Electronics®

January 11, 1965

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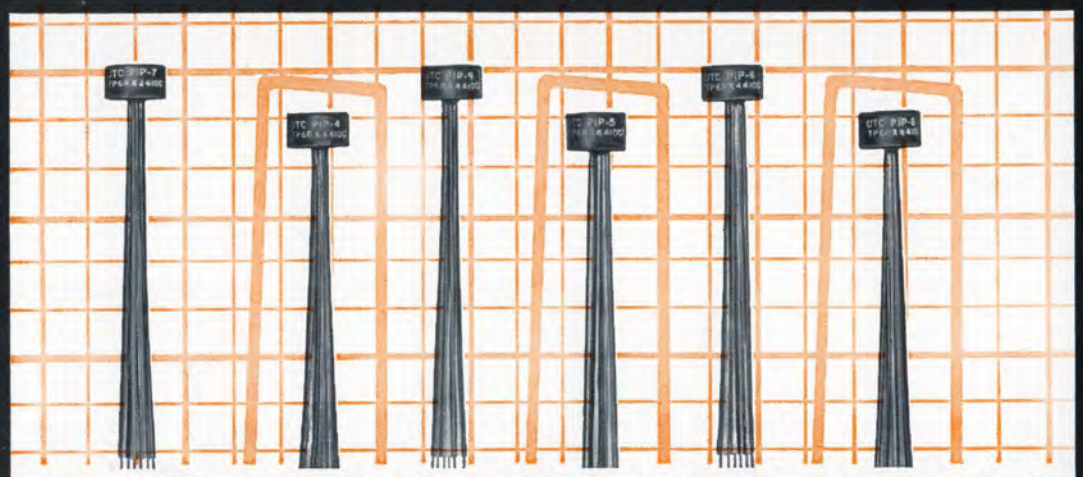
A McGraw-Hill Publication

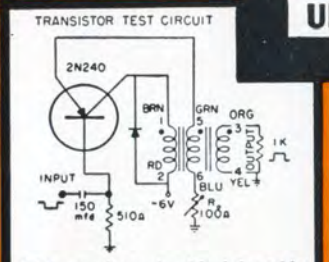
Below: new applications for microelectronics in 1965, page 87

NEW PIP SERIES
ULTRAMINIATURE TRANSISTOR
PULSE TRANSFORMERS

PIONEERS IN MINIATURIZATION

TM





All units individually checked and adjusted, in transistor circuit illustrated, to parameters in table.

DEFINITIONS

Amplitude: Intersection of leading pulse edge with smooth curve approximating top of pulse.
Pulse width: Microseconds between 50% amplitude points on leading and trailing pulse edges.
Rise Time: Microseconds required to increase from 10% to 90% amplitude.
Overshoot: Percentage by which first excursion of pulse exceeds 100% amplitude.
Droop: Percentage reduction from 100% amplitude a specified time after 100% amplitude point.
Backswing: Negative swing after trailing edge as percentage of 100% amplitude.

- RUGGED—COMPLETELY METAL CASED
- Manufactured & Guaranteed to MIL-T-21038B
- 5/16″ Dia. x 3/16″ Ht.; Wt. 1/20 oz.
- Ratios—4:4:1 and 5:3:1
- Anchored leads, withstands 10 lb. pull test
- Printed circuit use, plastic insulated leads
- Can be suspended by leads or clip mounted

	APPROX. DCR, OHMS			BLOCKING OSCILLATOR PULSE					COUPLING CIRCUIT CHARACTERISTICS						
Type No.	1-Brn 2-Rd	3-Org 4-Yel	5-Grn 6-Blu	Width μ Sec.	Rise Time	% Over Shoot	Droop %	% Back Swing	P Width μ Sec.	Volt Out	Rise Time	% Over Shoot	Droop %	Back Swing	Imp. in/out*
RATIO 4:4:1 MIL TYPE TP6RX4410CZ															
PIP-1	.18	.20	.07	.05	.02	0	0	37	.05	9	.018	0	0	12	50
PIP-2	.47	.56	.17	.1	.025	0	0	25	.1	8	.02	0	0	5	50
PIP-3	1.01	1.25	.37	.2	.03	2	0	15	.2	7	.035	0	0	5	100
PIP-4	1.5	1.85	.54	.5	.05	0	0	15	.5	7	.06	0	0	0	100
PIP-5	2.45	3.1	.9	1	.08	0	0	14	1	6.8	.15	0	0	5	100
PIP-6	3.0	3.7	1.1	2	.10	0	0	15	2	6.6	.18	0	0	2	10	100
PIP-7	4.9	6.05	1.8	3	.20	0	0	14	3	6.8	.20	0	0	2	10	100
PIP-8	8.0	9.7	2.9	5	.30	0	0	3	5	7.9	.22	0	13	25	200
PIP-9	13.1	15.9	4.7	10	.35	0	5	12	10	6.5	.4	0	15	20	200
PIP-100	Transistor pulse transformer kit, consisting of PIP-1 thru PIP-9 in plastic case.														
RATIO 5:3:1 MIL TYPE TP6RX5310CZ															
PIP-10	.55	.41	.15	.1	.01	0	0	20	.1	8	.01	0	0	5	140/50
PIP-11	2.9	2.2	.82	1	.02	4	4	6	1	6.6	.05	0	6	12	280/100
PIP-12	9.4	7.1	2.6	5	.05	0	12	12	5	8	.09	2	12	25	560/200

* Input winding leads Brn-Rd (1-2); output winding leads Org-Yel (3-4); leads Grn-Blu (5-6) open.

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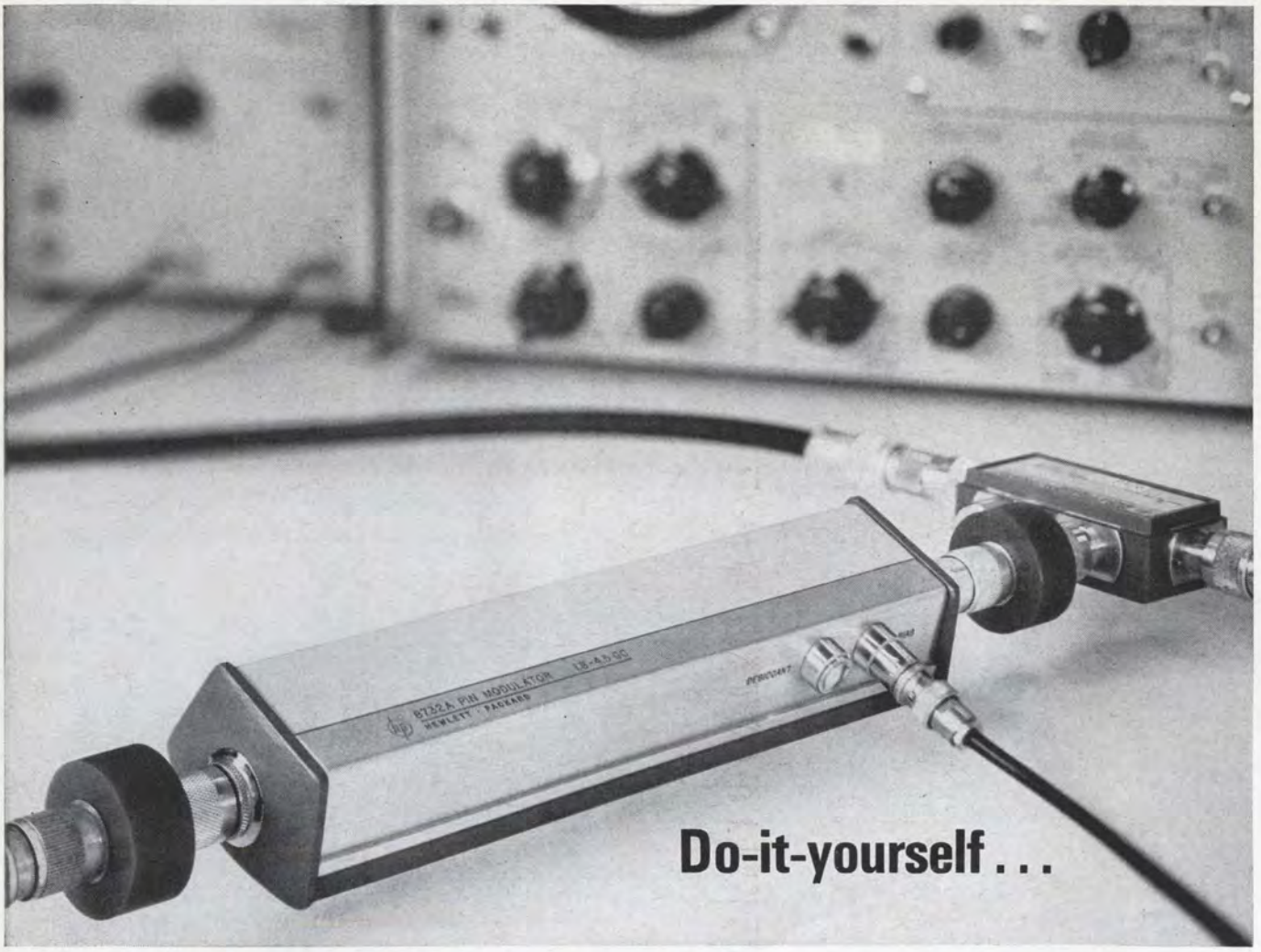
Circle 900 on reader service card



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8732A

hp 8730 PIN Modulators: "A" models for 30 db attenuation—for leveling, AM and noise modulation —"B" models for 80 db attenuation—for pulse modulation. Just add them to your system. Constant input and output match from these voltage-controlled devices, whose PIN diodes absorb rf power, and offer extremely fast rise times, typically 30 nsec. Four overlapping bands, 0.8 to 12.4 gc, plus X-band waveguide models. "A" models $300, "B" models $500.

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hp 8403 Modulator: Provides complete control for 8730 Modulators, including appropriate wave shapes and bias levels for fast rise times, rated on/off ratios and AM. Internal square-wave and pulse modulator, which can be synchronized with external signals, has a free-running prf 50 cps to 50 kc. Adjustable width and delay in pulse modulation mode. External AM input. hp 8403, $700; add $50 to have 8730 Modulator installed.

Whether your need is for modulation components or a complete system, this group of Hewlett-Packard products offers the answer. Call your hp field engineer for complete data or write Hewlett-Packard, Palo Alto, California 94304, Telephone (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

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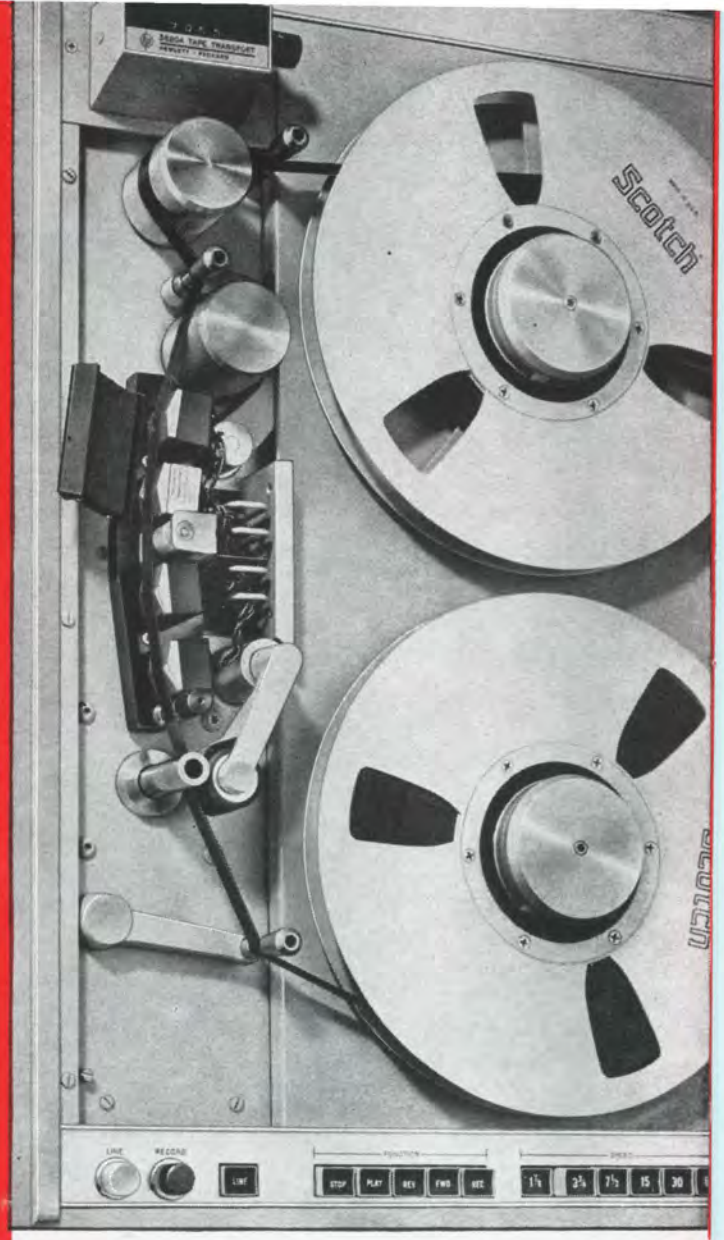
• Greatly reduced interchannel crosstalk with a new magnetic head assembly design using improved shielding. • High signal/noise ratio, gentle tape handling and reduced tape wear, through precisely controlled tape tension, driving and braking torques, and guide element designs. • Plug-in solid-state electronics with record/reproduce amplifiers on the same cards, and equalization plug-ins necessary only for speeds to be used. • No need for maintenance or lubrication, except for cleaning tape path. • Built-in footage counter accurate to 99.95%. • Quick, easy snap-on tape reel loading. • Cabinet, rack or portable case mounting.

Check the key specifications here, then call your local H-P Field Engineering Office for complete details and prices. Or write Sanborn Company, Industrial Division, 175 Wyman Street, Waltham, Massachusetts 02154.

SERIES 3907A (7-channel), 3914A (14-channel)

SPEEDS	6, electrically controlled, pushbutton selected, 1⅞ to 60 ips; other speed ranges optional. Max. start 2 sec., max. stop 1 sec.; ±0.25% max. variation in tape speed at nominal line frequency.
TAPE	7-channel ½"; 14-channel 1"; 2400 feet 1.5 mil, 3600 feet 1.0 mil; 4800 feet 0.65 mil; 10½" reels.
RECORDING MODES	Direct, FM or Pulse Record/Reproduce via interchangeable solid state plug-in electronics; 7-channels in 7½" panel space. Single-ended inputs, push-pull with optional coupler. Adjustable input/output levels.

Circle 2 on reader service card



BANDWIDTH	RESPONSE	SIGNAL/NOISE RATIO (RMS)
Direct (60 ips) 100-100,000 cps	±3 db	40 db
FM (60 ips) 0-10,000 cps (Wideband systems available soon — 250 KC direct, 20 KC FM)	±0, −1 db	44 db without flutter compensation 48 db with flutter compensation
P-P FLUTTER (30 & 60 ips)	0-1 KC, 0.2% max. 0-5 KC, 0.5% max.	
CONTROLS	Power, Stop, Play, Reverse, Fast Forward, Record; all can be remotely controlled	

PRICES (f.o.b. Waltham, Mass.) (Systems represent two of many choices available. Prices are correspondingly **lower** for fewer speed filters, or where direct record/reproduce electronics are specified, and higher when filters for all six speeds are ordered.)

Complete 7-channel system for FM recording and reproducing, with filters for 3 speeds, extra (8th) channel for monitoring, and console cabinet: **$8900**

Same system, **for 14-channels: $13,370**

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A DIVISION OF HEWLETT-PACKARD hp

Electronics

January 11, 1965
Volume 38, Number 1

Electronics Review

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Readers Comment

Nothing new under the sun

To the Editor:
In reading the story "Setting up radar behind enemy lines" [Electronics, Nov. 30, p. 85], one is tempted to cite World War II radars such as SCR 602-T1-T3 as well as the British Ames Type 5 and 6. I wonder if Joseph Enrino [who designed the system at the Air Force's Rome Air Development Center] doesn't get a chuckle out of being associated with similar beasties again! Shades of Pelican Island, circa 1941 and 1942! So what else is new in the field?

R.H. Boutillette
Huntsville, Ala.

Laser photography

To the Editor:
After reading your report on holography in "The little train that wasn't" [Electronics, Nov. 30, p. 86], I became quite interested in the optical technique used to produce the images. At the MIT Stroboscopic Light Laboratory, we have sufficient equipment to duplicate the experiment with pulsed laser equipment, if this can be done.

I would appreciate your giving me the addresses of Professors Stroke and Leith at the University of Michigan and any other workers you know of, considering this problem.

E.R. Schildkraut
Cambridge, Mass.

▪ G.W. Strofe and Emmet Leith, who developed the technique, can be reached at the University of Michigan, Physics Department, Ann Arbor, Mich.

Revisions for a robot

To the Editor:
I am most gratified to learn of others who are interested in the prosthetic end of medical electronics. I have been interested in this area for several years, however I have not had much spare time to devote to strictly personal research efforts.

I had planned to build an en-

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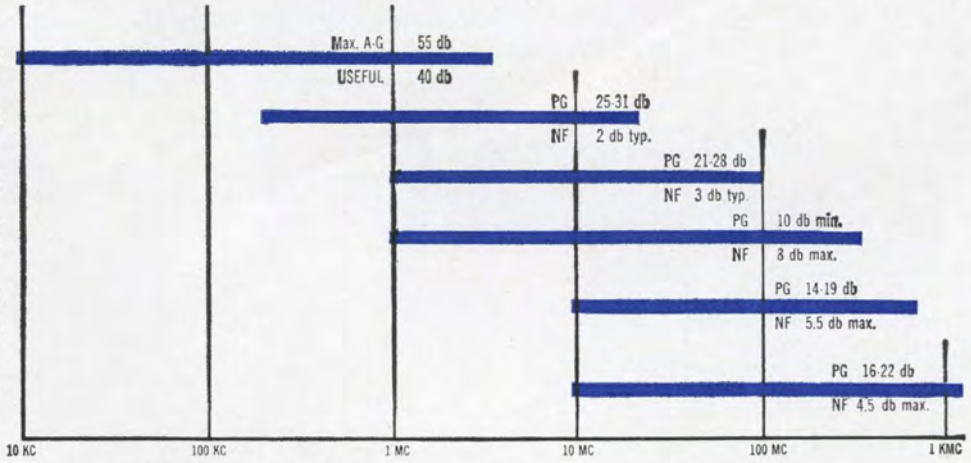

MADT Communications Transistors are proven, in production, and in field service!

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4ST-182-63R3

gineer's model of a programed robot which could walk erect; could feel varying degrees of cold or heat, could react to accoustical stimulations; and could sense pressure changes—actions which are now possible with microcircuitry and transducers.

The robot would be no larger than the average male adult human with most of the mental machinery of the average lower animal.

Its actions would be controlled by muscles, similar to the human counterpart. Its muscles would be tiny, flexible capillary tubes, stretchable laterally, not linearly. For nerves, tiny conductors would connect the expandable fluid within the tubes to differential amplifiers, like dendrites in the body of a neuron.

Two-way inputs were to be used with these amplifiers; one from the sensors in the limbs and other parts of the body and the other from the robot's brain, similar to the afferent and efferent neuron circuits of the human body.

My thoughts on prosthetic limbs were not concerned with the use of computers, other than the analog equivalents such as the effector neurons which are used as the input and output devices of mother nature. However, with the stimulus of Lee Harrison's article ["Paralytic's brain + myocoder = Hope", Electronics, Nov. 30, 1964, p. 74] tickling my reticular formation, I find that my planned receptors (diode ring counters with set thresholds) might better be replaced with the AND, OR and NOR microcircuits of modern technology.

S. Hamilton McNeill
G.E.E., Inc.
Addison, Ill.

Vote for one-man vehicles

To the Editor:
I want to second N.R. Griswold's recommendation for a system of local transportation made of one-person automated vehicles [Electronics Nov. 2, 1964, p. 6].

The idea is not new. I first wrote about it in February, 1958 after turning it over in my mind for some time. About 1960 I heard of two other people who had originated similar ideas independently.

After more than six years of further thought, I still feel that the individual automated vehicle is the only approach that really offers hope of solving our urban transportation problems.

Henry Bowen Brainerd
Wellesley, Mass.

Faster than fast

To the Editor:
In the story "Supercomputer" [Electronics, Nov. 30, 1964, p. 23], you state Univac is designing a computer "to handle *one* million instruction a second." It should be noted that Control Data has already delivered the first of the Model 6600 which executes an average of three million instructions per second.

Next you state "if all the 25,000 computers now in existence were placed end to end, they could handle at most five or six million instructions a second." Our figures show that as of November 30 the 23,340 odd computers are in fact executing approximately *446 billion* operations per second.

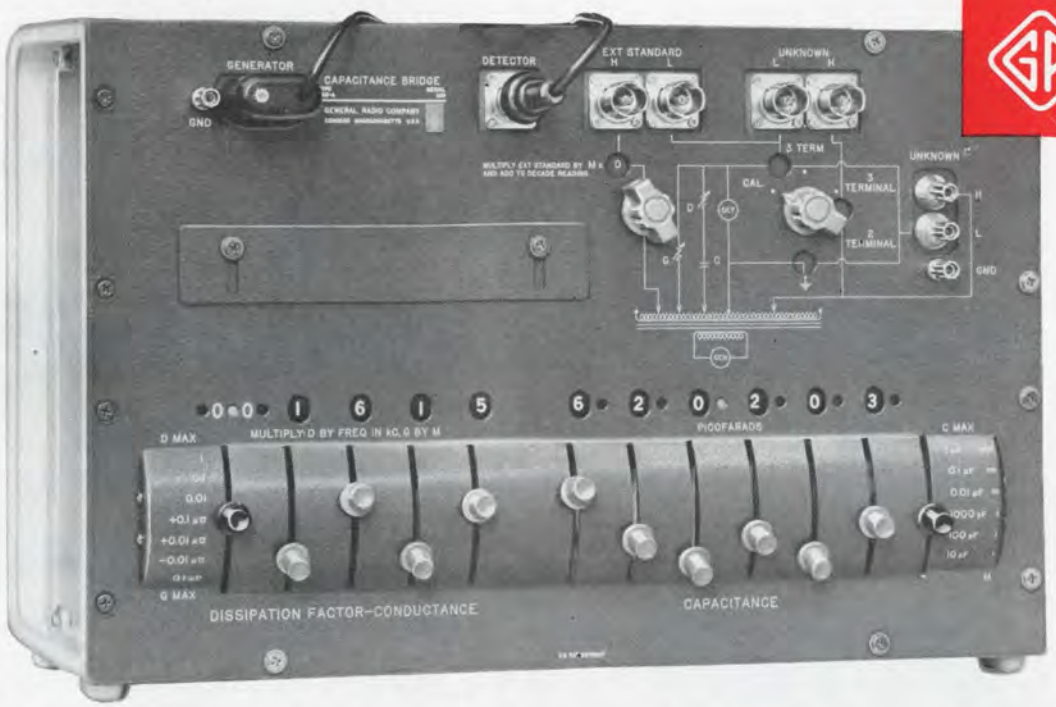
If your figures are correct; 6,000,000/25,000 = 240 instruction a second, for an average of 4.16 milliseconds per. In fact, most modern computers operate in the 2-20 microsecond range. For example the 320- odd IBM-7090's execute an add in 2.0 to 4.4 microseconds, and that one group of computers alone executes 100 million instructions per second every day.

Walter E. Misdom
Control Data Corp.
Minneapolis

FET switched

To the Editor:
Your listing of the French company Sesco as the manufacturer of a power type FET was in error [Electronics, No. 30, p. 48]. Sesco is the manufacturer of a low-power FET but the high-power unit referred to is the result of a cooperative effort between Forges et Ateliers de Constructions Electriques de Jeumont (France) and Ateliers de Constructions Electriques de Charleroi (Belgium). We represent all three companies in the United States.

Anthony H. Lamb
Atlantic Instruments
and Electronics, Inc.
Boston



Only One bridge has all these features

Wide Range — Capacitance from 10aF* to 1.1111 μF; Dissipation Factor from 0.000001 to 1; G from 10^{-6} μmho to 100 μmho. C range can be extended to 11.1111 μF with range-extension capacitor.

High Accuracy — Capacitance ±0.01%, better with external standards; D ±(0.1% of measured value + 0.00001); G ±1% + 0.00001 μmho. Accuracy holds over a 100-c to 10-kc range. Useful with reduced accuracy to 100kc/s.

Six-Figure Resolution — Smallest measurable division is 10^{-17} farad. Resolution can be extended to seven figures with external standards.

Easy To Use — Lever balancing controls, digital in-line readout, automatic decimal point location and unit location greatly simplify balancing. Panel engraving automatically indicates proper bridge connections for each measuring situation.

Excellent Stability — All metal parts used in the internal standards are constructed from low-temperature-coefficient Invar alloy to avoid differential stresses and are annealed and temperature-cycled to relieve strains. Plates are all hyperlapped to a tolerance held to better than ±0.00025 of an inch. The six largest standards are hermetically sealed for life in dry, high-purity nitrogen. The resulting stability is better than 5ppm/°C for temperature, and better than 20ppm/year for aging. D is less than 10ppm at 1 kc/s.

2- and 3-Terminal Measurements — The bridge is a transformer ratio-arm type with a guard point and is capable of measuring 3-terminal capacitors in one step without auxiliary balance adjustments.

Practically Checks Itself — All internal standards can be quickly checked against each other for consistency. Only a single external standard is required to establish the absolute calibration of the entire set

Fast — The combination of sensible panel layout, transformer ratio-arm circuitry, three-terminal design, and one-step balancing permits easy, rapid intercomparisons of capacitors differing in value by as much as 1,000 to 1.

Reasonable Price — The Type 1615-A Precision Capacitance Bridge is available for $1475 (in U.S.A.). The Type 1615-P1 Range-Extension Capacitor for extending measuring range to 10 μF is $35.

A Complete Capacitance Measuring Assembly

The Type 1620-A — includes the Type 1615-A Bridge; Type 1232-A Tuned Amplifier and Null Detector, a low-noise high-gain instrument with a 20-c to 20-kc range and a full-scale sensitivity of 1 μV; and the new Type 1311-A Bridge Oscillator, with 11 fixed frequencies from 50c/s to 10kc/s. Price for the complete assembly is $2090 in U.S.A.

*attofarad = 10^{-18} Farad

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People

William F. Ballhaus, at age 46, made a sharp turn in his career when he became president of Beckman Instruments, Inc., on Jan. 1. He came to Beckman from the Northrop Corp., where he was executive vice president.

Northrop, an aerospace company, had sales in 1963 of $346.9 million. Beckman, a manufacturer of instruments principally for industry, the medical field and other civilian applications, is much smaller—its 1963 sales totaled $78.7 million.

Ballhaus succeeds Arnold O. Beckman as president. Beckman, founder of the instrument company in 1935, will remain chairman and chief executive.

Ballhaus, a native of San Francisco, received a doctorate in mathematics and aerodynamics in 1947 from the California Institute of Technology. He is expected to be especially valuable in Beckman's optics group and systems division, both fields in which he has had extensive experience.

John H. Heck considers his new job one of devising "the most precise procurement ever made." The 10 million owners of stock in the Communications Satellite Corp. hope he succeeds, because Heck is Comsat's new manager of procurement.

The 54-year-old executive explains: "Getting equipment to work in the space environment calls for the most exacting workmanship that industry has ever faced. Now add the ingredient of a commercial operation where failures and delays mean a loss of money, and you can see what I mean."

The equipment he talks about is largely electronic.

He warns prospective suppliers that they'll have to gear up for a "reliable, economical performance, on time, with stiff penalties if they don't." Comsat, for its part, will provide precise specifications for industry, Heck adds.

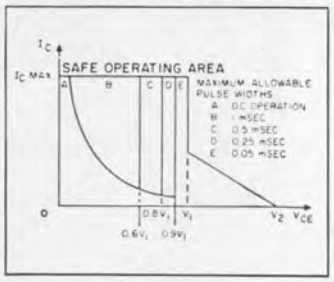
If Carmine Labriola ever thinks big, we'll transfer him.

Carmine is our engineer in charge of reducing transistor package size. One of his latest accomplishments is putting our 3 amp germanium power device into a standard TO-5 case. (You can still get it in stud nut heat sink or hex nut heat sink types, too.)

With the TO-5 case you can save a lot of space in card mounting or any other sort of high density packaging applications. And with the SOAR (Safe Operating ARea) specifying technique, you can save a lot of time, trouble and cost selecting the right switching transistor. As long as the unit is operated within the SOAR envelope (according to the specs in the 2N chart) secondary breakdown failure just doesn't happen.

And, if the little package and the SOAR technique interest you, take a look at the ratings. Fast switching time, high collector-to-base voltage: V_{CBO} to -100 V; high DC current gain: (h_{FE}) 33 to 200 with $V_{CE} = -0.5$ V, $I_C = -50$ mA; low collector cutoff current: I_{CBO}, -125 μA maximum; low saturation voltage: $V_{CE(s)} = -0.25$ V maximum with $I_C = -1$ A, $I_B = -0.1$ A. And on top of all that, eight types are available meeting military specifications, all capable of 12 watt operation at a case temperature of 55°C.

So if you're interested in transistors for audio amplifiers, pulse amplifiers, relay drivers or switching, contact your nearest Bendix Semiconductor sales office. They have complete data on our entire germanium transistor line. And, if you're interested in saving space in any sort of a transistor application, ask them what Carmine Labriola has been up to lately. It won't be anything very big.



TYPE NO.	I_C A	V_1 V	V_2 V
2N1038,-1,-2	3	30	60
2N1039,-1,-2	3	40	70
2N1040,-1,-2	3	50	80
2N1041,-1,-2	3	60	90
2N1042,-1,-2	3.5	30	60
2N1043,-1,-2	3.5	40	70
2N1044,-1,-2	3.5	50	80
2N1045,-1,-2	3.5	60	90
2N2552	3	30	60
2N2555	3	60	90
2N2559	3	60	90
2N2563	3.5	60	90
2N2567	3.5	60	90

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Meetings

Reliability and Quality Control National Symposium, ASQC, IEEE, IES, SNT; Hotel Fontainebleau, Miami Beach, **Jan. 12-14.**

NSPE Winter Professional Meeting, National Society of Professional Engineers; Jung Hotel, New Orleans, La., **Jan. 20-23.**

Fundamental Phenomena in the Material Sciences Annual Symposium, Ilikon Corp.; Sheraton Plaza Hotel, Boston, **Jan. 25-26.**

Integrated Circuits Seminar, IEEE; Stevens Institute of Technology, Hoboken, N.J., **Jan. 28.**

Northwestern University Science Symposium, NU; Pick-Congress Hotel and Thorne Hall of Northwestern University, Chicago, **Jan. 28-29.**

Winter Power Meeting, PEEC/IEEE; Statler-Hilton Hotel, New York, **Jan. 31-Feb. 5.**

Institute on Information Storage and Retrieval, The American University; Willard Hotel, Washington, **Feb. 1-4.**

On-Line Computing Systems Symposium, UCLA Extension Service, Informatics, Inc.; University of California Los Angeles, **Feb. 2-4.**

Winter Convention on Military Electronics, PTGMIL & L.A. Section of IEEE; Ambassador Hotel, Los Angeles, **Feb. 3-5.**

Electrical/Electronic Trade Show, Electrical Representatives Club, Electronic Representatives Assn.; Denver Auditorium Arena, Denver, **Feb. 15-17.**

Solid-State Circuits International Conference, University of Pennsylvania, IEEE; University of Pennsylvania and Sheraton Hotel, Philadelphia, **Feb. 17-19.**

Annual West Coast Reliability Symposium, ASQC, UCLA; Moore Hall, University of California Los Angeles, **Feb. 20.**

Particle Accelerator Conference, AIP, NSG/IEEE, NBS, USAEC; Shoreham Hotel, Washington, **Mar. 10-12.**

ISA National Conference on Instrumentation for the Iron and Steel Industry, ISA; Pick-Roosevelt Hotel, Pittsburgh, **Mar. 17-19.**

Management Conference on Operations Research, Systems Engineering and Electronic Data Processing, University of Pennsylvania, Philadelphia, **Mar. 17-19.**

IEEE International Convention, IEEE; N.Y. Coliseum and New York Hilton Hotel, New York, **Mar. 22-25.**

Society of Motion Picture and Television Engineers Semiannual Conference and Exhibit, SMPTE; Ambassador Hotel, Los Angeles, **Mar. 28-Apr. 2.**

Electron Beam Annual Symposium, Pennsylvania State University, Alloyd Corp.; Pennsylvania State University, University Park, Pa., **Mar. 31-Apr. 2.**

Electronic Parts Distributors Show, Electronic Industry Show Corp., New York Hilton and Americana Hotels, New York, **Mar. 31-Apr. 4.**

National Packaging Exposition, AMA; McCormick Place, Chicago, **Apr. 5-8.**

Cleveland Electronics Conference, Cleveland Electronics Conference, Inc., IEEE, ISA, CPS, Western Reserve University, Case Institute of Technology; Cleveland Public Auditorium, Cleveland, **Apr. 6-8.**

Conference on Impact of Batch-Fabrication on Future Computers, PGEC/IEEE; Thunderbird Hotel, Los Angeles, **Apr. 6-8.**

IEEE Region 3 Meeting, Robert E. Lee Hotel, Winston-Salem, N.C., **Apr. 7-9.**

Electronic Components International Exhibition, FNIE, SDSA, Parc des Expositions (Fair Grounds), Paris, **Apr. 8-13.**

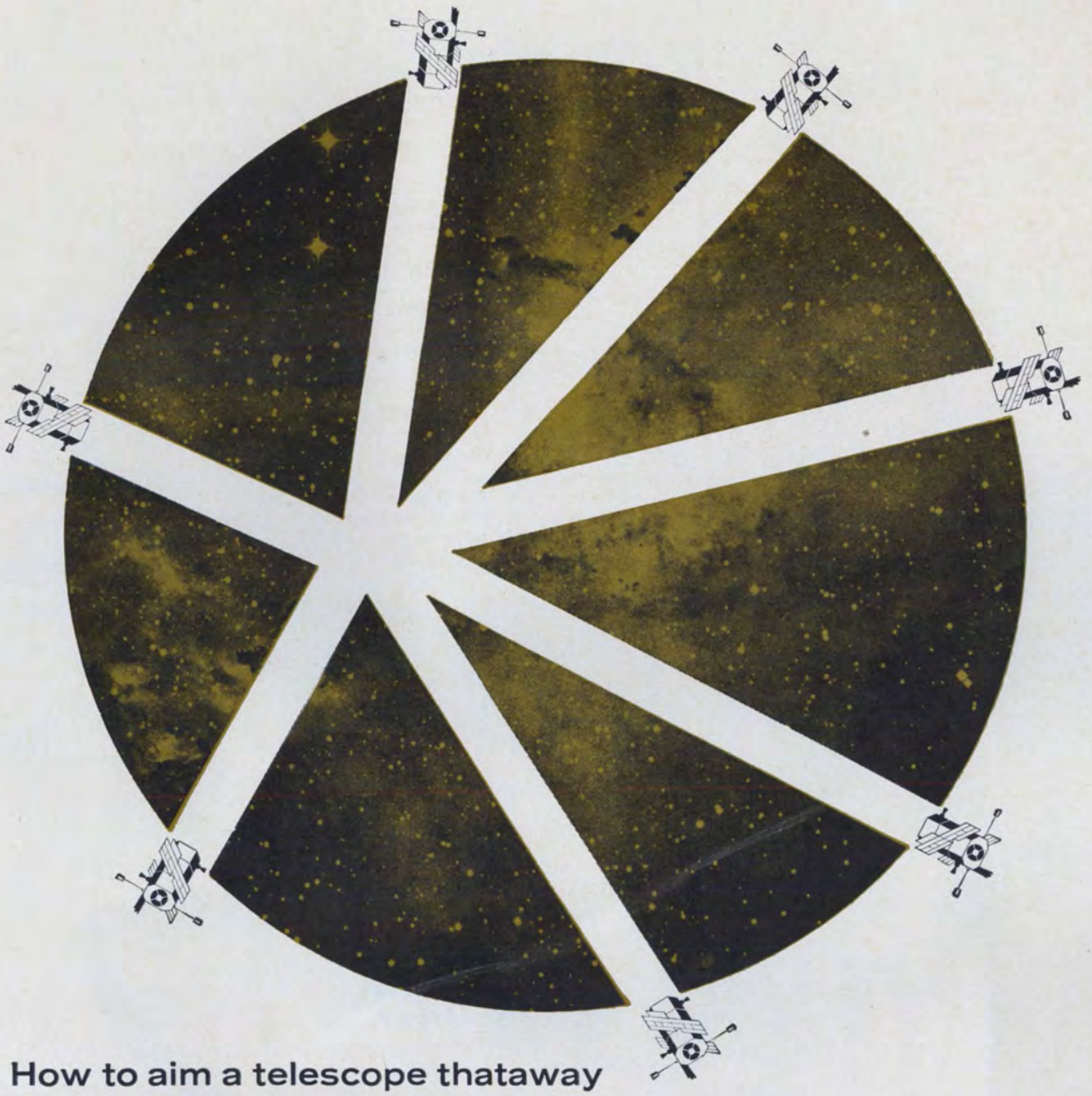
IEEE Region 6 Annual Conference, Nuclear Rocket Development Station, Development Station, Las Vegas, **Apr. 13-15.**

Telemetering National Conference, AIAA, IEEE, ISA; Shamrock-Hilton Hotel, Houston, Tex., **Apr. 13-15.**

Electronics Instrumentation Conference and Exhibit, IEEE, ISA; Cincinnati Gardens, Cincinnati, **Apr. 14-15.**

Call for papers

Opto-Electronic Components and Devices Symposium, AGARD; Paris, Sept. 6-9. **Feb. 1** is deadline for submitting abstracts to Daniel Coulmy, DRME, 7 rue de la Chaise, Paris, 7, France. Papers are invited on devices having electronic input and output but using photons in an intermediate stage; or on components in which the electrooptical transformation or the optical processing occurs.



How to aim a telescope thataway when it's 23,000 miles in space

... that was the astronomers' eventual problem. Plans call for placing a 3600-pound, 38-inch astronomical telescope in stable orbit in 1965. However, the first step in the solution was to design and build a system which could prove the feasibility of remote control for an earth-bound astronomical telescope. The difficulties of aiming a telescope at a distant star and holding this star in view as the earth rotates, are rather like hitting a rolling penny 20 miles away with a rifle bullet. Astrodata built a control system for the astronomers. The system uses computer-control techniques to acquire 30 channels of analog information from the telescope and transmits information received on various experiments, as they are conducted, to an on-line computer. This computer serves as a stenographer and edits and records the desired data. Certain critical engineering functions (voltages, frequencies, etc.) are also monitored and transmitted to the computer for comparison with their acceptable limits.

Perhaps you don't have an orbiting telescope to control, but you do have other problems in the data acquisition and processing, telemetry, or range timing instrumentation fields where Astrodata's vast experience in dynamic information handling and hybrid computer techniques can help you. *Write for your free copy of our 20-page brochure "Astrodata's Systems Experience".*

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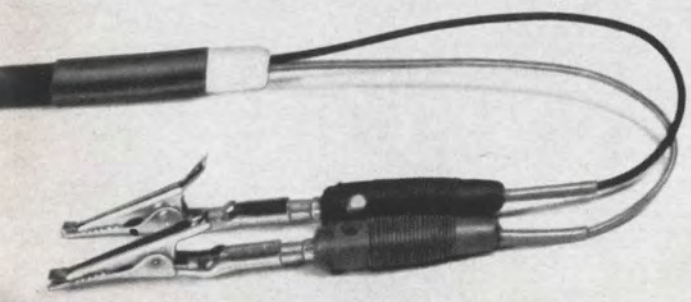
Weston Model 1420

Performance / price breakthrough!



- ±0.05% dc accuracy
- SIX ranges . . . ±20mv to ±1000v
- Input impedance up to 5000 megohms
- Common mode rejection >150 db
- Price: only $1500.00

Another outstanding product from the leader in measurement and display

Range	Input Impedance	Basic Sensitivity*
0—20mv	>50 megohms	10μv
0—200mv	>500 megohms	100μv
0—2v	>5000 megohms	1mv
0—20v	10 megohms	10mv
0—200v	10 megohms	100mv
0—1000v	10 megohms	1v

*Sensitivity on all ranges can be improved by 2 or 4 by increasing counting time. On 20mv range, for example, sensitivity can be increased to 5μv or to 2.5μv.

The PERFORMANCE of the Weston Model 1420 meets industry's need for accuracy, sensitivity, and noise rejection at a BREAKTHROUGH PRICE.

Accuracy: ±0.05% of range or ±1 digit.

Common Mode Rejection: Isolated-guarded "box within a box" construction provides excellent CMRR even with considerable unbalance of input leads.

150 db @ dc } with 5000Ω
130 db @ 60~ } unbalance

Series Mode Rejection: Count times are multiples of 60 cycle period, thus, giving excellent 60db rejection to powerline noise. Rejection to higher frequencies is also realized through integration of signal.

Solid State: All solid-state components except Nixie* readouts. Printed circuit boards are hinged to provide easy access without use of extender boards.

Automatic Polarity: The polarity of the input is sensed and automatically displayed.

Operating Modes: Automatic or Manual-Remote. Automatic mode: voltage is sampled and averaged 40 times/sec. In manual mode, sampling occurs with front-panel push button or by remote switch closure or by pulse.

Calibration: An internal Weston standard cell is built-in for quick "on-the-spot" calibration.

Printer Output: BCD printer output also available at slight addition in price.

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Applications: Ideal for laboratory, production testing or data logging. Excellent sensitivity makes Model 1420 perfect for direct readout from low-level transducers.

