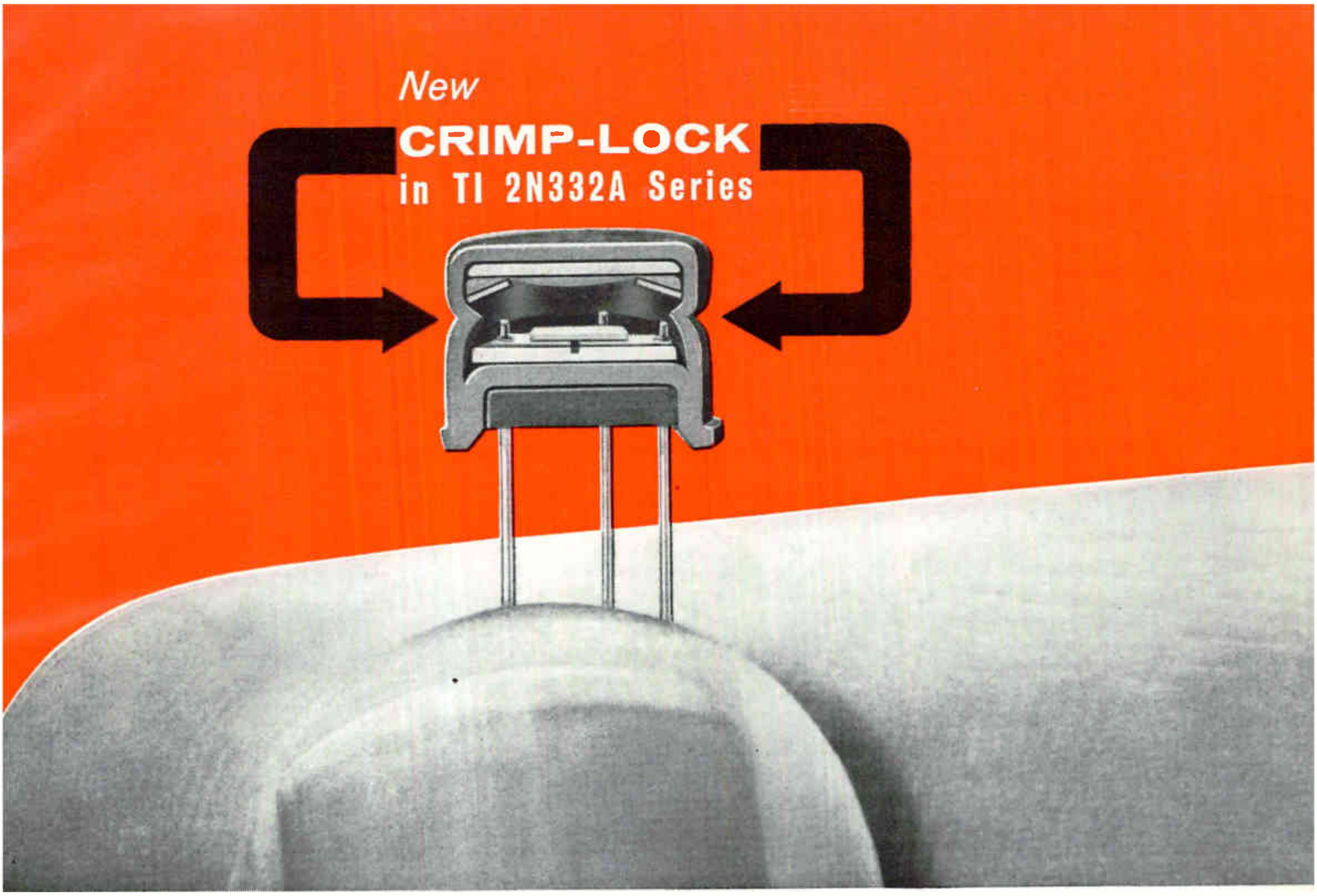
When add and subtract signals, separated by the normal resolution time, are fed to separate inputs, and where the time of one count is greater than that required for a carry to pass right through the counter from the units to the most significant decade, then considerable simplification of circuits is possible.

An add input signal applied to the units stage may, or may not, lead to an add carry between the hundreds and thousands stages, but it can never lead to a subtract carry in any stage. Therefore one sign-determining circuit prior to the input to the tens stage can provide gating signals for every decade.

The circuit uses glow transfer tubes, but the principle can be applied to any multidecade counter. A pulse applied to the add input steps the units counter clockwise, say from 7 to 8. It is also connected to one of the inputs of a bistable multivibrator to produce +40 v on the add bus and 0 v on the subtract bus. Each counter cathode 9 is clamped to the sub bus, and each cathode 0 is clamped to the add bus, so that although another add pulse steps the glow in the units tube on to cathode 9, the output is clamped at 0 v, therefore no output signal is generated. A further add pulse steps the discharge to cathode 0, which rises from ground to + 35 v. The leading transient is fed through a capacitor to the trigger of the trigger tube driving the tens stage clockwise, and so this counter steps. Should this cause a transfer from 9 to 0, a signal will fire the hundreds driver tube, and so on through all decades.

This design will handle rapid reversals of count direction, such as 8,9,0,9,8 because the charge on the coupling capacitors is not required to change; the only capacitance on the buses is that of the wiring and the clamping diodes.

The only critical value in the circuit is the + 165 v trigger tube bias, which must be held to ± 5 v.



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Electric Field Changes Viscosity of Fluid

LOUDSPEAKERS are among a number of devices being investigated that use an electro-viscous fluid. An impressed electric field changes viscosity of the newly developed fluid. Armour Research Foundation, which has verified the properties of the fluid, reports that changes in viscosity have been achieved at levels much greater than any previously recorded phenomena.

The magnitude of the viscosity change is dependent on field strength and is thus readily controllable. Relative changes in viscosity of more than 200 to 1 have been measured at a maximum field intensity of 75 volts per mil. And present indications are that the range of viscosity changes can be greatly increased.

Testing and further development is continuing at ARF and at Colorado Dynamics Corp., which is the developer of the electro-viscous fluid.

Possible areas of application of the fluid include various types of mechanical transmission and control devices, brakes, transducers, valves and hydraulic equipment. Armour scientists are working on use of the fluid to replace the conventional speaker used in radio and tv receivers. By placing the amplifier output leads in the fluid, the fluid acts as a nondirectional speaker and bounces the sound waves off the walls of the room, from which the sound will emanate. An ultrasonic washing machine is also being investigated through which the vibrations of molecules will clean and even dry clothes in one machine.

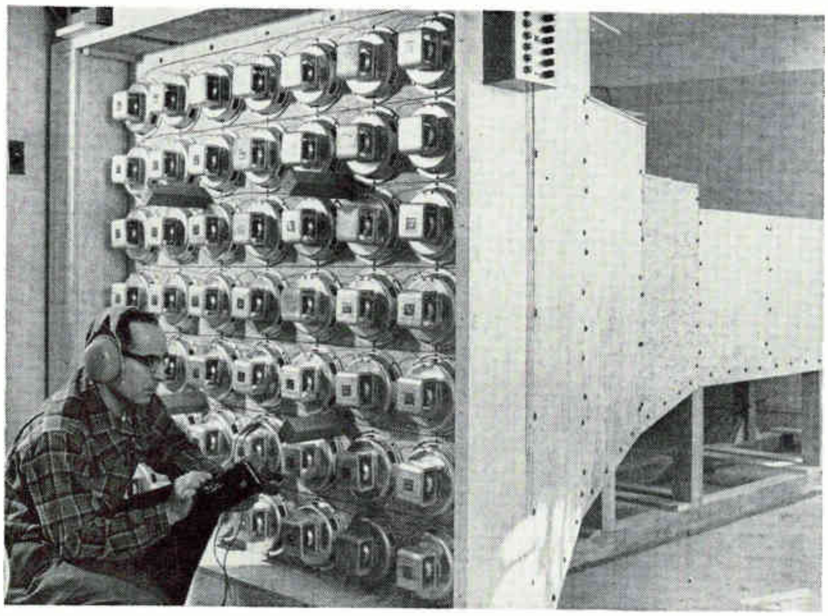
Viscous Fluid Clutch

A small experimental clutch 2 inches in diameter and 2 inches long is currently being constructed at Colorado Dynamics. Limited information so far available indicates that a number of desirable characteristics are feasible in such a clutch. It should have extremely short response times and should provide 20 ounce-inches minimum energized torque with de-energized torque of less than 0.1 ounce-inch. Excitation power at 330 volts a-c should be less than 10 watts at any frequency from 30 to 1,000 cycles per second, and life of the clutch should be well in excess of 1,000 hours. For a service life limited to 1,000 hours, the clutch could be produced with the same external size and consuming the same amount of power but with an energized torque of 200 ounce-inches and a de-energized torque of less than 0.2 ounce-inch.