This Performance/Price Breakthrough invites action. Call your nearest Weston office or write our headquarters for complete details and/or demonstration. Price is f.o.b. plant. *T.M.—Burroughs Corp.

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FREE!

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by thinking up a new way to use this one.*

Two winners! If you can suggest a unique or economical application for Fairchild's versatile μA702 integrated operational amplifier, you may win a superb SCOTT all-transistor stereo tuner-amplifier* shown above. Fairchild will award *two* of these stereo systems, one prize each for:

(1) the most unusual or original application for the μA702

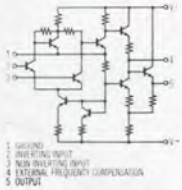
(2) the μA702 application that results in the greatest reduction in system cost.

To enter, simply send us a brief description of your application, including schematic, performance characteristics, and advantages of using the μA702. The box at right contains brief specifications for the Fairchild μA702. If you need more details, write for the data sheet and application note, or contact the nearest Fairchild outlet.

To help spur your thinking, here are a few examples of how the μA702 has been used: dc instrumentation amplifier, video amplifier, level discriminator, and peak-to-peak detector. Your application may be in any field—space/defense, commercial/industrial.

*SCOTT Model 344 uses Fairchild silicon Planar transistors. The system, complete with 2 SCOTT S-5 speakers, retails for $549.85.

***μA 702 OPERATIONAL AMPLIFIER**
INTEGRATED CIRCUIT



- Low input offset voltage: 2mV
- Low Thermal Drift: 5μV/°C
- High voltage gain: 2800
- Large Output Swing: ±5.5V
- Operation over a wide range of supply voltages

Mail your entry before Feb. 15, 1965, to "Contest," Fairchild Semiconductor, Box 880-C, Mountain View, California. The two winners will be picked by a committee of Fairchild applications engineers, and announced in a future Fairchild advertisement. Fairchild reserves the right to retain and publish any circuit design submitted (with appropriate credits, of course).

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Editorial

Engineer's changing outlook

For the electronics industry, 1965 looks like a good year with sales up 2% to $17.7 billion despite a continued cutback in military spending [see pp. 87 to 110]. For the individual engineer it's going to be a year fraught with difficulties but sweetened with opportunity for those who know where to look.

Behind the figures is a story of big change in the industry, a change that is radically modifying the engineer's role.

We think the surplus of engineers will continue this year; in fact, unemployment may even get a little worse before it improves. Still, to those engineers unaffected by layoffs, the change in their responsibilities has already started. And the shape of jobs to come —5 and 10 years from now—figures to depart even more radically from the familiar pattern of the late 1950's and early 1960's.

Nowhere is the engineer's role changing faster than in military electronics, still the biggest part of the industry. He can no longer be as interested in pushing the frontier of technology, because the Defense Department is buying more and more off-the-shelf equipment for aircraft and communications.

Cost-consciousness has suddenly forced the engineer in defense work to modify grandiose plans. The day is ending when "defense-industry profits tend to be maximized by maximizing allowable costs," as the Denver Research Institute declared in a recent report. Now the Pentagon is demanding economy with an insistence that would do credit to a buyer at the cost-conscious General Motors Corp.

Engineers on military projects have to learn to think in terms of flexible products that might be used in many applications, rather than a single system designed for a unique operation.

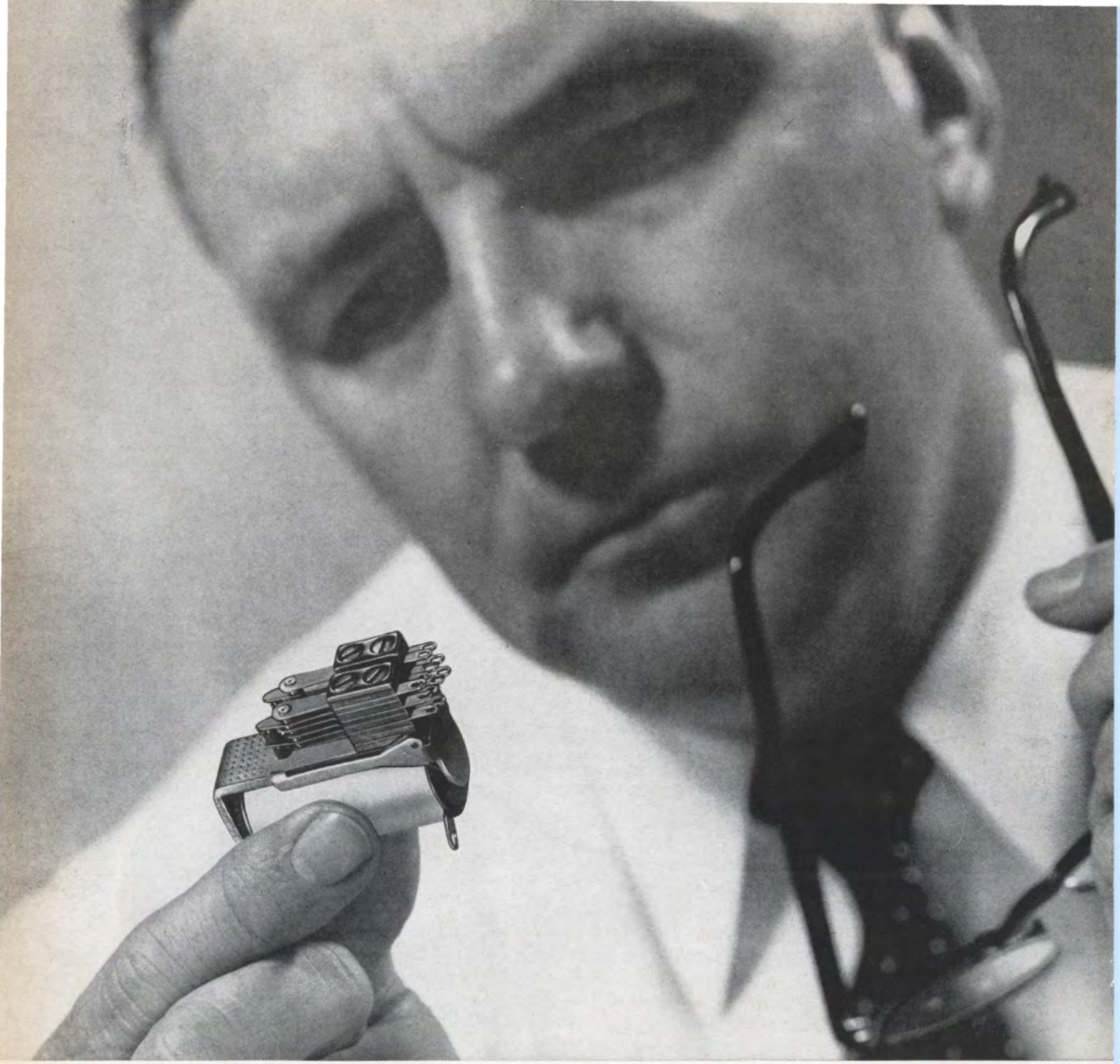
More momentous is the change resulting from the widespread acceptance of microelectronics.

In 1965 for the first time, civilian applications will represent a bigger market than the military for the tiny circuits. In most applications, the reason for the switch is economy. And it is not just a saving of components. Microelectronic circuitry lends itself to automation of manufacture and engineering.

As microcircuits become more common, the design engineer becomes less important and the draftsman is nearly eliminated. In fact, circuit design becomes almost automatic because economy often demands the choice of standard circuits. The big problems become organization of the system and subsystem—putting the off-the-shelf circuits together—also interconnecting and packaging them.

Fortunately for many electronics engineers, these changes are taking place while the industry is enjoying relative prosperity. But there is no guarantee that these good times will last. Now is the time for the engineer to get his personal technological house in order. The scope of his job is growing, and he must increase the breadth of his knowledge.

The alternative is obsolescence.



THIS SENSITIVE RELAY REPLACES COSTLY TRANSISTORS

You can operate this inexpensive relay using low cost, low power transistors. As little as 20 milliwatts of power per movable arm will effect switching. This combination—relays and solid state devices—often results in substantial savings when our ML is used in place of costly power transistors. The ML is especially suited for battery powered equipment.

You can specify up to 18 springs (9 per stack) for multi-pole switching. Single lot prices for standard ML relays range from only $6.05 (DPDT) to $8.60 (6PDT). Ask your P&B representative or write us for complete engineering data.

ML SERIES SPECIFICATION HIGHLIGHTS

Pull-In:
Current: 20 mw min. @ 25°C.
Voltage: 75% or less of nom. DC voltage @ 25°C.

Contacts:
3 amps @ 115VAC, 60 cycles resistive at nominal power. Other ratings available with additional coil power.

Power:
20 milliwatts per movable min., 3 watts max. @ 25°C.

Voltage:
To 110V DC.

Resistance:
33,000 ohms max.

Dimensions:
$1\frac{31}{32} \times \frac{25}{32} \times 1\frac{9}{16}$ (6 Form C).

STANDARD P&B RELAYS ARE AVAILABLE AT LEADING ELECTRONIC PARTS DISTRIBUTORS

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Circle 16 on reader service card

Electronics Newsletter

January 11, 1965

More competition due in transistors?

Texas Instruments, Inc., has begun selling transistors that are packaged in plastic and are made in the unique germanium planar configuration reported early last year [Electronics, April 6, 1964, p. 62]. The prices, 25 to 35 cents each in production quantities, are aimed directly at the commercial market. The first eight transistor lines in the new series are for radio and television.

TI's transistors are competitive with plastic-cased, silicon planar transistors offered by other producers. The General Electric Co., which had a virtual corner on the plastic-cased transistor market for two years, has more than 50 types that are priced as low as 22 cents in lots of 10,000. **The Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp. has been cutting into GE's business with a line of silicon planar transistors costing as little as 28 cents in lots of 1,000.**

A Fairchild executive says it makes sense to produce industrial transistors on special lines and to take advantage of the savings made possible by the less rigid specifications required by consumer-industrial customers.

GE says it has sold more than two million plastic-cased units. One Fairchild device, a pnp replacement for the 2N404, is in short supply and production is being adjusted to meet the demand. Even the military is buying some plastic units.

Pentagon drafts Syncom II and III

The military is taking over full control of Syncom II and III from the National Aeronautics and Space Administration. The move may provide a big boost to the Hughes Aircraft Co., which developed the communication satellites.

The military, plagued with poor communications between Washington and South Vietnam, has been using the twin satellites as an emergency radio link. The space agency has about completed its series of tests with the satellites.

The transfer will be completed April 1. In the meantime, the Navy will conduct tests with the satellites. The guided-missile cruiser Canberra is being fitted with electronic equipment for the tests. Additional gear will be supplied by Hughes.

In mid-February, Syncom II will be shifted from its orbit over the Pacific to one over the Indian Ocean.

Electronic voting is election winner

Despite sabotaged pens, human errors and other problems, **electronic voting machines [Electronics, Nov. 2, p. 24] seem to have passed the tests of the November elections.** Late in December a manual recount in Contra Costa County, Calif., indicated a net change of only 11 votes in ballots counted by the Coleman Engineering Co's Vote Tally system. Election officials accepted the Coleman count as official.

Orange County supervisors in December approved the lease-purchase of two units that were used on Nov. 3. **The only problem encountered was the sabotage of pens used to mark the ballots.**

Two Coleman units have also been purchased by Hamilton County, Ohio. Coleman officials say six other counties in the Midwest are con-

sidering purchase of the $850,000 system.

Other systems reporting successful tests included the Votronics manufactured by the Cubic Corp., the Votomatic made by Harris Votomatic, Inc., the Vote Master by the Cybernetics General Co. and the Coyle by the Coyle Voting Machine Co.

Companies reported that some changes are being made. George Tweed Jr., corporate director of engineering at the Cubic Corp., said, "The difficulties were primarily with people not following instructions. The action we are taking is to reduce the human participation as much as possible."

Higher Telpak rates ordered

Customers of the Bell System's bulk communication package face paying higher rates for the service.

The Federal Communications Commission has ordered the American Telephone & Telegraph Corp. to raise its prices for Telpak's Class A (12 circuits) and B (24 circuits) and to come up with more cost figures to support its rates for Class C (60 circuits) and D (240 circuits). AT&T has until September to file new tariffs.

AT&T is expected to ask the agency to reconsider its decision; meanwhile, some Telpak users may file to alter the FCC's ruling. And the General Services Administration, a major user, may try to pressure the FCC to reconsider.

FET's may enter consumer market

Field-effect transistors may soon be breaking into the consumer market.

Crystalonics, Inc., is about ready to announce two junction FET lines that are designed to interest manufacturers of radio, television and high-fidelity sets. One of these transistor lines will be called gigafets; **the units are designed for high-frequency applications and will carry ratings of as high as two watts.** Military and industrial gigafets will also be available. The second line will consist of a low-power FET's.

The General Instrument Corp. will offer a metal-oxide-semiconductor FET line specifically designed for the consumer market. The company also is bringing out a line of monolithic integrated circuits for the consumer market.

Major market for avionics

The super-size jetliner proposed for the military is expected to open an avionics market estimated at $100 million to $200 million. And if the commercial airlines decide to buy the craft, the sales figure could more than double. The plane would be able to carry 600 to 700 troops.

The Air Force expects to spend $750 million for development and an additional $1 billion to purchase 58 of the subsonic C-5A's.

In addition to standard navigational gear, the C-5A will carry inertial and doppler systems and terrain-avoidance radar for low flying. An all-weather landing system is expected to be standard equipment.

California contract to Aerojet-General

Aerojet-General Corp. has won the first of four study contracts that California plans to award to aerospace companies in a move to tackle down-to-earth problems. The company, a subsidiary of the General Tire & Rubber Co., received a $100,000 contract to apply its engineering and systems development techniques to a long-range plan for disposing of industrial and human wastes.

All these great component names are now one

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Printed circuit connectors, including new "Flex-1" flat cable connector

Rack-and-Panel connectors, including famous "Blue Ribbon"

MIL-Spec, AN/MS, and hermetically sealed connectors

Commercial plugs, sockets, receptacles, radio & tv components

Amphenol® CONNECTOR DIVISION

Now you see just one man

You assign responsibility to one man . . . from Amphenol.

Your nearby Amphenol man can give you complete specs, quantity discounts, and performance data on any connector you see here.

Printed circuits? He can show you dozens of PC connector types. And our new "Flex-1" flat cable connector that will let your production people weld 1,000 contacts an hour!

Reliability is designed into Amphenol *rack-and-panel* connectors. One example: 10,000,000 Blue Ribbon connectors have been used without a single reported failure. Our new 217 Series environmental model is the ultimate in ram-home reliability.

Amphenol *military* connectors can be found at almost every USAF, USN, Army, and NASA installation. Reliability is one of the key reasons. (Field data shows a failure rate of only 0.048/million hours on jet aircraft.)

Commercial electronics is big business at Amphenol. We make—and over 500 distributors carry on their shelves—just about every commercially used plug, socket, jack, microphone and circuit breaker type connector, in addition to military connectors.

So talk to your Amphenol Sales Engineer. Or write to: *Amphenol Connector Division,* 1830 S. 54th Avenue, Chicago, Illinois 60650.

Circle 151 on reader service card

Coaxial connectors for rf, audio, and pure power uses

Coaxial switches—low frequency, high frequency, solid state, and specials

Microwave components: rotary joint (top), cross guide coupler (bottom)

Amphenol® RF DIVISION

for any connector or rf switch

Coaxial connectors, coaxial switches, custom microwave components are products of Amphenol RF Division.

That *pulse receptacle,* for example, at the top left of the picture is one of our standard, high voltage connectors. Whatever *coaxial connector* you need, Amphenol's got it. We make standards and specials for radar, microwave, communications and more.

Take the *EDO sonobuoy connector* you see above (lower left). This is just one of hundreds of special military and commercial connectors we build.

Coaxial switches are our bread and butter. (Ask anyone who the world's leading supplier is.) We've made over 1,500 kinds.

Let's examine the five Amphenol coax switch types in the picture. The high-power, multi-position switch (top) is used for low frequency antenna switching aboard submarines. The high-frequency remote latching type, the SPDT and our manual high-frequency, multi-position switch are more common. The compact, ganged array you see below is now used for switching bright display radar at FAA installations.

Amphenol is big on *microwave components,* too. Just give us a chance to describe our unique capability.

Who makes all these great components? *Amphenol RF Division,* 33 E. Franklin St., Danbury, Conn. 06813.

Circle 152 on reader service card

Top to bottom: Coaxial cable, Triaxial polyfoam cable, Twin-Axial cable, Multi-conductor cable, Miniature Teflon cable

Top to bottom: Aluminum jacketed cable, Copper jacketed cable, High voltage wire, Antenna wire, Messenger supported coaxial cable

Amphenol® CABLE DIVISION

Ask your Amphenol man about cable, harness

Isn't it just common sense for your Amphenol connector man to know about cable, too?

He can get you any of the cables shown in this picture—and dozens of others, both catalog and special items.

We are probably best known for our *coaxial cable*, especially the RG types.

But maybe you didn't know we make *multi-conductor cables*, too . . . from subminiature to greater than two inches in diameter. Or that our catalog lists a 1000°F flexible cable.

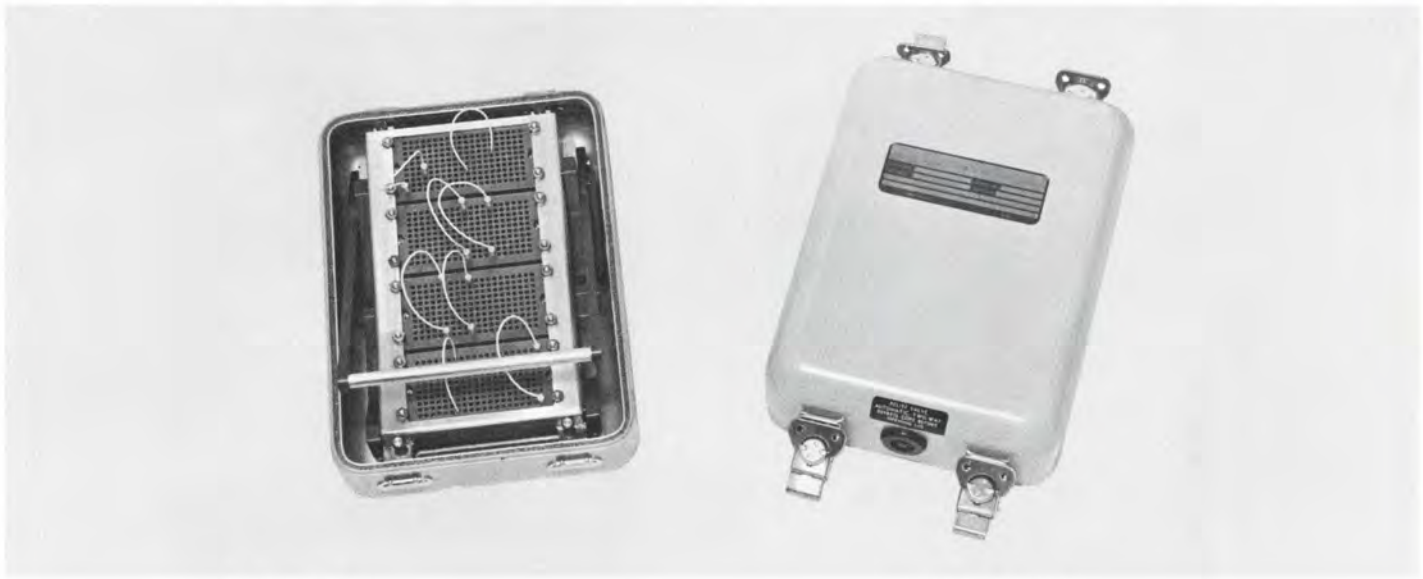
Amphenol gives you one of the biggest selections of jackets—copper, aluminum, PVC, dacron, fiberglass, polyethelene, polyurethane, and heat-shrinkable materials.

We don't claim to be the world's largest supplier of cable—yet. But we do have a big selection. And if you are concerned with on-the-spot availability, you will be pleased to know that Amphenol has over 500 distributors throughout the country who carry Amphenol cable in stock for immediate delivery.

Our engineers thrive on problems that may give you headaches. So don't forget to mention your current cable, wire, or harness problem to your Amphenol Sales Engineer next time you see him.

Or drop us a line at *Amphenol Cable Division*, 6235 S. Harlem Avenue, Chicago, Illinois 60638.

Circle 153 on reader service card



Top: Special ICBM instrumentation connector

Bottom: Patch panel

Amphenol® SPACE AND MISSILE SYSTEMS

assembly, and special interconnections

"You could save thousands of dollars in time alone if you could change circuitry in 90 seconds without removing or unmating a connector." Right. So we developed a Patch Panel that guarantees accurate mating and unmating of 800 contacts just by moving a lever. Old circuit panels are simply lifted out and replaced with pre-programmed ones. That's what we mean by design capability at Amphenol.

"It's going to have to stand temperatures to 5000°F for 2½ minutes." Fine. We delivered the Aft Umbilical connector for Polaris. That's a sample of the environmental protection you can get from Amphenol.

"It must meet the highest reliability of any operational ICBM program." So Amphenol Space & Missile Systems introduced the first stretch cable which allows for thermal expansion of solid fuel bottles with no induced stress on circuit wiring.

We've solved interconnection problems involving oceanic, man-made and space pressures, requiring hermetic seals, meeting elevated or cryogenic temperatures, as well as complying with man-rated reliability programs. Our experience can save your project time and money from design through production. Ask your Amphenol man. Or write *Amphenol Space & Missile Systems,* 9201 Independence Avenue, Chatsworth, California 91311.

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Trimmers—
wirewound and
infinite resolution types

Precision potentiometers—
single turns, 3-turns,
and 10-turns

Turns-counting dials—
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digital types

Subfractional
hp motors—
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and hysteresis types

Amphenol® CONTROLS DIVISION

He can help you trim circuits down to absolute

Your Amphenol Sales Engineer lets you choose from the world's largest selection—whether *you* need a military trimmer, a precision potentiometer, a subminiature dial, or a special low-inertia motor.

We have an infinite resolution trimmer with an ultra-low temperature coefficient. We have a subminiature trimmer with excellent resolution priced under $1.50. And others with high temperature or humidity-proof features (or both) in either rectangular or square packages.

Amphenol has one of the most reputable names in *precision potentiometers*—and one of the oldest. Lift off the case of almost any instrument, control, or servomechanism and you'll probably find an Amphenol Micropot® at work.

Dials? We not only offer you the biggest selection, but you can have a standard Microdial® *customized,* color-coded, or with dozens of options and variations to upgrade your product or control panel.

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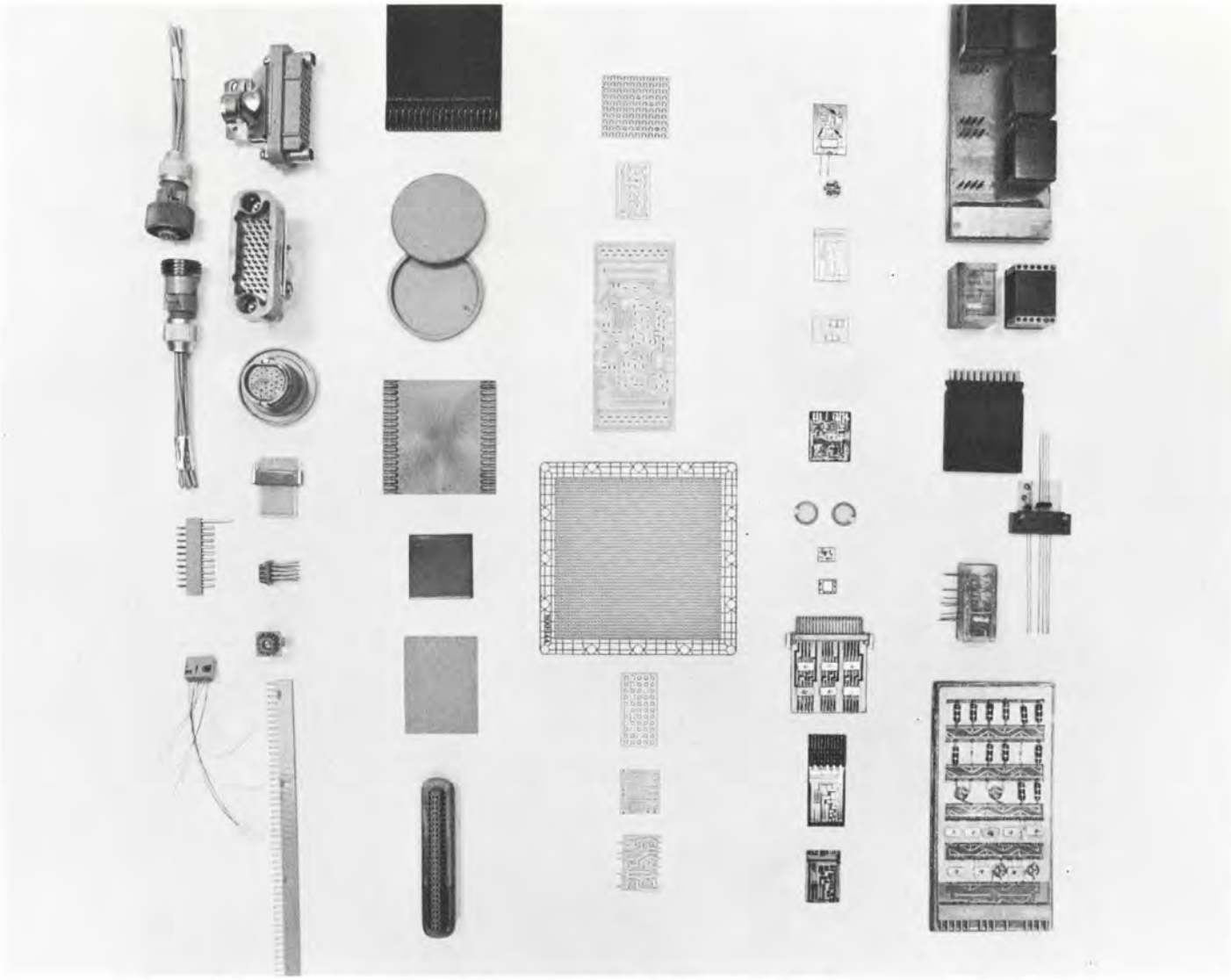

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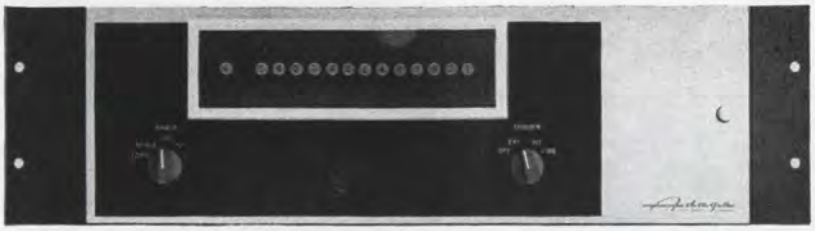

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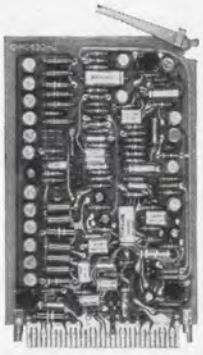

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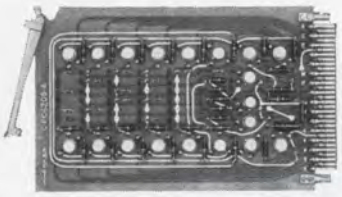

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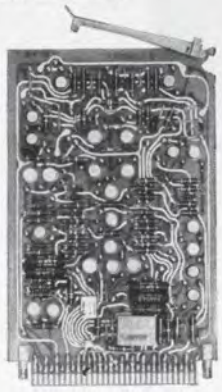

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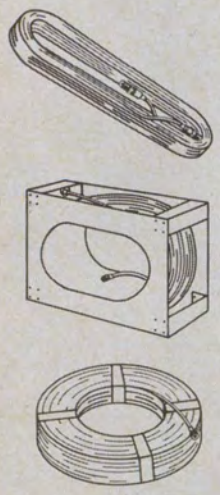
DELAY LINES



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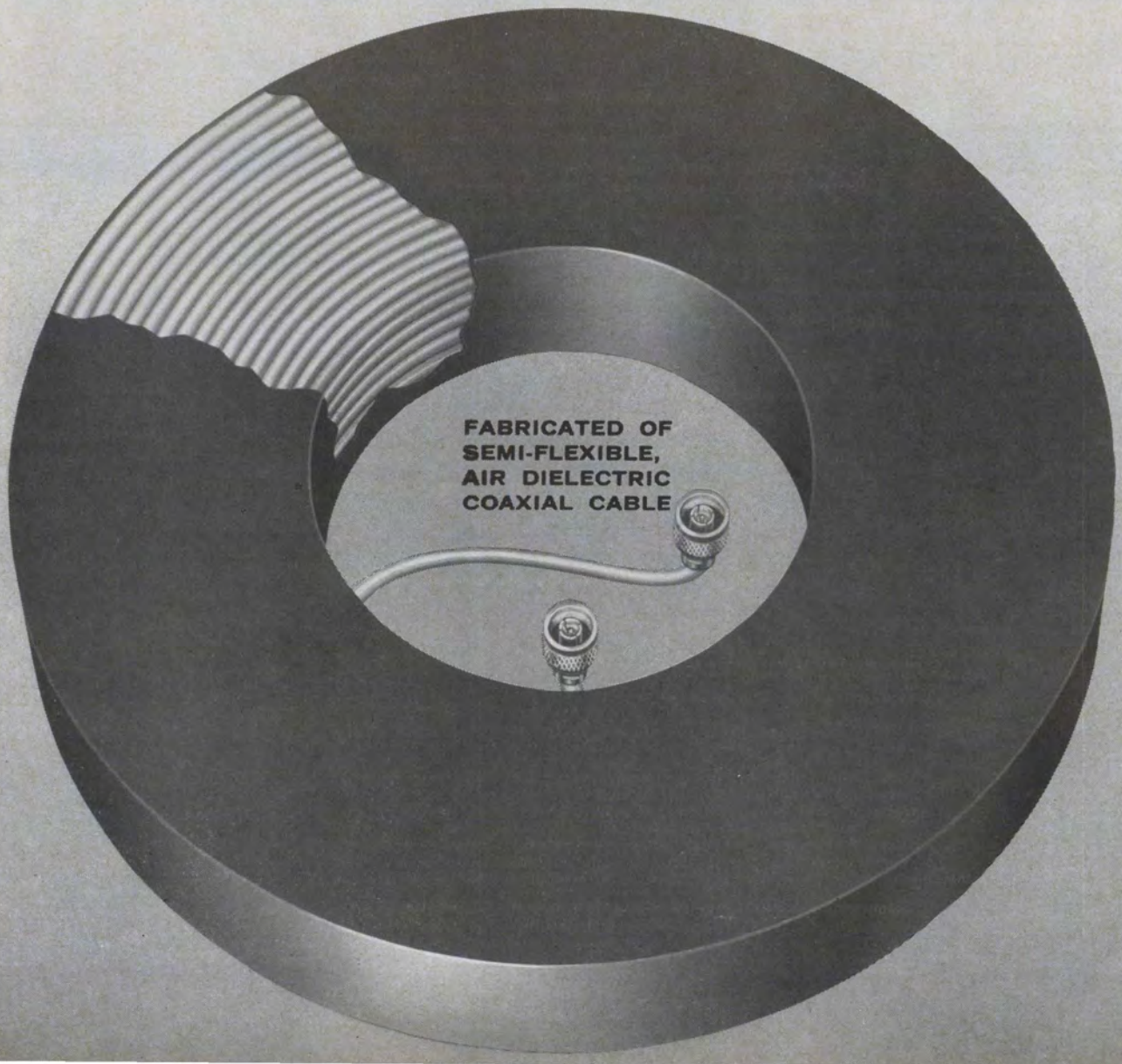
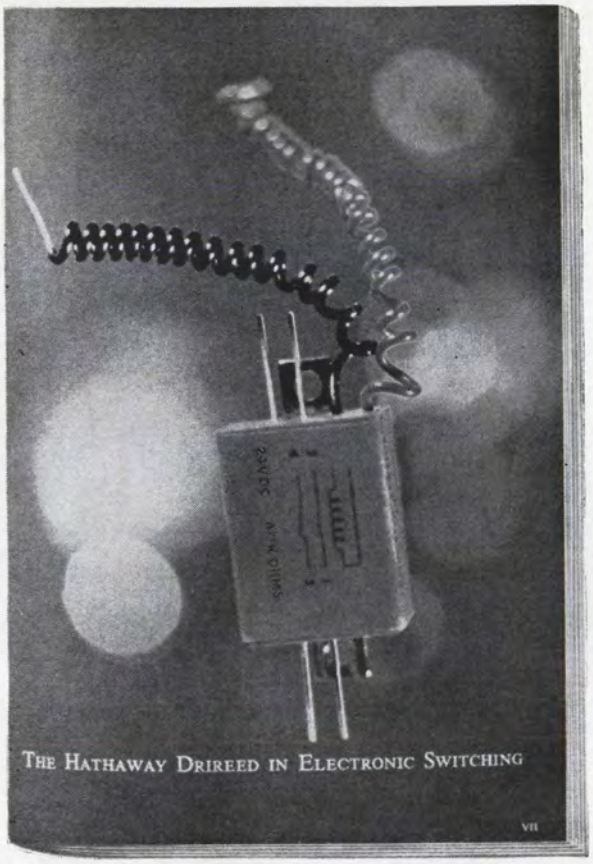


Here's everything you need...



56 pages
of relay principles,
contact characteristics
and testing parameters

to properly utilize and specify the reed relay

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INSTRUMENT GRADE STYLES

Daven Type	Dia.	Length	Max. Watts @ +150°C	Max. Res.	Lead AWG	Features
DAX ½	3/32	3/16	.15	4K	#22	Economy Line with improved performance characteristics at considerably lower prices.
DAX 1	3/32	13/32	.33	7.5K	#22	
DAX 2	3/32	½	.66	20K	#22	
DAX 2B	3/16	5/16	.66	15K	#20	
DAX 3	¼	5/8	1.0	30K	#20	
DAX 3A	¼	13/16	1.0	35K	#20	
DAX 5	3/16	13/16	1.5	60K	#20	

SUBMINIATURE STYLES

Type	Dia. (Inches)	Length (Inches)	Max. Watts @ +125°C	Max. Volts	Max. Res. .001" Wire	Leads AWG	Max. Res. .0006" Wire
1409	.1	.235	.03	100	7.5KΩ	#24	50KΩ
1282	.125	.312	.05	100	16KΩ	#22	100KΩ
1402	.142	.375	.1	150	30KΩ	#24	175KΩ
1403	.160	.500	.125	200	50KΩ	#22	400KΩ
1274	.187	.375	.125	200	60KΩ	#22	600KΩ

Features — Epoxy encased for max. insulation, & dielectric qualities designed for structural strength. Meets or exceeds MIL spec rates.

HI-RELIABILITY — AXIAL LEAD STYLES

Daven Type	Dia. (Inches)	Length	Max. Watts	Max. Volts	Max. Res. .001" Dia. Wire	Lead AWG
HR1282	.125	.312	.05	100	16K	#22
HR1258	.250	.30	.125	100	127K	#22
HR1250	.250	.50	.15	200	226	#20
HR1195	.250	.75	.25	300	511	#20
HR1257	.312	.812	.50	300	750K	#20
HR1252	.375	1.0	.75	600	1.5 Meg.	#20
HR1172	.500	1.0	1.0	600	2.0 Meg	#20

Features — Current failure rate of .02%/1000 hrs at 60% confidence. Over 10 million test hours accumulated with 8,627 units.
Conditions: At +125°C and max rated power.
Definition of failure: △R ±.5%.

POWER WIRE WOUND (Per MIL-R-26)

Daven Type	MIL Type	Char. "V" Watts	Dia.	Length	MIL Max. Res.	Commercial Max. Res.
DAC-7	RW55	7	½	1⅜	5K	90K
DAC-10	RW56	14	½	2	9K	175K
DAS-5	RW57	6.5	5/16	1 5/16	3.5K	60K
DAS-10	RW58	11	⅜	1 3/16	8K	175K
DAS-2	RW59	3	3/32	½	.9K	20K

HI-FREQUENCY STYLES — AXIAL LEAD

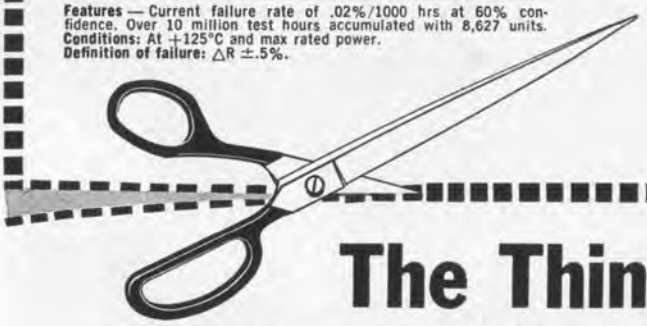
Daven Type	Dia.	Length	Min. Res.	Max. Res.	Max. Watts	Features
1301	¼	½	5K	150K	.15	Designed to provide a rise time of less than .1 μsec (from 10% to 90% of peak pulse amplitude).
1302	⅜	⅝	5K	150K	.15	
1303	¼	¾	5K	250K	.25	
1304	⅜	¾	5K	250K	.3	
1305	¼	1	5K	500K	.5	

MIL-R-93 AND MIL-R-9444 STYLES

	Daven Type	MIL-R -93C	MIL-R -9444	Dia. (Inch.)	Lgth. (Inch.)	MIL Watts	MIL Max. Volts	MIL Max. Ohms	Lead AWG
*	1283	RB56	—	¼	11/32	.125	—	127K	#20
*	1250	RB55	AFRT10	¼	½	.15	—	226K	#20
*	1195	RB54	AFRT11	¼	¾	.25	300	511K	#20
	1251	RB53	AFRT12	⅜	¾	.33	300	750K	#20
*	1252	RB52	AFRT13	⅜	1	.5	600	1.5 Meg.	#20
	1172	RB57	AFRT14	½	1	.75	600	2.0 Meg.	#20
	1178	RB58	AFRT15	½	1½	1.0	900	3.0 Meg.	#20
	1179	RB59	AFRT16	½	2	1.25	1200	5.11 Meg.	#20
	1173	RB08	AFRT17	½	½	.25	300	5.11K	#20
	1269	RB16	AFRT18	5/16	⅝	.33	300	1.0 Meg.	#20
	1270	RB17	AFRT19	5/16	1	.5	600	2.0 Meg.	#20
	1176	RB18	—	¾	1¼	.75	600	3.01 Meg.	#20
	1271	RB19	—	13/16	2 3/32	1.0	900	6.04 Meg.	#20
	1355	RB70	—	⅜	½	.25	150	301K	#20
	1350	RB71	—	¼	5/16	.125	—	100K	#22

Features — Many of these styles are available in decade values to ±.01% from factory stock to insure prompt delivery.

In stock for 48 hour delivery in standard decade values



The Thinking Man's Guide to Wire Wound Resistors

If you're thinking about precision wire wound resistors, you've stopped at the right page. Above, in a few square inches, is a short Guide from the folks who have been making them for over 30 years.

Daven, one of the originators of precision wire wound resistors, is today the world's leading source.

Here are the reasons:

- Daven wire wound resistors come in more lead types, including axial wire, radial wire, printed circuit wire, radial lug, printed circuit lug, plus most other wire lead materials and platings.
- Daven wire wound resistors come in 385 styles, including epoxy, varnish or silicone coated; metal encased; solder sealed.
- Daven wire wound resistors come in more sizes, from .1" diameter by .235" long to ⅞" diameter by 2⅛" long.
- Daven wire wound resistors range from 1 milliohm to 25 megohms.
- Daven wire wound resistors feature the highest reliability, with over 11,000,000 test hours at a calculated failure rate of .02% per 1000 hours on full power at 125° C!

There's more to know, of course. For an extensive course on the subject, or details on a particular type, write today!

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McGRAW EDISON

923A

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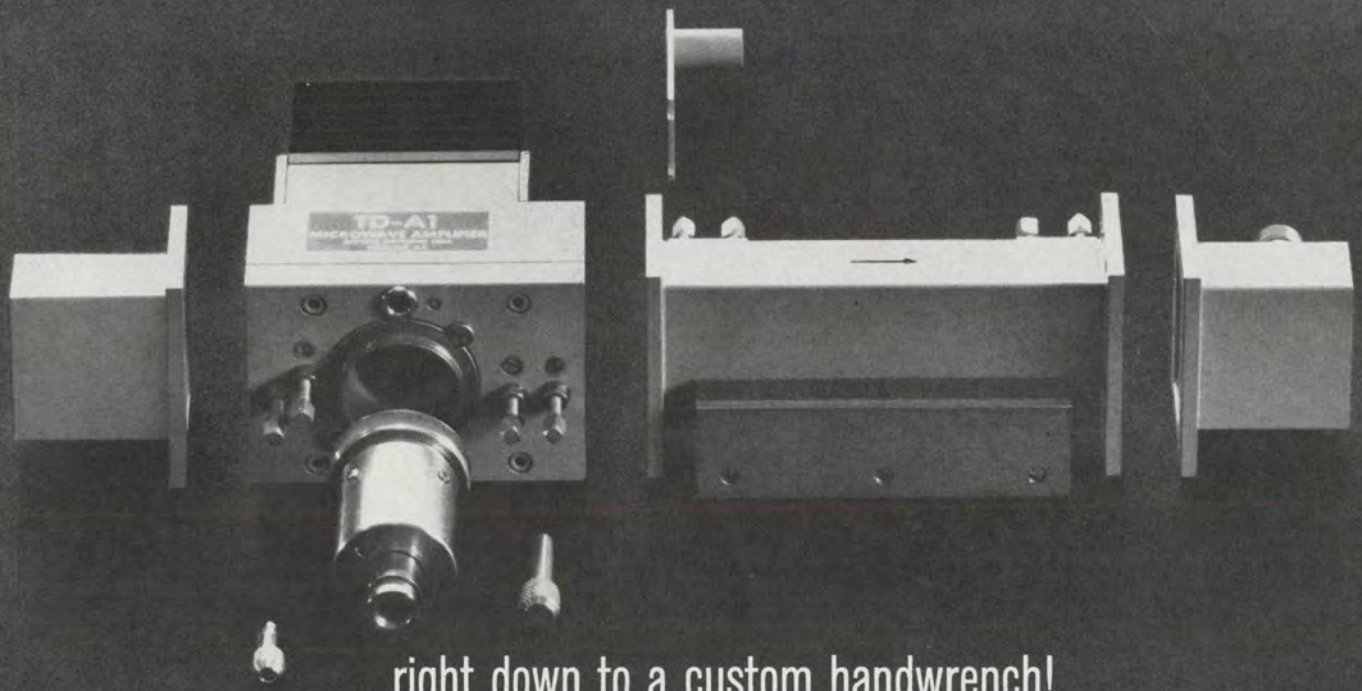
These Amperex microwave triodes are worth designing special hardware for...