The clutch, according to its developers, may be less expensive when in production than existing electromagnetic clutches having comparable torque ratings. The capabilies of the electro-viscous fluid clutch could range from miniature instrument clutches to large industrial units capable of transmitting hundreds of horsepower.

The electro-viscous clutch has the same potential applications as conventional electromagnetic dry powder, fluid and friction-disk clutches. However, it is believed to be a more practical and economical solution to clutching problems. Typical current applications of electromagnetic clutches include rotary indexing, positioning, rapid cycling and synchronization, torque and tension control, controlled acceleration, inching and jogging, and overload protection.

Materials Testing Sound Source



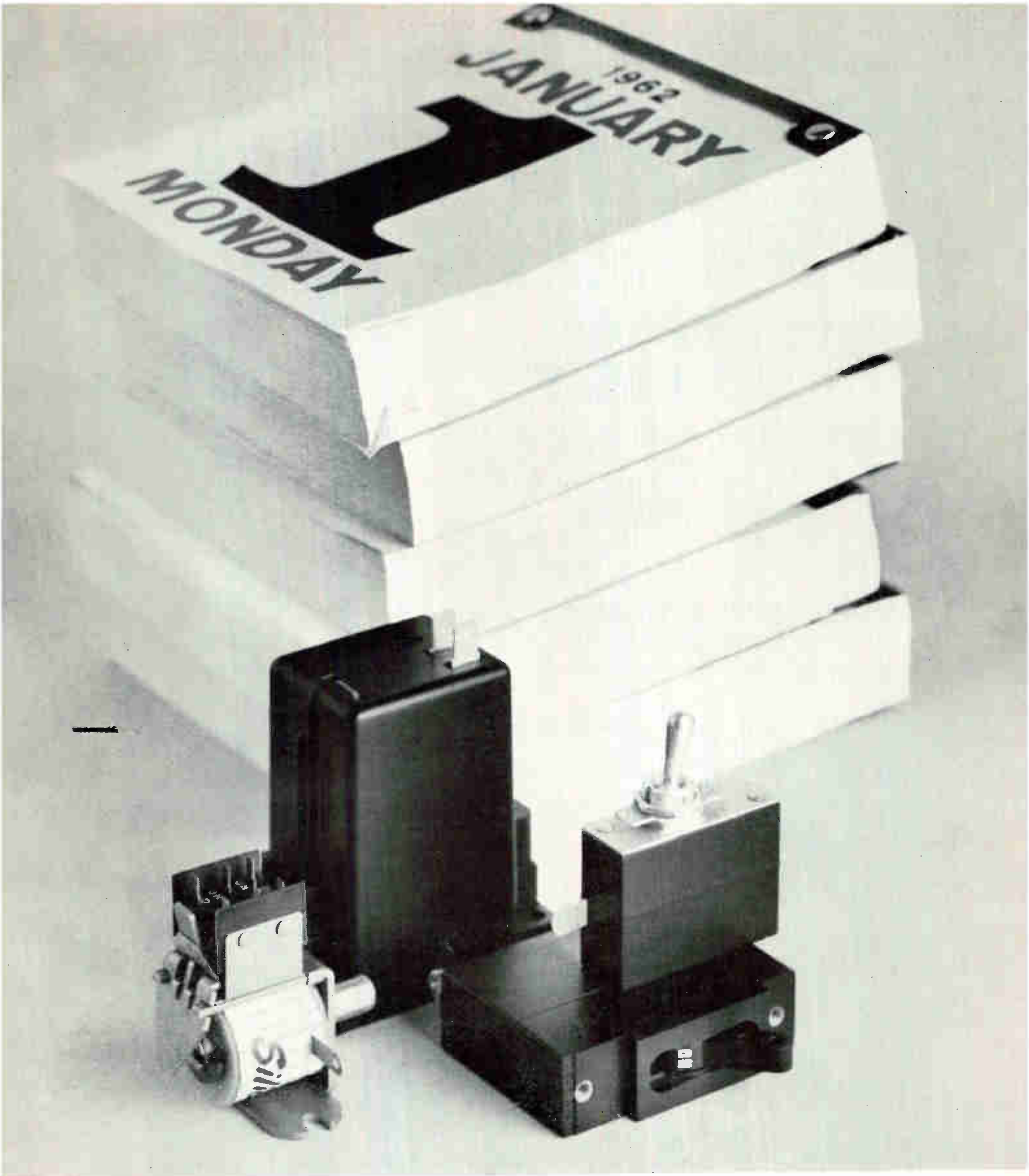
THE FRONT COVER. Sonic fatigue in materials will be investigated using exponential horn made by Illinois Institute of Technology. Goal is to produce sound intensity of 160 db in 3 inch tube at distance of 13 feet from 49-speaker array

Preventing Burnout In Resistor Tests

By B. ERLICHMAN
Rego Park, New York

USING a Wheatstone bridge to measure resistances of low-wattage precision potentiometers and resistors can result in burning out these components. Measuring current supplied by the bridge may exceed the maximum current rating of the unknown resistance. However, the measuring current can be determined before such tests, avoiding

CIRCLE 49 ON READER SERVICE CARD→



As of now Heinemann gives you a FIVE-YEAR guarantee. From here on out, every Heinemann circuit breaker, time-delay relay or overload relay you buy will carry a five-year "repair-or-replace" guarantee against manufacturing or material defects. ☐ Sound like a good deal? It is. Only you'll probably never have reason to take advantage of it. This, after all, is the real point of the five-year warranty. ☐ You might give that some thought the next time you're batting around the reliability question.

HEINEMANN
ELECTRIC COMPANY
2600 BRUNSWICK PIKE
TRENTON 2, NEW JERSEY

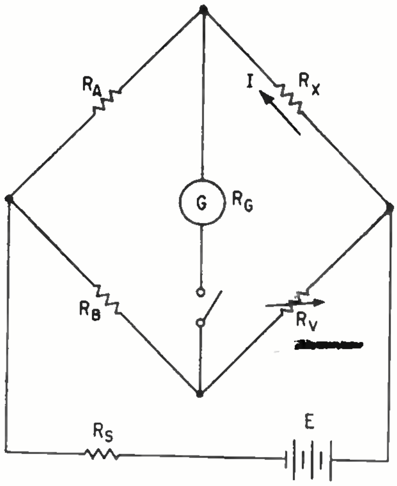
SA 2531

destruction of the component.

In the typical Wheatstone bridge in Fig. 1, current through the unknown resistance is $I = E(R_1 + R_2)/[R_1(R_2 + R_3) + R_2^2]$, where $R_1 = R_B R_G/(R_A + R_B + R_G) + R_V$, $R_2 = R_A R_S/(R_A + R_S + R_G) + R_X$ and $R_3 = R_A R_B/(R_A + R_B + R_G) + R_S$. With the galvanometer switch open, R_G is infinte and $R_1 = R_B + R_V$, $R_2 = R_A + R_X$ and $R_3 = R_S$.

Practical Example

Determining measuring current can be demonstrated using as an example 100 specially wound 0.3-watt, 1500-ohm potentiometers that are to be checked during incoming inspection. Resistance between the wiper arm and one end of the resistance winding is to be measured at 30-degree increments of shaft rotation. Maximum rated current of the test potentiometer is $I = (0.3/1500)^{\frac{1}{2}} = 14$ ma.



Current through unknown resistance tested in Wheatstone bridge can be predetermined

With the bridge set to measure 30 ohms (zero degrees rotation of the potentiometer), $R_A = 9.9$ ohms, $R_B = 990$ ohms, $R_A/R_B = 0.01$, $R_G = 250$ ohms, $R_S = 10$ ohms, $R_X = 30$ ohms, $R_V = 3{,}000$ ohms, $R_X/R_V = 0.01$ and $E = 4.5$ volts.

Substituting, $R_1 = 990(250)/1250 + 3000 = 3198$ ohms, $R_2 = 9.9(250)/1250 + 30 = 32$ ohms and $R_3 = 9.9(990)/1250 + 10 = 17.8$ ohms. Thus $I = 4.5(3198 + 32)/[3.98(32 + 17.8) + 1024] = 90$ ma. In this case, measuring current with the galvanometer switch open is also 90 ma.

If an attempt were made to measure resistance of a potentiometer at zero degrees, the component would be burned out. Destruction of the potentiometer could be avoided by using the bridge at higher ratios of R_A/R_B. Although this would reduce measuring current, it would also lower sensitivity (and accuracy) of the bridge.

Burnout can be avoided by measuring the total resistance of the potentiometer and then measuring the resistance of the opposite side of the unknown resistance. The difference between these two measured resistances is the unknown resistance. By measuring the larger value of resistance, the measuring current provided by the Wheatstone is automatically reduced.

Soft Landing System Stems From Bionics

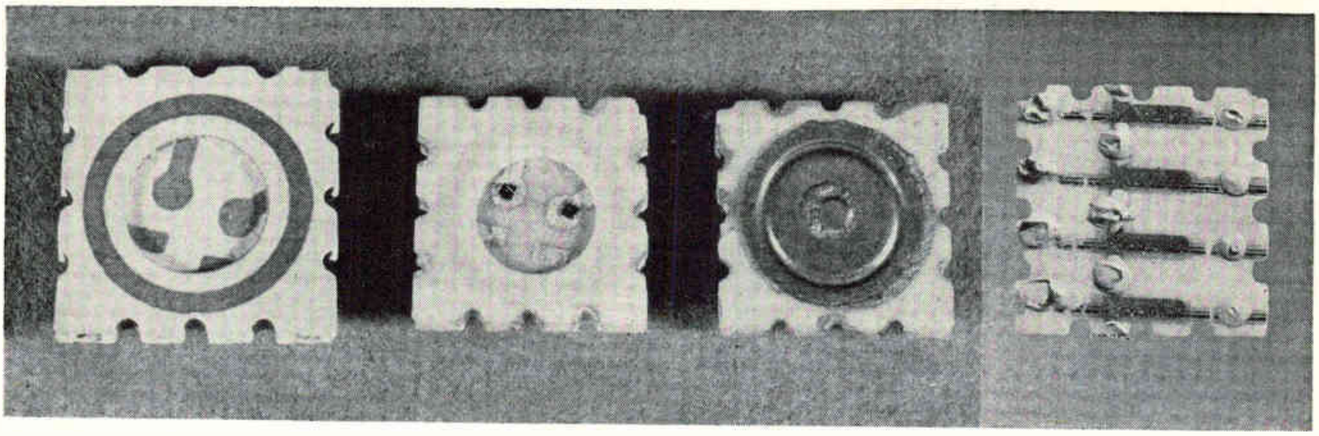
INVESTIGATIONS of how the eye judges distances and speeds of approach has led to development of an electronic system that aids pilots in determining distance above the ground, speed of approach and attitude. By adding a computer to the system, it could enable soft landings on the moon.

The bionics group at the GE Advanced Electronics Center, Light Military Electronics Dept., found that the eye judges distances by calculating density of the texture of a surface. The rate of change in the surface texture indicates speed of approach. The angle to the surface is determined by comparing the density of near texture to that farther away.

The pilot aid is a contact analog. A grid pattern on a tv screen moves toward the pilot, as though he were looking down a runway on which the grid had been painted. As distance to the ground decreases, the pattern gets larger; as distance to the ground increases, the squares in the pattern diminish in size.

The grid moves faster when the plane nears the ground and slower as altitude increases. Also, the pattern is stabilized relative to the ground so that the stable pattern gives and indication of attitude.

To make possible unmanned landings on the moon, a computer has been added. It can operate landing controls based on information from the contact analog.



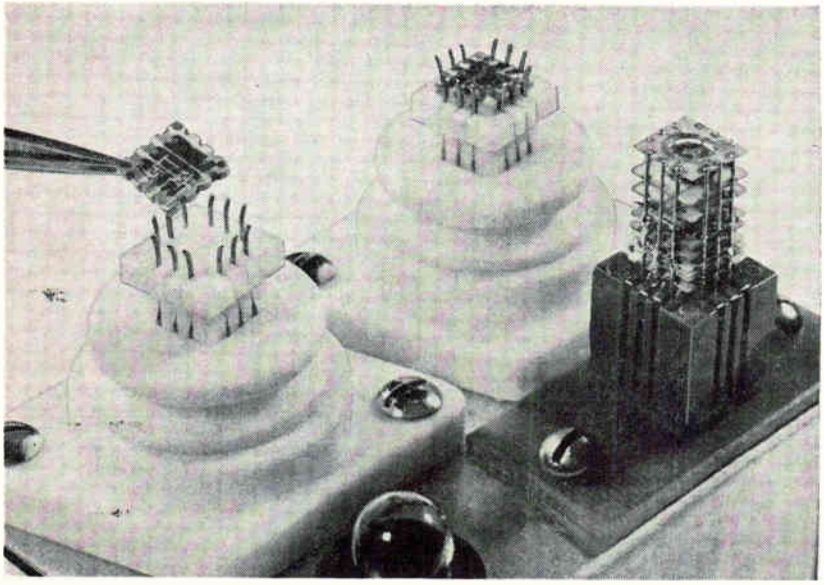
At extreme left is a solid ceramic circuit in the green or unfired state, incorporating all the passive elements plus interconnections between layers. Next is the same circuit after firing and with a diode and a transistor pellet mounted in the cavity or well. In the next step the active elements have been sealed in. At the extreme right is an array of four experimental thin-film transistors deposted on a ceramic circuit.

Ceramic Stacks Form Miniature Circuits

CERAMIC CIRCUITS that will compete on an economic basis with conventional circuits and that offer equivalent technical performance are scheduled to be in pilot production at RCA by the end of this year. Described as solid ceramic circuits, the devices are compatible with the micromodule and some other approaches to system miniaturization.

Solid ceramic circuits can be visualized as a group of very thin micromodule wafers that have been stacked one on top of another and fused together. Actually, the first step in making these circuits is to print patterns for resistors, interconnections, and capacitors on ceramic sheets of a few mils thickness. These sheets, after being cut, punched, and stacked, are pressed and fired until they become a solid heremetically sealed unit.

A well at the top of the stack is used to mound active devices in pellet form. A circuit containing four resistors, a capacitor, a diode and a transistor measures 0.3 in. square by 30 mils thick. This size will be reduced further should experimental work of thin film transistors lead to deposition of active devices on the ceramic.



Experimental counter uses two solid ceramic inverters as a flip-flop. Each inverter contains seven components—four resistors, a capacitor, a diode and a transistor. The unencapusulated micromodule is an oscillator

A wide range of resistors and capacitors can be incorporated in these devices. Resistors ranging from a few ohms to megohms have been fabricated. General duty capacitors with values up to 1 μf and precision capacitors with values to 2,500 pf have been developed. Voltage rating for the capacitors go to 50 volts. Dissipation factor for the precision capacitors (which have a temperature coefficient of 0 $\pm$ 60 ppm/C) is less than 0.3 percent, for general purpose capacitors less than 1.5 percent.