So we did—



right down to a custom handwrench!

Taken singly, or as a pair, these two disc-seal 2-6 Kmc triodes with 2 or 5 watts output—the Type 8108 and Type 8436 respectively—are unbeatable! Unbeatable because they are available off-the-shelf with matched cavities, wave-guides, attenuators and isolators to fit your particular application. Unbeatable because both tubes are warranted for 6000 hours (their actual life expectancy exceeds 10,000 hours) and yet cost you considerably less (cavities and all) than a travelling wave tube system. Unbeatable because both operate at only 180 volts, thus simplifying power supply, insulation and safety problems.

The 8436 offers from five to seven watts minimum power output in the S (2-4 Kmc) or C (4-6 Kmc) band, as you specify. As a broad-band power amplifier it will deliver 5 watts out at 4200 Mc, with a power gain of 6 db over a 50 Mc bandwidth (0.1 db points). The 8108 is a 2-watt power output version of the 8436 and is mechanically identical to it.

In addition to unattended link, telemetry and industrial microwave communications applications, either tube can be used as an oscillator or frequency doubler.

For additional information on the 8436, 8108 and other Amperex tubes (and associated hardware) for microwave applications, write: Amperex Electronic Corporation, Microwave Tube Department, Hicksville, Long Island, New York, New York 11802.

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features:

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- **Direct reading**
- **Easily calibrated**
- **Fully automatic operation**
- **Outputs for control, recording, or telemetry**
- **Modular construction**
- **High reliability**

The PAR Model DTS-1 offers a new order of reliability, convenience, and accuracy in laboratory and process control thermometry. The unit operates by comparing the resistance of a sensor element of platinum (the material whose characteristics define the International Temperature Scale) with an internally generated reference function which employs a unique resistance analog network** that precisely duplicates the temperature-versus-resistance change of platinum. This method allows an absolute accuracy* of 0.1°C to be achieved. A modified self-balancing Kelvin bridge eliminates sensor lead resistance errors, permitting precise remote temperature monitoring.

In addition to the direct visual readout, measured temperature information is available in binary coded or 10-line decimal form for printer or computer input as well as in pulse code modulated form for telemetry applications. For temperature control or strip-chart recording applications, an analog signal is provided which is proportional to the difference between the measured temperature and the desired temperature selected by front panel thumbwheel switches.

All circuits use solid state components except the comparator amplifier where two miniature nuvistor tubes are used to obtain high input impedance and the reference function generator where mercury-wetted relays are used. The entire Kelvin bridge, including the resistance analog network, is isothermally enclosed to assure a high degree of accuracy and good long-term stability. Rugged modular construction, utilizing printed circuit boards, contributes to reliable performance and extended service-free life.

Price: Approx. $4,000 (excluding probe). Write for Bulletin #118.

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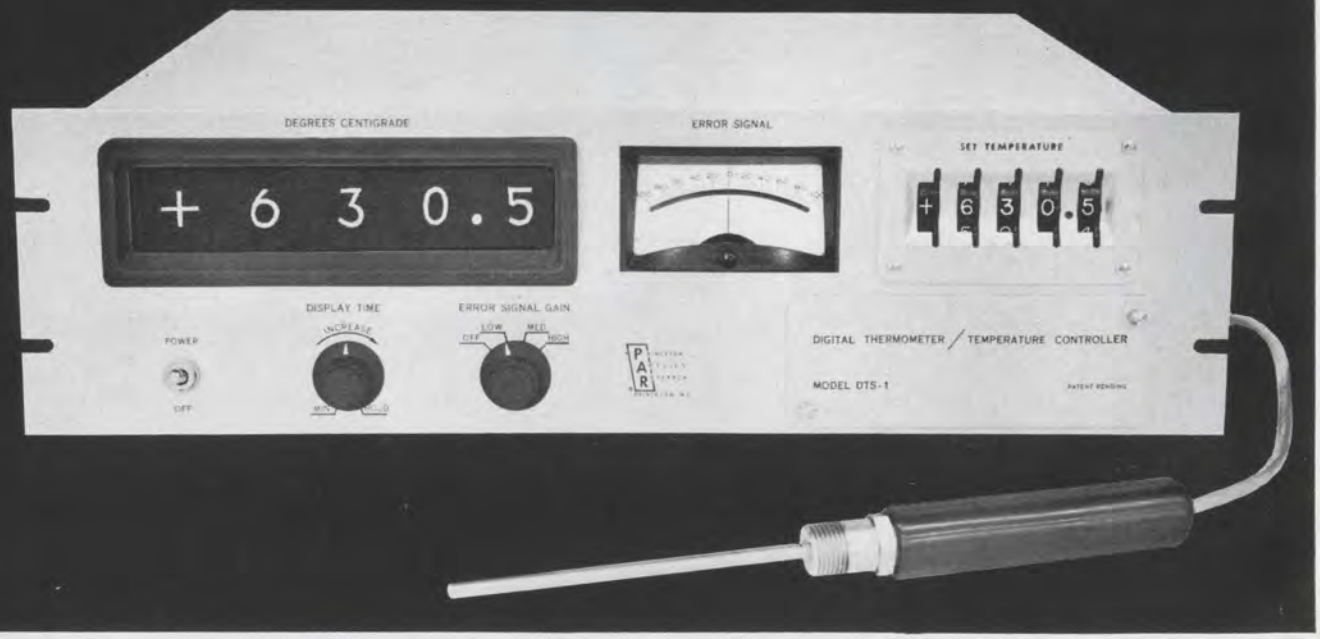


January 11, 1965

Electronics Review

Volume 38
Number 1

Manufacturing

Ion plating

Today's thin-film plating methods are good, but far from ideal. Some films won't stick to other films, and the best of films will peel off if the substrate isn't scrupulously clean or heated to the right temperature.

These difficulties have been overcome, for most of the materials useful in electronics, by a technique developed over the past two years by Donald M. Mattox, of the Atomic Energy Commission's Sandia Laboratory in Albuquerque, N.M.

Mattox calls it ion plating, because he scrubs the substrate by ion bombardment and then slams ionized metal atoms into the atomically clean surface. The film that forms generally adheres so tightly that the substrate breaks before the film can be pried loose.

All-purpose technique. Ion plating can be used to coat ceramic parts with brazing and soldering metals, to form electrodes on ceramic or quartz transducers and semiconductors, to plate relay contacts with noble metals, and to make printed circuits.

Mattox says that ion plating is as fast as electrodeposition or vacuum evaporation, and faster than sputtering, vapor plating or conventional ceramic metallizing because the cleaning and deposition steps have been merged into a single process.

Practically any metal can be ion plated onto another metal or ceramic—and not just as thin films. Aluminum films up to 250,000 angstroms thick have been deposited.

Sandia thinks ion plating will prove to be one of the most commercially significant developments to come out of its labs—a claim it can't often make since the main business of the lab is atomic weapons development.

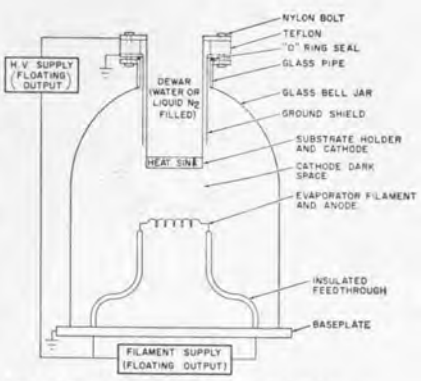
Mattox has reported his experimental methods and results to the Electrochemical Society. Details have also been published in two Sandia reports, SC-DR 281-63 (platings on metal) and SC-R-64-1330 (ceramic metallizing).

Reverse sputtering. Ion plating resembles sputtering, but polarity is reversed. The substrate is the cathode in a high-voltage direct-current system, and the material to be deposited is evaporated at a filament anode. The process takes place in an inert gas at low pressure. Commercial vacuum evaporators can be converted to ion platers.

When the current is turned on, the gas breaks down into ions that bombard the substrate's surface. Contaminants sputter off and the surface is atomically clean in about 30 minutes.

The metal to be plated is then evaporated. Some metal atoms are ionized, so they accelerate to the cathode surface and drive into the substrate. The evaporation rate is increased until more metal is deposited than is sputtered away.

The bombardment heats up the surface, further improving adhesion. In conventional vacuum deposition, the substrate is heated too, but in ion plating most of the substrate can be cooled. This is an important advantage. Heat may change the properties of materials such as piezoelectric ceramic used in transducers.



Heat-sinking cools the substrate while it is bombarded by ions traveling at high speed between the anode and cathode.

Donald M. Mattox converted a vacuum evaporator into an ion plater by putting insulated electrodes in the bell jar.

Deposition rates vary from 500 to 5,000 angstroms per minute. For example, gold is deposited at 1,000 angstroms per minute if the accelerating voltage is 5 kilovolts, cathode current density is 0.3 milliamperes per square centimeter and argon pressure is 10 microns.

The deposition method is similar for metal and ceramic. However, a surface charge that builds up on nonconductors can repel the ions. To get deposition started on insulators, the charge is dispelled by a grid placed in front of the substrate.

Pseudodiffusion. Some films that normally rupture after slight elon-

gation, such as gold on aluminum, withstand 50% elongation when ion plating is used.

Metals that won't normally bond together by diffusion will bond during ion plating by a mechanism that Mattox calls pseudodiffusion. Ion bombardment creates defects in the substrate surfaces; filling these defects locks the film in place.

Mattox can also make graded depositions of different metals, bonded by alloying, by starting to evaporate the second metal before the first is completely evaporated. This is useful for covering oxidizing films, like aluminum, with a more easily soldered or brazed metal like copper.

Another advantage of using a difference in potential to direct the flux is that cavities and odd-shaped parts can be plated. Symmetrical parts, like cylinders, can be plated without rotating the substrate.

Military electronics

A brighter view

Operators of command and control centers want to shed more light on their wall displays.

Scientists at Sylvania Electronic Systems—a division of Sylvania Electric Products, Inc., which is a subsidiary of the General Telephone & Electronics Corp.—will seek to improve electroluminescent techniques in an effort to develop a new generation of brighter and bigger displays. Electroluminescence is light emission resulting from the application of an electric field on phosphors.

Most wall-size displays use film-projection techniques. The units are cumbersome and can only be used in darkened rooms because the display is dim. Large electroluminescent systems have been built, but they too are limited by their lack of light power.

See more. The study is being made under an $87,000 contract from the Rome Air Development Center. Researchers will attempt to develop devices and methods that could lead to the design of large arrays of electroluminescent elements—perhaps a million luminescent dots in a flat panel eight feet square—and capable of displaying numbers, letters, line patterns, vectors and any other computer-generated data.

Sylvania will start by building a much smaller display. Each dot of phosphor will have its own switch, mounted behind an electroluminescent panel. In effect, each switch will perform a memory as well as a control function. When the switch is on, it will stay on until pulsed off, and vice versa. In a monostable device, a computer memory outside of the system recycles the information quickly to prevent flicker. This is unnecessary in a bistable system.

Bistable operation is a major factor in boosting the brightness of the display. The storage of energy behind each dot will permit the full brightness that electroluminescent material can provide, and for as long as the information is desired. Each dot will be energized for the full duty cycle and averaging will not be necessary. In monostable operation, brightness has to be averaged over the full array, so the duty cycle to any single dot is low. The information has to be recycled into the display and each dot pulsed in turn. For example, if there are 30 dots and the array is energized for a 30-millisecond cycle, then each dot will have a duty cycle of only 1 microsecond.

Better phosphors. The company will also evaluate materials. Newly developed plastic-based phosphors are expected to provide brighter displays. Ceramic-embedded phosphors, which are now widely used, will reportedly give a satisfactory yield of 10 to 15 foot-lamberts under steady-state conditions.

Sylvania is developing silicon controlled rectifiers in a solid integrated-circuit configuration to fit the unique needs of the system. Thin-film techniques are being considered for the interconnections. The scr's will have to be smaller than anything currently available with comparable voltage-breakdown and low-current characteristics.

"It's a circuit problem as well as a microminiaturization problem," says Joseph L. Hallett, who heads the Sylvania project. And the integrated circuits must be reproducible and cheap enough to be considered for million-element displays.

A major design consideration is the choice of a technique for isolating the densely packed elements to prevent arcing. The scr's will be operating at about 250 volts a-c near lower voltage circuits. Either a dielectric film or some type of physical separation will be necessary. "Our size and density situation rules out the use of semiconductor junctions as insulating barriers," says Hallett.

Keeping it apart. On each chip there will be an scr, its input circuit and some type of isolation circuit. The scr will have to be less than 20 mils square and each element must be less than 100 mils square to allow for separation between elements.

The Sylvania group is considering an elongated flatpack construction for packaging the integrated circuits and mounting them to the electroluminescent panel.

Employment

'Dehired,' not fired

Defense companies, which are often faced with the problem of dismissing some engineers while hiring others with different specialties, are studying a new plan that they hope will make it easier for the engineers and the companies.

The Martin Marietta Corp.'s subsidiary, the Martin Co., which recently inaugurated the plan, says it is no longer firing key people it doesn't need after a contract is phased out—it's "dehiring" them.

Finding new jobs. Central to the plan is getting the dehired engineers new jobs. Since these men are highly qualified—but not in an area that the company needs at the time—Martin retains a company to help find them jobs.

Martin laid off 162 people recently when the Titan I and II programs were phased into the

Titan III, a much smaller project. The company found that it was overstaffed in some areas while it was hiring new men for work in other fields.

So far, H. H. Harberts Associates, a Los Angeles management consulting concern that is being paid $1,500 a month by Martin, has placed 40 men in equivalent positions and others are believed to have found jobs on their own.

There are two kinds of benefits: Martin is able to get rid of men it doesn't need right now, and other companies get a crack at some competent top-level people.

Company's reputation. Martin considers this important because any dismissal program makes the company look bad and it increases the difficulty of hiring new people. Douglas V. Dorman, Martin's vice president for industrial relations, says, "The company wants to maintain its image as a good place to work."

The government's Bureau of Labor Statistics estimates that 10,000 scientists, engineers and other defense-industry specialists are currently between jobs.

The reaction from other companies has been more than offers of jobs. Paul L. Faranda, supervisor of professional and general employment for the Northrop Corp.'s Nortronics division, says: "Most of us in the business would be interested in a follow-up report." Similar interest was posted by such companies as the Aerojet General Corp., a subsidiary of the General Tire & Rubber Co., and by the Fairchild Camera & Instrument Corp.

So far, the dehiring program includes only men in the $15,000 salary area. No such program is being contemplated for the blue-collar ranks. "They represent a local hiring program," says Dorman.

Advanced technology

Sighting the enemy

Getting the enemy's range during the night or in bad weather may spell the difference between victory and defeat in a military campaign.

Laser range finder can measure distance of a target at night, in fog or in heavy rain. A unique memory device helps the operator pinpoint a target despite nearby clutter.

TRG, Inc., had developed a laser range finder that operates in rain, snow, dead of night and all but the thickest fog and is accurate to within 10 meters. The range finder uses a unique memory arrangement to filter out signals produced by rain, snow flakes or fog.

The instrument comes in two models, a 35-pound portable and a 50-pounder tank-mounted unit.

Small and fast. The company, recently acquired by the Control Data Corp., says the pulse-ruby laser unit is smaller and operates faster than conventional optical instruments. Another advantage: because of a periscope arrangement, the artilleryman need not expose himself to enemy fire to take a measurement.

A 0.2-joule laser pulse 20 nanoseconds long travels through the periscope, hits the target and is reflected back to the instrument. The time it takes for the signal to travel both ways determines the distance to the target. A readout in meters is visible in the range finder's telescope, so the operator can keep his eyes on the target at all times. Ranges can be read between 300 and 10,000 meters.

Radar and relativity

A new test of Einstein's theory of general relativity has been proposed by a scientist at the Massachusetts Institute of Technology's Lincoln Laboratory. Made possible by the development of very-high-power radar, it is the first relativity test devised in 50 years, and the fourth such test ever.

Einstein's theory predicts, among other things, that the speed of a light or radio wave depends on the strength of the gravitational field along its path. Scientists hope to verify this by sending a giant radar pulse to Venus or Mercury in such a way that the pulse and its echo must pass close to the sun. The 300-million-mile round trip will take some 25 minutes, and, if Einstein is right, the sun's gravitational pull will delay the return pulse by about 0.2 millisecond.

MIT's Irwin I. Shapiro believes this delicate measurement can be accomplished using a very-narrow-beam radar antenna, accurate timekeeping techniques and a 500-kilowatt radar transmitter now under development which will work at 8 gigacycles. The 120-foot dish antenna already exists at Lincoln Laboratory's new Haystack Microwave Research Facility in Tyngsboro, Mass. If the transmitter klystron development is completed in time, the experiment can take place this spring, when Venus and Mercury are in a favorable position.

Although radars of comparably high power are not new, they operate in the hundreds-of-megacycles range. At such low frequencies the sun's corona effects would outweigh the relativistic time delay and make the test inconclusive.

Heightened sensitivity. Before undertaking the test, Project Haystack receiver's sensitivity will have to be sharpened by using a maser in its front end; present equipment includes a bank of parametric amplifiers.

The necessary timekeeping equipment already exists at Hay-

stack and at the adjoining Millstone Hill radar installation where, in 1958, radar echoes were first bounced off Venus. The 1958 return echo was so weak it had to be sorted out of background noise by a computer. This time, if all goes well, says Shapiro "there'll be no trouble getting a healthy return signal".

Communications

Sorting space signals

Next month the United States Air Force Cambridge Research Laboratories in Bedford, Mass., expects to put its brand-new decommutator center to work on data from space probes.

The facility will forecast space weather, using observations made by probes like the Mariner 4. Adverse conditions such as solar winds, radiation, cosmic rays and dust will be picked up by sensors on a satellite and transmitted to the decommutator center. There the signals will be sorted, digitized and stored. Analysis of the data can then be performed by a standard computer.

Multiple reception. The quarter-million-dollar installation by Astrodata, Inc., of Anaheim, Calif., will differ from existing decommutators in its ability to receive and process more than one type of signal simultaneously. Initially, the 24-channel reception will consist of 23 frequency - modulation/frequency - modulation (f-m/f-m) channels and one pulse-amplitude modulation/pulse-duration modulation (pam/pdm) channel. Pulse code modulation (pcm) can be added at a later stage.

Synchronizer. At the decommutator facility, the 24 information channels carrying information from the space-borne sensors are received at the same time. The analog signals are put through an analog-digital converter. It can handle only one signal at a time, so a multiplex synchronizer samples each channel in rotation. But it works so fast that all 24 channels are effectively handled at once and each sample is identified before being fed into the converter. This feature is what makes the new decommutator unique. A rate of 20 kilocycles was chosen for conversion as the best compromise between speed and accuracy. The higher speeds that were used in the preliminary tests reduced the accuracy.

System controller. Bursts of digitized data stream into the controller—similar to a small computer—that sorts out the data, stores it in the proper buffer-store device for recording on magnetic tape in the form of data blocks. A typical recording may comprise a few seconds of plasma-probe data followed by a few seconds of cosmic-radiation data and so on. Each block has been assigned an identification that enables the analyzing computer to use it immediately.

Presently installed decommutators send to a buffer and then to tapes without sorting. As a result, computer time, costing about $130 an hour, is required to perform an elementary function. It's believed that the cost of the new decommutator can be written off in about four years as a result of savings in computer time.

The tape decks are standard Datamec D2020 holding words that are 12 bits long. Data is checked for errors by conventional parity check techniques.

Versatile. Although the facility is designed for immediate recording of live signals, it can do a number of other useful jobs. Analog charts of space-science and vehicle engineering data can be produced for immediate viewing. The quad-helix tracking antenr as are controlled by the facility. And, during its spare time, the equipment will also be used to reduce and digitize data on about 4,000 reels of previously recorded tape.

Telecast insurance

Borrowing an idea from military communications, television station WBKB in Chicago has just gone on the air with two new transmitters connected to the same antenna. If one unit develops trouble, the other continues to broadcast smoothly.

Because this round-the-clock reliability is an important requirement for remote control, Bill Kusak, chief engineer of Chicago's American Broadcasting Co. outlet, says that only minor changes will be necessary to initiate unattended operation.

Extending service. A 140-foot traveling-wave antenna with a power gain of 18, fabricated by the Radio Corp. of America, tops a 425-foot mast above Marina City, the world's tallest apartment complex—60 stories. The new height extends channel 7's so-called grade A (3,560 microvolts per meter) signal contour from 43.5 to 45 miles. The grade B (630 microvolts per meter) signal contour from WBKB's 316-kilowatt effective radiated power has gone from 55 to 61.5 miles.

The teamed operation of two General Electric Co. 12-kw transmitters eliminates the need for a 24-kw standby transmitter that probably wouldn't be used more than a few minutes a year.

The parallel connection, standard practice in critical military installations, also makes it possible to shut down one transmitter for maintenance while the other handles broadcasts.

Dual hook-up. The transmitter driver circuit includes an emergency switching diode and coaxial-cable delay-line compensation loop, that sends exciter radio-frequency power to the transmitters in the proper phase. A hybrid combiner-diplexer adds the output signals from the transmitters in the right phase to drive the traveling-wave antenna.

The new system will permit remote unattended operation from the studio master control room, a quarter of a mile away from the transmitters.

A time-operated switch can be set to bypass the combiner diplexer five seconds after a transmitter failure. In this way, the good transmitter is automatically returned to the air, even in cases when the remote-control operator is unable to act.

Emergency operation. Should one transmitter fail, the 6-decibel drop in signal, shared between the

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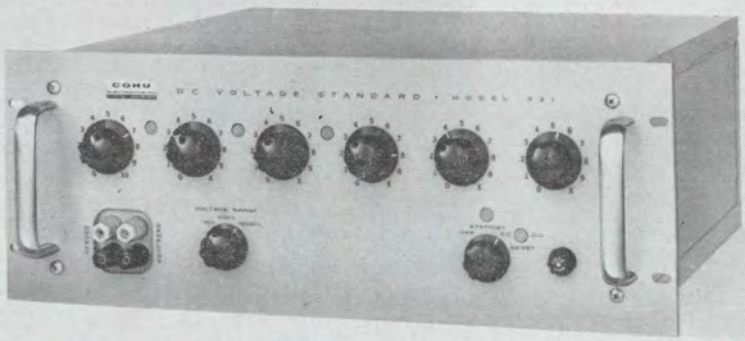
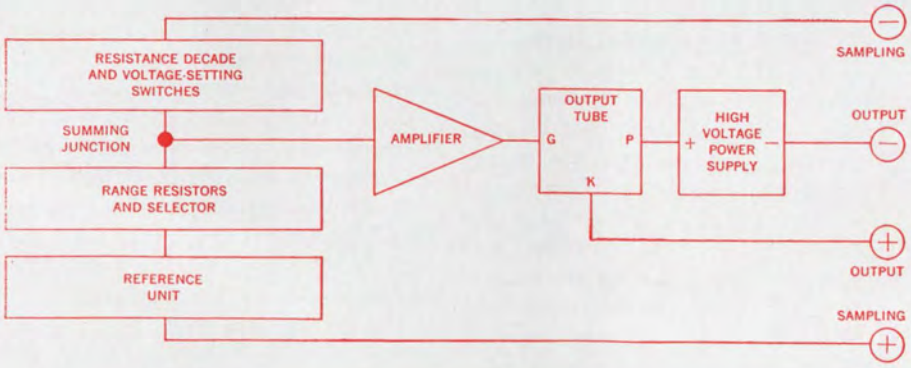


diagrammatic view:



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down transmitter and the combiner net, would hardly be noticed.

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If the regular picture antenna is ever disabled, sound and picture signals can be fed to the separate bays of the antenna used normally for sound.

Gamma-ray weighing system for fill dirt used in road construction costs from $5,000 to $7,000. It is expected to cut road-building costs by $10,000 per mile.

Industrial electronics

Gamma scale

Coal, potatoes and, now, fill dirt used in road building are being weighed by a system, called Ray-Weigh, that uses gamma rays. The Michigan State Highway Dept. is testing the system, developed by the Ohmart Corp., on a construction job near Jackson and expects to save $10,000 for each mile of road.

Two-pronged scale. The receiver-detector portion of the system consists of two prongs, halfway up the conveyor belt. The bottom prong holds radioactive cesium 137, an isotope. Gamma radiation is directed through the belt and its load of fill. The top prong, an Ohmart cell, detects any gamma rays not absorbed by the dirt.

The rays are converted into minute currents that are fed to the grid of an electrometer tube in the input stage of an amplifier. The output of the amplifier, proportional to pounds per foot of belt loading, goes to a solid-state multiplier.

Simultaneously, the multiplier receives the output of a tachometer attached to the belt-drive pulley. This is proportional to the belt speed in feet per minute. Then the multiplier's output, in pounds per minute, is totaled and displayed on a direct-reading digital meter.

Easy adjustment. The system has been accurate, plus or minus one percent, after three and four days of operation without calibration. Calibration tests are routine. An official of the highway department said, "Adjustments can be made by a construction worker. The system is so simple you can forget about teaching the man any electronics."

$50-million market. According to the Ohmart Corp. there is a $50-million annual market for the Ray-Weigh. The company says the system can be used wherever conventional scales are employed.

Avionics

Better missile detection

One of the chief headaches in anti-missile technology is the difficulty in quickly distinguishing between live and dummy missile warheads in flight. But now a radar that can measure irregularities of moving targets has been developed by Cornell University's Cornell Aeronautical Laboratory in Buffalo, N. Y.

Nike-X program. The system, called the Delta radar, is being developed under the Nike-X antimissile program. It will be used as a research tool to perform radar cross-section measurements on scale models of potential targets. The radar will also enable scientists to observe, identify and measure quantitatively scattering discontinuities caused by surface curvature and reradiation from the "creeping wave" portion of a target body. Such waves are caused, among other things, by energy diffraction behind the target body.

The radar is a quasi-monostatic system that uses two antennas and linear frequency modulation. The frequency is swept from 8.2 gigacycles per second to 11.7 gigacycles per second 123 times per second. Ultra-linear frequency modulation is obtained with a broadband backward-wave oscillator. To obtain this modulation, the frequency of the oscillator versus helix voltage characteristics are experimentally determined and the required sweep waveform is then synthesized.

Harmonics canceled. Range sidelobe levels are reduced by modulating the amplitude of the signal with a Taylor weighting function and linearizing the transmission with compensative modulation of the backward-wave oscillator. Residual sidelobes were observed to be related to sweep-rate harmonics. These were canceled by the generation of a similar sinusoid phase locked to the sweep rate and injected onto the helix and cathode of the backward-wave oscillator.

The radar has made range-resolution measurements as small as three inches. The system's primary objective is to measure radar cross-sections with a range resolution equal to a small fraction of the target's length.

Tracking down CAT

Laser beams may shed some light on the meteorological mystery known as clear air turbulence,

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CAT, when an experiment gets underway this month in the Rockies.

A research group from Honeywell, Inc. is setting up its equipment in Rollinsville, Colo. under a contract with the Air Force Cambridge Research Laboratories and will bounce laser beams off a known area of turbulence in the hope that the backscatter from particles in the atmosphere—dust, ice crystals, gasoline and smoke—as small as one micron will provide some clue to the nature of CAT.

Abnormal pattern. "For about two years we've been convinced that it's possible to get scattering from particles trapped in turbulence," says Andrew S. Carten, senior engineer at Cambridge, "and we believe that this scattering will show a characteristic abnormal pattern."

Researchers will be looking for amplitude variations in the reflected laser energy. Signals returned from the turbulent area will be collected by a five-foot searchlight reflector and focused onto photomultiplier tubes. Variations in amplitude will be displayed on an oscilloscope and optical filters will cancel ambient light.

The ruby laser puts out one joule and can be pulsed once or twice every second. It requires 30 kilowatts of input power and, for the feasibility experiments, is mounted on a flatbed trailer.

From the air. Next on the agenda, if these tests show promise, will be an airborne investigation of CAT. The Cambridge group, despite reported pressure to put lasers on planes to "see what happens," decided to try ground experiments first. The forthcoming tests will help determine what kinds of power and equipment might be used in airborne detection systems.

"You can't put five-foot collectors and big laser power supplies on planes," said Wilbur H. Paulsen of AFCRL, "so we'll try to determine what can be done with smaller equipment."

In a tunnel. The hypothesis has been tested in a 100-foot tunnel, with turbulence introduced into the airflow through holes in the side of the tunnel. The results were not definitive and the Colorado tests were scheduled.

Big questions. Because clear air turbulence is believed to have contributed to a dozen crashes and near-crashes of jet planes during the last five years, civil and military aviation authorities are pushing hard to get answers to two big questions: what causes it, and how can you detect it in advance? Maybe some answers will come this month.

Space electronics

Laser's second chance

Despite initial failures, researchers expect to succeed this month in using lasers to measure distance and direction of the geodetic satellite, Explorer 22. The satellite is due to come back into view some time in January.

Distance is measured by bouncing a laser beam off the satellite and measuring the time it takes to make the round trip. The satellite carries a 10-pound array of fused silica glass reflectors on its base; these cube-corner mirrors reflect the laser beams back to the earth.

So far, two groups of experimenters have reported receiving the reflected beam, but results weren't good enough to measure the satellite's distance from the earth. Three other groups haven't reported yet. Two groups have reported failure.

Improving the aim. At the Goddard Space Flight Center of the National Aeronautics and Space Administration, scientists are working on better aim for the laser. "We were getting signals back (from Explorer 22)," says Henry H. Plotkin, project scientist for the laser tests, "but they were few and far between."

He blamed much of the trouble on atmospheric disturbances. Another problem was that the reflected beam missed the receiver by about 50 yards; Goddard engineers picked up only the edge of the beam.

Goddard engineers have moved their receiver to a point where they expect it to pick up the strongest part of the reflected signal. They're also considering a programed pedestal that would operate with a television camera and long-focal-length telescope. This would permit corrections and finer remote control of the laser.

Explorer 22 has mirrors which reflect laser beams

The transmitter at Goddard is a "giant pulse" laser with a 0.8-joule output and a one-microsecond pulse. Pulses were transmitted, one per second, to the satellite.

How others fared. Results similar to Goddard's were reported at the General Electric Co.'s ground station, where a 0.5-joule ruby laser, air-cooled, fired pulsed four or five times during each pass of the satellite.

Two other teams apparently failed to hit the satellite. The Air Force Cambridge Research Laboratories and NASA's station at Wallops Island blamed atmospheric problems and poor aim of the laser. Both groups tried to photograph, on film, the laser beam against a star background. This would have given additional information about the satellite's direction.

Results still have not been reported by experimenters in Britain, France and an unidentified location in the United States.

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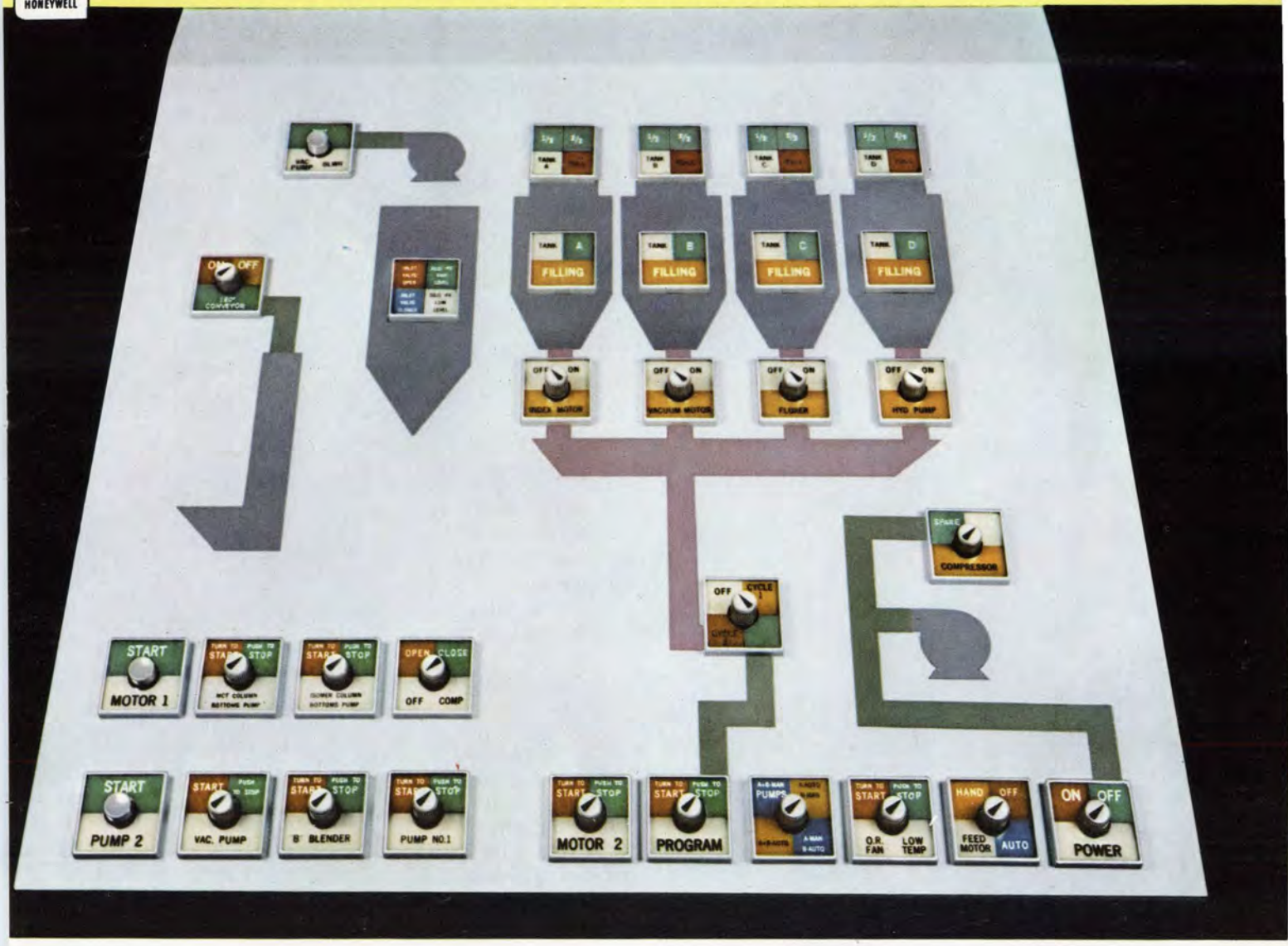

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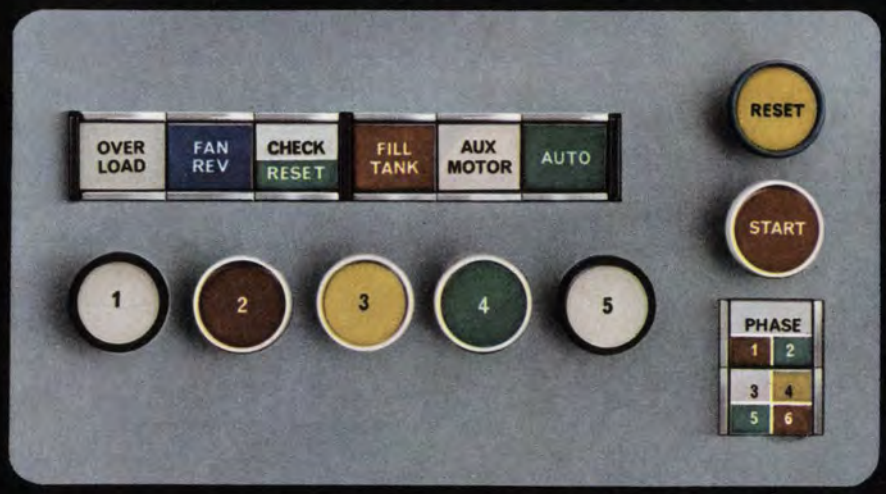

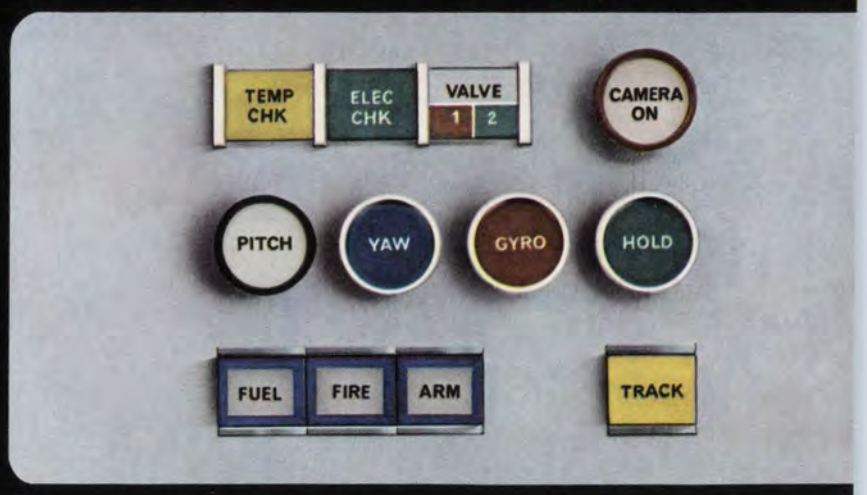

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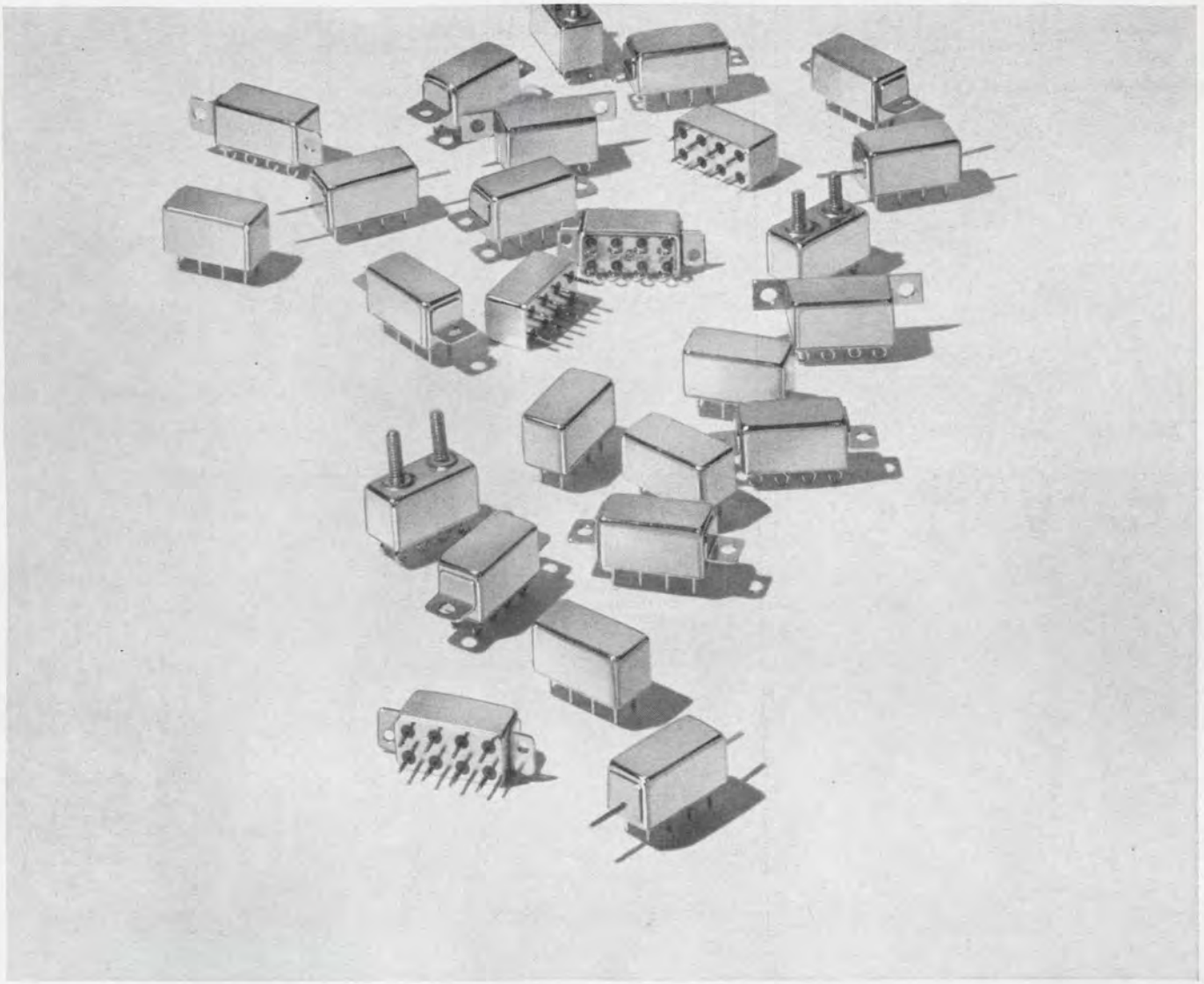

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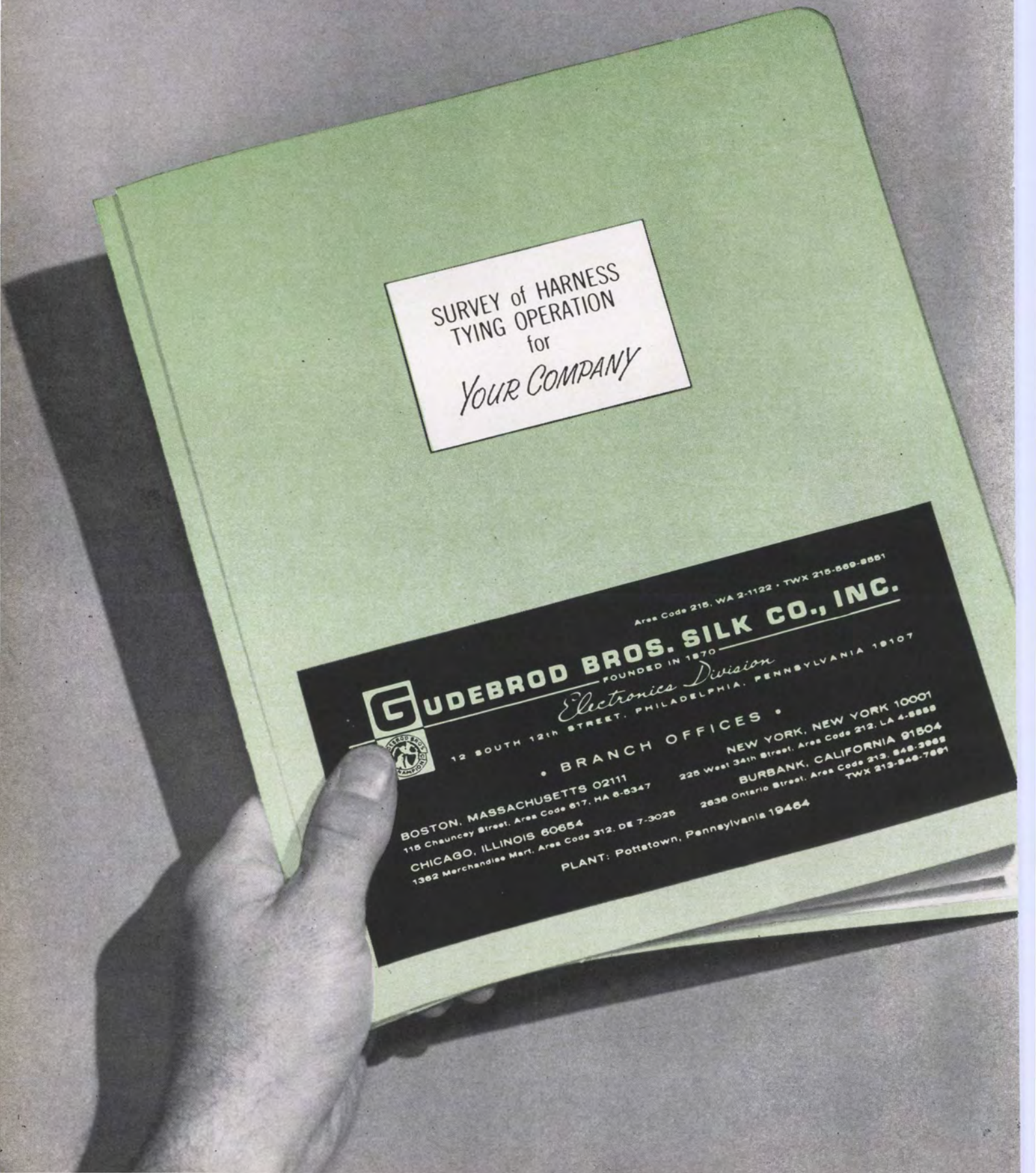

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With time displacement error held within ±0.5 μsec, TICOR II updates all your data reduction equipment. Write for specs. Ask for a demonstration.

Mincom Division 3M COMPANY
300 South Lewis Road, Camarillo, California

ULTRASONIC spectrum analyzer

SB-15a/ultra-compact/ultra-versatile/ultra-fast!

100 cps to 600 kc

GPL DIVISION ENGINEERS SPECTRUM ANALYZE RADAR DOPPLER SIMULATOR

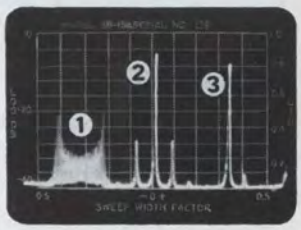
Panoramic* Model SB-15a Spectrum Analyzer automatically and repetitively scans 1 kc to 200 kc spectrum segments through its entire range . . . plots amplitude vs frequency instantly on a calibrated long-persistence CRT display, or on a 12 x 4 1/2" chart (optional RC-3b/15). Automatic optimum resolution (selectivity) provides detailed examination of signals as close as 100 cps. Selectivity can also be manually set from 100 cps to 4 kc bandwidth. The SB-15a is self-checking with internal frequency markers every 10 kc and internal amplitude reference; 8 3/4" high; and completely self-contained, including power supply.

FEATURES: ■ Quick signal location, minimum chance of missing weak signals or holes in spectrum ■ Faster measurements — no tedious point-by-point plots ■ Reliable spotting of low level discrete signals in noise ■ Positive identification and dynamic analysis of all types of modulation.

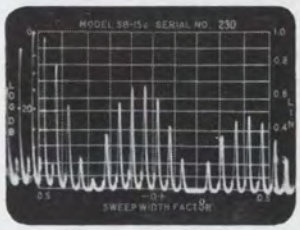
APPLICATIONS: ■ Noise, vibration, harmonic analysis ■ Filter and transmission line checks ■ Telemetry analysis ■ Communication system monitoring and testing ■ Spectral density analysis with Model PDA-1 Analyzer ■ Response plotting with Model G-15a Companion Sweep Generator.

Frequency Range — 100 cps to 600 kc, temperature stabilized
Sweep Width — Variable, calibrated from 1 kc to 200 kc
Center Frequency — Variable, calibrated from 0 to 500 kc
Markers — At 10 and 100 kc intervals, ±0.02% acc.
Resolution — IF bandwidth variable 100 cps to 4 kc
Sweep Rate — 1-60 cps, free-running or synchronized

Amplitude Scales — Lin, 40 db log (usable 60 db), 2.5 db EXP
Distortion — Harmonic and IM at least 60 db down
Sensitivity — 200 μv to 100 v full scale deflection
Accuracy — ±0.5 db any 200 kc segment 200 cps-525 kc
Attenuators — 0 to 120 db, step and smooth
Smoothing Filter — 0 to 0.25 sec time constant, low pass



Dynamic analysis shows SB-15a versatility: (1) FM (shows dynamic deviation), (2) AM, (3) SSB with sine wave modulation.



Harmonic analysis of 20 μsec 11,000 pps video pulse waveform on SB-15a 200 kc sweep width, linear amplitude scale.

ASK YOUR METRICS SALES REPRESENTATIVE ABOUT THE NEW SINGER TIME PAY AND LEASE PROGRAMS

Panoramic*
*A Trademark of THE SINGER COMPANY

THE SINGER COMPANY
METRICS DIVISION

915 PEMBROKE ST., BRIDGEPORT, CONNECTICUT
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Design and production of PANORAMIC • SENSITIVE RESEARCH • EMPIRE • GERTSCH instruments for measurement

We took our cue from the sardine.

IEI'S NEW WET SLUG TANTALUM SUPER-PAK COMPRESSES THE VALUES OF UP TO FIVE ELECTROLYTICS INTO A SINGLE, COMPACT PACKAGE

The use of new tantalum powder compressing techniques and an ingenious method of internal wiring and packaging have achieved remarkable savings in size and weight: these new SUPER-PAK wet slug tantalum capacitors are as small as one-third the size of other units of similar capacitance and working voltage.

Particularly convenient for printed circuit and terminal board applications, the IEI SUPER-PAKs are manufactured in a flat, rectangular configuration with parallel leads of solder-coated Grade "A" nickel wire. The lead pattern and an index pin assure correct polarity when assembled into the circuit.

IEI SUPER-PAKs are available in a capacitance range of 160 ufd to 2640 ufd, at working voltages of 10, 15, 20, 25, 30, 50, 75 and 100 volts at 85°C operating temperature (continuous). They may be operated at 125°C by derating the voltage.

The highly reliable SUPER-PAKs assume performance characteristics typical of MIL-C-3965/4C requirements. Special ratings and non-polar construction are available on special order.

Send for complete information.

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Box 9036-12, Nashville, Tennessee

A DIVISION OF SPS STANDARD PRESSED STEEL COMPANY "Where reliability replaces probability"

ELECTRO INSTRUMENTS ANNOUNCES

NEW LINE

OF DIGITAL CAPACITANCE METERS

PROVIDING RAPID, PRECISE MEASUREMENTS
WITHOUT TEDIOUS MANUAL ADJUSTMENTS

By Dr. Walter East
President, Electro Instruments, Inc

It is always a satisfying experience to introduce a product which is an improvement over anything in its field. But it is doubly satisfying when the improvements inherent in the product are such that they may open up whole new areas and fields of usage for it. That may well be the case with our new line of Digital Capacitance Meters.

Their primary users will continue to be those industries and firms which have a need to measure capacitance to highly precise degrees. As electrical engineers are well aware, this has heretofore required the services of a technically competent operator, and the measuring process itself could not be accomplished with any degree of accuracy in less than minutes of time.

Offer Production Savings

Our new capacitance meters, by completely eliminating the need for manual adjustment, make capacitance measuring a job which can now be handled by relatively unskilled personnel. Also, they cut the time element involved to less than a second. On both counts, therefore, these new capacitance meters offer such firms as manufacturers of electronic components, and manufacturers who utilize such components, valuable production savings.

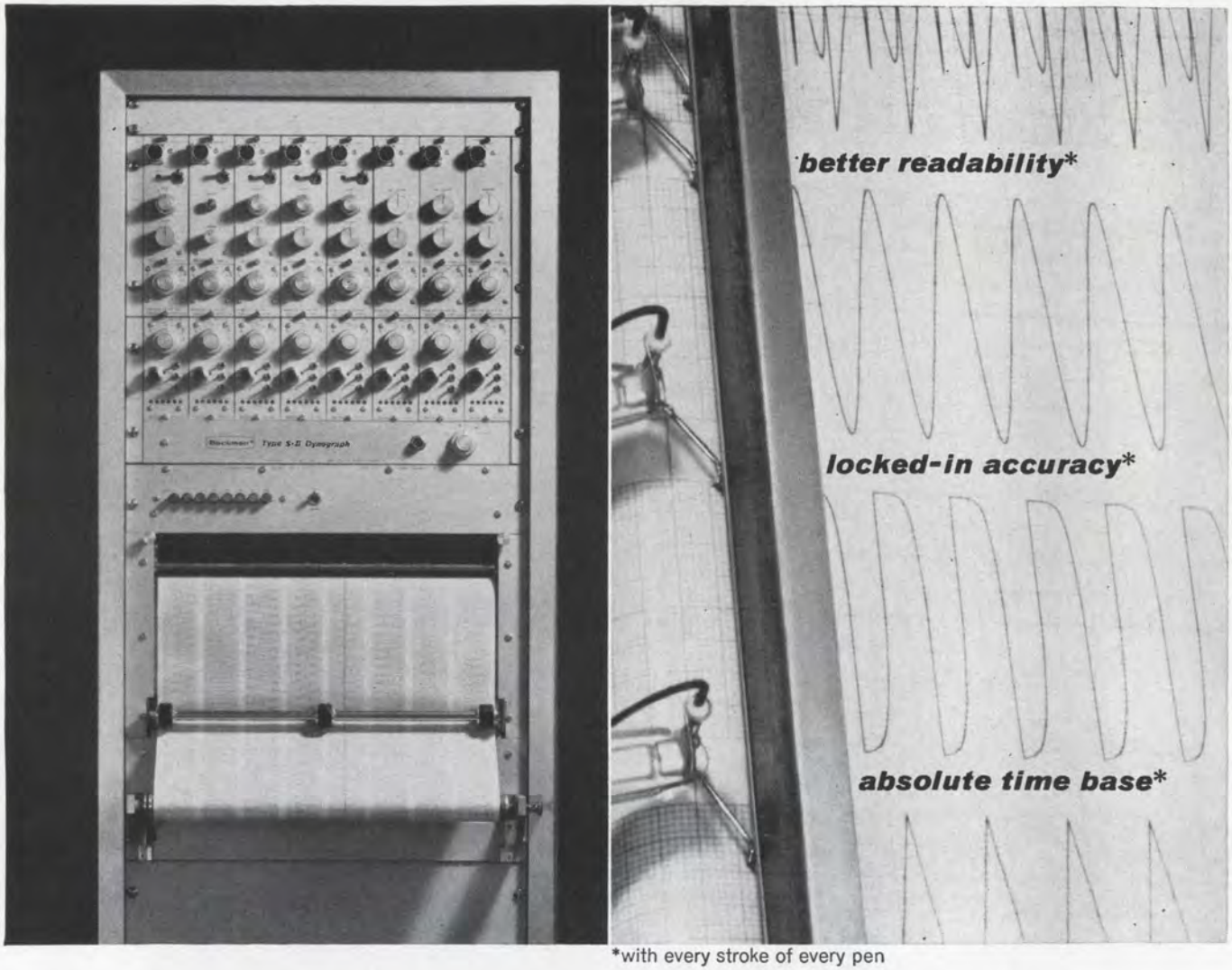
Other Possible Uses

But I can visualize a practical use for these new meters on research and manufacturing jobs where capacitance meters are not now normally employed. Automatically monitoring thicknesses, molecular structure, insulating properties of such solids as paper, plastics, fabrics—and many forms of liquid and gaseous matter.

Let one of our field sales engineers acquaint you with the advantages of our new digital capacitance meters today. Or call or write me directly.

Electro Instruments, Inc.
8611 Balboa Avenue San Diego, California 92112

ELECTRO INTERNATIONAL, INC., ANNAPOLIS, MD. • TRANSFORMER ENGINEERS, SAN GABRIEL, CALIF.



*with every stroke of every pen

Dynograph® pressurized ink-rectilinear recorder

Better Readability...The completely new pressurized ink system is controlled by a pump that maintains an unvarying pressure at all times while the instrument is in operation. This means that the tracing will retain its high resolution characteristics, regardless of variations in paper speed or signal frequency...never any skipping, or broadening of the line.

Locked-in Accuracy...Servo-control feed-back *from the pen tip* constantly matches the pen position to the input signal...for unsurpassed recording accuracy.

Absolute Time Base...All the pen tips are constrained to the same straight line by the slide-wire assembly...in effect a "straight edge" guarantee that completely valid time comparisons can be made between any or all channels.

Reliability...The all solid-state circuitry in the Dynograph recorder has been proven in the field for over seven years. In the event that problems do arise, the "plug-in" construction expedites service to minimize downtime.

Versatility...A multitude of inexpensive input couplers allow the conditioning of virtually any type of signal, making unnecessary the purchase of expensive special-purpose amplifier systems.

Interested?...Check the specification box, then contact your local Offner sales engineering representative, or write for Data File S645.

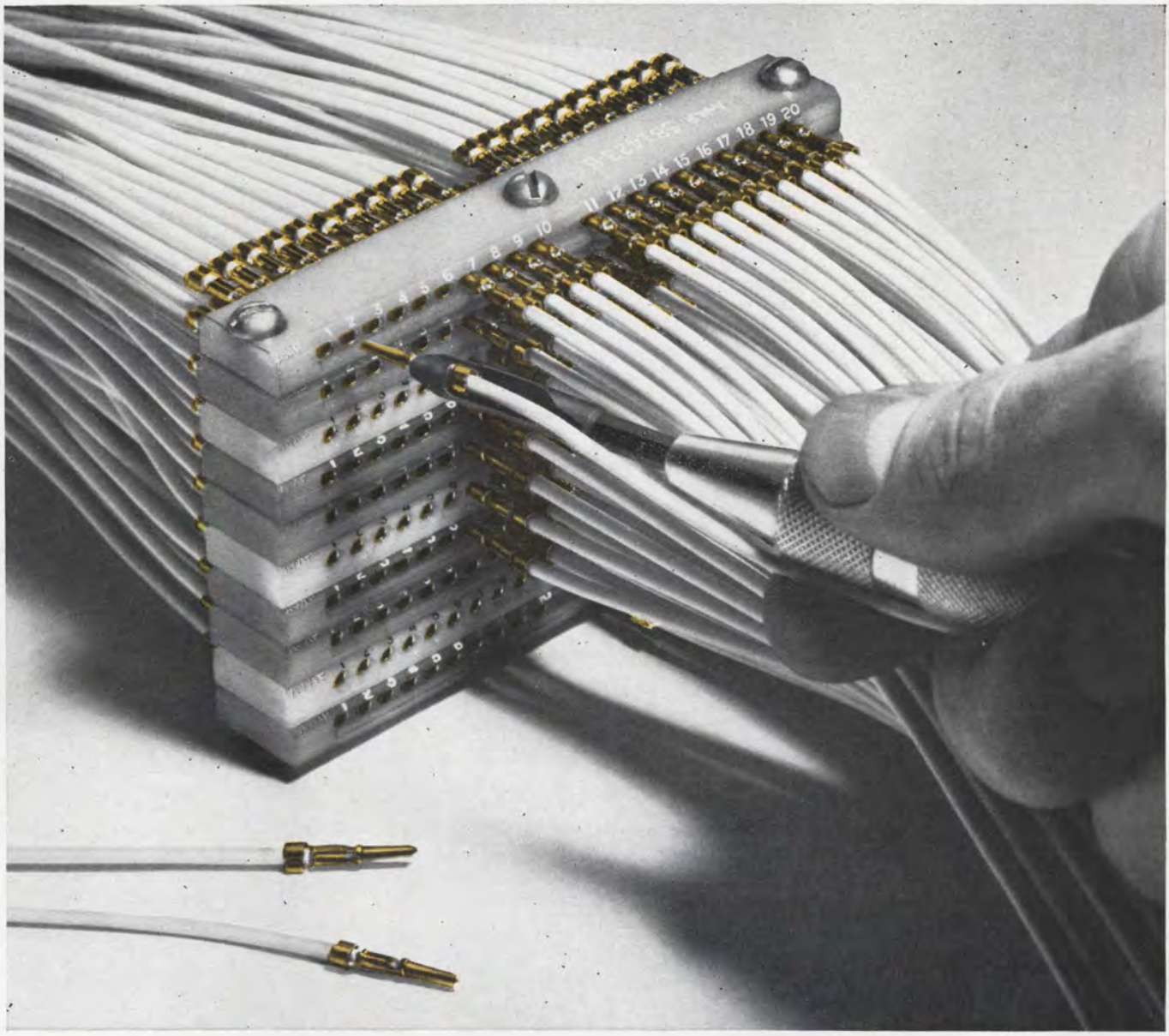
SPECIFICATIONS

Number of Channels	1-8 standard
Sensitivity	with preamp, 1 μv/mm to 5 v/mm. without preamp, 1 mv/mm to 5 v/mm.
Frequency Response	DC to 150 cps
Linearity	±0.25%, or less
Drift	1 mm/hr
Input Impedance	1 megohm DC; 1 megohm shunted by 1,000 p.f. or less AC.
Power Required	230 watts, maximum (8 channels)
Input Couplers	28 standard, plus specials

Beckman® INSTRUMENTS, INC.
OFFNER DIVISION
Schiller Park, Illinois

C64-101

International Subsidiaries: Geneva, Switzerland; Munich, Germany; Glenrothes, Scotland



How small can a pin be?

It can be within a mere few thousandths of an inch of the outside diameter of the wire insulation. Or even less. That's the way we engineer our A-MP★ Taper Pins.

Anywhere the wire fits, our pins fit. That's the kind of density that gives you the extra design space you need.

With nominal retention strength of 25 pounds, our taper pins assure peak mechanical and electrical characteristics. Even when subjected to temperature cycling of −85° F to +500° F, and being vibrated at 150 cps, 20 g accelerations, these taper pins hold fast. And they become better with age—joint resistance decreases, while joint disengagement forces increase. Combine this with a taper design that makes pins self-cleaning and self-locking and you've got reliable performance under the toughest conditions.

Want further assurance? Check these features:

- Our matched crimping tools eliminate cold solder joints, burnt and brittle insulation
- Automatic application for lowest installed cost
- Pre-insulation prevents flash-over and possible shorting
- One piece solid molded blocks and two piece for customer assembly
- Standard configurations, 10, 20 and 30 cavities

So why look further? We have the most complete line of taper products in the industry. Pins stamped and formed, uninsulated and insulation piercing types, screw machine with insulation support and pre-insulated types. Plus all kinds of companion items, such as vertical entrance blocks, taper bus bar and taper tab blocks. Write today for complete information.

★Trademark of AMP INCORPORATED

AMP INCORPORATED
Harrisburg, Pennsylvania

INDUSTRIAL SALES DIVISION

A-MP★ products and engineering assistance are available through subsidiary companies in:
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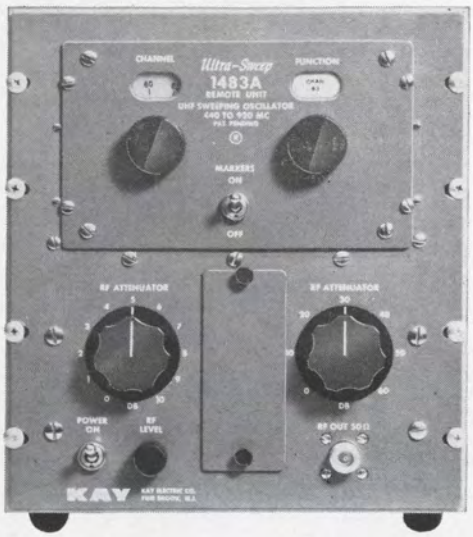
Circle 53 on reader service card



NEW KAY OCTAVE SWEEP

1400 SERIES: Provides full two-to-one fundamental frequency sweep to display broadband circuits in a single sweep. Sweeps an octave, anywhere in the 100 –1,000 mc range; electronically, agc'd flat, and frequency linear. May also be used as a continuously variable (width **and** center frequency) narrow band sweep.

Choose a 200-400 mc model to sweep 225-400 mc receivers. Sweeps the entire input simultaneously; no spurious signals, excellent waveshape. Narrow-down the sweep for IF response. Add an IF band at 20 mc, or 60 mc, etc., on special order. All units contain crystal controlled frequency markers, precision attenuators and remote tuning.

$895.00
(PLUS MARKERS)

UHF-TV MODEL, 1483-A: Sweeps from 440 to 920 mc at once, or sweeps narrow sweep. Any width anywhere in the range. Contains 3 crystal markers.

$845.00

FOR COMPLETE LITERATURE, WRITE

KAY ELECTRIC COMPANY
PINE BROOK, MORRIS COUNTY, N.J.

Motorola is your **ONLY COMPLETE SOURCE...**

For

MILITARY SILICON TRANSISTORS

...and they're all

ANNULAR*

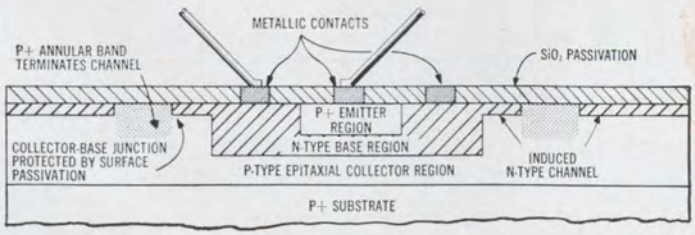
Here are just two examples showing the outstanding reliability of Motorola's silicon annular transistors:

1. In one of the nation's major missile programs, three successive qualification life tests were made on Motorola's PNP silicon annular transistors involving a total sample of 9300 devices — *with no failures reported!*
2. Since the introduction of the first PNP silicon annular Star† transistor, *not one lot failure has occurred* in a military qualification or acceptance test!

The Motorola-developed annular process has enabled Motorola to design and fabricate virtually any PNP or NPN silicon transistor you need... with performance characteristics (such as high voltage) and reliability previously impossible to obtain with any other manufacturing technique.

For your next military silicon transistor requirements, specify *annular* transistors... for reliability ... for performance... for availability... *for sure!*

Cross Section of an Annular Transistor



NPN
USA2N2218 USA2N2219
per Mil-S-19500/251C
USA2N2221 USA2N2222
per Mil-S-19500/255C

PNP
USA2N2904 USA2N2905
per Mil-S-19500/290
USA2N2906 USA2N2907
per Mil-S-19500/291

PNP
USN2N1132
per Mil-S-19500/177A

NPN
JAN2N706
per Mil-S-19500/120A
USN2N2481
per Mil-S-19500/268A

*The annular process provides true silicon oxide surface passivation and eliminates uncontrolled "channeling" and leakage to the edges of the transistor die. Patents pending.

†Trademark of Motorola, Inc.

MOTOROLA® Semiconductors

200-1

QUICK REFERENCE CHART FOR DAYSTROM POTENTIOMETERS

SQUARETRIM® CORNER LEADS

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Notes	Power Rating at 50°C. Watts	Operating Temperature from −55 Degrees C.	Stranded Flexible Insulated Leads 6" Min. Length Nylon	PVC	Teflon
200	3/8 x 3/8	.150	10Ω to 50K	8	1	150			X
210	3/8 x 3/8	.150	10Ω to 50K	8	1	175			X
300	1/2 x 1/2	.187	10Ω to 50K	8	1	125	X		
300	1/2 x 1/2	.187	10Ω to 50K	8	1	150			X
303	3/4 x 3/4	.280	10Ω to 150K	2, 8	1.5	125		X	
303	3/4 x 3/4	.280	10Ω to 150K	2, 8	1.5	150			X
310	1/2 x 1/2	.187	10Ω to 20K	4, 8	2	175			X
311	1/2 x 1/2	.187	5K to 5MEG	3, 5, 8	.5	85	X		X
313	1/2 x 1/2	.187	10Ω to 50K	8	1.5	200			X
313-118HS*	1/2 x 1/2	.187	10Ω to 50K		.75 (at 85°C)	150			X

SQUARETRIM® BACK PINS

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Notes	Power Rating at 50°C. Watts	Operating Temperature from −55 Degrees C.	Solid Bare Terminals 3/16" Length	1½" Length
201	3/8 x 3/8	.150	10Ω to 50K	8	1	150	X	
212	3/8 x 3/8	.150	10Ω to 20K	8	1	105	X	
218	3/8 x 3/8	.150	10Ω to 50K	8	1	175	X	
301	1/2 x 1/2	.255	10Ω to 50K	8	1	150	X	
312	1/2 x 1/2	.195	10Ω to 100K	1, 2, 3, 8	1	150	X	
318	1/2 x 1/2	.255	10Ω to 50K	8	1.5	200	X	
318-105HS*	1/2 x 1/2	.255	10Ω to 50K		.75 (at 85°C)	150	X	
358	1/2 x 1/2	.195	10Ω to 100K	1, 2, 3, 8	1	200	X	
368	1/2 x 1/2	.255	10Ω to 6K	7, 8	2	175	X	

SQUARETRIM® SIDE PINS

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Notes	Power Rating at 50°C. Watts	Operating Temperature from −55 Degrees C.	Solid Bare Terminals 3/16" Length	1½" Length
215	3/8 x 1 3/32	.150	10Ω to 50K	8	1	150	X	
255	3/8 x 1 3/32	.150	10Ω to 50K	8	1	175	X	
302	1/2 x 1/2	.260	10Ω to 50K	8	1	150		X
315	1/2 x 1/2	.200	10Ω to 100K	1, 2, 3, 8	1	150	X	
316	1/2 x 1/2	.195	10Ω to 100K	1, 2, 3, 8	1	150		X
356	1/2 x 1/2	.195	10Ω to 100K	1, 2, 3, 8	1	200		X
357	1/2 x 1/2	.200	10Ω to 100K	1, 2, 3, 8	1	200	X	

*Meet MIL-R-27208A-50Ω to 5K

Special Features & Modifications Available for SQUARETRIM®

- Resistance Tolerance
- Resistance Value
- Resistance Wire Material
- Temperature Coefficient of Potentiometer
- Stops within the Resistance Range
- Lead Length, Insulation Material and/or Color
- Terminal pin Length, Diameter and/or material for weldability
- Center Taps
- Rheostats
- Marking
- Packaging
- Adjustment Screw Location, Length, Diameter and/or Configuration

TRANSITRIM*

*Trademark Applied For

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Notes	Power Rating Watts	Operating Temperature from −55 Degrees C.	Solid Bare Terminals 1½" Length
510	.360 (Flange) .335 Dia. (Body)	.275	10Ω to 30K		1.25 (at 50°C)	175	X

Available with or without stops.

COMMERCIAL TRIMMERS

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Notes	Power Rating Watts	Operating Temperature from −55 Degrees C.	Solid Bare Terminals 3/16" Length	3/8" Length
515	.500 Dia.	.317	10Ω to 50K		1 (at 55°C)	150	X	
333	1/2 x 1/2	.187	50Ω to 10K	6	.2 (at 40°C)	80		X

Daystrom commercial trimmers have the inherent reliability of the MIL type potentiometers. The same patented "Wire-in-the-groove" method of winding the resistance element is used, assuring locked-in linearity and resolution.

METAL FILM TRIMMERS

Series Number	Size (In.)	Thickness (In.)	Resistance Range Ohms	Power Rating Watts	Operating Temperature from −55 Degrees C.	Solid Bare Terminals ½" Length
520--526**	1.25 x .310	.360	50Ω to 200Ω	0.5 (at 85°C)	150	X
521--527**	1.25 x .310	.360	1K to 25K	0.5 (at 85°C)	150	X
522--528**	1.25 x .310	.360	50K to 200K	0.5 (at 85°C)	150	X

**High Reliability Units

Patent No. 2,880,293.

Note 1. Factory quote for values over 50K.
Note 2. Stops not available.
Note 3. Humidity proof not available.
Note 4. Factory quote for values over 10K.
Note 5. Factory quote for values less than 5K.
Note 6. Factory quote for values less than 50Ω.
Note 7. Factory quote for values over 6K.
Note 8. Slotted or Allen-head screws standard.

Certified drawings and specifications available on request.

DAYSTROM POTENTIOMETERS ARE ANOTHER PRODUCT OF
WESTON INSTRUMENTS, INC.
ARCHBALD, PENNSYLVANIA 18403

Made to the best of MIL-R-10509E requirements

OHMITE
SERIES
66
METAL FILM
PRECISION RESISTORS

AVAILABLE ONLY IN 0±25 PPM/°C, CHAR. E

TYPICAL TEST DATA FOR SERIES 66 RESISTORS

TYPICAL TESTS	MIL SPEC. REQ. CHAR."E"	Series 66 Resistors (Avg. of all tests)	⅛-Watt (RN60E) (661E-⅛)		¼-Watt (RN65E) (661E-¼)			½-Watt (RN70E) (661E-½)			1-Watt (RN75E) (661E-1)		
			309 Ohms	499 K Ohms	402 Ohms	348 K Ohms	1 Meg	402 Ohms	237 K Ohms	1 Meg	365 Ohms	237 K Ohms	2 Meg
Temp. Coeff. PPM/°C −55°C	0±25	7.93	−8.0 to −10.7	−5.1 to −12.5	−0.5 to −12.0	+0.3 to +5.8	−0.1 to −8.7	+0.3 to +10.6	+1.6 to −10.5	−7.9 to −13.6	−7.0 to −25.0	−1.0 to −19.0	−0.6 to −20.0
Temp. Coeff. PPM/°C +175°C	0±25	17.79	+14.8 to +18.2	+10.5 to +23.7	+21.1 to +24.9	+13.0 to +25.0	+15.1 to +24.0	+18.2 to +23.0	+14.0 to +24.0	+6.6 to +24.5	+7.0 to +15.0	+6.0 to +21.0	+15.3 to +24.3
Load Life %△R After 1000 Hrs. @ 125°C	±0.5	0.107	−0.017 to +0.250	−0.002 to +0.407	+0.014 to +0.404	+0.051 to −0.149	+0.049 to +0.069	+0.009 to +0.360	+0.147 to +0.387	0 to +0.129	+0.057 to +0.117	+0.025 to +0.172	+0.004 to +0.115
Short Time Overload %△R	±0.25	0.019	0 to −0.104	0 to −0.043	0 to −0.005	0 to −0.003	−0.003 to +0.010	+0.004 to +0.069	0 to −0.077	0 to −0.010	−0.088 to −0.151	0 to −0.009	0 to +0.009
Moisture Resistance %△R	±0.5	0.058	+0.035 to +0.432	+0.039 to +0.222	+0.024 to +0.034	+0.011 to +0.017	+0.009 to +0.039	−0.030 to −0.065	+0.008 to +0.029	0 to −0.050	+0.021 to +0.032	+0.012 to +0.337	+ 0.039 to +0.084

NOTE: 440 Units Total Tested; 40 Total for Each Resistance Value; 10 Each Test.

Ohmite's new Series 66 metal film resistors give a significant edge, an extra margin of reliability, wherever you need very low T.C. resistors of this type. And the "why" of this added value is understandable. Series 66 resistors are founded on Ohmite's 10 years of research and production experience in evaporated metal films plus 30 years of concentration on quality resistance products.

There is a difference in metal film resistors. Test these and see for yourself.

The resistance element is a film of special non-noble alloy vacuum-evaporated on to a ceramic core of exceptional surface finish. The film terminates on gold terminal bands fired to the core ends. Gold-plated end-caps are pressed over the core ends and leads are butt-welded to the caps. The assembly is covered with a special protective resin and completed with a molded coating. Film, core, caps, and coating are matched to provide a stable, moisture-resistant component.

Present sizes are ⅛ watt (309 ohms to 499 K ohms), ¼ and ½ watt (402 ohms to 1 meg), and 1 watt (365 ohms to 2 meg). Tolerances are 1, 0.5, 0.25, and 0.1%. Temperature coefficient, 0±25 ppm/°C over the operating range of −55°C to +175°C.

Standard leads are nickel, solder-dip coated for soldering; furnished bare for welding, or gold-plated on order.

Write for Bulletin 110

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MANUFACTURING COMPANY
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Phone (312) ORchard 5-2600

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • TANTALUM CAPACITORS • TAP SWITCHES • RELAYS • R.F. CHOKES • SEMICONDUCTOR DIODES

Circle 57 on reader service card

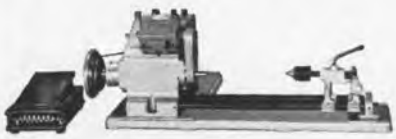
NEARLY EVERY FIRM IN THE WORLD WHICH WINDS COILS USES A GEO. STEVENS MACHINE

CROWN COIL TURNS ANALYZER

Determines within one minute the precise number of turns in any wound air core coil.

SOME REPRESENTATIVE TYPES ARE SHOWN

HAND FED WINDER
MODEL 310-AM



Types of Windings: All random, close, solenoid, and bobbin wound coils. Can be used for space windings on grooved forms.
Max. Coil OD: 6″

MULTIPLE TRANSFORMER WINDER
MODEL 37-S

Types of Windings: Multiple winds paper section Power, Audio, Fluorescent Ballast and similar types of transformer coils.
Max. Coil OD: 9″ if round, 4½″ if rectangular.

MINIATURE BOBBIN COIL WINDER
MODEL 39-AM

Net Wt. 41 lbs. Types of Windings: Small precision instrument-type and miniaturized Windings.
Max. Coil OD: 1½″.

HIGH PRODUCTION SEMI-AUTOMATIC VOICE COIL WINDER

MODEL 62-PM

Covers over 80% of all voice coil winding requirements . . . Can produce over 800 finish wound voice coils per hour. Eliminates coil rejection due to winding errors. Eliminates hand sizing operations; eliminates coil handling during winding.

VARIABLE PITCH PROGRESSIVE UNIVERSAL WINDER

MODEL 600-AM

For lab and production runs . . .
Types of Windings: Variable pitch progressive universal coils; variable pitch solenoids; progressive universal coils; automatic pi-wound coils; universal coils; close and space wound single layer solenoids; random wound bobbin coils.

6″ OR 12″ PRECISION SPACE WINDER

MODEL 332-AM (SCREW FEED)

New solid state circuitry; instant fingertip re-settable wire guide; winding range; 44 to 3040 turns per in. Types of Windings: Space Wound Resistors, Distributed Constant Delay Lines and Precision Linear Potentiometers.
Max. OD: 4″.

COIL WINDING

The only book available on coil winding. 192 pages; 100 illustrations. 2700 Gear Ratios (never before available). $5.00

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HIGHLY RELIABLE PRECISION ELECTRONIC COUNTER
MODEL 184 SERIES

SOLID STATE. Only 8 VDC operating voltage. Only 12 watts power consumption. 4 digits within one compact enclosure. Instant easy readability. Counting rate 30,000 RPM or 1.5kc at ±1 turn accuracy with photocell pickup. No warm-up. Downtime virtually eliminated. Very low initial cost.

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The Most Complete Line of Coil Winding Machines Made

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Washington Newsletter

January 11, 1965

Tv-guided bomb studied for Navy

The Navy has selected three companies to begin program-definition studies of Walleye, a 1,000-pound bomb that can adjust its own glide path in flight.

After studying 11 proposals for 3½ months, the Navy's Bureau of Weapons awarded contracts to the Hughes Aircraft Co., the Orlando division of the Martin Marietta Corp. and North American Aviation, Inc.

The bomb will have no propulsion system, but it will have fins that can be adjusted in flight to change the angle of the bomb's fall. A television camera in the nose locks onto a target and feeds signals to the fins.

The bomb would be carried by light attack planes for use against hardened targets that are defended.

Problems beset trade fair plans

The United States may sponsor an international aerospace and science trade fair in June, 1966, at Washington's Dulles International Airport. If the fair is successful, it will be held every two years thereafter.

Two problems can still stall the fair. One is a lack of industry support; electronics companies are more enthusiastic than aircraft makers, who have less trouble selling their wares abroad. The second problem is a financial dispute. Some manufacturers want to write off the cost of participation as an allowable expense on their government contracts. The government is resisting this demand.

President Johnson would have to approve any government sponsorship, and Congress would have to underwrite the administrative expenses and the cost of constructing buildings at the fair. Admission and exhibitor fees would be expected to recover most costs.

The idea for the fair was developed by a task force representing the Federal Aviation Agency, the Pentagon, the National Aeronautics and Space Administration, the Commerce Department and the Civil Aeronautics Board. The group was organized by the Commerce Department, which is seeking to promote exports of aerospace equipment.

Cost may stall mobile missile

Army officials believe that many of the technical problems besetting its mobile antiaircraft Mauler missile have been solved. **But the future of the weapon is still in doubt because additional work increased the weapon's development cost.** The question now is whether the higher price tag can pass the Defense Department's stiff cost-effectiveness tests.

The General Dynamics Corp. is prime contractor for the Mauler. Electronic equipment subcontractors are the Hughes Aircraft Co. for the infrared guidance system; De Havilland Aircraft of Canada, Ltd., for the infrared acquisition system; the Raytheon Co. for acquisition and tracking radars and the Burroughs Corp. for the computer system.

Most versatile antisub torpedo

The Navy's most versatile antisubmarine torpedo, the Mark 46, has gone into production. The weapon follows a programed search pattern, using either active echo ranging or passive listening methods. When the target is found, the torpedo pursues and destroys it.

The Mark 46 uses an electronic guidance system, a computer and an autopilot. **It is the first antisub torpedo that can be launched from either**

a fixed-wing aircraft, a surface ship or a helicopter. The Bendix Corp. developed the guidance control system under a subcontract with the Aerojet-General Corp., a subsidiary of the General Tire & Rubber Co.

The Navy is now concentrating on the Mark 48, formerly the X-10, a weapon that will move faster, deeper and quieter and can spend more time in acquiring a target than the Mark 46.

Although secrecy surrounds the Mark 48, it has been disclosed that the launch vehicle's computer facilities help in guiding the torpedo.

Academy amplifies engineers' voice

The electronics industry is expected to have a stronger voice in shaping federal science and research policies with the establishment of the National Academy of Engineering.

The academy was created in response to objections by engineers that fewer than 10% of the 600 members in the National Academy of Sciences are engineers. One of its principal functions is to advise the government.

Members of both academies represent industry, schools and nonprofit research organizations. **About half of the National Academy of Engineering's founding members represent industrial companies, many of which have a stake in electronics.**

Navy replacing Tartar and Terrier

The Navy is working on a new antiaircraft missile to replace both the short-range Tartar and medium-range Terrier for use on destroyers and cruisers. General Dynamics is receiving a $13-million contract for development and pilot production of the new missile. It would come in two versions, with ranges of 10 miles and 30 miles, and would use semiactive homing techniques for guidance.

The Navy decision to replace the Tartar and Terrier with a new missile came after a crash program failed to correct problems of accuracy and dependability.

NASA extends JPL contract

The National Aeronautics and Space Administration has extended its contract with the California Institute of Technology's Jet Propulsion Laboratory for two more years.

The contract extension seems to be evidence that the peace treaty between the laboratory and NASA is working out. After disagreement mushroomed some months ago over the lab's management of subcontractors, a new arrangement, incorporating many of NASA's recommendations, was instituted.