Experiments with ferrites indicate inductors of a few millihenries and with fairly high Q's are possible. With reasonable values of inductance available, solid ceramic circuits can be used in communication and linear amplifier applications, in addition to digital circuits.

Since the components can be built to close tolerances, power dissipation can be decreased to increase reliability for a given parts density. According to RCA, when these components with narrow tolerances are combined with low-power semiconductors at low power levels they give more effective operation than now possible. Complex interconnection of parts can be obtained by using multiple intenconnection wafers. One experimental unit has provisions for interconnecting 10 active devices in the well at the top of the present ceramic circuits.

Matched pair of inverters and their equivalent

The passive elements are self packing because they are fused into a hermetically sealed unit during manufacturing. Transistors and diodes, after being mounted in the top of the units, are protected by a metal hermetic seal.

Operating temperature range of solid ceramic units is limited by the semiconductor used for the active device. The passive components can be operated to 500 C. Using gallium arsenide devices, unit operation to 350 C is possible.

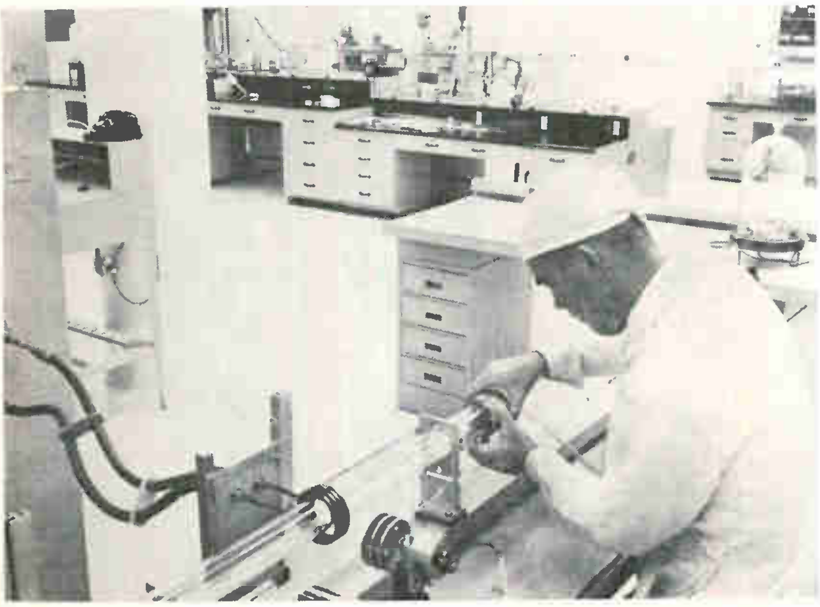
Because ceramic technology is not new, it's felt that no new breakthrough in materials is required to make ceramic circuitry practical. In addition, RCA officials feel the approach is flexible enough to incorporate future developments in such areas as active device and miniature memory cells.

Designers can breadboard circuits with conventional components and microelements made of the same basic material as the ceramic solid circuits prior to making pilot line production runs. Although compatible with the micromodule, the shape of the ceramic circuit is not fixed. Because the ceramic is bendable prior to firing, wrap around circuits are possible.

These new circuits are the result of work started four years ago to develop capacitors for the micromodule program. In experimental counter using two solid ceramic inverters has been operating since June, 1961. Present laboratory facilities at RCA can fire up to 1,000 units per hour.

Because many micromodule components (micro elements) are made from the same materials employed in the solid ceramic circuits, it is expected the new circuits will have reliability characteristics similar to those of microelements.—MMP

Sensors for the Middle Infrared Band



Germanium crystals, doped with gold, zinc, copper, cadmium and mercury, are processed in the Martin Marietta Infrared Laboratory, Baltimore. Materials will be used in infrared sensors for the difficult middle infrared radiation frequency band, and beyond. Devices detect heat emitted by moving objects in the form of infrared radiation

Scheduling Projects by Critical Path

By C. B. STEGNER
Weston Instruments Div.,
Daystrom Inc., Newark, N. J.

PLANNING AND CONTROL of development projects is as important to a company as production planning and quality assurance. Schedules of tooling, parts, production, and product availability are all in vain if the expected release date of the project from engineering is not attained.

The control of all the engineering work scheduled simultaneously is a complex problem requiring a comprehensive knowledge of the individual phases of each project and a means of determining inter-relationships between projects. The Gantt chart, Fig. 1, has often been used to indicate the time necessary to complete projects. The technique shows the duration of various phases and gives a certain amount of information with regard to the inter-relationship of the various jobs. It is not, however, immediately apparent from a Gantt chart which jobs follow any particular phase of the entire project.

Also, due to the simplicity of scheduling by the Gantt chart method, various phases of the project are often unintentionally overlooked and corrections are not projected with relation to the completion date. As a result, the fact that the project is behind schedule is sometimes not evident until shortly before the release date.

Critical path scheduling offers an improved method of planning projects. The technique provides a detailed analysis of the phases of the project with respect to function, time and manpower. Inter-relationships of the phases form a composite picture, showing when each phase of the project requires special attention.