The lab is responsible for the management of about $200 million of Ranger and Mariner programs, plus the deep-space tracking network and related projects.

Phantom fighter to be improved

The Air Force plans a new version of the McDonnell Aircraft Corp.'s F-4C Phantom fighter that will have improved electronic equipment for tactical all-weather bombing. **Modifications and improvements in the sighting system of the F-4C will give the new Phantom greater accuracy in bombing small targets.**

McDonnell is being awarded a $40.7-million supplement to its existing F-4 contract for items that have long lead times.

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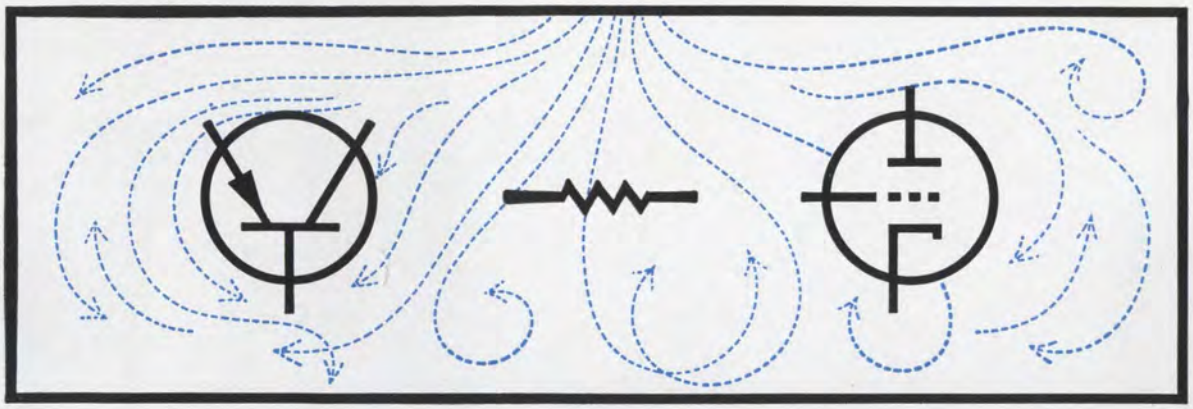

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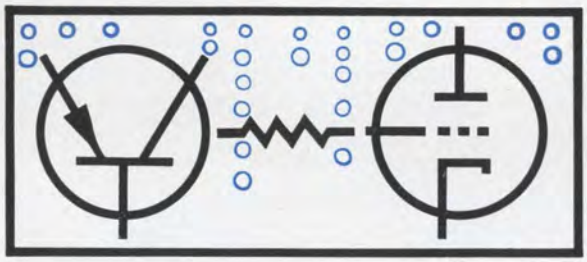

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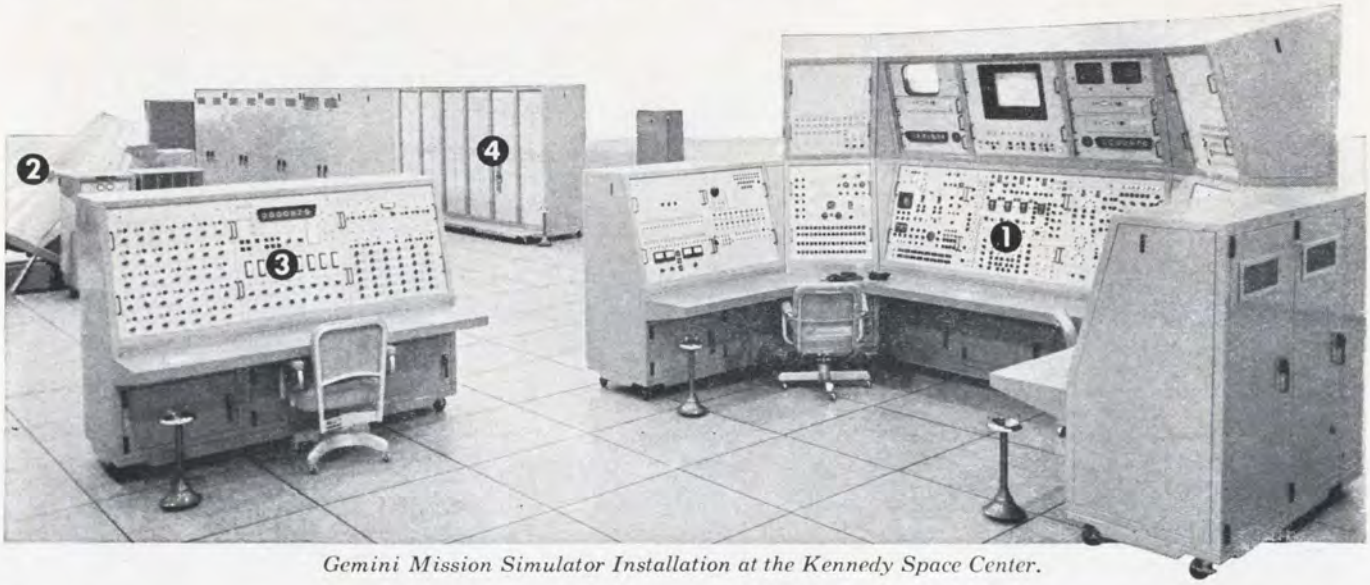

Gemini Mission Simulator Installation at the Kennedy Space Center.

The **Instructors Station** ❶ permits monitoring of all instruments and controls and allows the introduction of flight control, environmental control, and communication systems malfunctions. It provides crew and instrument panel TV monitors, digital communications with the simulated onboard computer, and the capability for creating realistic noise and communication distortion.

The interior of the **Crew Station** ❷ is a visual and tactile duplicate of the Gemini Spacecraft cabin. The Crew Station is hydraulically mounted to tilt the cabin for crew comfort.

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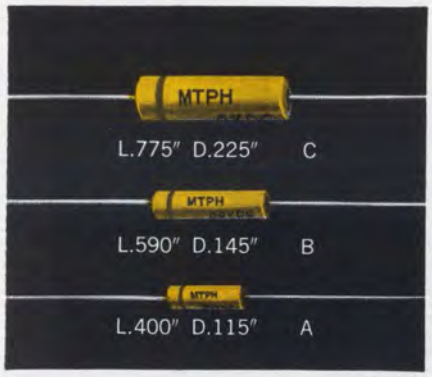
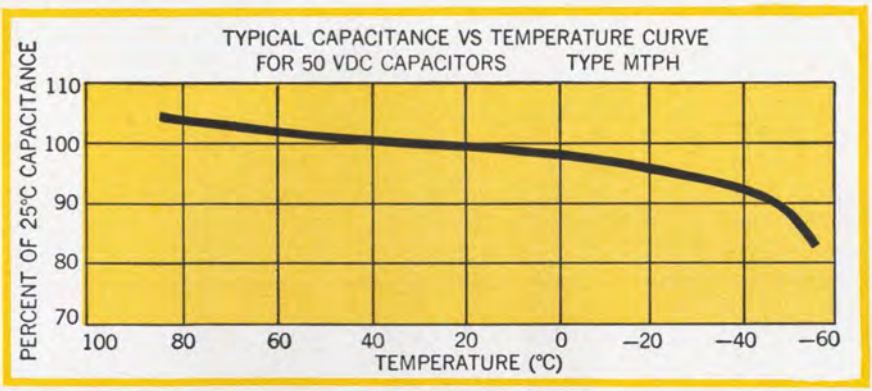
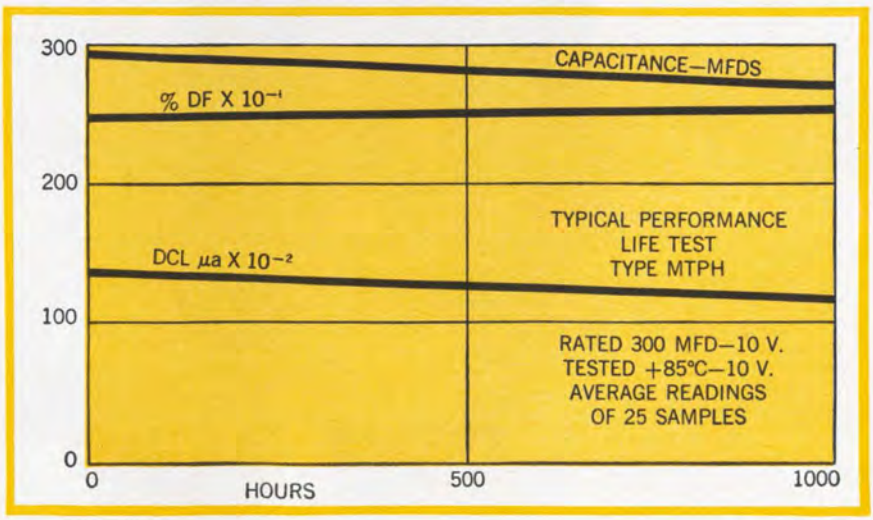


During 1,810,000 unit hours of life test at 85°C, at full rated voltage, using a low impedance power source, not one MTPH capacitor has failed through short circuiting or excessive DC leakage current. Type MTPH capacitors were developed by Mallory as a result of experience gained producing a similar line for use in the Minuteman II missile system made by Autonetics Division of North American Aviation, Inc.

STANDARD RATINGS

MTPH NO.	Rated Cap Mfd.	Rated Voltage D.C.	DCL μa +25°C	DCL μa +85°C	DF% +25°C	% of +25°C Cap at −55°C	120 CPS Z at −55°C	DF% +85°C	Case Size
MTPH1	6.8	50	3	10	20	70	400	10	A
MTPH2	30	50	8	25	20	70	120	15	B
MTPH3	78	50	10	30	20	60	55	18	C
MTPH4	10	30	3	10	20	65	290	10	A
MTPH5	45	30	8	25	25	60	100	20	B
MTPH6	120	30	10	30	30	55	48	25	C
MTPH7	60	20	7	20	25	55	90	20	B
MTPH8	80	15	6	18	30	55	82	25	B
MTPH9	200	15	8	25	30	50	44	25	C
MTPH10	120	10	5	15	35	50	66	25	B
MTPH11	300	10	7	20	35	40	35	28	C
MTPH12	180	6	5	15	37	50	40	25	B
MTPH13	450	6	6	18	50	40	33	40	C





The MTPH style of capacitors are produced in the same "white room" manufacturing facility and by the same highly trained operators used for Minuteman II parts. The materials, production processes and quality controls are also the same, thereby assuring the highest degree of reliability.

MTPH capacitors have higher capacity-voltage product per unit volume than any conventional wet slug, foil or solid tantalum line. This size factor makes these capacitors very desirable for applications with thin film, integrated and other microelectronic circuits. An additional advantage of the wet slug construction is the absence of the familiar catastrophic failure mode of solid tantalum devices.

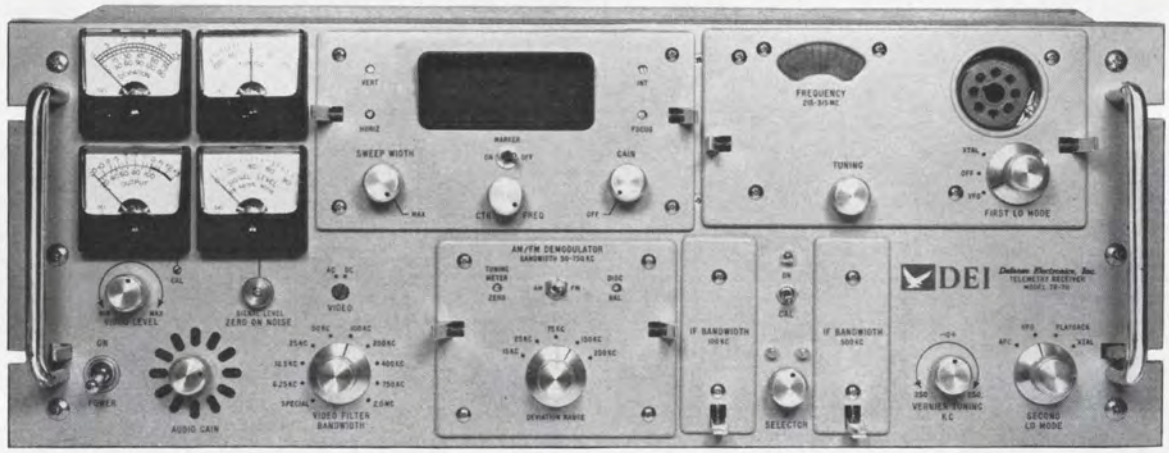
For complete data and prices, write or call Mallory Capacitor Company, Indianapolis, Indiana 46206—a division of P. R. Mallory & Co. Inc.

MALLORY

Circle 65 on reader service card 65

This is DEI's Solid State Receiver

It's new
Tunes in the range of 100 to 2300 mc
Superior performance characteristics
The TR-711 is virtually spurious free
Sets the standard for comparison



The TR-711 Receiver is modular in construction and can be supplied with a complete complement of plug-in modules including RF tuning units from 100 to 2300 mc, IF amplifiers with 10 kc to 3.3 mc bandwidths, AM, FM, and phase demodulators, and plug-in spectrum display unit, oscilloscope, predetection up and down converter, or high capture ratio discriminator. Any combination of plug-in modules can be utilized, thus providing unlimited receiving combinations adaptable to any known or projected telemetry system.

Characteristics and accessories are described in Bulletin TR-711.

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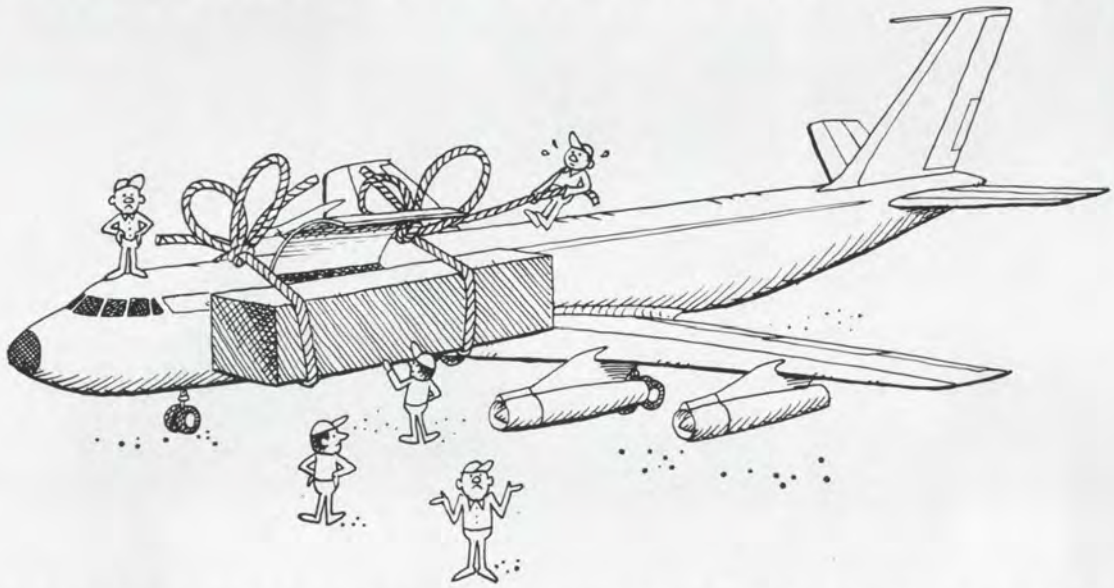

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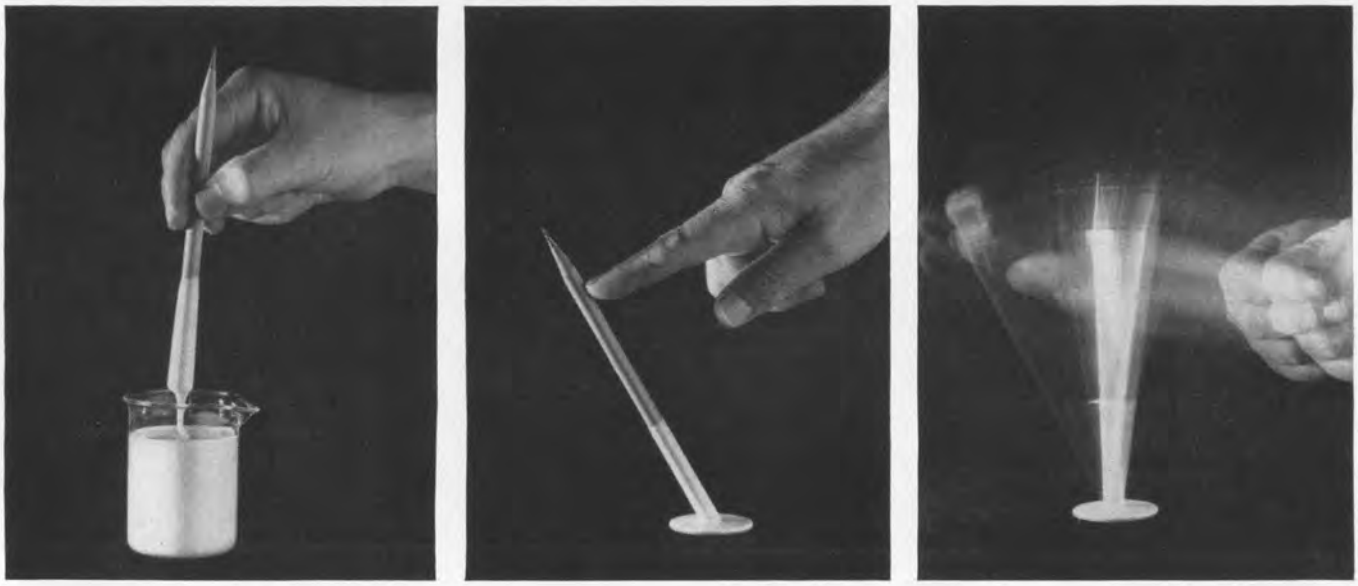
The first ready-to-use RTV silicone rubber that flows, adheres and flexes



RTV-112 silicone rubber has four characteristics that make it an easy-to-use production line sealant.

Pourable. It's conveniently dispensed automatically or manually.

Ready-to-use. No catalyst to be mixed beforehand. No stirring, either.

Adhesive. Bonds to most surfaces without a primer.

Flexible. Absorbs shock and vibration. Puts no stresses on components.

RTV-112 handles like paint. It can be sprayed and brushed. Parts can be dipped in RTV-112 for easy encapsulation. It's tack-free in 30 minutes, and cures in 24 hours at room temperature. No solvents, so there's no flammability hazards and virtually no shrinkage.

RTV-112 silicone rubber is unique. Virtually ageless, it won't crack, crumble or harden. You can cut it away and add more for easy repairs. Stays rubbery from −85°F to 300°F. It also has excellent electrical properties. It's waterproof.

Where should RTV-112 be used? Because of its easy pour-on protection, RTV-112 is a natural for many production line applications . . . conformal coatings for electronic components and assemblies, high temperature seam sealing and potting of intricate electrical apparatus to mention a few.

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GENERAL ELECTRIC

Technical Articles

Designing for space radiation, part 2: page 70

Part 1 discussed the radiation environment. In this section, the selection of components for radiation-resistant circuits is examined. These radiation-proof circuits—mainly for amplifiers—use transistors and tunnel diodes.

Marketing 1965: page 87

Electronics' annual examination of what's for the industry. (Index on page 191)

Comeback for very low frequency: page 80

Almost forgotten, the portion of the spectrum between 1 and 30 kilocycles has bounced back into importance because it penetrates water without appreciable attenuation. In the Polaris program it is the major communication medium for missile-carrying submarines, but its potential includes worldwide time signals and navigation aids.

Annual index of technical articles: page 191

Listing of the technical articles—and their authors—which have appeared in Electronics through 1964.

Coming January 25

- **A collection of circuits for display equipment**
- **New thin-film dielectrics**
- **Three computers run a steel mill**
- **An engineer's view of the tape-recorder controversy**

Designing against radiation: Part 2

Part I analyzed radiation effects on materials. This concluding article deals with selecting components and designing radiation-proof circuits for use in space

By Henning H. Lind Olesen

Reentry Systems Dept., General Electric Co., Philadelphia

Designing radiation-proof circuits is a matter of selecting components that will survive the space environment with the least possible degradation, and using design techniques to circumvent other radiation problems.

Transistors, for example, are particularly sensitive to radiation, both to ionization and to displacement effects. But field-effect transistors have been found to withstand neutron doses of 10^{15} per square centimeter without drastic change in their electrical characteristics.

Tunnel diodes behave better than transistors when exposed to radiation. Types are available that retain their electrical characteristics in intensities of 2 x 10^{16} neutrons per square centimeter.

Vacuum tubes' glass envelopes fail at about 10^{16} neutrons per square centimeter. But ceramic tubes have survived 10^{17} neutrons per square centimeter.

Ceramic and titanium construction also improve capacitors' and resistors' resistivity to radiation.

Careful selection of components reduces the danger of permanent damage from neutrons.

Choosing the right transistor

Space radiation poses a double threat to the transistor. The ionization effect unbalances circuit parameters temporarily inducing primary and secondary photocurrents in the transistor. And the displacement effect causes permanent damage by displacing atoms from their usual positions in the lattice; this results in a reduction of current gain.

For neutron-particle doses that are 25% of the amount that causes complete failure of a particular transistor, the change in transistor current gain with neutron dose can be calculated from the following equation to an accuracy of 50%:

$$\frac{\beta_f}{\beta_i} = \frac{1}{1 + \frac{.194\ \phi\beta_i}{Kf_{\alpha co}}}$$

where β_f = current gain after exposure
β_i = initial current gain
ϕ = neutrons/cm² (> 10 Kev)
$f_{\alpha co}$ = alpha cut-off frequency
K = degradation constant

Base material	$K\left(\frac{n}{cm^2} - sec\right)$
Ge n	5×10^7
Ge p	2.4×10^7
Si n	2.8×10^6
Si p	3.2×10^6

The nomograms at the left represent this equation.[1]

Degradation in low- and medium-frequency cutoff transistors (less than 50 megacycles) is caused by a neutron-induced change of the minority-carrier lifetime in the base region. The lifetime is the period during which the carrier injected from the emitter can exist in the base region before combining with an impurity. As neutrons collide with atoms in the base material, the atoms move out of their crystal lattice, creating new impurities with which minority carriers can combine. These combinations shorten the carriers' lifetime.

Neutron collisions also change the base material's conductivity. Except in very-high-frequency transistors (greater than 1,000 Mc), however this effect is much less drastic than the effect on minority-carrier lifetime. The two effects are of approximately equal magnitude in the very-high-frequency transistors.

The current generated in the transistor by ionizing gamma radiation is approximately[2]

$$I(t) = \frac{q\,[\dot{R}(t)]\,\rho\,A}{e}\,(x_1 + x_2)$$

where

q = electronic charge = 1.6×10^{-19} coulomb
$\dot{R}(t)$ = gamma dose rate = ergs/gr(x)/sec; (x = semiconductor material)
ρ = density of semiconductor material =

ρ = gr/cm³

A = area of junction = cm²

$\underline{e}$ = ionization efficiency = ergs (for germanium, $\underline{e} = 4.8 \times 10^{-12}$ ergs; for silicon $\underline{e} = 5.6 \times 10^{-12}$ ergs)

x_1, x_2 = width in cm on either side of the transistor junction containing generated electron ion pairs

Recent data shows that the total ionizing dose associated with the dose rate must exceed 10^4 ergs per gram before the above equation applies. The first term of the equation

$$\frac{q\,[\dot{R}\,(t)]\,\rho\,A}{\underline{e}}$$

is based upon known data. The second term ($x_1 + x_2$) is determined by device parameters and radiation pulse-time history.[2]

The recovery time from the induced current is a function of the minority-carrier lifetime, and ranges from 10^{-6} seconds for high-frequency transistors to 10^{-3} seconds for low-frequency devices. Circuit recovery time may be considerably longer, however, because of inherent circuit-time constants. A fast-recovering circuit can be designed by reducing time constants.

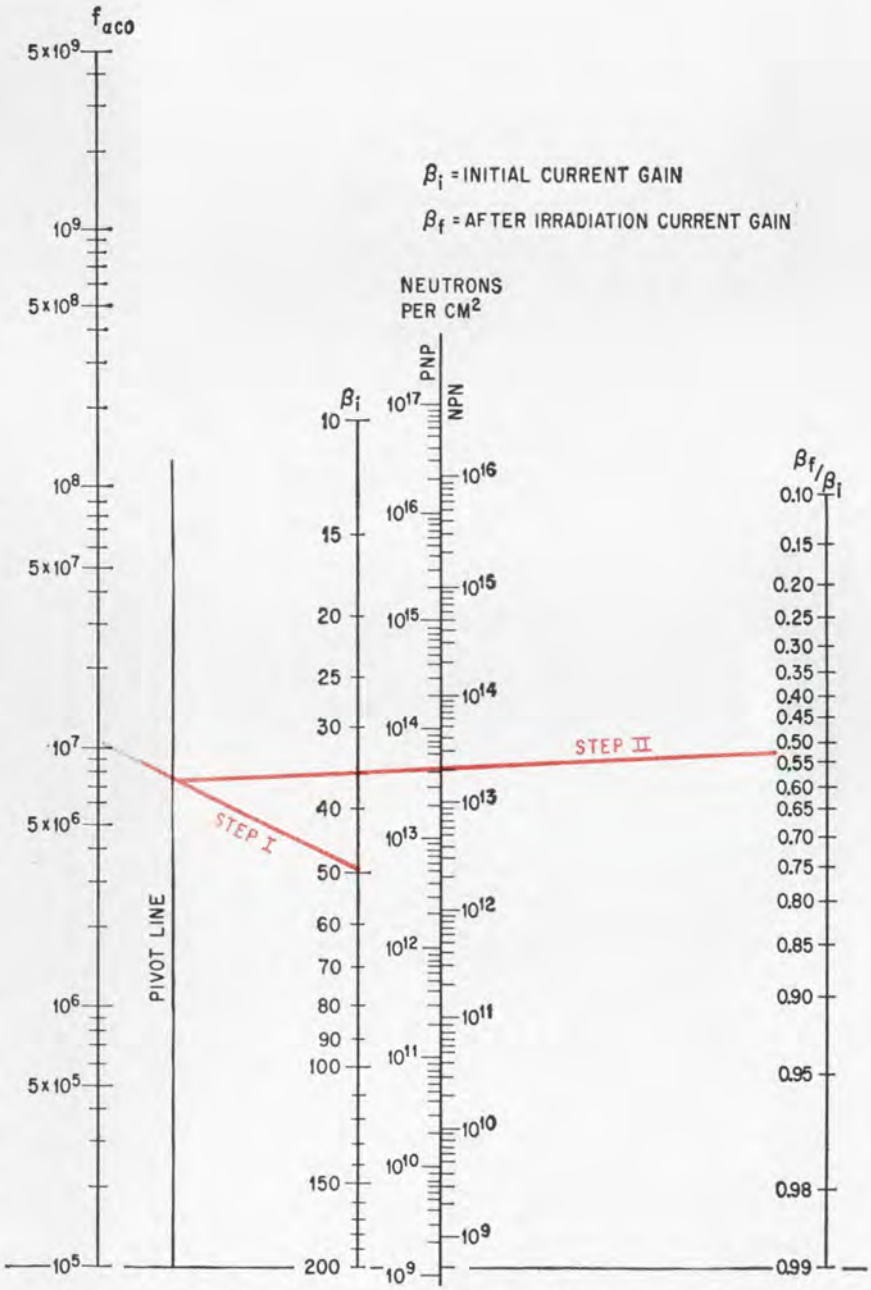
Field-effect transistors do not depend upon minority-carrier lifetimes for proper operation. Therefore they are less sensitive to displacement damage.

Two types of FET's are available. The diode-gate type is the more common and the more sensitive. It has a semiconductor junction between the gate and the channel. A small leakage current flows across this junction, increasing with neutron dose as in an ordinary diode. The pinch-off voltage increases with the leakage current.

The other type of FET, the insulated-gate type, introduces a layer of semiconductor material between gate and channel. The leakage current is reduced to a very low value, allowing the pinch-off voltage to be practically unaffected by neutron radiation. The insulated-gate FET retains its electrical characteristics until neutron radiation drastically changes the conductivity of the semiconductor material in the channel. This does not occur until neutron doses are applied at between 5 x 10^{14} and 5 x 10^{15} neutrons per square centimeter (>10 kev). Because both types of FET have comparable degradation at these doses, uhf germanium junction transistors may be better. FET's are also sensitive to the ionization surface effect. Ionization effects in the FET can be calculated as shown for transistors.

The tunnel diode

Another majority-carrier device is the tunnel diode. As the neutron dose increases, the diode's peak-to-valley current ratio decreases. In selecting a tunnel diode for operation in a radiation environment, it is



To determine relation of neutron flux to current gain of a germanium transistor, if either value is known, connect $f_{\alpha co}$ (alpha cutoff frequency) with rated β_i. Line intersects pivot line. If neutron flux is known, draw a second line from intersection through this known value to β_f/β_i scale and read off current gain.

helpful to consider that radiation tolerance is a function of current density which, in turn, is related to the ratio of capacitance to peak current. Hence, maximum peak current and minimum capacitance indicate a radiation-resistant tunnel diode.

Tunnel diodes are available that will survive and retain their electrical characteristics in a total neutron dose up to approximately 2 x 10^{16} neutrons per square centimeter (>10 kev).

For diodes, the figure at the right shows the effects of neutron radiation on a typical diode-rectifier structure. Here are some major changes in a diode's characteristics caused by radiation;

1. Forward resistance increases with the dose.
2. The zener point increases slightly.
3. Reverse leakage current increases.
4. The knee at the zener point becomes less sharp.

The application of the diode then determines which of these changes will affect its operation. A rectifier diode and a switching diode are affected by changes 1 and 3. A zener diode is affected by changes 2 and 4.

Experimental evidence indicates that zener diodes with a low zener point are not as vulnerable as those with a high zener point. For example, a 1N 429 zener diode exposed to 10^{15} neutrons per square centimeter (>10 kv) and 10^{6} rads (H_2O does not exhibit an out-of-tolerance change in zener point.

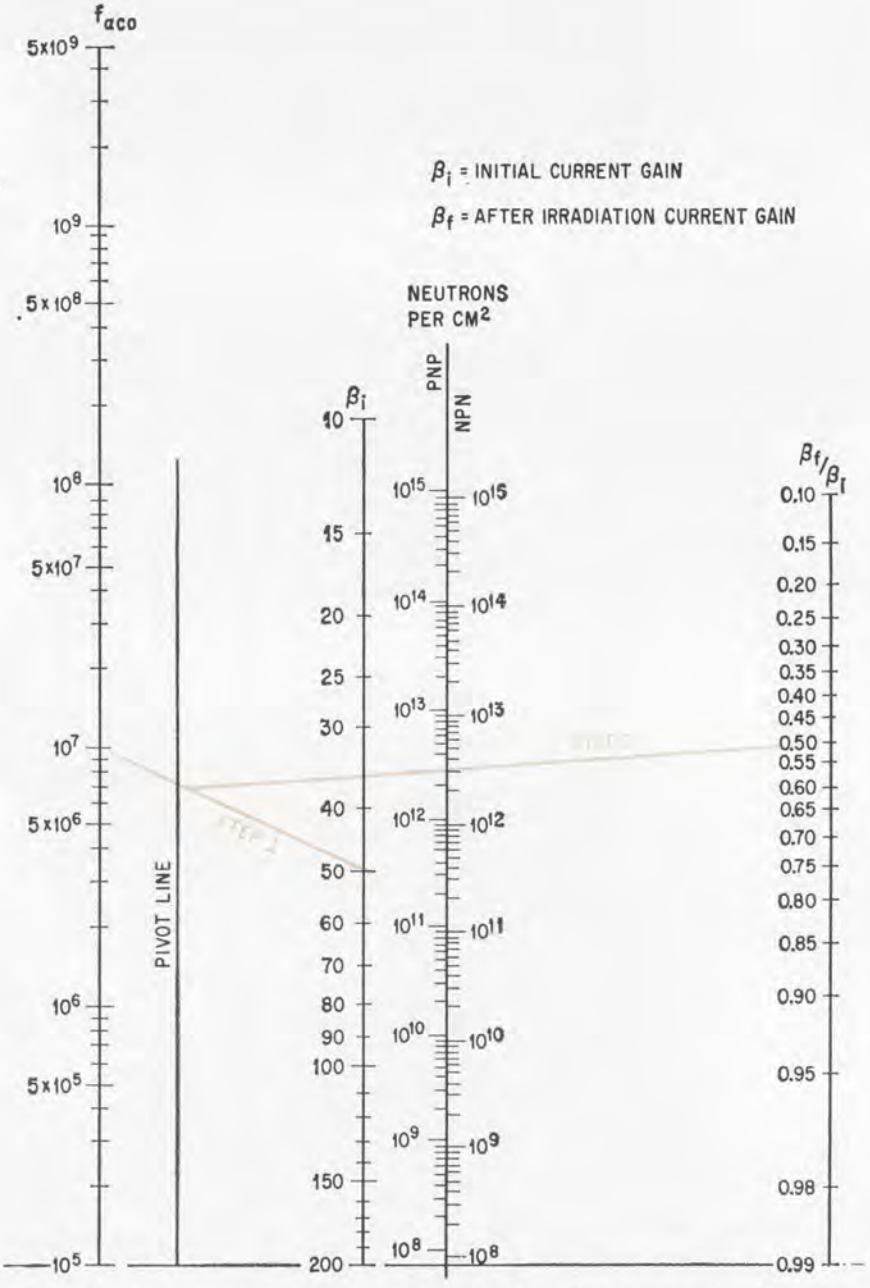
Filamentary vacuum tubes are of two types, glass and ceramic. Many glass envelopes contain boron in radiation, these envelopes often break as the boron captures thermal neutrons and increases the thermal stress in the envelope. Sometimes materials used for the electrode elements outgass. These tubes often fail at between 5 x 10^{15} and 5 x 10^{16} neutrons per square centimeter.

Ceramic vacuum tubes have been tested to 10^{17} neutrons per square centimeter (>10 kev) without failure and are estimated to have a failure threshold of between 10^{18} and 10^{20} neutrons per square centimeter.

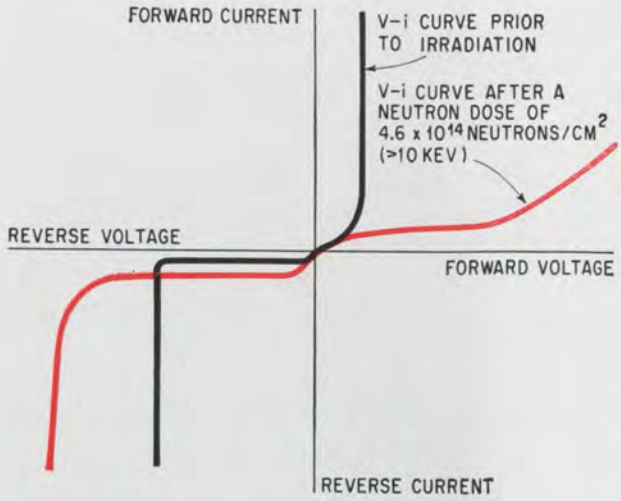
Ionization effects in vacuum tubes are caused by secondary electron emission from the envelope and the electrodes. The current persists only during the gamma pulse. At 10^{7} Rads(c) per second, this current is approximately one milliamepere, in in a ceramic tube. Current generation is a function of dose rate, although experiments have shown that it is not a linear function.

Recovery from ionization effects is also related to a circuit's time constants, and because vacuum-tube circuits generally have high impedances, they also have long recovery times. Low-impedance circuits with shorter recovery times can be designed, but their lower gain requires more stages.

Heaterless vacuum tubes, called thermionic integrated micro-modules (TIMMs), begin operating when heated to 580°C. They are made with heat-resistant materials such as ceramic



Silicon transistor nomogram shows how grounded-emitter current gain of silicon transistors varies as neutron flux varies. The nomogram is used in the same manner as the germanium transistor nomogram.



When a diode rectifier is neutron-irradiated, the forward resistance increases with the dose, the zener point and reverse leakage current increase and the knee at the zener point becomes less sharp.

and titanium, which are insensitive to nuclear radiation. Resistors and capacitors have been constructed from similar materials. This has resulted in a component family that makes for radiation-hard designs. The threshold for neutron damage is at least as high as that for the standard ceramic vacuum tube. A design will be described later that takes advantage of the features of the TIMM components.

Because of their small size and great ability to operate at elevated temperatures, TIMM circuits are less susceptible to ionization effects than the ordinary vacuum-tube circuit. Recent experimental evidence confirms this.[3]

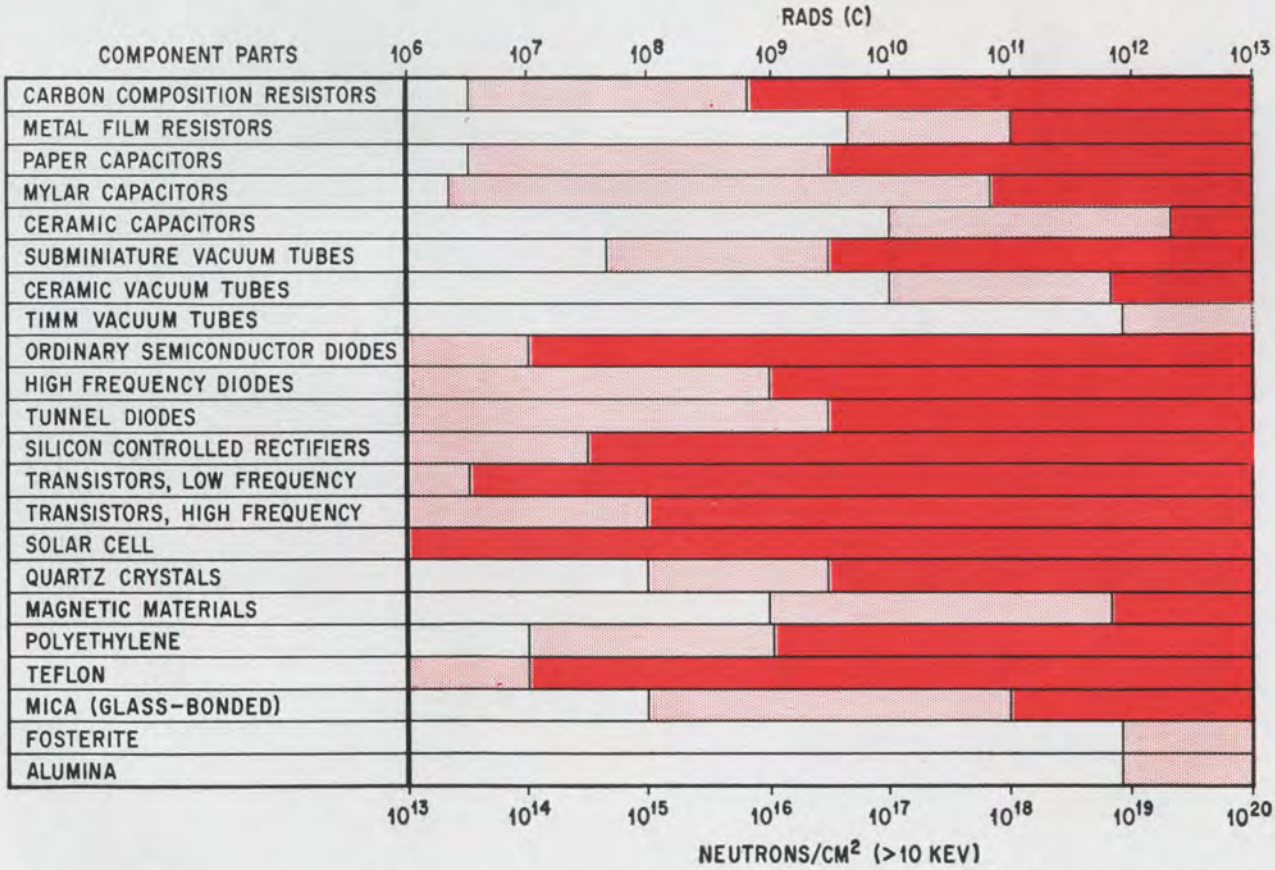
Radiation effect on the performance of capacitors, resistors, cable and insulation can be compared for devices of different materials. The table below summarizes the effects on electronic components and materials.

Radiation-resistant circuits

Designing a radiation-resistant system begins with an analysis of the nuclear environment to be encountered. The designer must determine, as precisely as possible, what kinds of radiation are likely to be encountered—gamma rays, or particles, or a combination—and how high a radiation level is expected.

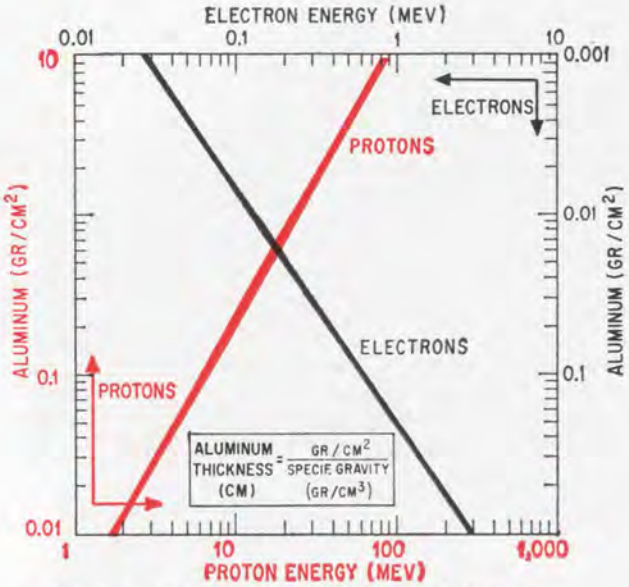
The next step is to determine how much shielding is provided by the space vehicle itself, and to calculate the new radiation spectrum and the new total radiation dose. The designer should decide whether further shielding of individual electronic subsystems is necessary and feasible.

The designer should then analyze the entire electronic system to determine how the failure or

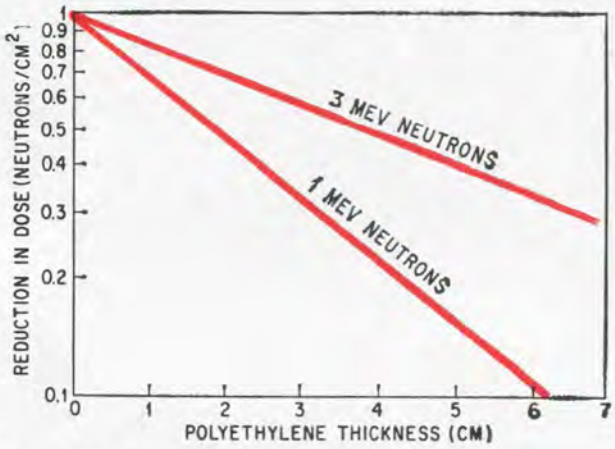


Comparative component sensitivity to a gamma-neutron environment. White area shows region where components can be used without any degradation. Components operating in shaded area lose some of their properties; in solid colored area they fail completely.

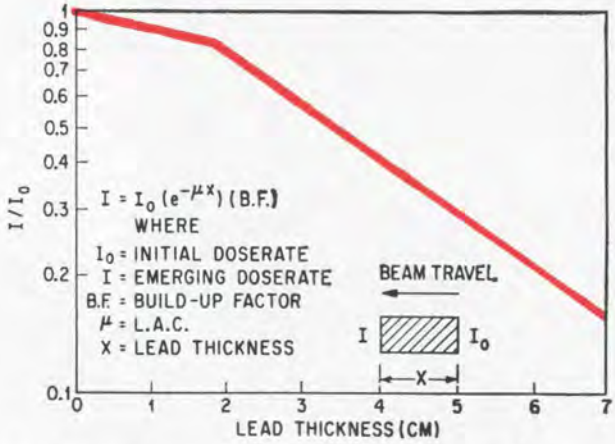
Shielding design curves



Aluminum shielding thickness required to stop different energy electrons and protons



Thickness of hydrogenous material required to reduce a neutron dose



Reduction in gamma dose (1 mev energy) by lead

degradation of any subsystem would affect the over-all operation of the electronic system. With the radiation-sensitive subsystems identified, he can begin designing to make the subsystem's circuits more resistant to radiation.

A circuit's radiation tolerance is no better than its weakest link. The designer, therefore, should analyze all materials and parts for resistance to radiation. He should select parts and materials that will not suffer unexpected degradation in the space environment. The component-sensitivity graph can serve as a guide.

With analysis results at hand, the designer can then substitute radiation-resistant materials and components for those that are known to be poor performers in any particular radiation environment.

Some components have a favorable history of performance in radiation environments. If these components are not available, or suitable, the designer may want to make his own tests. Because radiation testing of electronic components is fairly new, standards are lacking and the various kinds of test data are difficult to correlate. It's important to use care when comparing performance on the basis of test data from different environments.

In a neutron environment, the designer should try to eliminate materials that exhibit a large cross-section to thermal neutrons—such materials as boron, cadmium, gold and silver, when these occur in large concentrations in weight and volume.

If surface effects are a potential problem, transistor devices should be chosen carefully. Only devices with passivated surfaces should be used, and the transistor containers may be evacuated.

Design techniques can compensate for compromises that may have been made in selecting parts. There is no one correct way to solve any particular problem, but two designs are described later in this article as examples.

A circuit's hardness to ionization effects depends to a great extent upon packaging. It is wise to lay out the packaging of the circuit early in the design. From a radiation standpoint, the packaging's main function is to keep air from contact with circuit surfaces; this prevents ionized leakage paths during gamma radiation.

Air can be excluded by evacuation or by encapsulation. If evacuation is used, the vacuum pressure must be reduced to well below 10 millimeters of mercury. Encapsulation should be done with a well-adhering compound such as silicone rubber or epoxy, which adhere tightly.

The trouble with shielding

Shielding as a design technique for space applications can be discounted except for low-energy electrons and protons. Even then, it is important to bear in mind that the absorption of these particles by a shield produces secondary ionizing radiation that may be just as undesirable for other reasons, including surface effects. The curves at the left show the thickness of aluminum shielding required to stop electrons and protons of various energies,

the reduction in gamma dose (1 mev energy) by lead, and the volume of hydrogenous material required to reduce a neutron dose. Neutrons with energies greater than 5 mev may produce photonuclear interactions with the nuclei of materials.

Because of its weight, a shield is rarely used exclusively as a design element. But new shielding techniques may become available at any time. For example, electrostatic or magnetic shielding is receiving considerable attention as protection against the charged particles of the Van Allen belts and those produced on the sun[4].

Designing an amplifier

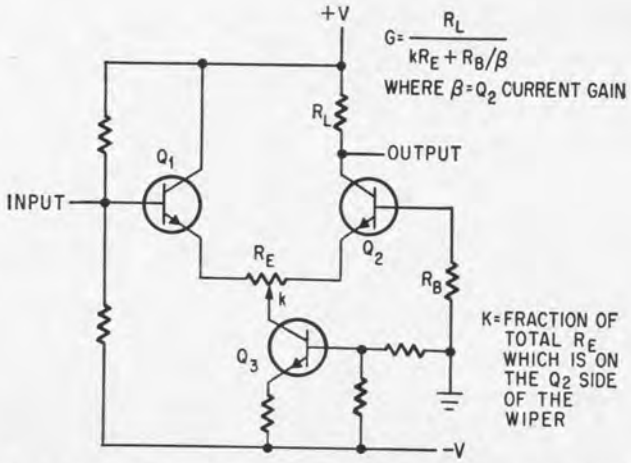
Here are two examples of radiation-hardened circuits that can be used in space.

For the first circuit, an amplifier is needed for a computer aboard a nuclear-propelled space ship. The system analysis indicates the total environment to be as follows:

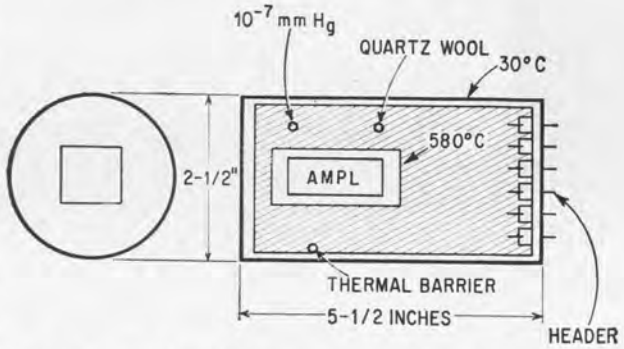
Total neutron dose = 10^{13} neutrons/cm^2 (>10 kev)
Total gamma dose = 10^7 rads(c) (average energy 1 Mev)
Quiescent doserate = 10^3 rads(c)/hour
Short bursts at = 10^6 rads(c)/second

Shielding has been taken into account. The design approach is established by first considering the degradation caused by the total radiation dose. At 10^{13} neutrons per square centimeter and at 10^7 rads(c), most transistors retain much of their inherent gain. It seems reasonable, therefore, that a transistor design will be adequate for this application if the thermal environment is controlled to suit the transistors thermal characteristics.

A severe surface-effect problem is possible in this environment. The transistors to be used must be selected with this in mind. First, the devices[5] surfaces should be protected perhaps by passivation. This is best achieved during manufacture of the devices. Slight variations in manufacturing processes may affect a transistor's electrical characteristics very slightly but these small changes may have a large effect on the device's response to surface effects.

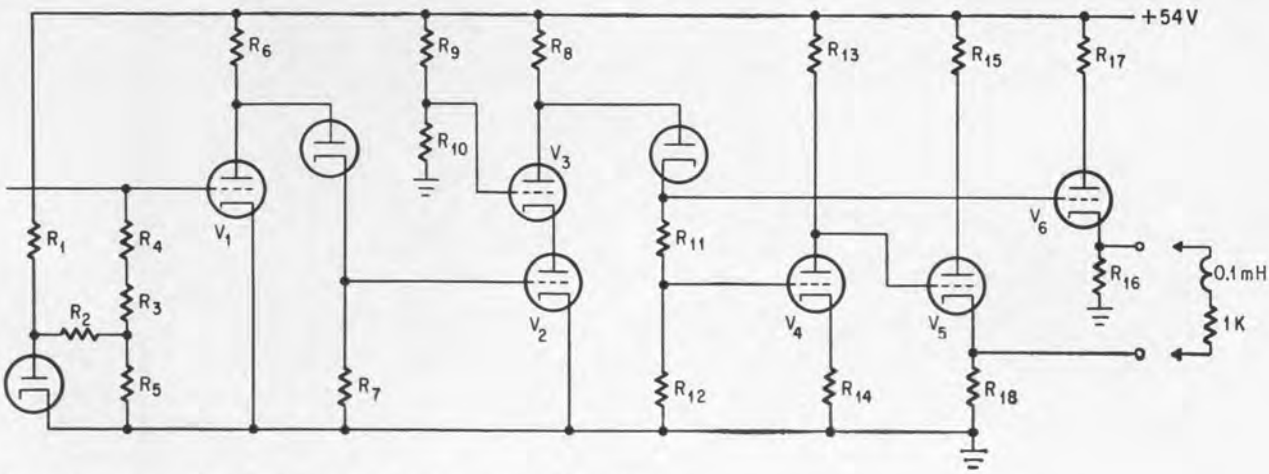


Degradation in circuit gain produced by neutrons is reduced by designing circuits like this, where the transistor-gain term becomes less important in the gain equation.



Radiation-proof, direct-record amplifier is packaged in a ceramic chassis which supports the TIMM circuit elements and holds platinum heater wires. Chassis is supported by quartz wool thermal insulating material. Evacuated stainless steel container contains the package.

Work is in progress whose goal is to predict a transistor's response to surface effects as a function of certain electrical characteristics. Creating a vacuum around the transistor surface may also be warranted. Encapsulation of the junction surface has not been successful because of contamination. It may be helpful in designing against this condi-



Direct-record amplifier designed with direct coupling. Capacitors were eliminated to reduce time of recovery from ionization effect.

tion to irradiate the transistors prior to use. The circuits can then be designed to accommodate the parameters of the damaged transistor.

Degradation in transistor gain by neutrons is avoided by designing circuits where the transistor gain term becomes less important in the gain equation. Such a circuit is shown at the left. The gain equation for the circuit is:

$$G = \frac{R_L}{KR_E + \frac{R_B}{\beta}}$$

By making R_E much larger than R_B, the circuit's gain becomes almost independent of transistor parameters. The resistors can be any standard type at the given radiation level. Insulation and other materials used for circuit construction are relatively impervious to the given neutron radiation level. However, the total gamma dose is higher so that organic materials should be chosen carefully.

The high gamma-dose rate of 10^6 rads(c) per second produces temporary disturbances in the amplifier which, as in the following switching circuit stages, can be interpreted as trigger signals. It is important to minimize ionization effects in the amplifier. Ionized air, which would create leakage currents across the surfaces, must be removed. In transistor circuits this can be done by encapsulating the circuit in a firmly adhering encapsulant such as silicone rubber.

After transistors, largest producers of ionization effects are capacitors, especially coupling capacitors. These produce large effects while being exposed, and prolong the effect for a period determined by the time constant of that part of the circuit. Therefore, a design is preferred that can either eliminate the capacitor as a circuit element or at least reduce circuit capacitance. Resistors produce ionization effects to a lesser extent, especially if they are encapsulated.

The transistor itself produces ionization effects. By using transistors with small device volumes such as very-high-frequency transistors, the internally produced ionization current can be reduced. By using this type of transistor in the sample circuit, the effect of internally produced currents is reduced. When the circuit is balanced electrically and exhibits good common-mode rejection for electrical noise impulses, it also tends to reduce the circuit ionization currents.

It is difficult to find a pair of transistors in which the common-mode rejection factors for the ionization induced currents are identical. By electrically balancing the circuit, however, the rejection of ionization currents may still be sizable.

A direct-record amplifier

The second example is that of a direct-record amplifier, which was developed by the Reentry Systems Dept. of the General Electric Co. The specification called for no degradation in system performance for a neutron dose of less than 10^{16} neutrons per square centimeter with energies higher than 10 kev and a total gamma dose of 10^6 rads(c). The system performance had to recover rapidly from the ionization effects caused by 10^{12} rads(c)/second gamma dose rate.

Because of the high neutron dose, the chosen design was based upon the heaterless ceramic-tube family of components, the TIMM. These components were developed by GE to provide a family of components which, when used in circuits, were resistant to both radiation and high temperatures, were lighter and smaller than conventional ceramic vacuum tubes, and consumed less power. All components, vacuum tubes, resistors and capacitors in the TIMM family are of similar design; this makes it possible to design compact circuits. All the components are constructed from titanium metal and insulated with an inorganic ceramic material.

In the TIMM amplifier, direct coupling is used. To reduce the recovery time form ionization effects inherent in circuits with large R-C time constants, capacitors are eliminated. To further reduce the effects of transient ionizing radiation, which develops and persists easily across very high impedances, the highest-value resistor in the design is 63 kilohms.

The amplifier is linear for input voltages from 0 to 15 millivolts. It provides a current gain of 40 decibels. The input impedance varies with frequency, from 100 kilohms at direct current to 20 kilohms at 250 kilocycles per second, which is the band width of the amplifier.

Metals and inorganic insulating materials were used for the package. Metals with low secondary-electron emission efficiency were preferred. A ceramic chassis supports the TIMM circuit elements and holds the platinum heater wires to maintain the TIMM vacuum tubes at their operating temperature of 580°C.

The ceramic chassis is approximately in the center of a cylindrical container, and is supported by thermal insulating material made from inorganic quartz wool. The cylindrical container is made of stainless steel, with a header of kovar metal and steel welded to one end. To eliminate surface ionization effects, this assembly is evaculated to a pressure of 10^{-7} millimeters of mercury.

After the materials' thermal lag is overcome, the heating power required for this package is five watts.

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5. R.R. Blair, "Surface effects of radiation on transistors," IEEE Transactions on Nuclear Science, November, 1963.

Designer's casebook

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

Antenna's reflecting surfaces increase beacon bandwidth

By W.A. Cumming

National Research Council, Ottawa

In the microwave region, beacon antennas are commonly designed in the form of slotted arrays cut in the walls of circular or rectangular waveguides. If the radiant energy is to be directed perpendicular to the waveguide, a resonant array must be employed with a resulting restriction in either bandwidth or array length. If a nonresonant array is used, the bandwidth is greatly increased but the energy is no longer concentrated in a plane normal to the array. To obtain a wide bandwidth, a choice of polarization and a simple means of adjusting the beam angle, an antenna was developed that uses reflecting surfaces.

From the antenna model shown in the photo it can be seen that the beacon consists of a circular waveguide illuminating a paraboloidal reflector, which in turn is directed at a 45° cone. The antenna has a base diameter of 12 inches and a vertical aperture of 7 inches. It was tested at a center frequency of 16 gigacycles.

Microwave beacon antenna consists of a circular waveguide that illuminates a paraboloidal reflector, which then directs the radiant energy at a 45° cone.

The circular waveguide can be excited in the TM_{01} mode, in which magnetic field lines are concentric circles and the transverse electric field is radial. This mode produces vertical polarization with respect to the beacon axis. The waveguide can also be excited in the TE_{01} mode, in which electric field lines are concentric circles and the transverse magnetic field is radial. This mode produces horizontal polarization. The TM_{01} was excited directly from a coaxial line by an axial probe projecting along the waveguide axis. The TE_{01} was converted from the TM_{01} by a barrier-type mode-converter and filter.

The mode-converter consists of several conductors placed across the guide in such a way that they are excited by the incident radial electric field. These conductors reradiate a circumferential component of the electric field because of their position in the guide. The filter consists of a series of radial plates that short-circuit the radial field but pass the circumferential field.

In both modes the aperture diameter is 1.53λ at midband. The primary pattern for the TM_{01} mode is given by

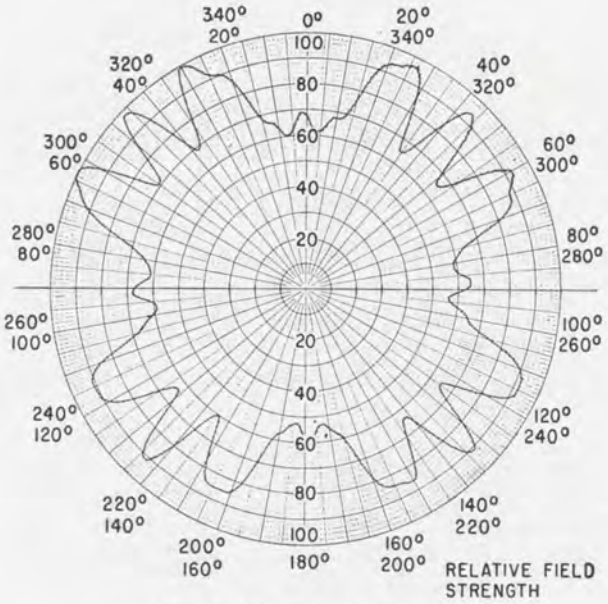
$$E \propto \frac{\left(\frac{\lambda_o}{\lambda_g} + \cos\theta\right) \times J_o\left(\frac{2\pi\alpha}{\lambda_o}\sin\theta\right)}{\sin\theta\left[1 - \left(\frac{\lambda_o}{\lambda_c \sin\theta}\right)^2\right]}$$

and the mode for the TE_{01} pattern is given by

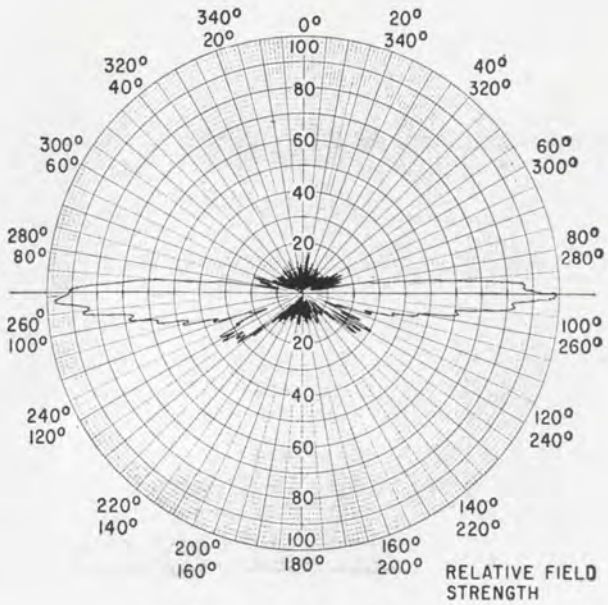
$$E \propto \frac{\left(\frac{\lambda_o}{\lambda_g} + \cos\theta\right) \times J_o'\left(\frac{2\pi\alpha}{\lambda_o}\sin\theta\right)}{1 - \left(\frac{\lambda_c}{\lambda_o}\sin\theta\right)^2}$$

where a is the waveguide radius, θ the antenna angle with the waveguide axis, J_o is a zero order Bessel function, J_o' is the first derivative of J_o, λ_o is the free space wavelength, λ_g is the guide wavelength, and λ_c is the cut-off wavelength.

Both of these functions have a null on-axis and a peak about 30° off-axis. As a result, the ratio of the focal length of the paraboloidal reflector to the antenna diameter, f/D, could be as large as 0.4; but a series of measurements showed that this gave excessive spillover, at least for the aperture size

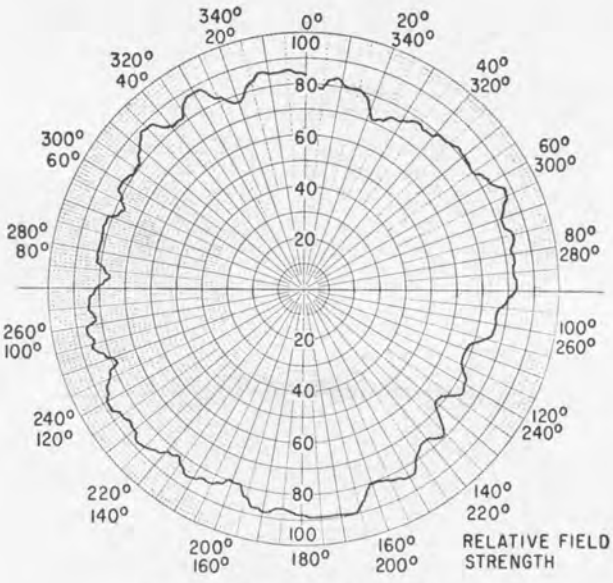


VERTICAL POLARIZATION
AZIMUTH PATTERN

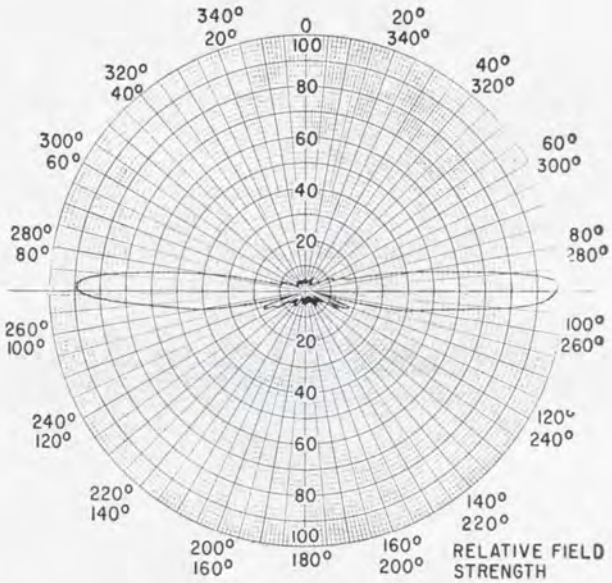


VERTICAL POLARIZATION
ELEVATION PATTERN

Azimuth and elevation patterns for the beacon antenna when it is vertically polarized. The dips equally displaced by 90° in the azimuth pattern show the effects of the metal support struts used to separate the two reflectors.



HORIZONTAL POLARIZATION
AZIMUTH PATTERN



HORIZONTAL POLARIZATION
ELEVATION PATTERN

Azimuth and elevation patterns for the beacon antenna when it is horizontally polarized. The reflector support struts do not significantly affect the horizontal patterns.

used. Spillover is that energy radiated by the feed but not intercepted by the paraboloidal reflector, and is therefore lost energy. A larger aperture and a larger secondary gain would permit the use of a larger f/D than the 0.25 used in the present case, with a resulting increase in aperture efficiency.

Patterns for both vertical and horizontal polarization are shown above. The azimuth-plane patterns for vertical polarization show the effect of the metal struts used to separate the two reflectors. This can be overcome by using a dielectric sheet to support the two reflectors continuously around their periphery.

The elevation patterns show that spillover past

the paraboloid is considerably less than spillover past the cone. The spillover past the paraboloid would be reduced if the gain were increased. The spillover past the cone can be reduced by increasing the cone size.

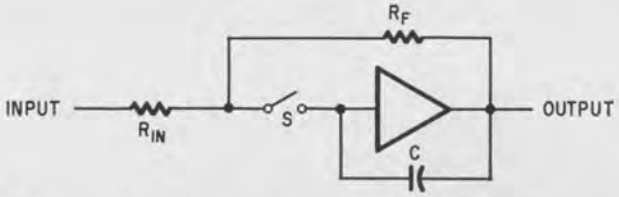
The horizontally polarized patterns are considerably less affected by the support struts. This is expected because of the relative orientation of the struts and of the electric field. Similarly, the diffraction by the edges of the two reflectors is reduced for horizontal polarization because the field is tangential to the edges.

All patterns shown were obtained with the phase center of the feed located on the focal point of the paraboloid. The secondary beam can be made to squint up or down from the horizontal plane by moving the waveguide either out or in from the focal point of the paraboloid.

Transistor switch passes current both ways

By Robert W. Maloy

North American Aviation Corp., Downey, Calif.



In a sample-and-hold-type circuit, switch must pass current in either direction. Operating voltage level of switch is very low because operational amplifier input is practically at ground potential.

The speed requirements of an operational amplifier control switch prohibit the use of a solenoid-operated mechanical relay. For example, the sampling interval in the sample-and-hold circuit shown above, is about 500 microseconds.

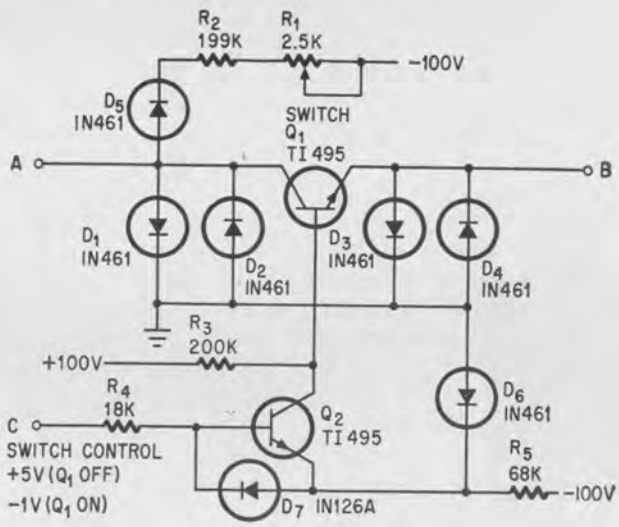
The switch is basically an on-off unit that has very high open-circuit impedance and low closed-circuit impedance. The switch must be able to pass current in either direction; it operates at low voltage because the amplifier input is always close to ground potential—approximately 200 millivolts.

The values of the components shown in the circuit diagram are suitable for an amplifier switch that must pass one milliampere in either direction. Diode pairs D_1 — D_2 and D_3 — D_4 are voltage limiters. Transistor Q_1 is the basic switching element. A type TI495 silicon transistor made by Texas Instruments, Inc., was selected for Q_1 because its collector characteristics pass exactly through the origin (zero collector current at zero collector voltage). This is important if the low input voltage is not to become loaded by the switch impedance. The beta of the TI495 is greater than two when the emitter and collector are interchanged.

When the base voltage is negative, Q_1 is off and it presents an open circuit; when its base voltage is positive Q_1 is on, creating a short circuit. Although the circuit operates with either polarity input, the forward current gain of Q_1 is 40 times the reverse current gain.

When Q_2 is open, Q_1 will be biased on because of the current flowing through R_2 and R_3 (collector and emitter interchanged).

R_1 must be adjusted so that the current through R_2 equals the current through R_3; otherwise the bias network will contribute extraneous current to the summing junction of the amplifier. Diode D_5



Basic switching element is transistor Q_1. The collector and emitter can be interchanged to fulfill the requirement that current pass in either direction. However, the forward current gain is 40 times the reverse current gain.

matches the temperature characteristics of Q_1 and limits thermally induced current variations to about 0.001 microampere per degree centigrade.

If Q_2 is driven into saturation, the base voltage of Q_1 becomes negative, turning Q_1 off. When Q_1 is off, the current through R_3 flows to ground through Q_2 and R_5. The currents through the input and R_2 go to ground through D_1 or D_2. Diode D_6 is the bias regulator for Q_2, and D_7 limits excessive reverse bias at the base of Q_2.

Switching time is about two microseconds.

Very low frequency antennas are going back to work

Abandoned since the 1920's, very long wave technology has made its comeback with reliable, superpower transmission to Polaris submarines

By John C. Walter

Potomac River Naval Command, Washington

The almost forgotten very low frequency portion of the spectrum, from 10 to 30 kilocycles, has become vital. Because it penetrates the water without excessive attenuation it is the only band in which signals can be transmitted reliably from shore installations to submerged submarines many hundreds of miles away. Effective communication to submarines carrying the Polaris missile is as important as the missile itself. Because it depends primarily upon propagation over the ground rather than reflection from the ionosphere vlf is immune to nuclear blackout.

Besides its use in the Polaris missile submarine program, vlf is a valuable tool in other services. It is excellent as a means for disseminating worldwide time and frequency standards. It has been effective as a navigation aid covering large areas, like the Indian Ocean.

The physical characteristics of the antenna system control the bandwidth of the signal and the efficiency with which the power is radiated at vlf. Because of the enormous size of components, potentials in the hundreds of kilovolts, the impossibility of erecting self-resonant structures and the impracticability of cut-and-try methods, careful design of the antenna and its feeders is imperative at very low frequencies.

The author

John C. Walter is a consultant on vlf and high-power radio systems for the Bureau of Ships, U. S. Navy. He was responsible, at the Radio Corp. of America, for the design, production and installation of the Jim Creek, Washington, megawatt vlf Navy transmitter. Walter is a captain in the Naval Reserve and a registered professional engineer.

Basic trades

Bandwidth and efficiency are important engineering tradeoffs at lf and vlf because bandwidth varies inversely with efficiency. Earlier use of relatively slow-speed telegraphy at data rates of 15 to 20 bauds made it possible to optimize the radiation efficiency of the antenna, which was only 10% to 20%. Modern vlf antennas must be designed for minimum radiation efficiencies beyond 50%, with sufficient bandwidth to accommodate data rates up to 50 bauds.

The absolute or intrinsic bandwidth of an antenna is determined by the Q factor or kva/kw ratio of the antenna for which Q is also the ratio X/R. The reactance X is derived from the static or zero-frequency capacitance of the antenna alone and R is the total resistance looking into the base or driving point of the antenna through its tuning coils. An important difference between design of high-frequency antennas that are long with respect to wavelength and vlf antennas that are shorter than a quarter wave lies in the need to consider static capacitance rather than the apparent capacitance that results from the combination of "top hat" capacitance and inductance of the down leads.

When assessing the bandwidth capability of an antenna system (as contrasted with a simple antenna in free space) it is necessary to consider the loading introduced by losses in the generator, or transmitter, the transmission lines and networks.

Multiple feeds.

Many of the older vlf antenna systems and some of those more recently installed employ one or more variations of the basic multiple-tuned an-

In the foreground a counterweight track of the Cutler, Me. vlf antenna system. The antenna tower, separate from the track, is in the near background. (Continental Electronics Mfg. Co.)

tenna developed by E.F.W. Alexanderson nearly fifty years ago. Unfortunately, the details of his work are only briefly recorded and have proved insufficient for a complete design. As a result, much of the recent work has been costly. It is to prevent further duplication of effort that many of the important design parameters are set forth here.

Since the multiple-tuned type of antenna is derived from the basic capacitance-loaded, single-tuned Marconi antenna, it is convenient to start with the Marconi in developing the concepts represented in the more complex multiple-tuned antenna.

The basic single-tuned Marconi antenna operated below its fundamental frequency, or quarter-wave resonance, may be viewed as a series-resonant loop having two series resistance elements, radiation resistance and loss resistance. The capacitive reactance of the antenna is neutralized by an inserted inductive reactance so that the input impedance seen by the generator is $R_t \pm jO$, where R_t is the sum of the radiation and loss elements, R_a and R_l. The circuit, A, is shown on p. 82.

It is convenient to break the loss resistance into two parts; R_c, the loss resistance of the series loading inductances and R_b, the remainder.

Power delivered to the antenna system in the resonant condition is I^2R_t and the radiated power is I^2R_a. Radiation efficiency is therefore R_a/R_t. Determination of R_t is accomplished by resistance variation or resistance substitution methods, while R_a is derived from either field-strength measurements or mathematical analysis of the R_t versus frequency characteristic after the method suggested by A. Hund.

Added downleads

The Alexanderson multiple-tuned system consists of a basic Marconi antenna with one or more added downleads, each downlead being resonated to neutralize a multiple of the capacitive reactance of the antenna. By appropriately spacing these tuning points, the distributed capacitance of the horizontal antenna is divided into equal parts.

The elementary theory of operation is that by dividing the antenna into equal capacitance sections and operating these sections in parallel, a

Vlf-the forgotten art

The hiatus in long-wave technology, spanning two generations of engineers, started in the 1920's with the discovery that short waves—except for periods of radio blackout—could get through better with less power.

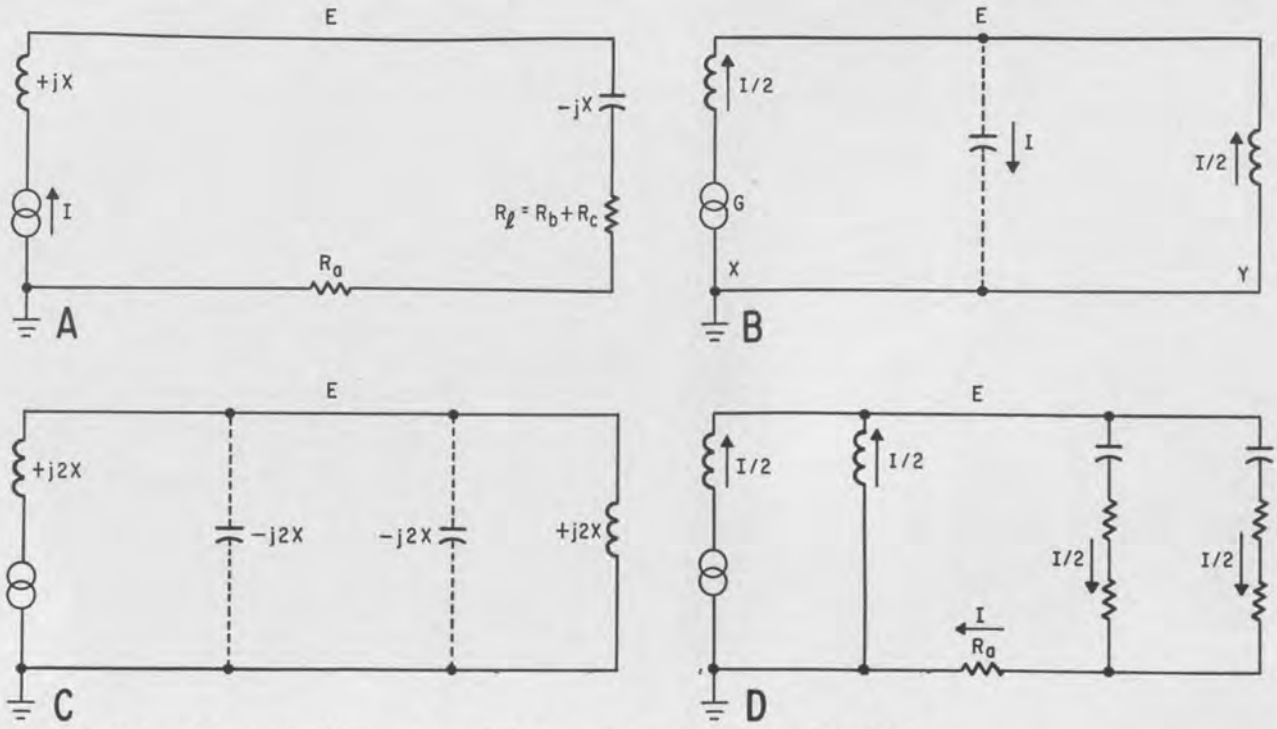
Now, very low frequency is making a comeback. Vlf, the range from 10 to 30 kilocycles, is the only known way to communicate with submerged submarines at great distances. The need to control the deployment of nuclear-powered and nuclear-armed undersea craft shares strategic and tactical importance with the Polaris missile itself.

Because of the sudden transition to high-frequency systems and the subsequent abandonment of vlf for commercial use, many engineers are unfamiliar with the fundamental properties of the multiple-tuned antenna. This basic knowledge is essential to further development into new dimensions of higher power.

Antennas, the most critical elements in vlf communications, must be built from designs that provide voltage gradient control to prevent power loss through corona discharge. A major breakthrough is needed to obtain conductors with large effecitve diameters without lessening their tensile strength or increasing weight per unit length because present conductor-bundling techniques are inadequate. Insulators also need redesigning to equalize dielectric stress.

To melt sleet from today's vast antenna structure requires taking a section out of service for as much as an hour while 60-cycle heating power is applied. Development of better chokes or antiresonant circuits could permit electrical de-icing during radio-frequency operation.

In particular, many engineers familiar with high-frequency antenna design do not immediately recognize the fact that static capacitance, rather than apparent capacitance (which includes the effect of downlead inductance) strongly influence antenna bandwidth at vlf.



Basic single-tuned Marconi antenna represented as a series resonant loop with radiation resistance and loss resistance (A). Simplified circuit showing current flow in a two-downlead antenna system (B) redrawn in a form that shows division into two equal capacitive elements (C). The previous scheme is redrawn, folded back on itself, and the resistance elements inserted (D).

net reduction in loss resistance is achieved without altering the radiation resistance, thereby improving the radiation efficiency of the system.

Omitting the various resistance elements for the time being, the simplified circuit B shown above illustrates the mechanics of the current flow in a two-downlead system, the most elementary multiple-tuned form.

Downlead X represents the feeder containing the generator, G, which charges the horizontal capacitance element of the antenna to a potential E. The voltage along the horizontal element is essentially constant owing to the very short electrical length of the flat-top capacitance element. If the inductive reactances of downleads X and Y are equal, the voltage E causes equal in-phase currents to flow upward in both downleads.

Because the antenna has been effectively divided into two equal capacitive elements, each fed by its own downlead, the resultant network may be redrawn as in C.

Halving the capacitance doubles the reactance in each half, requiring twice the inductive reactance to resonate each antenna-half. Once the current and reactance conditions are established it is possible to examine the various resistance elements and their effect upon radiated power and efficiency.

Because E is essentially constant, diagram C can be folded back on itself and redrawn as D with the resistance elements in the appropriate places.

Dual feed

The radiation resistance, R_a, is a function of the physical height of the antenna and remains the same for either single-point or multiple-point tuning. It is therefore shown as a series element.

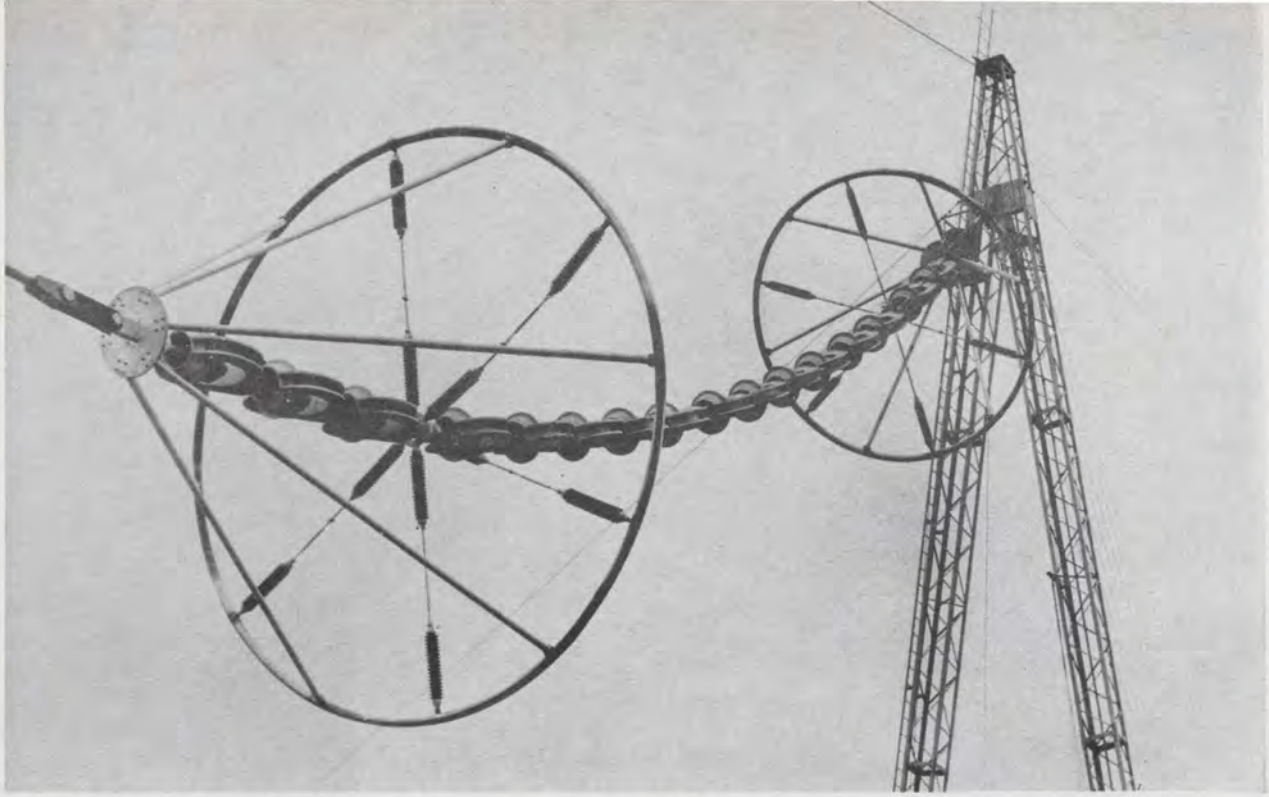
Loss resistances become parallel elements in multiple-tuned systems. In this case each half of the antenna system contains portions of the loss resistance. It might be assumed that for parallel operation of the two halves the net loss resistance is one-fourth that of the original. Such is not the case, however, because it is necessary to double the downlead tuning inductances in each downlead for multiple operation. The portion of the loss resistance contributed by the inductors is increased by a factor k that is determined by the form factor, copper losses and coupled-in losses of the coils.