At Weston, critical path scheduling has been employed to relate

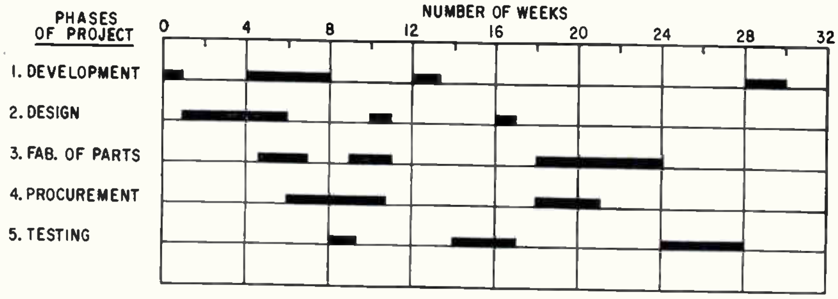


FIG. 1—Gantt chart shows when a project should be completed

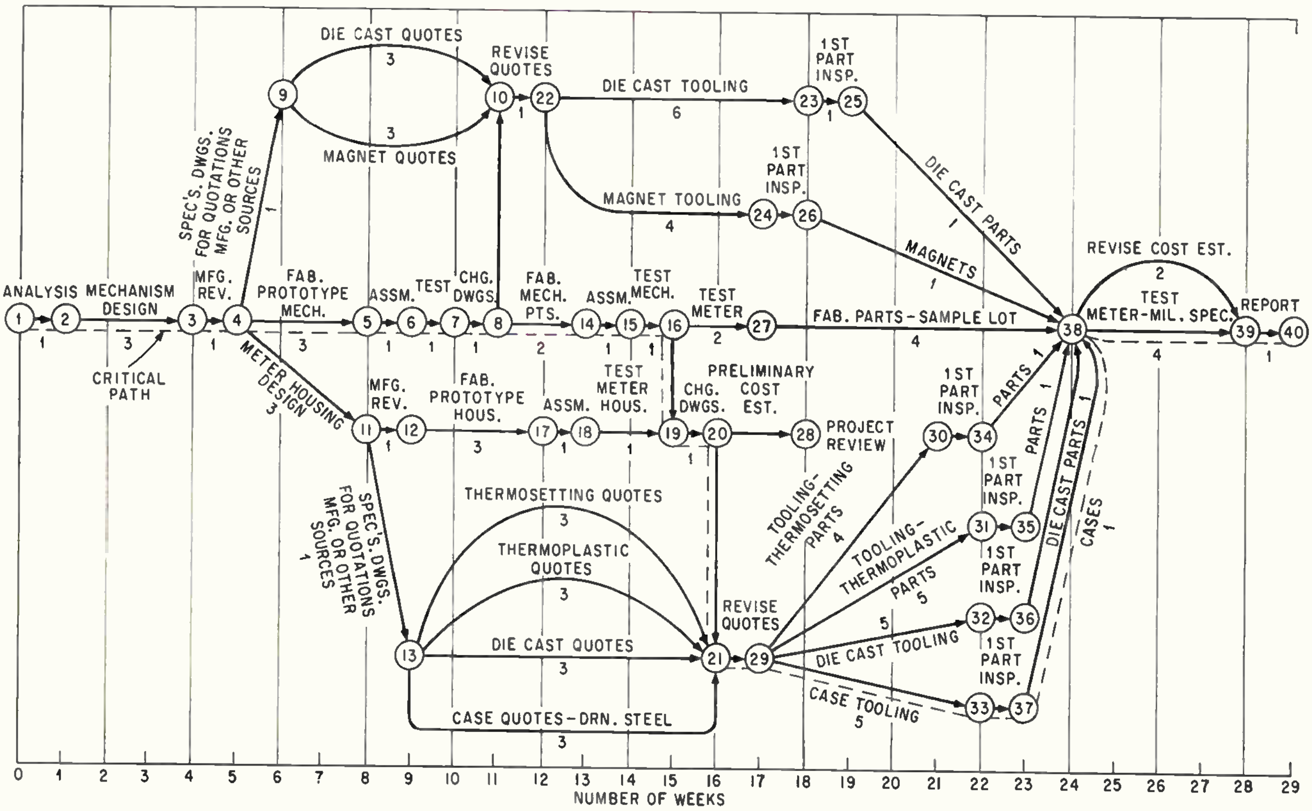


FIG. 2—Critical path is indicated by the dashed line. Any delay along this path dalays the entire project. Conversely, any improvement over the estimates speeds the project, but only to where another path becomes critical

all phases of engineering projects, including design, prototype fabrication, quotations, purchase parts, testing, redesign, retesting and evaluation. The phases are sequentially connected in a network diagram and programmed through a node system.

Phase or task completion is designated by circles or nodes, as shown in Fig. 2. The rule for assigning node numbers is that each node is reached from a lower numbered node. Thus node 10 is reached from nodes 8 and 9. Jobs are defined by arrows whose direction indicate the proper sequence, with the estimated time for each job placed below the arrow.

Using the expected time for each job, all the series paths through the network are calculated; the longest path is defined as the critical path and shorter ones are called slack paths. The critical path drawing, Fig. 2, illustrates a typical network of a recent development project for a ruggedized d-c panel meter. The critical path for the project is indicated by a dashed line.

In exercising control, attention is focused on those tasks that lie along the critical path. But since the other paths can be delayed, or estimates proved wrong, the diagram must be reviewed to determine whether the critical path has been changed. For example, in Fig. 2, ten weeks was estimated between nodes 4 and 16, which is along the critical path. From node 4 to 19, a 9 week period was allocated; if the time between 4 and 19 extended beyond 10 weeks, this would become the critical path. The drawing is revised as necessary and sometimes is redrawn.

When a number of projects are scheduled, the determination of which path is critical is sometimes not too apparent. When this happens, a computer can be programmed to solve the problem. Programming initially involves tabulating the phases of the projects for punched cards in the following manner:

From Node	To Node	Duration (weeks)
001	002	001
002	003	003
003	004	001
004	011	003
004	005	003
004	009	001

Program cards are then used to convert the punch card information into computer language. Readout will provide the following information: earliest starting date; latest starting date (latest finishing time — shortest duration); earliest finishing date (earliest starting date + shortest duration); latest finishing date; total float or amount of delay possible between phases without affecting completion date; free float, or the amount of delay of a phase without affecting the earliest starting date of subsequent phases.

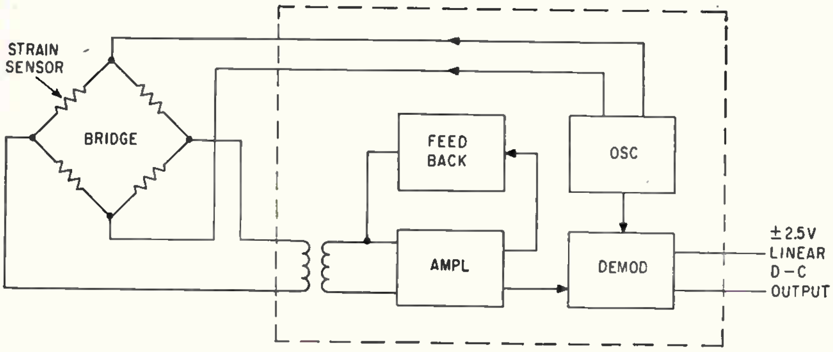
Several node points in Fig. 2 are natural project review points; these occur primarily where cost estimates have become reasonably firm for particular phases. If cost estimates are found to be greatly out of line, for example, a general review by management might lead to project cancellation before too great an investment has been made.

Slanted and curved lines are used in making the drawing for convenience only; they have no other significance. From node 29 to node 38 only one critical path is shown on the drawing, although 3 paths are actually critical.

Automatic Diode Test

Diode testers and classifiers are designed to measure and sort diodes at temperatures up to 200 C. Testing is around 3,600 units per hour. Three different models have been made and the manufacturer, Transistor Automation Corp., Cambridge, Mass., states that the machines can be adapted to test other types of axial lead components

DESIGN AND APPLICATION

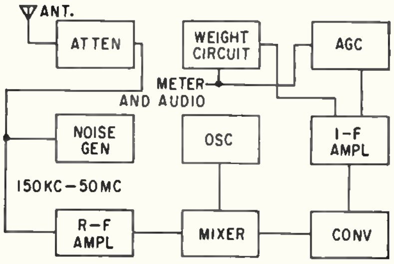


Strain Gage Amplifier

USES VARIABLE-GAIN CIRCUIT

RECENTLY introduced by Natel Engineering Co., Inc., 15922 Strathern St., Van Nuys, California is the model 9036 strain gage amplifier. The transistorized unit has a 0 to 5 v d-c output which can be zero-shifted for telemetering applications. It operates from zero to 2.5, 50 or 500 mv with the gain being controlled remotely or internally set. The unit provides 5 v sine wave excitation signal to a 300-ohm Wheatstone bridge circuit which is completed by the external transducer. The sealed unit, shown in the sketch, includes a subcarrier oscillator, negative-feedback amplifier and a phase-sensitive demodulator. Gain is adjustable over 20:1 dynamic range and the frequency response is ±5 percent to 600 cps. The amplifier is critically damped and linearity is ±1 percent over the operating temperatures of −55 C to +71 C.

CIRCLE 301 ON READER SERVICE CARD

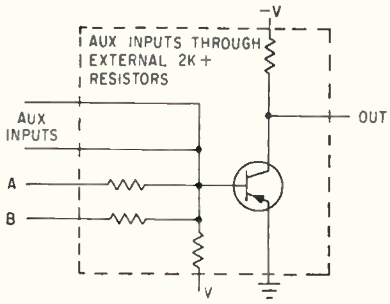


RFI Measurement Meter

FROM 150 KC TO 400 MC

RECENTLY announced by Interference Testing and Research Laboratory, Inc., 150 Causeway Street, Boston 14, Massachusetts, is the model BYD-552 Radio Interference Measurement Meter. Designed specifically for optimum pulse reception with associated high image rejection and low-noise figure, the device features plug-in head tuning between 150 Kc and 50 Mc with tangential sensitivity of 0.2 μv, between 50 Mc and 400 Mc the tangential sensitivity is 2 μv. Another head, tuning to 1,000 Mc, is under development. The i-f amplifiers are six synchronously-tuned stages with agc compensated to eliminate center frequency changes and bandwidth as agc voltage varies. Each amplifier has 10^{6} gain into a 50-ohm load, noise figure is less than 4 db and output dynamic range is over 6 v. I-f output is applied to weighting circuits with accurately controlled charge and discharge time constants. Audio output can be derived from metering circuits. An impulse noise generator having a flat spectral response over entire receiver range permits gain calibration at any frequency. Step attenuation is by a 50-ohm input circuit and the meter can measure between 1 μv and 1 v. The meter has a low-impedance input and can be used as a two-terminal voltmeter for measurement of r-f.

CIRCLE 302 ON READER SERVICE CARD

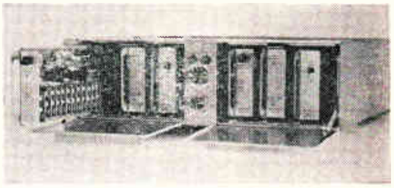


NOR Logic Circuit

IN WELDED TO-5 CASE

MANUFACTURED by Kearfott Semiconductor Corp., 437 Cherry Street, West Newton, Massachusetts, this *pnp* germanium NOR Logic Micro Function Circuit combines the functions of five individual components in a single lightweight package. Designed for application in digital computers and other data handling systems, the device features delay time of 60 nsec, rise time of 140 nsec and storage time of 175 nsec all with a 1 Mc pulse repetition rate, 50-percent duty cycle. The fall time is 140 nsec and the input signal for A and B input is −10 v.

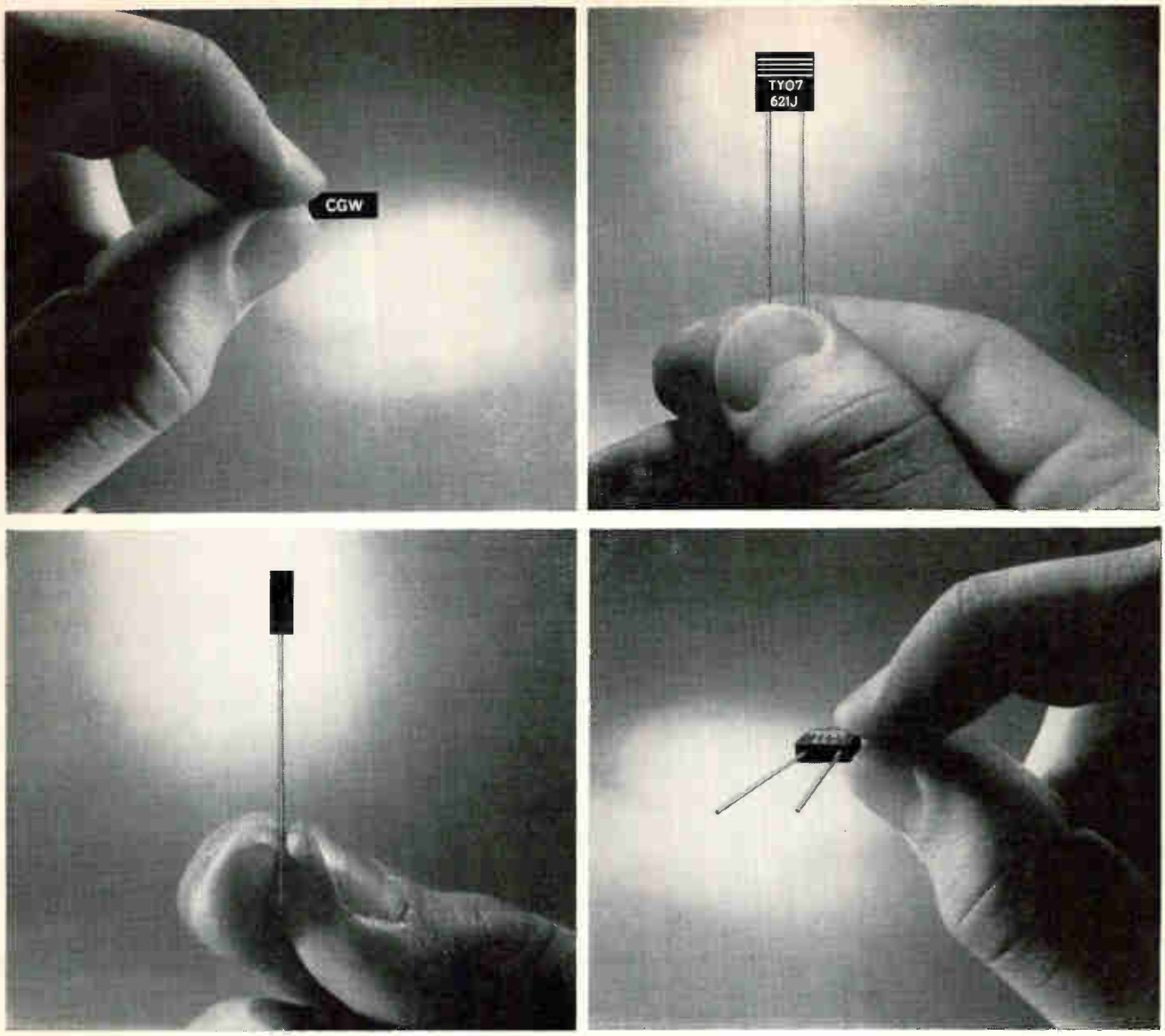
CIRCLE 303 ON READER SERVICE CARD



Sync Generator

FOR C-C TV SYSTEMS

COHU ELECTRONICS, INC., 5725 Kearny Villa Road, San Diego 12,



New
Corning TY capacitor

gives you glass stability in a new package

Check the TY from every angle against what you need in a printed circuit capacitor:

High stability—You get the same type basic capacitive element of fused glass and foil that we put in the hi rel Minuteman and all other Corning capacitors.

Small size—The "T" in TY is for tiny. See the table.

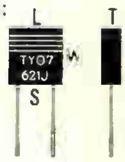
No shorts—The case and potting compound prevent intercomponent, wire, or chassis short circuits.

Easy mounting—Parallel leads are symmetrical with the case, spaced uniformly on 1/10" grids. The standard gold-flashed Dumet leads are *welded* to the conductive plates for greater strength, and are easier for you to weld or solder. No "pants" on the TY—it sits flat on your board—and its dimensions are stable.

Try the TY06 now, with a capacitance range of 1 to 560 *pf*, and the TY07, with a range of 560 to 1000 *pf*. These values hold at 300 volts from −55°C. to +125°C. with no derating. Corning TY capacitors retain the electrical performance inherent in glass capacitor construction as evidenced by their stability, life performance, and TC.

Check these TY dimensions for your application:

	L ±.005"	W ±.010"	S ±.020"	T ±.005"
TY06	.300"	.200"	.200"	.115"
TY07	.300"	.300"	.200"	.115"
Lead diameter 0.020" ±.002				



For more information, write Corning Glass Works, 539 High St., Bradford, Pa.

CORNING
Electronic Components

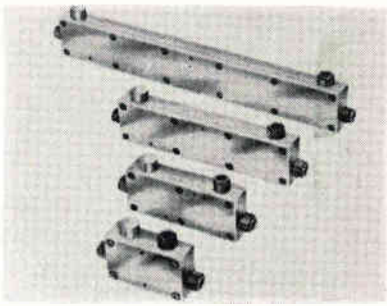
Calif. The SG-7 provides complete timing pulses for either single or multichannel c-c tv systems. Designed to conform to EIA requirements, it furnishes horizontal and vertical drive pulses, mixed blanking and sync-all negative, all 4 v peak-to-peak (nominal) for application to 75-ohm lines. Pulses are timed by a master oscillator that operates free-running or can be locked to the 60 cps a-c line or to an internal precision crystal.

CIRCLE 304 ON READER SERVICE CARD

Output Power Meter

GENERAL RADIO CO., West Concord, Mass. Type 1840-A, a passive instrument, serves as a load and can be used to measure the output power and output impedance of oscillators, amplifiers and other audio-frequency devices.