It has been determined experimentally that coil resistance varies approximately as the square root of the inductance when the optimum form factor is

Operating data for a multiple-tuned antenna*

Number of downleads	1	2	3	4
R_t, ohms, single downlead	0.565	—	—	—
R_m, ohms, multiple	—	0.307	0.259	0.242
R_d, ohms, per downlead	0.565	0.614	0.777	0.968
Radiation efficiency, %	19.8	36.5	43.3	46.2
Radiated power, kw	112	206	245	261
Q	265	488	579	618
Bandwidth, cps	98.5	53.5	45.0	42.2
Current amp per downlead	1,000	678	493	382
Coil reactance per downlead	109	218	327	436
E_c, kV, rms, top of helix	109	148	161	167
f_o, kc	49.8	75.0	89.0	100.
E_a, kV, rms	168	182	192	200

* Operating at 26.1 kilocycles with two, three or four downleads compared with a single-downlead Marconi type



Insulator units at Cutler, Me. Navy vlf station are mechanically fail-safe. Failure of a porcelain unit will not drop the antenna because the coupling rod has a large head that cannot pull through the base of the insulator yoke, frame. The large corona ring assemblies reduce potential gradient and allow corona-free operation up to 250 kilovolts under severe icing.

maintained. Thus, doubling the inductance when reconnecting for two-point tuning increases the coil resistance per downlead by a factor of 1.41 under ideal conditions. In practice, however, it is not economical to redesign large helices for multiple tuning in the field, nor is it feasible to provide ideal coils for each of the various inductance values required for different operating frequencies. The best coil form factor is necessarily restricted to an initial design aimed at achieving maximum efficiency at a chosen frequency.

Design detail

The total resistance of a single downlead system consists of three elements: radiation resistance, R_a; the portion of the loss resistance that is not contributed by the loading inductances, R_b; and the portion of the loss resistance due to the loading inductances, R_c.

When an existing antenna system is modified for multiple tuning the loss resistance is redistributed. The b portion follows an inverse square law since it is divided into equal parts by the number of downleads and the parts are paralleled. The b portion of the multiple resistance becomes $R_b/4$, $R_b/9$, $R_b/16$ for two, three and four downlead operation, or, for n downleads, $R_bn = R_b/n^2$. The R_b element of resistance in each downlead will be R_b/n.

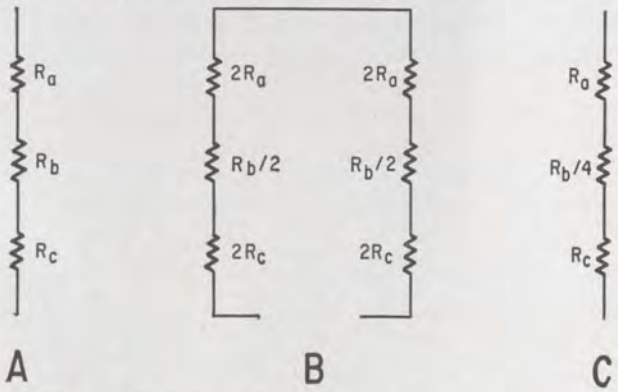
Subtracting the R_b portion from the total loss resistance leaves a remainder constituting the R_c element. Because the loading coil inductance increases proportionately with the number of downleads and, for the practical case, the k factor is 1.0, the R_c portion of the multiple resistance will be R_c, regardless of the number of downleads, and the R_c element of resistance in each downlead will be R_cn.

Since each downlead contributes half the radiated power with only half the total current flowing in it, the effective radiation resistance in each downlead is $2\,R_a$.

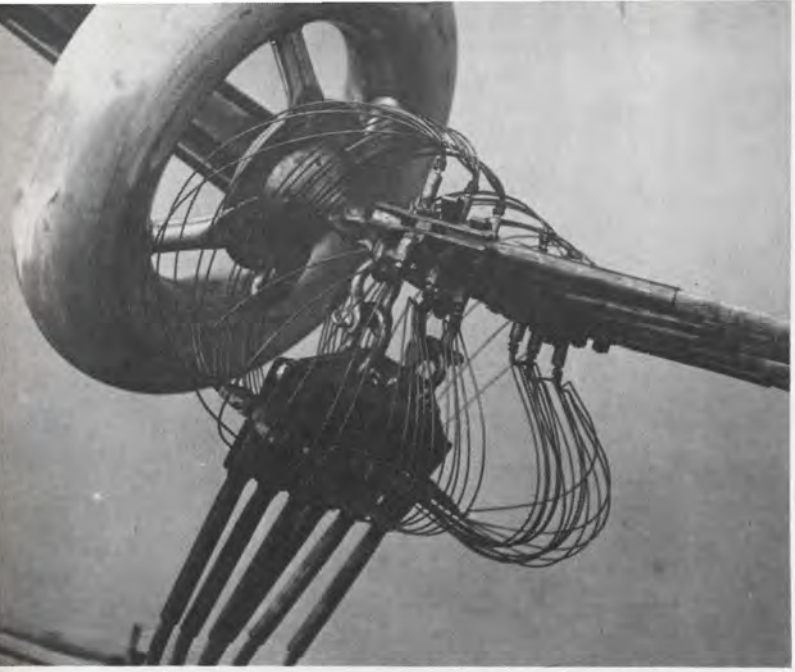
It is clear that the effective multiple resistance, R_m, of two downleads is one-fourth the total series resistance, R_s, of the two-downlead system as measured at the driving point.

$$R_s = 4R_a + R_b + 4R_c$$
$$R_m = R_a + R_b/4 + R_c$$

The diagrams shown left illustrate the redistribution of the resistance elements, including radiation resistance, in a two-downlead system. Section A represents the single downlead system before modification, where the total resistance, R_t, is



Redistribution of resistance elements, including radiation resistance, in a two-downlead system showing single downlead (A), two downlead series circuit as measured (B) and equivalent two-downlead circuit showing multiple resistance (C).



Downlead hinge point at Jim Creek Navy vlf radio station. Small hard-drawn wires provide a current shunt around flexible mechanical connections. Spread out, they shield rough edges of the hardware assembly and form an anticorona surface. The spun-aluminum ring reduces potential gradient at the end of the porcelain tube-insulator. Conductors handle 1,200 amps at 180 kv.

Anticorona fittings applied to the high-voltage trunk at Navy radio station in Cutler, Me. The room is copper-shielded to prevent eddy currents in building structure.

$R_a + R_b + R_c$. At B the actual two-downlead series circuit as measured, shows R_s is $4R_a + R_b + 4R_c$; the total power is $(I/2)^2R_s$ and the radiated power is $4R_a\ (I/2)^2$. The total resistance per downlead is $2R_a + R_b/2 + 2R_c$.

The equivalent two-downlead circuit at C indicates multiple resistance, R_m, is $R_a + R_b/4 + R_c$, or $R_s/4$, and the total power is I^2R_m, radiated power aI^2.

The foregoing definitions lead to the general expressions for both the multiple resistance, R_m, and the per downlead resistance, R_d, of a multiple tuned antenna having n downleads is

$$R_m = R_a + R_{bn}{}^{-2} + R_c$$
$$R_d = R_{an} + R_{bn}{}^{-1} + R_{cn}$$

Application

Two characteristic measurements provide the basic analytical data to check the validity of this design approach. The total resistance of the system must be measured with one downlead connected, and also the series resistance of the system with both downleads connected and the loading reactances doubled in each downlead.

Measurements obtained at an existing installation before and after conversion furnish a means for deriving the values of the two components of loss resistance, b and c, at 26.1 kc. The total resistance with single downlead is 0.565 ohms, series resistance, two downleads, 1.228 ohms and radiation resistance, derived elsewhere, is 0.112 ohms. From the measured series resistance data the equivalent multiple resistance for the two downlead connection may be taken as 1.228/4 or 0.307 ohm.

The value of 0.112 ohm for the radiation resistance was derived from a mathematical analysis of the recorded resistance versus frequency characteristic of the station used in the example.

Rewriting in equation form to include the derived factors:

Single downlead, total resistance, $R_t = R_a + R_b + R_c = 0.565$

Multiple resistance, two downleads, $R_m = R_a + R_b/4 + R_c = 0.307$

Series resistance, two downleads, $R_s = 4R_a + R_b + 4R_c = 1.228$

Using the expressions for R_t and R_s and subtracting the equivalent radiation resistance in each case, $R_b + R_c = 0.453$ and $R_b + 4R_c = 0.780$. By subtraction, $R_c = 0.109$, and by substitution $R_b = 0.344$.

The resistance elements for single, dual and series downlead connections check as follows

Single	Dual	Series
R_a 0.112	R_a 0.112	$4R_a$ 0.448
R_b 0.344	$R_b/4$ 0.086	R_b 0.344
R_c 0.109	R_c 0.109	$4R_c$ 0.436
R_t 0.565	R_m 0.307	R_s 1.228

Bandwidth vs efficiency

A measured value of 0.0406 μf has been taken for the static capacitance of the antenna used in the

Antenna tuning equipment at Jim Creek Navy radio station. Two Litzendraht conductors, two inches thick, are run in parallel to reduce copper losses and potential gradient. The room is copper shielded to reduce eddy currents in the reinforcing steel of the concrete structure. Pedestals supporting the variometer (left) and the helices (center and right) are completely shielded with 0.025-inch copper. All seams are soldered and fastened by blind rivets to brass furring.

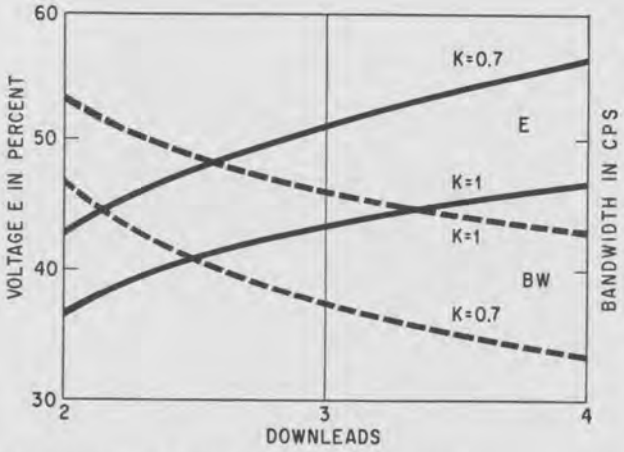
preceding sample calculations of resistance. The frequency of fundamental resonance, f_o, has been measured as 49.8 kc for single downlead operation and 75.0 kc for two-downlead multiple operation. This information is needed in the determination of the per downlead load coil reactance required to tune out the apparent antenna reactance over the range of operating frequencies. The relationship between the true, or static, capacitance and the apparent capacitance of the antenna is expressed by $C_a = C_s/(1 - f^2/f_o^2)$, where f is the operating frequency and f_o is the quarter-wave resonance frequency for a 90° electrical length.

In determining bandwidth, the total effective resistance and the effective reactance as derived from the static capacitance, are the controlling elements. This follows from the basic definition of Q as the kva/kw ratio of a circuit.

At 26.1 kc, the operating frequency used in this example, the reactance of the static capacitance is 150 ohms. Therefore the circuit Q for the single downlead connection is X_s/R_t, or 150/0.565, resulting in a Q of 265. The bandwidth, f/Q, is 98 cycles per second.

For the two-downlead connection the static reactance of the whole antenna is unchanged, the multiple resistance becomes 0.307 ohms, the Q is 150/0.307, or 488 and the bandwidth 53 cps. The same result is obtained if the Q of each downlead is considered individually, where X_s is 300 and R_d is 0.614. According to coupled circuit theory, the system Q is $(Q_1Q_2)^{\frac{1}{2}}$, or $Q_o = Q_1 = Q_2 = 488$.

Since each downlead contains twice the original inductive reactance, two downleads in series must



Interdependent characteristics of efficiency and bandwidth plotted for limiting conditions of the coil form factor. Generally, design will be most useful for values of k approaching 1.

have four times the original stored energy in kva. The driving point, or series, resistance has also been multiplied by four, so the kva/kw ratio of the series system, is identical with that of the effective multiple connection and the bandwidth is the same in either case.

Some of the published material on folded unipole radiators may be misleading on this point if it is not critically examined. In the low-frequency area, particularly when dealing with relatively slender vertical radiators, the addition of multiple downleads radically increases the static capacitance of the system so that for a given kw input the system kva is significantly reduced.

The relatively large increase in driving point resistance obtained by using multiple downleads does not contribute to increased bandwidth because the added downleads actually reduce the effective multiple system resistance, but not to the same degree as with a large multiple-tuned flat-top antenna. An increase in bandwidth gained through the use of multiple downleads with a vertical l-f radiator results from a net reduction in the kva/kw ratio of the system.

Radiation efficiency in a multiple-tuned system is simply the quotient of radiation resistance divided by the effective multiple resistance, or R_a/R_m. As in most systems, improved efficiency is gained at the expense of bandwidth.

Voltage considerations

Following a cosine law of distribution, the maximum voltage on an antenna system operated at or below quarter-wave resonance appears at the point most distant from the helix. Terminal voltage is a function of antenna length in electrical degrees. Its voltage effects are somewhat amplified by the lines of stress owing to the edge effect of the capacitor plate formed by the top horizontal loading element of the antenna.

The voltage stress at the far end of the antenna comprises three principal components; the terminal voltage at the top of the helix, computed from IX_a; the potential rise across the self-inductance of the antenna (principally in the downleads), and the capacitance edge effect at the terminal point. The vector potential rise owing to self-inductance may be computed from $dE_{rms} = 1/\cos 90\ (f/f_o)$.

The edge effect may vary between 10% for the end of a long isolated span in a catenary suspension to less than 5% for the boundary of a multiconductor flat-top with peripheral conductors, the condition assumed here. Terminal voltage at the most distant point of the antenna is approximately $E_a = 1.05\ I_d X_d\ [1/\cos 90(f/f_o)]$.

Typical operating data

Using factors developed in the foregoing sections, significant operating data is compiled in the table for 26.1-kc operation of a multiple-tuned antenna having two, three and four downleads and compared with a single-downlead Marconi antenna. An input power of 565 kw to the antenna system is assumed.

The performance figures are computed for a coil factor k of 1.0. The efficiencies of the multiple-tuning system could be improved if the coil designs achieved an ideal k of 0.707. Because the voltage at the top of each helix increases with the number of downleads, corona control requirements will normally outweigh considerations of copper economy and a k of 1.0 is a reasonable upper limit in a multifrequency design. The significant characteristics of efficiency and bandwidth are plotted above/left for the limiting conditions of $k = 1.0$ and $k = 0.707$.

In the usual application with operation at several frequencies, k is usually assumed to be 1.0. A more exact value of k may be obtained by measurement of the coil resistances if required.

General equations can be developed to predict the performance of systems with any number of downleads. But as efficiency increases with the number of tuned circuits the transmission bandwidth is reduced proportionately. This immutable trade-off has the practical effect of limiting the application of multiple tuning to a two-downlead arrangement if a reasonable compromise between bandwidth and efficiency is the design target.

The improved efficiency gained by the use of multiple-tuned systems is not the result of any real increase in radiation resistance but is the direct result of a reduction in losses.

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The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or of the Department of the Navy.

Electronics markets 1965

by Leon H. Dulberger, Staff Writer
and Joel A. Strasser, Space Electronics Editor

Electronics markets 1965

Despite another decline in government spending, the electronics industry will reach new heights in sales this year, with the consumer and industrial markets scoring gains that more than balance the downturn in military procurement.

These are the major findings in Electronics' annual study of the industry's market and outlook for the coming year.

Sales are expected to inch upward 2.13% to $17.6 billion from $17.2 billion last year. Federal spending for electronics probably will drop to $9.5 billion from $9.8 billion last year, but will still comprise the biggest electronics market. Military spending will drop to $7.7 billion from $8 billion.

Consumer electronics will climb to $2.7 billion from $2.5 billion, and industrial buyers will spend over $4.5 billion compared with $4.1 billion last year. Replacement component sales are expected to remain at the $700-million level.

The military will continue its swing in emphasis, from strategic weapons to those designed for fighting limited wars. The Pentagon is determined to bolster its ability to squelch brushfire conflicts; it's stressing counter-insurgency aircraft, night-vision equipment that uses ambient-skyglow light, anti-submarine warfare studies and a system of communication satellites.

The National Aeronautics and Space Administration will continue to buy electronic equipment for space probes and for manned flights into space, with spending expected to rise to $1.7 billion from $1.6 billion last year.

In civilian fields, the biggest gains are expected in sales of computers and data-processing equipment. Industrial sales will be spurred by increased spending for automation. Makers of equipment for testing and measuring also should share in the gains.

The biggest consumer gains should be in color television, with two million sets expected to be sold in 1965. More consumer appliances will contain solid-state controls, and integrated circuits will invade the commercial and industrial electronics fields.

Military electronics: Slower decline in spending

The Pentagon will continue to be the electronics industry's biggest customer this year, although military procurement is expected to slide to $7.7 billion from $8 billion in 1964.

The swing will continue away from strategic systems and toward tactical weapons for brushfire wars. In fiscal 1964 the military spent twice as much for tactical as for strategic weapons; in 1965 the ratio jumped to 3½ to 1; in 1966 the difference will be even wider.

The multibillion-dollar strategic projects are being phased out, and few successors are in sight. The military is seeking new tactical equipment with which to fight in jungles, deep below the ocean's surface and in other places far from Pennsylvania Avenue.

Over-all military spending next year is expected to decline $500 million to match a drop in the Soviet Union's military budget, but the total will still be $49.3 billion. Reductions will hit hardest at suppliers of military hardware; spending for research and development will decline slightly if at all. Nonelectronic expenses—such as military pay—will get a bigger share of the budget.

For electronics concerns, the decrease will be magnified. Higher military salaries and mainte-

What's in the marketing report

nance costs will give those categories a bigger share of the smaller budget, leaving less money for electronic hardware.

No more bombers

No bombers of any kind will be purchased next year. If anything is done toward building a new manned bomber, it will probably be no more than a token study.

The Air Force may get a green light, however, to develop an advanced avionics program for a bomber. Hardware from such a project would be useful in other aircraft, such as the Navy and Air Force versions of the F-111 tactical fighter. At present, F-111's are getting only off-the-shelf avionics gear—called Mark I equipment. Mark II, with advanced equipment, won't comprise a market until 1967.

A new troop-transport aircraft, planned by the Defense Department, will be able to carry 600 troops and some large equipment. It will result in a healthy market for aircraft electronics. The jet-powered CX transport, with a range of about 5,000 miles, will fly at about 550 miles an hour. The aircraft is scheduled to become operational by 1969. About $750 million will be spent for development of the CX, and $1 billion more for operational squadrons. The Pentagon plans to ask Congress for about $160 million to start development on the transport. Airlines are also interested in civilian versions of the plane.

The Navy hopes to begin research and development of a fourth-generation Polaris missile, called the B-3; testing and evaluation also may be done. The B-3 would have the same range as the present A-3, but would carry a bigger payload.

Purchasing of air-to-surface missiles will be small-scale next year, but there's a chance that a program-definition contract will be awarded for SRAM—Short Range Attack Missile—air-to-surface missiles with a 60-mile range.

Surface-to-surface missiles will be confined largely to the Polaris and Minuteman II's.

No mobile medium-range ballistic missile (MMRBM) will be developed in the coming fiscal year.

Gain for penetration aids

On the positive side, spending is expected to continue heavy for penetration aids such as ballistic decoys and electronic devices to deceive enemy radar. To date, $1 billion has been spent on this program, mostly for research and development. This year the emphasis will be on procurement.

Substantial funding also is likely for the SR-71 reconnaissance plane, scheduled for initial delivery this year to the Strategic Air Command. President Johnson calls this a $1-billion program. The outlook for the YF-12A fighter plane is foggier. The Air Force wants the aircraft but the Pentagon is still doubtful.

Military communication satellites

At least $50 million will be spent on electronics in a communication satellite system for the military, but the funds won't show up in the new budget because most of the money is already on hand from deceased satellite programs such as the Advent Communication Satellite.

The fate of the Nike X won't be decided until August; that will put off funding until fiscal 1967. If the Pentagon orders it into production, and if there are no comparable reductions elsewhere in the military budget, the antimissile program would propel the budget upward again by $4 billion to $5 billion and keep it there for a few years.

Barring a turn for the worse in U. S.-Soviet relations, however, production of Nike X is unlikely. The best bet is that R&D will continue to be maintained at a minimum level.

Laser range finder developed for the Army by RCA uses pulsed laser and digital readout. Integrated sighting and receiving telescope developed by Bausch & Lomb, Inc., transmits light to photo detector and protects the user's eyes. The Army is testing several laser range finders for possible field use.

The search for new ways to defend against submarines probably will get a 10% boost in funds from the present $350-million annual level. Spending for antisubmarine warfare will climb more steeply, however, to about $3.5 billion from this year's anticipated $2.75 billion.

The major needs are in detection, particularly

◀ **Antisubmarine warfare** is simulated by system developed for the Navy by Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corp. It simulates conditions that aircraft encounter in finding and killing subs in a 250,000-square-mile portion of the ocean.

Navy's new utility helicopter is demonstrated in missile transfer exercises. The tandem rotor aircraft, built by the Boeing Co., Vertol division, can take off and land on water. Its hull is watertight.

Manned interceptor ▶ aircraft, the YF-12A is designed to travel twice as far as conventional aircraft. It's being tested by the Air Force. The 2,000-mile-an-hour plane has an advanced fire-control system and is equipped with very-long-range missiles.

sensors. Signal-processing techniques also are sought, for better evaluation of received data.

For limited warfare

The Army's light observation helicopter, the LOH, will create a big avionics market in fiscal 1966. This equipment will be off-the-shelf navigation, identification-friend-or-foe, and communications gear. Microminiaturized equipment will be installed in later models of the LOH. This is the same procedure being used for the F-111 fighter and Val, the light attack plane now being developed for the Navy.

No decision has been made yet on how far to go in buying air-assault helicopters for the Army. They'll be tested thoroughly in spring maneuvers. Any purchase would be big.

Installing more modern equipment in the F-4 tactical fighter aircraft with a new fire-control system will be an expensive program. The F-4, used by the Air Force and Navy, fires the Sparrow air-to-air missile and the Bullpup air-to-surface missile. It will also use Walleye, the bomb guided by television, when the bomb is developed.

Nuclear ships will be absent from the 1966 budget. Defense Secretary Robert S. McNamara is said to favor a nuclear aircraft carrier, but this decision doesn't have to be made until 1967.

New radar

The plan to initiate a new generation of tactical radars—ground-based for surveillance, and for tracking aircraft and missiles—will stimulate one segment of the industry. Others will be used to locate mortars and artillery. Some of the new radar will be height finders, some three-dimensional. The units to be assigned to the unified Army-Navy-Air Force Strike Command, must be highly mobile.

The first generation of night-vision equipment will be bought for the Army. These low-light-level systems will use photomultiplier techniques for gunsights and binoculars, and closed-circuit tv for aircraft.

Electromagnetic reconnaissance and countermeasures—jamming, antijamming, electronic spying—may be off a little next year. Purchases will be for pretty much the same gear that was bought last year. Nothing new or exciting is scheduled.

Communications will continue healthy but nothing new is planned. Communications systems are vital to command-and-control systems, strategic and tactical, which will comprise a big market in fiscal 1966.

Proposals for bids for new tactical command and control systems should be sent out this month. Initial work will consist of feasibility studies to determine how existing communications and data-processing equipment can be used in the field for command-and-control. A way of automating the equipment also will be studied. No development of data-processing methods will be initiated this year —but it may come in 1967.

Procurement for navigation and guidance will slack off, but is expected to pick up in 1967 and

1968, when the F-111 is ready for such equipment. Research and development will slow down even more.

Lasers are no longer only experimental. The first big application will be in optical range finders for tanks. For this function, lasers have overcome serious doubts by the Army.

The research outlook

Two profitable areas this year are basic research and exploratory development. Funds will be provided for both categories and there is always the possibility that a development may be so important that the Defense Department would have to go beyond research and order its production.

Good research prospects seem to exist in such fields as materials, propagation, quantum theory of lasers and mathematics in all these areas.

Exploratory development could be profitable in communications, navigation, laser application and quantum theory.

The Pentagon is also receptive to new equipment and techniques developed with private funds. There are two advantages to a company's concentrating such efforts on weapons for limited warfare: work on smaller weapons costs less than for big systems, and smaller weapons for brushfire wars are in present demand.

Space electronics: New components needed

The United States will continue its race into space next year, but at a somewhat slower pace. Like an advancing army, the space explorers have outdistanced their "supply lines"—in this case, communication technology and adequate electronic components.

The National Aeronautics and Space Administration is expected to spend $1.7 billion for space electronics in calendar 1965, up from $1.67 billion last year. Huge new markets are opening up, but much of the government appropriations are already spoken for. Money for prime contracts is increasing, but the number of new contracts is getting smaller.

The military's glamor project is still very "iffy." Though the Air Force proposed the manned orbital laboratory, NASA may ultimately build it. MOL could need as many as 30 to 35 vehicles before 1980, with electronics costing $600 million to $700 million.

Electronic gear for a manned space lab would include navigation equipment, star trackers, inertial navigation equipment and geodetic instrumentation, communication gear for vehicles and ground stations, and instruments for control and ground checkout.

NASA's manned-flight program offers few markets that aren't already spoken for through the Apollo project that's tentatively scheduled to take men to the moon around 1970.

Communication satellites

New electronic products are needed in communication satellites. For such satellites, says a top NASA official, "we need a reliable, wideband-microwave output tube that's more efficient than the present traveling-wave tube." But an engineer at the Communications Satellite Corp. says, "We've

Saturn I launch vehicle is forerunner of the giant Saturn V booster that is expected to carry three astronauts to the moon by 1970. The Saturn I is shown during a radio-frequency-interference test prior to a recent launch at Cape Kennedy.

Dual-diversity telemetry receivers, built by the Vitro Corp. of America for space use, are shown in a NASA aircraft. At right are the predetection combining and recording systems that extend the receiver's signal-noise threshold and permit use of a small airborne antenna.

given up expecting more efficient tubes. Now we're looking to solid-state devices."

The solid-state amplifiers could be transistors or power varactors with power outputs of at least five watts and efficiencies of 20% to 30%, to operate at 4,000 megacycles, the Comsat man adds. Present solid-state devices have efficiencies of less than 10%.

Another cry of Comsat engineers might be paraphrased as: "What this country needs is a cheaper front end for a ground-station receiver." The demand is really international. Commercial satellite systems will create a market abroad for satellite ground stations, says one NASA project manager. Many countries would be interested in a more economical front-end package that costs about $100,000. It should have a low-noise, broadband (25 Mc) traveling-wave maser and a closed-circuit cryogenic system to cool the maser, the NASA man declares. Today's front ends cost about $500,000.

NASA and Comsat agree that there will be demand for low-noise antenna feeds, receivers with improved feedback threshold-extension detection, multiple-access communication systems and low-cost antenna dishes.

Day-and-night sensors

Television and infrared sensors that can operate day and night in operational weather satellites are sought by NASA's Goddard Space Flight Center. NASA wants a television sensor, which now sees in daylight, to be able to see in the dark, too. And it wants an infrared sensor, which takes cloud pictures at night, also to be able to operate in daylight.

NASA seeks a tv tube with a low-light capability of nearly 10^{-5} foot-lamberts illumination, with near-infrared spectral response for night operation, and a resolution of about 1,000 tv lines. Image orthicons and image dissectors are among those being considered.

One obstacle to using infrared sensors has been the inability to cool them so i-r detectors will operate at 50°K, in a spacecraft. In January, Goddard will ask suppliers to bid for the hardware development of a solid argon cooler weighing 30 to 35 pounds.

If detectors can be cooled to 50°K, they can operate in the 11-micron region to obtain infrared pictures day and night. At 50°K, a germanium-silicon alloy, doped with zinc-antimony, can operate out to 14 microns wavelength, with high sensitivity. If the detectors could be cooled even lower, say to 28°K, NASA could use photoconductive detectors. They are even more sensitive and easier to work with.

Space communications

"The space communications problem will become more complex as we build larger boosters able to loft bigger spacecraft," predicts Albert J. Kelley, deputy director of NASA's Electronics Research Center. Besides the weight limit encountered in space-vehicle design, he continues, "we could run into a communications-data limit." "We want industry to come up with new multiplexing equipment," says another NASA official.

To increase data-handling ability, later space programs will require equipment that provides "as much bandwidth as possible for voice, television and telemetry," an industry source adds. "There will be an increasingly large market for digital transmission techniques—vocoders, digital television and audio," he continues.

Eyeing another technical shortcoming, Kelley adds, "We need a broad range of measuring instruments, counters of high-speed particles and high-temperature measuring devices. These are available but they're not packaged for the space environment."

NASA favors digital instruments and digital communications equipment over analog. These would eliminate the analog-to-digital converter and would be "compatible with pulse-code telemetry and digital systems on the ground." Another NASA expert advises, "All products should be digitally oriented."

Components—the key to success

The key to making profit from space technology is to design components to operate in radiation, in high vacuum, at space-temperature extremes, and at high levels of shock and vibration. "We've used up our inventory of military specifications," says Kelley. "Now we've got to have space specs. The biggest problem is understanding the space environment."

Components manufacturers must understand the problem, he continues. They need a good applied-research and development staff.

"The problem is to develop components and to be able to specify them," according to Kelley. "One of the things we expect to do here at the Electronics Research Center is come up with a set of standards. And of course reliability is always a problem."

Avionics: Same size, new stress

The market for avionics will be about the same size this year as last, but there will be many changes in emphasis.

Inertial guidance systems for the Apollo spaceship are nearly all purchased or spoken for. With that big project practically over, the market for such equipment will continue to slip until it bottoms out around 1968. Military procurement will continue to dominate the field, but the civilian market should represent a steadily growing portion.

The Federal Aviation Agency expects to spend $100 million on electronics this year, down slightly from $103 million in 1964. But by 1968 the FAA figures it will be spending $225 million a year.

Construction of airport facilities is expected to decline because the FAA has added about all of the operational facilities it needs for the present. Immediate needs are for equipment—all-weather landing systems and semi-automated control of air traffic. That's why outlays for research and development are staying about at the 1964 level.

The boost in FAA funds by 1968 is expected to come when the agency speeds the construction of 21 air-traffic control centers. One semi-automatic center is already being built in Jacksonville, Fla. Each center should cost $12 million to $18 million.

As more airlines shift to high-speed jets and NASA's space flight program moves into high gear this year, the development of sophisticated electronic training aids such as flight simulators will be an important part of the avionics market.

Oceanography: Prospecting for future markets

At a recent government-sponsored briefing on oceanography, one participant remarked, "The funds involved wouldn't even pay the transportation costs of the people attending this meeting." As many as 40 firms bid for a $10,000 contract.

The sea is becoming increasingly important in defense and in economics, and it's expected to account for higher and higher expenditures. Meanwhile, however, companies' interest is in "getting a foot in the door" rather than any immediate windfall prospects.

In submarine warfare, the game of seeing without being seen cannot be played without a lot more information about the ocean. In the not-very-distant future, control and instrumentation of deep-sea research vehicles will comprise a healthy market for electronics companies. Sea houses and "flying submersibles" may also come someday. But at present the markets consist almost entirely of fundamental devices such as sensors.

Needed: measuring devices

The most urgent need is for instruments and techniques for long-term measurements, both stored and telemetered. Subsurface variables which are unaffected by winds and waves are getting increased attention. Temperature and pressure both affect the speed of sound; precise measurements of both gradients are necessary for better oceanographic studies and for submarine warfare.

On a broader scale, oceanographers are seeking ways to find out where the water enters and leaves the ocean, and how oceans affect the earth's heat.

Buoys that surface when told

A market is developing for 4,000 to 5,000 deep-sea buoys a year, to which sensors and special power supplies would be attached. The instruments would sense and transmit information on currents, salinity, pressure and other ocean variables.

The problem of tracking and recovering is becoming more serious. Conventional subsurface buoys return to the surface at a time fixed by a clock mechanism. "As often as not, they surface during a screeching gale," says Robert G. Walden of the Woods Hole Oceanographic Institution. Woods Hole is sponsoring development of acoustic anchor releases that would bring buoys to the surface only on command from an encoded signal. To pinpoint locations, ocean research groups are turning to high-frequency beacons that can operate unattended over long periods.

"We have found that a reliable, simple, low-power transmitter, operating in the two-to-five-megacycle band and working into a relatively short but rugged whip antenna is the most satisfactory single-buoy location device," Walden states.

The Navy buys about 200,000 sonobuoys a year to pick up underwater sounds and radio them back to antisubmarine patrol aircraft. A new design, by Sanders Associates, may change the technical direction of the sonobuoy market. Sanders has shrunk the conventional cylindrical form, five inches in diameter and 39 inches long, to a sphere only a fraction as large. The new sonobuoy requires no mechanical rotor to slow down its descent, and its miniaturized electronics on printed circuit boards are shock-mounted to permit launching of the sphere from aircraft at about 10,000 feet.

Electrical fishing

To test a theory, that the sea's surface temperatures can lead fishermen to schools of tuna and other fish, a trawler from the Exploratory Fish Base in Gloucester, Mass., is going to sea equipped with

a marine radio facsimile recorder. The device will receive temperature charts radioed by the Navy's Fleet Weather Prediction Service, and determine whether tuna can be found in small areas where sharp temperature changes are detected.

Also under investigation at Gloucester are techniques for electrical fishing. Transformers and electrodes are positioned on nets, and the electrical fields stun the fish so that more of them are scooped into the net.

With conservation in mind, the laboratory hopes to be able to set the pulse rate of the electronic firing circuits to catch only fish of a specific size.

An electronic clam sounder, a modification of the jet clam dredge that is used to dig surf clams, is another target of electronic fishermen. On conventional dredges, the scraping noise from the clams is picked up and transmitted by hydrophones to a monitor who directs the dredging. "We'd like to do this electronically," says Leon E. French of the Exploratory Fishing Base. Hydrophone signals are being put through wave analyzers to see if clams, striking the prongs emit a characteristic vibration that is distinguishable from the vibrations caused by collision with rocks, sand and gravel. The Hewlett-Packard Co. is analyzing the waveforms from tape recordings made during clam dredging operations.

Industrial electronics: Automation on land and sea

The industrial electronics market is expected to soar in 1965.

A big factor in this growth will be advances in mass-transit electronics, process-control computers, numerical-control systems and automation of ships; in the past, engineers have shunned electronic equipment in those areas.

"The process industries are expected to spend between 20% and 35% more (for process-control computers) in 1965 than in 1964," says Lewis S. Geiger, marketing manager for the General Electric Co.'s process computer section. The market last year was about $22 million.

Utilities are expected to remain the biggest customers. And their sales are likely to rise about 10% in 1965 from a year earlier. The primary metalworking industry, such as steelmakers, is expected to boost its buying nearly 80% while chemical and petroleum processors' buying levels should about match 1964's level.

Currently, there are about 500 computer-controlled process installations around the world, and by the end of 1965 that level should reach 700. The average price of a system is $275,000.

Auto industry

Computers are being given a broader role by car makers and by producers of automotive equipment. One computer maker says it is negotiating with several companies in this area for the sale of at least 11 machines. These computers would be used in machine shops, for warehouse and conveyor-belt control and for quality testing.

Marshall Brittan, manager of marketing for the Westinghouse Electric Corp.'s computer systems division, puts it this way: "The trend today is for small computer systems. The price tag is low enough to allow smaller companies to buy, and they are buying."

Direct digital control

No sudden increase this year is seen in the market for direct digital control. Most potential customers are waiting to see the outcome of tests now being conducted in this area. The Monsanto Co., for example, recently installed a trial DDC system at a detergent plant.

Numerical control

Machine tool producers are looking for low-cost and simplified numerical-control equipment. Jay Gorham, manager of marketing for the Bendix Corp.'s industrial control division, believes sales of such electronic positioning systems will increase 20% to 25% this year from 1964 to a record $25 million. But, he adds, "This is for equipment that has some of the frills cut out, and gives more responsibility to the parts programer and the machine-tool operator."

Electronics on ships

Ship automation is one of the newest markets for electronic gear. Ship owners and maritime unions are beginning to accept the idea of electronic monitoring and control. The equipment is used to monitor and record data about the ship's power plant. Sales in 1965 are expected to rise to between $3 million and $5 million from $2 million last year.

But the growth of this market is limited by a slump in America's shipbuilding industry, which is being undercut by foreign competitors.

According to a spokesman for the Westinghouse Electric Corp.'s marine systems division, "The market will never be worth more than $5 million in any one year." There will only be about 17 or 18 new ships a year that could use electronic controls, he adds. And older ships being refitted with electronic gear wouldn't be given complete systems, he says.

Mass transit

Certainly, the greatest potential for electronic gear is in the mass-transit field. Every city in the United States with a population over about 250,000 is stuck with the problem of moving peo-

Sound analysis of machine bearings is done by translating 30-to-50 kc ultrasonic energy into audible sound in a Delcon Corp. instrument. Transistor-operated unit is applied to 42 identified probe points on bearings of wood bevel-and-tenon cutting machine, to listen for wear and plan replacements.

ple from one place to another. Mass-transit railway systems with electronic controls may provide a solution to the problem and 1965 may be a significant year in this field. Test results of mass-transit systems in Japan, San Francisco and Pittsburgh will begin pouring in by mid-year.

W. J. Walker, manager of transit systems for Westinghouse, says, "Cities will buy after they see the results of the systems to be tested in 1965."

The San Francisco tests, says Thompson A. Nooner, director of marketing services for the General Railway Signal Co., one of the companies involved in the project, are the most extensive in the history of mass transportation.

According to Nooner, these tests point the way to the future use of electronics in the transit industry. The building-block concept, adding additional functitons to a basic system, isn't new to the electronics industry, but to the transportation industry, the idea is revolutionary.

"In 1964," he says, "transit companies spent about $13.1 million for electronics to update old systems, add electronic interlocking controls or timing systems and consolidate control. In 1965, the industry is expected to buy $15.3 million of new equipment to replace old systems."

But Walker of Westinghouse estimates that the 1964 market was only between $10 million and $12 million and the market in 1965 is likely to equal or be a bit below that level. In 1966 and 1967, however, he sees a sudden surge if the tests are successful.

"The market for digital computer-directed systems using solid-state controls could be $35 million to $45 million (at that time)," he estimates.

Consumer electronics: Another big year for color tv

It looks like a banner year in consumer electronics for two million reasons—the number of color television receivers that are expected to be sold in 1965.

Officials generally agree with Ted Herkes, vice president of consumer electronics at Motorola, Inc., who predicts that color tv will score another resounding success while other consumer fields remain at the high levels attained last year.

Receiver sales at the factory are expected to climb to $600 million this year from $430 million in 1964. This climb would be accomplished in the face of price-cutting; in addition, prices are expected to drop below $400 by 1970 from the present average of about $500.

Price competition has already set in, even in broadcasting equipment. The Radio Corp. of America insists that its profit was unaffected by a $50 cut in the price of its least expensive model, which now sells for $400. Competition was intensified last in 1964 by Sears, Roebuck & Co., charging $300 for a color set that uses a 16-inch tube made in Japan.

The color boom should get a boost from engi-

Color-tv receivers in Bloomington, Ind., tested at RCA Life-Test Labs. Many receivers are selected at random from this group for test and evaluation. Two million color-tv sets are expected to be sold in 1965.

neering that perfected the rectangular color tube. These color tubes allow reception of the complete, uncropped picture as sent from the transmitter.

The National Video Corp. is building a 23-inch rectangular color tube for Motorola and has started developing a 25-inch model. RCA will push its 25-inch rectangular tube this year after selling limited quantities over Christmas. The move should increase sales of higher-priced receivers.

Rectangular 19-inch tubes will be introduced early this year. Sets using them will employ an automatic degausser so the receiver can be moved around in an apartment without additional service charges, to overcome the effects of magnetic fields.

National Video will introduce its 19-inch rectangular tube in April. At Sylvania Electric Products, Inc., a 19-inch rectangular color tube is being developed; plans are to introduce it early this year. Sylvania is a subsidiary of the General Telephone & Electronics Corp.

Lynn Long, product sales manager at Sylvania's electronic-tube division, predicts that color tv sales will surpass black-and-white "in a few years" and that black-and-white will begin to decline by 1970, eventually perhaps to suffer the fate of the player piano and the stereopticon.

For 1965, however, the round 21-inch tube will remain the basic color-tv component, and manufacturers are selling all they can make. Rectangular tubes are still expensive. They require complex technology to make their triple electron beams and the complicated circuitry needed to deflect these beams through sharper angles and to achieve positioning of color-dot triads on the face of the tube.

Black-and-white tv

Not everybody agrees with Long, of Sylvania, on the impending demise of black-and-white tv. One reason for continued optimism in some quarters is the growing popularity of small, personal

units for every member of the family. Herkes, of Motorola, predicts that 12 million to 14 million black-and-white sets will be sold annually by 1969, up from a predicted 8 million this year. But Herkes adds that the biggest volume will come in small sets in $59-to-$69 range.

The addition of ultrahigh-frequency channels should bring broader programming to nearly every area, even in secondary cities. The new channels will dilute the importance of networks and maybe even of rating services.

The community antenna business should boom for three or four more years, according to Bryce Durant, president of RCA's service subsidiary. But Durant says the community-antenna business' days are numbered; the systems will be replaced by multiple uhf channels in five years, he declares.

Sound systems for the home

Quality sound equipment, housed in quality furniture, is attracting more and more consumers. The Magnavox Co., for example, says sales of high-fidelity consoles have been growing "incredibly well." Magnavox introduced all solid-state hi-fi more than two years ago and developed transistors to eliminate cross-modulation in tuning circuits. Magnavox's top-of-the-line units include remote-control tuning with signal-seeking circuitry similar to that in car radios.

The addition of f-m multiple stations are spurring sales of home tape recorders. However, the lack of standard cartridge sizes throughout the industry restricts the owner of any particular system to a limited library of prerecordings.

An electronic message center for recording brief messages has been introduced by the Westinghouse Electric Corp. The five-pound unit, about the size of a hard-cover book, lets a housewife store up to three minutes of instructions, telephone numbers or other information on a closed loop of tape that can be played back on demand. Since its introduction last summer, sales of the unit have taxed Westinghouse's ability to supply the home appliances at $39.95 apiece.