CIRCLE 305 ON READER SERVICE CARD



Coaxial Couplers

MAXIMALLY FLAT

BOGART MFG. CORP., 315 Seigel St., Brooklyn 6, N.Y. Coaxial 10 and 20 db type N couplers to operate from 250-4,000 Mc in octave bandwidths. They feature flat coupling (±0.2 db) low vswr (1.10, 1.15) and high power capability (2,000 w forward, 200 w in reverse). Dielectric loading results in smaller units with greater mechanical and electrical stability. Price is $175 for quantities from 1-10.

CIRCLE 306 ON READER SERVICE CARD

Sleeve Cutter

MARTIN ENGINEERING CO., 40 Woodbine Lane, Holyoke, Mass., has announced a compact, versatile, high speed, low cost automatic sleeve cutting machine.

CIRCLE 307 ON READER SERVICE CARD

PRODUCT BRIEFS

STATIC CONVERTER high voltage. Jordan Electronics. 121 S. Palm Ave., Alhambra, Calif. (308)

MYLAR DIELECTRIC CAPACITOR fully molded. Good-All Electric Mfg. Co., Ogallala, Neb. (309)

RARE EARTH FLUORIDES 15 types. Kleber Laboratories, Inc., 2530 N. Ontario St., Burbank, Calif. (310)

POWER RESISTOR DECADES for rack mounting. Clarostat Mfg. Co., Inc., Dover, N. H. (311)

TRANSISTORIZED DIGITAL CLOCK two models. Non-Linear Systems, Inc., Del Mar, Calif. (312)

TOROID INDUCTORS hermetically sealed. Microtran Co., Inc., Valley Stream, N. Y. (313)

INDUSTRIAL LAMINATES six new Textolite types. General Electric Co., Coshocton, O. (314)

TEST EQUIPMENT for microwave industry. Westinghouse Electronic Tube Division, Box 284, Elmira, N. Y. (315)

SILICON RECTIFIERS for close-quarter mounting. Universal Rectifier Corp., 2055 Pontius Ave., Los Angeles 25, Calif. (316)

PULSE GENERATOR wide operating range. Lavoie Laboratories, Inc., Morganville, N. J. (317)

REGULATED POWER SUPPLIES portable. 100 amp. Chatham Electronics Division of Tung-Sol Electric Inc., Livingston, N. J. (318)

TEMPERATURE SENSORS platinum resistance. Trans-Sonics, Inc., Box 328, Lexington 73, Mass. (319)

SAUCER FAN 400 cps military version. Rotron Mfg. Co., Inc., Woodstock, N. Y. (320)

THERMAL TRANSFER METER rapid switching time. Tensor Electric Development Co., Inc., 1873 Eastern Pkway., Bklyn., N. Y. (321)

MODULAR POWER SUPPLIES for klystrons. Micro-Power 20-21 Steinway St., L. I. C. 5, N. Y. (322)

TEMPERATURE CONTROLLER versatile unit. Acromag, Inc., 15360 Telegraph Rd., Detroit, Mich. (323)

Literature of the Week

DIODE ENCLOSURES National Transistor Mfg., Inc., 500 Broadway, Lawrence, Mass., has available a bulletin entitled "Reliable Glass Enclosures for Diodes." (324)

STATOR YOKES Syntronic Instruments, Inc., 100 Industrial Road, Addison, Ill. Catalog covers stator type magnetic deflection yokes for 1½ in. neck diameter crt's in transistor or tube circuits. (325)

ELECTRON TUBES Litton Industries, 960 Industrial Road, San Carlos, Calif. A 24-page 1962 Electron Tube Condensed Catalog features 65 new products. (326)

TIME DELAY SWITCH Leesona Moos Laboratories, 90-28 Van Wyck Expressway, Jamaica 18, N. Y. Data sheet describes model 5419, which provides a time delay of from 2 to 12 hr between actuation and switch operation. (327)

SILICON TRANSISTORS Silicon Transistor Corp., Carle Place, N.Y. The 2N2034 series of miniaturized high power silicon transistors are discussed in a bulletin. (328)

PLASTIC FOLDER Liquid Nitrogen Processing Corp., Malvern, Pa. Six-page bulletin describes use of plastics as molding compounds, lubricants and coatings. (329)

DELAY LINE DESIGN DATA Allen Avionics, Inc., 255 E. 2nd St., Mineola, N.Y. A 10-page technical booklet describes how to design a delay line that can be delivered in 24 hours. (330)

WIREWOUND RESISTORS Aerovox Corp., 1110 Chestnut St., Burbank, Calif. Bulletin presents specifications on Hi-Q microminiature Aerohm 600 high-reliability wirewound resistors. (331)

TRANSISTOR TRANSFORMERS Stancor Electronics, Inc., 3501 Addison St., Chicago 18, Ill. Three transistor transformers—a driver, an output, and a power unit—are described in bulletin 606. (332)

INSULATING MATERIAL Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill. Bulletin No. 43 contains descriptions and specifications for a line of Teflon products. (333)

A-C MOTORS Kearfott Division, General Precision, Inc., Little Falls, N.J. Four-page folder completely describes a line of general purpose a-c motors. (334)

DELAY LINES Kenyon Transformer Co., Inc., 1057 Summit Ave., Jersey City, N.J. Catalog D-621 covers a wide line of delay lines with time delays from 1 nsec to 5,000 μsec. (335)

SERVO AMPLIFIER Diehl Mfg. Co., Finderne Plant, Somerville, N. J., offers catalog sheets describing its 75-w vacuum tube servo amplifier and associated solid state power supply. (336)

POTTING COMPOUND Mereco Products, 530 Wellington Ave., Cranston 10, R. I. Bulletin describes the use of Mereco No. 4583, an epoxy resin compound that utilizes an intrinsic dispersion method, which produces a permanently suspended filler/resin system. (337)

L-F OSCILLATORS Bulova Watch Co., Inc., Electronics Div., 40-10 61st St., Woodside 77, N.Y. Catalog sheet covers a number of l-f crystal-controlled oscillators. (338)

ROTARY SWITCHES Markite Corp., 155 Waverly Place, New York 14, N.Y. Brochure covers conductive plastic rotary switches for controls and instrumentation. (339)

TEST PORT STATION Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Two-page bulletin describes the 24-025A test port station. (340)

SOLID STATE COMPONENT Diodes. Inc., 7303 Canoga Ave., Canoga Park, Calif. A one-page bulletin describes the Stabistor which is used in transistorized or tube circuits where a high current non-linear resistor is needed. (341)

SERVOMOTOR Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. Data sheet describes a 26-v, 400-cycle size 5 servomotor. (342)

IGNITRONS General Electric Co., Schenectady 5, N. Y. Bulletin PT-57 contains complete information on ignitrons in capacitor discharge and crowbar service. To obtain a copy request on company letterhead.

Lambda Settles in New Plant

LAMBDA ELECTRONICS CORP. recently opened a 76,000-sq-ft air-conditioned plant on a 14-acre site in Huntington, L. I., N. Y., as part of a program of expansion to meet increased demand for its products.

Capable of tripling previous production capacity and providing ample space for increased product R&D, the one-story plant accommodates assembly-line production, transformer manufacturing, sheet metal fabrication and design and prototype development.

Lambda power supplies are used in the Tiros and Mercury programs, Sage and digital computer intervention and display systems, and other major projects. Full production of seven new solid-state regulated power supply models is underway.

Matcovich Moves Up At Bulova Labs

PHILIP A. MATCOVICH has been named to a new position as director of manufacturing for the Bulova Research and Development Laboratories division of Bulova Watch Co., Inc., Woodside, N. Y.

Before this new assignment Matcovich has been chief design engineer.

Continental Connector Expands Facilities

CONTINENTAL CONNECTOR CORP., manufacturer of precision electronic connectors for commercial and military applications, has purchased a 23,000 sq ft building adjoining its main plant in Woodside, N. Y., as part of an expansion program.

The company recently terminated its exclusive sales agreement with DeJur-Amsco Corp. for the sale of Continental connectors, and will now handle all sales activities through its own direct sales force and manufacturers' reps throughout the country. The firm's sales department will occupy a portion of the new building.

Arrance Advances At Centralab

FRANK C. ARRANCE has been promoted to general manager, technical ceramics department of Centralab, The Electronics Div. of Globe-Union Inc., Milwaukee, Wis.

Arrance will be in charge of R&D, production engineering and manufacturing engineering. He will also be responsible for the manufacturing of all steatite and high alumina products.

Texas Instruments Renames Division

TEXAS INSTRUMENTS, INC., Dallas, Texas, has changed the name of its Geosciences Division to Science Services Division to reflect the broadened scope of its activities, president P. E. Haggerty recently announced.

The division's activities now include geophysical exploration, earth sciences research and development, and scientific data collection, data processing and data interpretation.

Its organization remains unchanged, Haggerty said, with TI vice president Robert C. Dunlap, Jr., as division general manager.

Myers Accepts Post At Martin Marietta

APPOINTMENT of Peter B. Myers as manager of a new research and advanced technology department at Martin Marietta Electronic Systems & Products division, Baltimore, Md., is announced.

Myers formerly was staff scientist in the semiconductor products division of Motorola.

Electronics Company Opens in Dallas

SCIENTIFIC DALLAS, INC., recently started operations in Dallas, Texas, according to R. E. Cormier, president. Company will manufacture aircraft navigational instruments and static power conversion systems.

Other officers of the firm are W. T. Shelton, vice president, and W. H. Wren, secretary-treasurer.

Temco Promotes Campbell

AARON R. CAMPBELL has been promoted to manufacturing manager of Temco Electronics division of Temco Electronics & Missiles Co., subsidiary of Ling-Temco-Vought, Inc.

He will direct all of the division's manufacturing operations in Garland, Arlington and Grand Prairie, Texas. His chief offices will be at the Garland headquarters of the division.

PEOPLE IN BRIEF

Bruce A. Winner is new v-p and g-m of Welton V. Johnson Engineering Co., Inc. **C. B. Lou**, ex-North American Autonetics, appointed to engineering staff of California Computer Products, Inc. **Edward T. Butler**, senior v-p of Electro Instruments, Inc., is named g-m of its San Diego subsidiary. **Jack D. Rowley**, previously with Melabs, joins Pulse Engineering Inc. as mgr. of quality assurance. **Warren T. O'Brien**, from General Electric to Philco Corp. as mgr. of operations of the Communications and Weapons div. **Kenneth M. Miller**, formerly with Daystrom, Inc., new g-m of Singer-Bridgeport. **Walter A. Schwalm** moves up at TELvision Laboratories, Inc., to president and chairman of the board. **Guy E. Inshaw** leaves Northrop Corp. to take post of senior staff engineer and head up the western engineering office of Dunn Engineering Corp. **Bruce Emonson** is elevated from v-p to president of TelePrompter of Canada Ltd. **Uno Hedin**, previously with Allied Control Co., appointed project engineer for Wabash Magnetics, Inc. **David Zeheb** advances to chief engineer of electronics at Weston Instruments div., Daystrom, Inc. **William H. Reinholtz**, ex-Librascope and Marchant Research, joins Datex Corp. as product engineering mgr.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper 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.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
BOEING COMPANY Seattle, Washington	19	1
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	111*	2
GENERAL DYNAMICS/ELECTRONICS Military Products Div. San Diego, California	111*	3
HAMILTON STANDARD Div. of United Aircraft Corp. Windsor Locks, Connecticut	115*	4
INTERNATIONAL ELECTRIC CORPORATION Div. of International Telephone & Telegraph Corp. Paramus, New Jersey	82*	5
LABORATORY FOR ELECTRONICS Boston, Massachusetts	78*	6
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	80, 81*	7
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	111*	8
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	113*	9
OHIO STATE UNIVERSITY Radio Observatory Columbus, Ohio	112*	10
REMINGTON RAND UNIVAC Div. of Sperry Rand Corp. St. Paul, Minnesota	53	11
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts	115*	12
SIKORSKY AIRCRAFT Div. of United Aircraft Corp. Stratford, Connecticut	67	13
SPACE TECHNOLOGY LABS. INC. A Subsidiary of Thompson Ramo Wooldridge Inc. Redondo Beach, Calif.	15	14

CONTINUED ON OPPOSITE PAGE

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS ....

CITY .....................ZONE......STATE.............

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

3262

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

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

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities — executive, management, technical, selling, office, skilled, manual, etc.

Look in the forward section of the magazine for additional Employment Opportunities advertising.

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured 7/8" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

ELECTRONIC DEVELOPMENT ENGINEERS

Immediate openings for EEs experienced in original semiconductor circuit and component design. Positions require problem definition, system design and prototype evaluation. Salary open.

Send resumes to Mr. J. E. McMahon.

UNION SWITCH & SIGNAL
Division of WABCO Pittsburgh 18, Pa.

SELLING OPPORTUNITY WANTED

Sales Engineers—New Group Engineers to represent equipment manufacturer. Territory —Texas, Kansas, Oklahoma, Missouri—retainer or commission. RA-8391, Electronics, Classified Adv. Div., 645 N. Michigan Ave., Chic. 11, Ill.

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IN THE ELECTRONIC INDUSTRY

SAMUEL K. MACDONALD, INC.
manufacturers representatives over 25 years
1531 SPRUCE STREET, PHILA. 2, PA.

Territory:
Pennsylvania • New Jersey
Delaware • Maryland
Virginia • West Virginia
District of Columbia

Other Offices:
Pittsburgh
Baltimore
Washington, D.C.

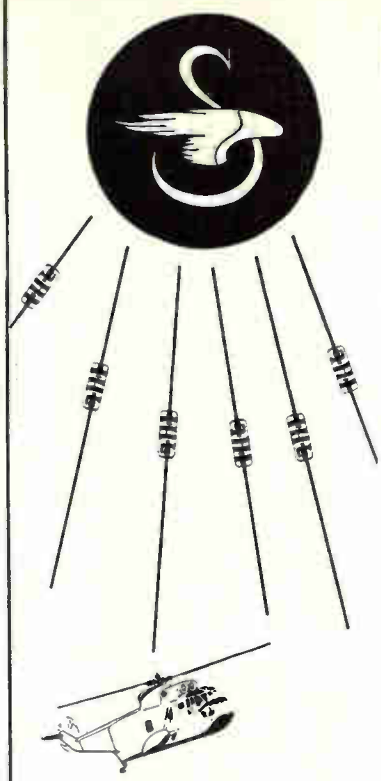
electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from opposite page)

COMPANY	SEE PAGE	KEY #
SPERRY GYROSCOPE COMPANY Div. of Sperry Rand Corp. Great Neck, L. I., New York	112*	15
SYLVANIA MOUNTAIN VIEW OPERATIONS Mountain View, California	114*	16
UNION SWITCH & SIGNAL Div. of WABCO Pittsburgh, Pennsylvania	67	17
P-7950	111*	18
P-8290	112*	19

* These advertisements appeared in the 2/23/62 issue.



helitronics

new areas of challenge for electronic engineers

Helitronics . . . the merging of two major technologies: **helicopters** and **electronics** . . . stems from the long-range military and commercial programs now in effect at Sikorsky Aircraft.

This area of Sikorsky activity provides for the integration of guidance and navigation systems, specialized electronic search and detection equipment to enhance the mission capability of the helicopter; specialized sensors and automatic controls to increase its versatility as an optimum military weapon system and a commercial carrier.

The need for such sophisticated electronics in V/STOL systems provides exceptional opportunities for electronic engineers with particular skills in: **design • automatic controls • instrumentation • test • development • air-borne systems • production and service support equipment • trainers and simulators.**

If you are interested in these career opportunities, please submit your resume, including minimum salary requirements, to Mr. Leo J. Shalvoy, Personnel Department.

Sikorsky Aircraft DIVISION OF UNITED AIRCRAFT CORP.
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34 Dover St.

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