Home video tape recorders

No licenses have been awarded for the home video recorder that was made available last summer by the Illinois Institute of Technology Research Institute. Almost every company in the industry has taken a look at it, according to John Skinner, manager of magnetic tape recordings at IITRI. Production would be at least a year or two away even if a manufacturer were licensed now. RCA has also been working on home video tape recorders, according to Durant.

But much technical work remains if these recorders are to achieve technical maturity and a price near that of a home movie system.

Electronic extras for autos

A trend in automobile radios is an a-m/f-m stereo unit, as an extra by Chevrolet. The stereo system uses multiplex circuitry, four speakers and a cross-over network. The equipment, by the General Motors Corp.'s Delco Radio division, employs the same circuitry as home stereo instruments.

F-m reception in car radios also is being improved by adding vertical polarization to f-m broadcasts that are horizontally polarized. The aim is to achieve better reception with whip antennas that are standard for use in autos. Automobile f-m should hit 200,000 receivers this year, according to Frank Brewster of Motorola's Automotive Products division.

The newest trend in auto electronics is toward capacitor-discharge ignition systems that use silicon controlled rectifiers rather than transistors. A condenser accumulates voltage, which is discharged across the ignition coil's primary winding by the scr trigger. Spark plug life of 100,000 miles is forecast with capacitive systems.

Home appliances

Solid-state electronic controls should find a big market in consumer appliances this year according to John Mungenast, a General Electric Co. sales manager executive. Low-cost remote controls, using carrier current, will be introduced for ovens, air conditioners, fans and furnaces. Pioneered in a model train, and tested in carrier intercommunications and hi-fi speaker systems, all by GE, these remote controls code and insert low-level signals on 117-volt service lines at any outlet. Receivers decode these signals and deliver them to the control gates of scr's. The remote controls transmit variable-amplitude commands and on-off functions.

Half a dozen manufacturers will offer variable-speed scr controls for blower motors in 1965, for air conditioners and furnaces. The systems will vary speeds automatically with heating or cooling loads.

Silicon-controlled rectifier systems for vacuum cleaners, blenders and floor polishers will be introduced this year, with similar controls for cooling and baking expected in 1966.

More consumer trends

The rapid development of integrated circuitry holds great promise for appliance designers. According to Texas Instruments, Inc., low-cost integrated-circuit packages are ideal for decision-making logic in automatic appliances. The trend is toward more direct sensing controls that measure and monitor progress and control cycles of such appliances as dryers.

Citizen-band radio

A single-sideband technique has been introduced by the Dynascan Corp. for 27-megacycle citizen-band radio. A power gain is achieved by eliminating one sideband. The bandwidth reduction permits assigning to ssb systems to each 10 Kc channel. Dynascan says the technique doubles the number of channels available. A built-in oven holds the transceiver's frequency stability at 0.0005%.

A communication antenna, exploiting the phased-array principle, is now available for citizen-band

Tape recorder, built by Craig-Panorama, an "electronic notebook." It uses a half-hour tape pack and rechargeable nickel-cadmium batteries. Microphone is built in. Market for miniature tape recorders is considered strong.

use. It's made by the Antenna Specialists Co. Electronic scanning selects among three 120° sections of the horizon surrounding the antenna. Directional gain is 7.75 decibles, according to the manufacturer. The pulsed-array technique has long been used in radio telescopes and for satellite tracking.

In electronic pianos, a professional 73-key model with 100-watt output has been introduced, using four 12-inch speakers. It's for pianists who are tired of being overwhelmed by electronically amplified bass and guitar. Developed by Harold Rhodes of the Fender Electric Instrument Co. in Fullerton, Calif., the instrument uses a modified tuning fork and pickup coil on each key.

The Wurlitzer electronic piano has grown in popularity in the past year, especially in colleges that employ clusters of the instruments. The piano uses steel reeds to vary their capacitance relative to pickup plate. The piano uses a nine-transistor amplifier and produces 10 watts, more acoustic power than a spinet, Wurlitzer says.

Electronic organs are the most promising consumer applications for integrated circuits. They should become big sellers within a couple of years, says John Brand, chief design engineer of the Thomas Organ Co., a subsidiary of Pacific Mercury Electronics. One use might be for repetitive tone generators and similar circuitry.

The Thomas line is completely transistor-operated. Industry sales are growing at 10% to 15% a year, and reached 120,000 units last year, according to Thomas Organ.

Medical electronics: Bigger than space effort by 1975?

To make money in electronics, you often have to become a specialist in another field. This is particularly true in medical electronics.

Prof. James B. Reswick of the Case Institute of Technology predicts a national program of medical electronics in 10 years that will surpass even the space effort. But first, engineering companies must acquire medical know-how.

The doctor is a necessary ingredient in the development and marketing of medical hardware. He is the only person who knows what physiological functions need to be measured or treated. But too few doctors know much about electronics, and fewer engineers know much about medicine. Furthermore, doctors are a notoriously cautious group, and almost inaccessible to salesmen. A wedding of medicine and engineering is in order, and there are signs that it's being planned.

A few schools—Washington University in St. Louis, for example—have begun to turn out doctors with strong electronics backgrounds. And Northwestern University is creating a biophysics department designed to give engineering physicists a solid understanding of the human body.

Companies whose staffs include medically trained engineers—or electronics-conscious doctors—will have a big head start in the coming race into medical electronics.

If physicians do not keep up with engineering techniques, one specialist warns, they may one day find themselves unable to direct and control them in developments, and they could be forced into the position of assisting the engineers.

Prof. Reswick, director of the Engineering Design Center at Case declares "We are going to see engineering systems branch out more and more from the diagnostic applications into therapy and assistive devices." Therapy systems will cure bodily malfunctions, assistive systems will replace malfunctioning organs and appendages," he explains. Diathermy treatment, heart pacemakers and laser-beam operations on the eye are examples of these advanced applications of electronics in medicine.

Previews of some future roles

A few advances in 1964 hint at exciting develop-

ments ahead as the medical profession learns to use electronic aids. An ultrasonic diagnostic instrument was used last year for the first time to remove a large piece of brass from a boy's eye. Some specialists believe ultrasound will also complement x-ray techniques some day in nondestructive diagnostic applications.

Diagnostic and therapeutic uses of lasers are receiving extensive study. Some researchers believe that the laser will lead to many medical instruments.

More regulation proposed

The Food and Drug Administration wants tighter control over medical devices that use electronic techniques. The agency is concerned that some devices may not perform as well as their manufacturer's claim they do. The FDA is gathering data from other agencies on their use of electronic medical devices.

Early this year, the FDA will submit another proposal to Congress asking for more control over medical electronic devices; at the last session of Congress, no action was taken.

Electronic system in operating room measures depth of anesthetic and critical physiological reactions. The system, at upper right, is built by the Hewlett-Packard Co.

Educational electronics: A $100 million market, and growing

Many college buildings are now being designed with large, elaborate wiring ducts under the floors, easily accessible, to accommodate electronic teaching equipment—most of which hasn't been invented yet. That's how confident the educators are that automation is going to move into the classroom although widespread use of sophisticated apparatus is still years away.

Whether solid-state circuits will ever replace teachers en masse is highly doubtful. But electronic equipment already accounts for about $100 million a year in education expenses.

Much of the electronic equipment for education is conventional. A spokesman for the Educational Equipment division of the Radio Corp. of America says educational electronics is merely a fashionable new term for audio-visual aids.

The equipment sold to schools and colleges is designed mostly for other uses: consumer-type tape decks, commercial distribution systems and industrial closed-circuit television systems.

Teaching languages electronically

Innovation consists almost entirely of ways to combine the equipment into systems and use them. Ingenious programing techniques and an increasing amount of available software make tape-recorder language laboratories increasingly useful.

Language laboratories are one field of education where electronics has found practical application. According to RCA, about 5,500 classroom-size systems are now in use, principally in colleges. A system may serve from one to 64 pupils; and portable systems are also manufactured. A system may cost up to about $7,000. The electronic systems help students to correct pronunciation and inflection, either with the aid of prerecorded tapes or with a teacher at the console. This market, estimated at $8 million a year and growing is spurred by the government's use of such labs.

Video equipment

Federal funds are also nourishing educational television. Educational tv stations now exist in major cities, though generally not connected with any particular school or college.

However, the use of closed-circuit networks in schools and colleges is growing. Such networks frequently serve two purposes: to supply educational programs, and to train students in all phases of television production, both technical and programing. The closed-circuit tv market in education is

about $4 million to $5 million a year, while the educational tv market for general broadcasting is about $8 million.

Mass teaching and individual learning

Two major trends are emerging in educational electronics. One is toward mass instruction systems that enable one teacher to lecture to larger numbers of students, perhaps scattered over a campus or through a city. The other is toward individual instruction—learning machines—that enable a student to study at his own speed and in his own way. The two are expected to complement each other in different phases of the learning process.

Individual-instruction machines have not yet won wide acceptance. Those available today are mostly books and other printed material such as printed rolls contained in cardboard or metal boxes, arranged in a sequence designed for step-by-step learning. The electronic teaching machine is only experimental so far; several have been developed and some are being evaluated. But they all cost too much.

Electronics in the library

College libraries are buying more and more playback turntables, tape decks, amplifiers and headsets. They're also showing increasing interest in audio lessons to which pupils can listen with headphones.

Educational television center at Brooklyn College was installed by RCA. Students are studying tv program production. Educational electronics had $100 million sales in 1964.

However, the great revolution in electronic information-retrieval in school libraries is still a long way off. No simple method for video retrieval of book material exists and the same problem of information storage and retrieval prevails in education as in other fields.

Communications: Trend toward digital techniques

Digital computers started a swing away from conventional analog communication techniques. During the past seven years, the shift has become irreversible.

Data is transmitted around the world digitally by telephone line and microwave. Aircraft send digital messages to air-traffic control stations. NASA transmits pictures from satellities and space probes by digital television. Now telephone experts predict that the general public will start using digital techniques for communications soon.

At a recent demonstration, a Florida housewife told her bank—through a push-button telephone that generated numbers—to pay her shopping bills.

The International Telephone & Telegraph Corp. predicts a large increase in data transmission using pulse-code modulation and time division. Both satellites and cables will carry the extra traffic. There will be a demand for wideband transmission and terminal equipment, including specialized computers and switching devices.

Eavesdrop-proof communications equipment for the military and other government agencies will be one big market; one big seller is expected to be the vocoder, a digitizing device for conversion of voice to bit codes.

Automatic card-dialing and push-button telephones may be used soon for paying bills, sending billing information, getting a voice answer from a computer, and handling retail billing and accounting. The plastic card used with the American Telephone & Telegraph Co.'s system can be punched to serve as a bank credit card, because it can deal directly with a bank's computer.

Solving scatter problems

The coming-of-age of digital communications

poses problems, especially for troposcatter circuits. Occasional short-term dropouts of signals, which do not noticeably affect voice and are not troublesome to moderate-speed data, can produce disastrous errors in high-speed data transmission. Various solutions have been proposed, including development of threshold-extension circuits and combiners for diversity reception.

Tropo equipment is being used in mobile and transportable military situations. This may speed the design and development of commercial equipment for applications outside the United States. In Africa and Asia there is a need for a better system than standard high-frequency, but one that is less complete than most military tropo. Often two, three or four channels could handle the information, compared with the military's 30 channels.

Mobile radio growing

The land mobile radio consists of police and taxicab communications and other such equipment. It is a big market, with over two million transmitters licensed. The industry expects 3.7 million transmitters to be in use by 1970.

The only limiting factor seems to be a lack of operating frequencies. The Federal Communications Commission has received many petitions to provide more channels, but it generally replies by urging additional study by industry. Plans to date include further splitting of existing channels to accommodate more transmitters, greater sharing of existing channels by present users, and sharing of television channels—very-high and ultrahigh-frequency—in regions where tv is not using its assignments.

Telemetry shifts to S-band

The government is the biggest user of telemetering radio equipment. The market should expand when users shift to S-band, which the FCC has ordered by 1970, and as preparations are made for space flights through 1968. Ground stations are beginning to add S-band capability well in advance of the 1970 deadline, and purchasing should start to increase this year. A big upcoming telemetry market is the Apollo program to send a man to the moon by 1970. Apollo requires extensive outfitting of ground stations. About 26 surface vessels must also be equipped.

Ham growth slowed

The growth of amateur radio seems to be leveling off at 260,000 licensed amateurs, not all of them active. John R. Huntoon, secretary of the American Radio Relay League, is at a loss to explain exactly why. He thinks the reason may be a combination of stiffer rules proposed for amateur licenses, and the fact that FCC now charges a fee for an amateur license.

Hams used to be largely builders and fabricators. Now they buy about 90% of their basic units ready-made or in kit form. Only smaller items are still home-built.

Computers: Year of change

This may be a year of radical change in computer design and organization. A small revolution is being wrought by three developments: time-sharing, to allow many people to use the same computer; microcircuits, which should reduce computer size and cost; and associative memories, to speed information-storage and retrieval.

Time-sharing

Time-sharing has already made inroads in multiple-terminal fixed-program systems for airline reservations and bank systems. Now the state of the art is being sped up to perfect "open shop" computation facilities that would be available to any participant in a sharing program.

Equally important are new input-output programs that permit the scientist or engineer to communicate with the computer in simple English. A logical extension of time-sharing would be a system that allows a small business to have a direct connection to a computer center.

In 1965, the first computers with microcircuits will be delivered. System 360, the International Business Machines Corp.'s big entry in the field for 1964, will use hybrid microcircuits. But the Radio Corp. of America will use monolithic integrated circuits in two of its Spectra 70 machines.

Several other companies offer integrated-circuit computers. But the fastest computer now in operation, built by the Control Data Corp., uses discrete-component cordwood modules. According to John Baird, director of research at Control Data, it will be three to five years before completely integrated circuits are available with propagation delay times low enough to permit the design of very fast computers and only then will Control Data use them, Baird says.

Not everybody agrees. IBM claims that its components in the System 360 operate at a rate of 300 to 500 megacycles—or a operation time of 2 or 3 nanoseconds.

Integrated circuits now available have at best about a 10-nanosecond delay time, due mostly to capacitance between electrodes. The cordwood modules have 3-nanosecond delay time; hybrid, thin-film and discrete circuits are even faster.

The Spectra 70 computers, announced in December, are noteworthy for two reasons: They use monolithic integrated circuits, and their prices are reported to be 15% lower than IBM's System 360, which RCA units resemble in programing and performance.

Some of the 360's hybrid microelectronic circuits have been improved to the point where they are several times as fast as monolithic integrateds. They'll probably be around for several more years

Core-memory at left (single plane in foreground) stores up to eight million characters, accessible in .000008 second, a major advance in IBM's system 360 computers. Another important feature, in photo at right, is the 360's hybrid microelectronic circuits, which combine thick films (passive elements silk-screened on a ceramic wafer) and discrete components (active elements such as transistor and diode chips, made separately and soldered to the wafer).

—at least until the integrated circuits catch up in speed.

Beyond integrated circuits

Much work is being done on optical logic elements, such as gallium-arsenide diode lasers small enough for several to fit into a transistor can. Optical logic gives promise of logic speeds as high as anything now available, plus larger ratios of circuit fan-in and fan-out with much less power dissipation. But they won't be sold this year—1970 is a better guess.

Readout techniques

Associative memories, also called content-addressable and parallel-search memories, are storage devices in which the storage locations are identified by their information content rather than by an arbitrarily assigned address. Being independent of address location, the entire memory can be queried in one access cycle; this increases the speed of data retrieval 10 to 1,000 times. The military is interested in associative memories for providing tactical commanders with large amounts of up-to-date information on local conditions. The Goodyear Tire & Rubber Co.'s aerospace unit has developed an associative memory for the Navy's Bureau of Ships, to be tested as part of a tactical data system. The computer's performance in the data system is theoretically increased 100 times by adding the associative memory. Goodyear says this area is not yet a big market but that the sales curve should rise steeply in the next few years.

Future libraries

Improving computer techniques may revolutionize libraries. The library of the future will be part of a network in which large ones will share computerized files of bibliographical data with the small ones. Graphic storage and retrieval systems will reproduce copies of the documents at any library on demand. Computers and information retrieval techniques have a friend in Vice President-elect Hubert H. Humphrey. He was instrumental in getting the National Library of Medicine to use computers.

Solid state: Advances in FET's

Silicon field-effect transistors should provide most of the activity in the transistor field this year. They're certain to surpass the present frequency limit of 300 megacycles for use as amplifiers and operation at frequencies of 1,000 megacycles is likely.

Only six companies made field-effect transistors in 1963. Last year the figure rose to 14. It's likely to reach 25 this year.

Much of the new activity will center on the insulated-gate metal-oxide-semiconductor version of the field-effect transistor. The MOS FET has already achieved input impedances of 10^{15} ohms with low noise levels. Power field-effect transistors, almost nonexistent today, should also appear before 1966 as transistor manufacturers battle for new markets.

Varactor-diode manufacturers will be highly competitive as they bring out new devices to replace tubes for generating microwave power. Tubes will also give way to new high-power, high-frequency transistors in aircraft and mobile transmitters, air-rescue gear and other communication equipment.

Solid-state manufacturers will continue to extend the capabilities of junction transistors, eclipsing the 2,800 megacycles of gain bandwidth that was achieved experimentally by the Philco Corp. on a transistor, and the 300-watt, 150-ampere power transistor that the Silicon Transistor Corp. announced late last year.

Silicon and germanium devices will continue to dominate the solid-state market. Specialized materials, such as gallium arsenide, indium antimonide and silicon carbide, will find uses in devices that require high-frequency response, operation at very cold temperatures, and stability at high temperatures. But these specialized materials will not make a noticeable dent in the market.

More solid-state in consumer products

Solid-state devices will make broad inroads into consumer product areas in 1965. The long-awaited invasion of the large-screen television market finally seems imminent. High-power gate-turnoff silicon-controlled rectifiers permit the design of horizontal-output stages for 19- and 21-inch tv sets. The Emerson Radio & Phonograph Corp., which brought out an 11-inch set in September that uses 35 devices made by Texas Instruments, Inc., has announced plans for a 21-inch line by mid-1965. Other manufacturers are expected to follow Emerson's example.

Continued penetration of the high-fidelity stereo market will discourage manufacturers from carrying both tube and solid-state high-fidelity lines. The price gap between tube and comparable solid-state products will narrow enough in 1966 to threaten seriously new tube-equipped hi-fi gear.

Transistorized clock-radios, both line-operated and battery-operated, will take over their field. Transistorized light-dimmers for the home will increase in popularity, and scr-controlled tools for the home workshop will become more common. Solid-state devices will also appear widely in phonographs, tape recorders and intercommunication systems, and will enlarge their toehold in camera-exposure modules. Transistorized toys will become more common and more complicated. More advanced toys may even require servicing by radio-television shops when they malfunction.

Several makers are quoting transistor prices to toy manufacturers by the pound. At least one company ships transistors in barrels.

Automobile manufacturers will be wooed again by the solid-state manufacturing industry. But this time the scramble will be for ignition-system sales instead of transistorized radios. Makers of scr's will compete with transistor manufacturers for the ignition-system market. Breakthroughs also are expected in programed home appliances; one field is the solid-state controlled washer-dryer unit.

Microelectronics: Donning mufti

Nineteen sixty-five will probably be the year in which microelectronics became a civilian electronics field. It should be the first year in which civilian sales surpass military volume.

New designs of instruments, industrial-controls, computers and appliances are already in the prototype stage and many are expected to go into production this year.

Initially, monolithic and hybrid microcircuits were designed for military use, primarily to improve reliability by reducing size and the number of connections. Now automation has reduced manufacturing costs and increased production capacity to the point where manufacturers are cutting prices. Both kinds of microcircuits are becoming more attractive in increasing numbers of industries.

Storming the industrial market

The use of integrated circuits in computers is growing rapidly. Last December, many experts were surprised to see the Radio Corp. of America use monolithic integrated circuits throughout its new Spectra 70 commercial data processor. They thought it would be years before monolithic devices would be used in such. Several smaller machines also will have microcircuitry this year.

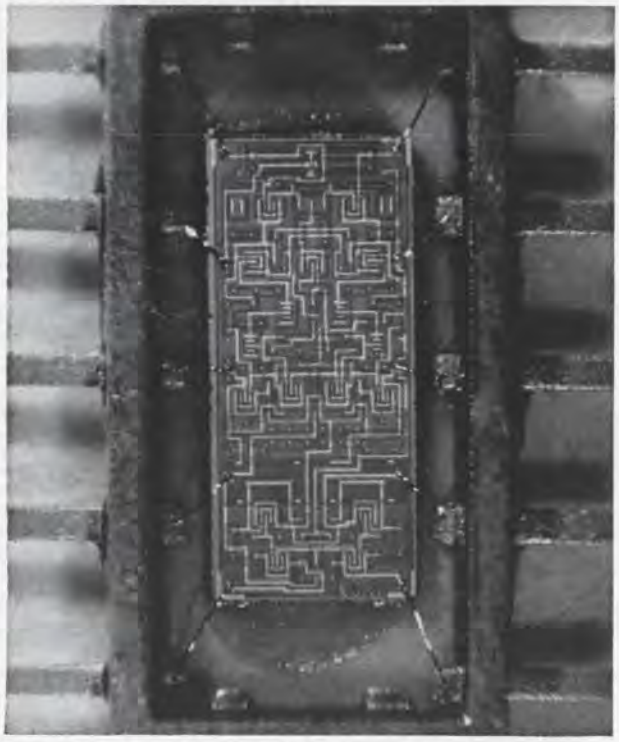
Two companies are known to be developing busi-

ness machines that use GME integrated circuits: General Micro-Electronics, Inc., and the Victor Comptometer Corp.

Several makers of integrated circuits confirm that they are working with manufacturers of mass-produced consumer products. Although they're reluctant to talk, almost all of them see an attractive potential in television and automobile-radio markets by 1966. The Westinghouse Electric Corp. and Motorola, Inc., both have developed integrated circuits for high-fidelity equipment. Texas Instruments, Inc., is developing appliance controls for laundry equipment and dishwashers.

But it won't be an easy year for microcircuit companies. Monolithic integrated circuits—those in which transistors, diodes, resistors and capacitors are deposited in electrically isolated areas on a single silicon chip—will run into stiff competition from multichip and thin-film microcircuits. Multichip circuits are constructed by making several identical components on the same wafer, dicing them apart into microelements, then combining them with other components to form circuits.

Activity in thin-film circuits will increase this year. Recent advances at the Autonetics division of the North American Aviation Co. and at RCA indicate that thin-film circuitry, in which transistors and passive elements are deposited on the same substrate, will be feasible early this year.



Monolithic broad-band-amplifier integrated circuit. It is sealed in a standard flat package measuring ¼ by ⅛ by 1/32 inch. Texas Instruments, Inc., uses epitaxial technique to fabricate 17 transistors, 31 resistors and two capacitors on the chip. A major use is to amplify signals from film memory circuits to trigger logic circuits. Typical frequency response is d-c to 10-Mc; typical gain is 36-db single-ended, 42-db differential.

Components: Where the squeeze hurts the worst

Almost everything that happens these days puts more pressure on the component business. Now, intensive price-cutting follows a drop in defense business, inroads by foreign manufacturers, and the continued gains of integrated circuits and thin-films; this may be the last turn of the screw. Competitive bidding for military contracts—favored by the Defense Department—has produced some dog-eat-dog struggles. Some companies are winning bids with quotations that barely cover overhead costs and leave no room for profit. A few military contracting officers have charged that these low prices are responsible for a flow of "junk" components.

Competition has driven the price of some components so low that a few companies have stopped selling military-specification components. The hardest hit items: passive components in standard sizes, such as quarter-watt resistors and tubes.

Companies selling high-quality components, however, report a rising demand from the field of industrial electronics. Then, too, some consumer items that must meet environments almost as tough as those faced by military equipment—such as better quality auto radios—are outlets for better components.

Military systems

A change in the military's design approach to major weapons systems is complicating suppliers' problems. More of the work is done on paper—using design definition studies—than by developing competing prototype systems. Thus, fewer components suppliers get in on the ground floor in new weapons systems.

The rapid acceptance of microelectronics in new and proposed military electronics systems—especially military computers, air navigation and guidance systems, and missile systems—hurt the sales of discrete components to the military.

While some discrete components are still used in military microelectronics systems, the quantities are smaller. Far fewer are used when the system is designed with integrated circuitry, and even fewer in systems employing thin-films. Thin-film circuits still require transistors and diodes, but most of them don't need resistors and capacitors. Where discrete components are used, they are usually unpackaged devices that sell for less than packaged devices. Though a number of military systems, particularly communications equipment and radio-command guidance for tactical missiles, are using or being designed to use conventional

components, the trend toward the use of microcircuits seems irreversible. As microelectronics technology improves, it is expected that thin-film transistors and higher-power integrated circuits for linear applications will reduce the demand for all types of discrete components even further.

Industrial components

Industrial electronics companies, particularly those making or planning digital control and instrumentation equipment, are shifting to microcircuits. Some digital integrated circuits can now be purchased for only half the cost of the same type of circuit in discrete component form. Sales of industrial digital control equipment are still small but an impressive growth is anticipated. Microcircuits should capture most of the industrial market by the time digital control sales hit their stride.

Power-type components, such as microwave tubes, are doing well in sales volume but poorly in profit because of the intense competition. Specialized tubes based on proprietary designs, however, bring good profit margins.

Instrumentation: New products are the answer

A major share of the electronics market will continue to go to instrument makers even though reduced defense needs will make a heavy dent in some instrument companies' sales. The companies that alter their marketing goals to serve industrial and commercial markets will fare best.

For today's changing industry some instrument makers are adopting the systems concept in test and measuring instrumentation. One aim is to develop systems for the check-out of complex automation and data processing.

Others are diversifying into more sophisticated instruments such as new frequency synthesizers and spectrum analyzers. For example, new spectrum analyzers can plot the entire signal spectrum through microwave regions with an error of only two parts in 10^{10}. Even better accuracy is possible by coupling the analyzer to an atomic clock but few such instruments would be sold at $15,000 each.

Programed testing for production

Programed instrument systems for production testing are sought by the manufacturers of sophisticated electronic items. This kind of equipment

Test and maintenance of instrumentation used in commercial jet aircraft are carried out using an impedance-measuring instrument by Hewlett-Packard's Boonton Radio division.

reduces confusion and requires less-skilled test technicians.

Old-time bench instruments are changing, too. According to John M. Cage, manager of advanced technical planning for the Hewlett-Packard Co., research and development engineers try to get flexibility by stacking their benches with a huge variety of devices. The alternative to bench overcrowding will mean bigger sales as new instruments are developed to perform the variety of jobs now handled by individual instruments. Bench-type test instruments will make increasing use of solid-state techniques.

The reliability and compactness of general-purpose test instruments is being improved. For better performance and to lower the manufacturing cost of new instruments some integrated circuit techniques will be used and discrete components will be coupled with them to get precise performance. Except for digital instruments the emphasis is not on size.

Right now, the noise characteristics of diodes and transistors are a limiting factor in instrument sensitivity. Electroluminescent devices and photo diodes will become more common in bench instrument design.

More versatile oscilloscopes

To almost every electrical engineer, the oscilloscope is the instrument used most often. Now the scope is becoming more versatile, accomplishing more functions. It has improved stability, a brighter display, and a capability for handling higher frequencies. Still in the experimental stage is a flat display tube that could shrink the size of scopes so that even more functions could be designed into the standard instrument.

Voltmeter design continues to improve. New instruments have higher input impedance, increased common mode rejection, and faster response. Voltmeters are still fragile; the new taut-band meters improve reliability and reduce zero shifts, starting friction, and sticking. Taut-band meters also cost less and scales can be calibrated individually.

Microwave instrument squeeze

Instrument makers serving the microwave market are in a squeeze. They are being asked to provide more accuracy, better sensitivity and more sophistication, but the over-all market is too small to justify expensive development programs. Too little systems business may be the reason. For example, a deep space system may have only 15 ground stations, and 15 pieces of test equipment of any one type isn't much business.

Most efforts in microwave instrument development are directed to the problem of spectrum analysis, or spectrum measurement. The radio-frequency interference (now called electromagnetic compatibility) business could be as much as $10 million a year.

Phase measurement was expected to trigger a big instrument market, but so far it hasn't. If the interest in phased arrays grows, phase-measuring equipment could go into quantity production.

Microwave: Decline will continue

The microwave market, hit hard by cutbacks in defense spending, will probably experience further declines this year, according to marketing officials.

A few companies expect to buck the tide and score sales increases this year. One of these is the Hewlett-Packard Co. in Palo Alto, Calif., which is diversifying and expanding its microwave division. Precision machine-shop facilities are being used to produce the company's new line of low-cost tape recorders for instrumentation. The division has also moved into chemical instrumentation with a complete system of microwave spectrometry with which chemists can identify molecules and study their structure.

But smaller concerns, without the capabilities to diversify, are going to suffer. John Minck, sales manager of H-P's Microwave division, predicts that many small microwave companies will go out of business this year and next. Other industry executives agree. One big reason for gloom is that no major technological achievement seems to be in the works.

Industrial applications

Continuous, high-speed microwave processing of thin materials is expected to continue to dominate the industrial market. Both Litton Industries, Inc., and Eitel-McCullough, Inc., have active microwave programs.

According to James A. Jolly, manager of Eitel-McCullough's Industrial Applications Laboratory, thin-film processing is used in drying paper, paint, cloth, and even in a new application for processing potato chips. This in contrast to microwave cooking, where the food is a bulkier workpiece.

Applications cover a wide range of materials. The lumber industry will be able to process lumber at 1,600 feet per minute, producing preprimed dry lumber. Liquid may be pasteurized by pouring it onto a belt and passing it under a microwave generator. The Eastman Kodak Co. is going to experiment with a microwave technique for cleaning solvents off a magnetic recording strip that has been applied to eight-millimeter movie film.

Many developments are expected in microwave

Microwave repeater system for television transmission, similar to the system shown operating in Canada, will be supplied to Yugoslavia by the General Telephone & Electronics Corp.'s Italian subsidiary, Marelli Lenkurt S.p.A. The equipment, costing $1 million, will consist of four microwave links operating over 600 miles.

cooking. But the home market will still be small in 1965 compared with the commercial market, which includes restaurants and hospitals. Both commercial fields will grow rapidly this year.

Communication systems

The biggest potential market for microwave relay systems in the next few years is statewide educational television. Gerd D. Wallenstein, vice president of product planning at the Lenkurt Electric Co., a subsidiary of the General Telephone & Electronics Corp., estimates that about $25 million to $30 million will be spent for television transmission systems now being planned.

Most of the proposed systems are in the southeast. These will include closed-circuit and open-circuit tv systems. The transmission systems are being designed to accommodate color, although receivers for classroom use are still too expensive.

There's also a good market in replacement of older microwave equipment with higher-capacity gear. Ten years ago, the typical 900-megacycle link contained 48 channels. Today that equipment is designed to carry 960 voice channels. A trend toward higher frequencies also exists because of wider bandwidth requirements. Better voice quality and capability to carry color tv is needed.

Millimeter-wavelength market

Millimeter systems are turning out to be a disappointment. Few specialists see any potential in millimeter waves any more. There are problems of atmospheric absorption and production difficulties.

Now it is possible to use optical techniques instead, and the problems are no more severe, without the added difficulties involved in manufacturing the millimeter devices. One application in controlled fusion research is heating plasma with large amounts of millimeter power. But such a market is very small.

Lasers: Further practical applications loom

For the laser, 1965 will be another year of gestation: many novel uses but few sales. But by year-end, some applications should appear with good market potential.

About 500 companies are making or testing laser equipment. The curiosity market for laser parts is still the only substantial one, but laser systems for scientific and industrial use are beginning to appear.

Applications are becoming established in such fields as microscopy, metrology, spectroscopy, microwelding and micromachining; these will probably be joined in the next year or two by up to 50 new industrial and scientific applications. Some producers are restating, with more assurance than before, their expectation of $300 million in civilian sales by 1970.

Shortcomings for the military

But government money still dominates the laser scene. Military laser development goals are chiefly in ranging and tracking systems, eavesdrop-proof communications on land, navigation and guidance aids, and optical analog computers.

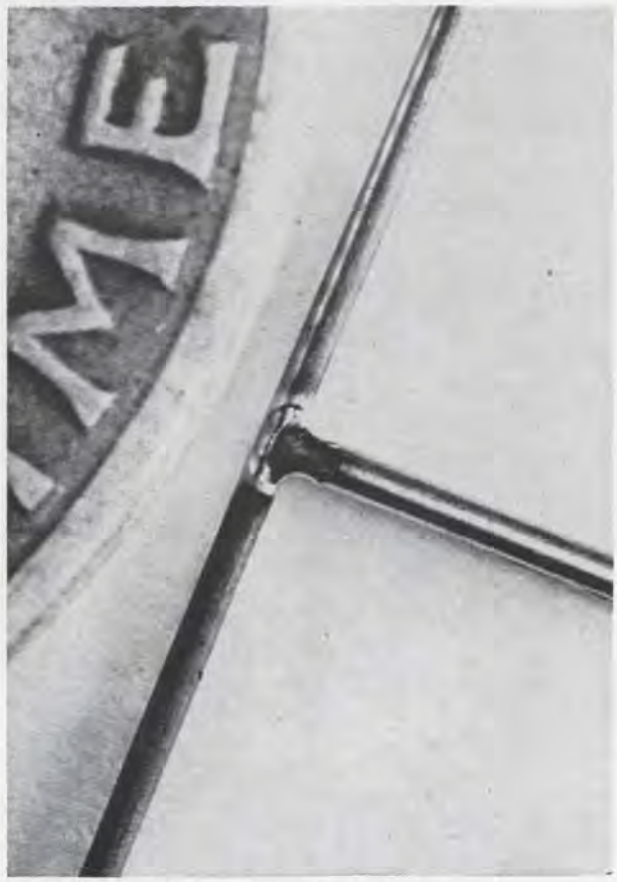
Prototypes have been built for most of these systems, but the military is still not satisfied with the laser's efficiency and reliability. The wavelengths needed for some applications still are not available, nor is the power available that is required to overcome atmospheric attenuation for long-range radar and communications.

In contrast to the military demands, no further breakthroughs are required for many industrial and scientific applications of lasers. If anything, low-power lasers have been underexploited. For most present applications, the laser is a source of intense light energy as in welding, illuminating microscope samples, vaporizing spectroscopic samples or pulsing a laser beam like a strobe light for high-speed photography.

Welding and machining

Pulse lasers have already been developed with enough power and simplicity for precision welding and machining. Getting them onto production lines will be the big task this year—a selling job that was made difficult by the premature marketing of inadequate systems a few years ago. Companies believe such a laser system must sell for less than $10,000 to compete with conventional equipment.

High-power lasers may also find uses with heavy-duty tools for welding and machining. Massive expensive structures now keep machine tools accurate under the mechanical stresses of cutting. Accuracy could be maintained at less cost if lasers could shape metal by melting and ablation.



Dissimilar metal wires, near the edge of a dime, were welded by ruby-operated laser equipment shown on page 109.

Analysis and measurement

The Raman spectrometer, in which samples are excited by a laser beam, is already on the market. Lasers are also being used for inspection of optical parts with interferometers, also in polarimeters, in systems that photograph stress patterns in materials through the use of plane-polarized light, and in schlieren and other types of high-speed photography. None of these is a mass market.

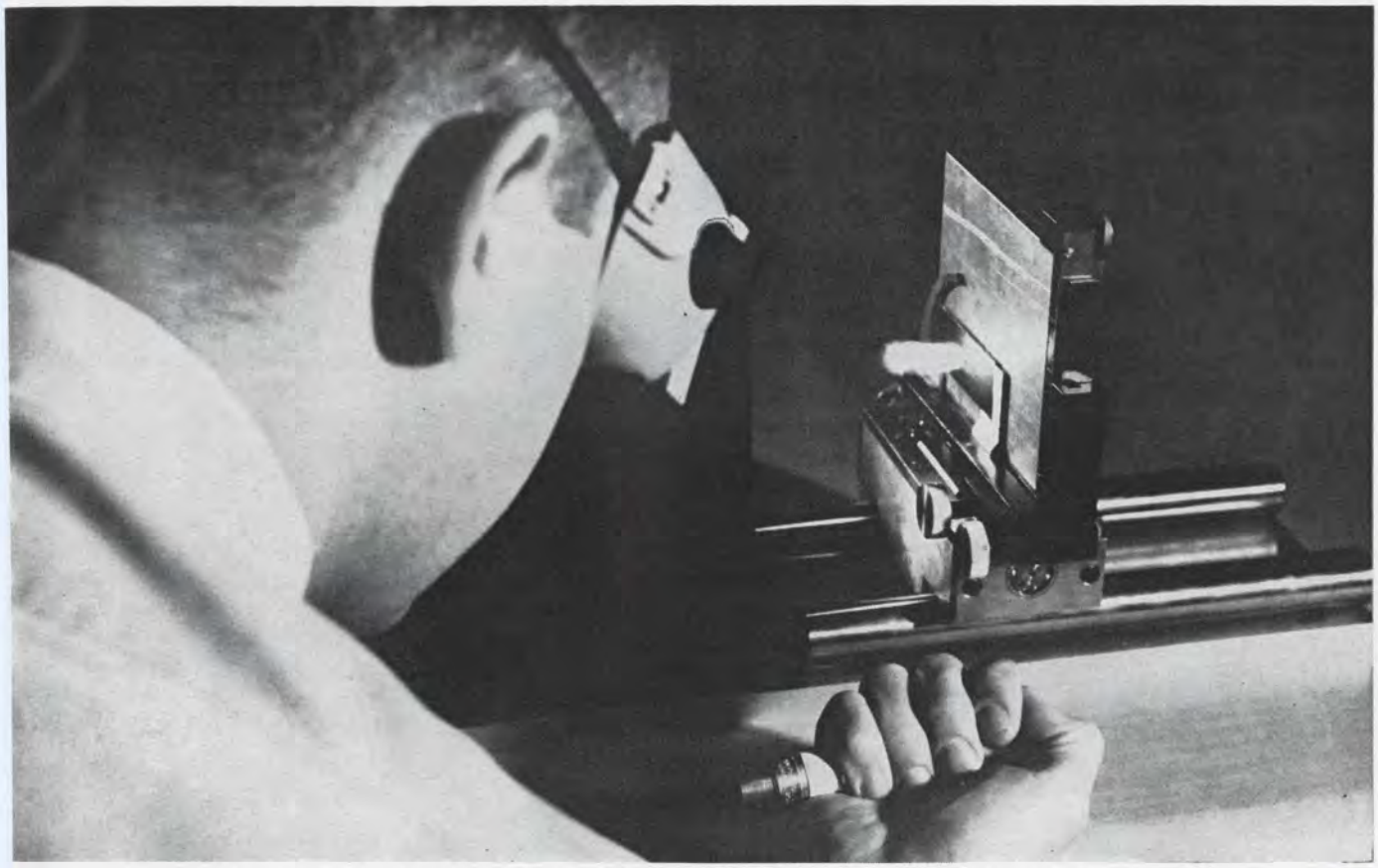
A recent development, the use of lasers to photograph three-dimensional objects, may eventually lead to 3-D optical recorders and perhaps stereo television.

Interferometer-type equipment that can measure dimensions with an error of only one part per million was placed on the market last year. At least 100 measuring-standards laboratories will be customers in the next few years.

Lasers are also beginning to show up in surveying equipment for measuring angles and distances and for optically aligning large structures and machine tools.

Communications becoming practical

Transmitting data and voice over short distances by amplitude-modulated beams is now practical.



Laser welder system, developed by Union Carbide Corp., has a ruby-operated laser-head that produces a pulse output focused on the workpiece by an optical system. Laser welders are expected to be one of the most practical applications of high-energy coherent light.

Analog signals can be transmitted conveniently by modulating the beam with a transducer output. The photodetector at the other end receives the signal in analog form. The best prospects for early sales of such systems are space-launch centers that require a large number of short communication links without overcrowding the radio-frequency bands. Another early application is expected in remote relays, in which a photodetector turns on apparatus when it receives a laser signal.

More clinical testing

Despite considerable research, doctors will be slow in adopting lasers for clinical uses. Too little is known about side effects and techniques. This is expected to remain a courtesy market for at least a year, with much of the equipment donated or loaned by laser manufacturers or by a laboratory that owns a laser.

The only laser instrument in medical use is an ophthalmoscope to repair detached retinas.

Ranging and radar

Production contracts for short-range tracking systems and weapon rangefinders are anticipated this year or early in 1966.

Optical radars can accurately track cooperative targets such as space boosters equipped with reflectors. Lasers can track these boosters as they lift off the ground, a phase during which radio-frequency systems are blind. Installations at launch facilities are anticipated this year or next.

Small ranging units, to monitor distances between ships refueling at sea, are expected to appeal to the Navy. Another type of laser ranger that may become practical soon is a clear-air-turbulence detector for high-speed aircraft. A compact pulse system with a range of 25 or 30 miles should suffice to detect wind shear, a phenomenon that accompanies turbulent air.

Optical computers.

Optical computers are being developed for recognition systems. Because the beam is coherent, it provides a way to obtain, process and display information. One anticipated use is an analysis of recorded curves such as cardiographs. The cardiograph obtained from a patient can be correlated with curves that are characteristic of certain heart ailments.

Ways of cross-correlating two unknown functions are also being developed, as are ways of phasing a laser beam with electro-optical crystals to solve equations with the beam. Some optical computers are already being offered for sale, and are expected to comprise a substantial market within five years.

Nerve center for the State Department's communications operations in Europe is this Paris facility that switches and processes digital information. Developed by International Telephone and Telegraph Corp., the system accepts information from high-speed computers and slow-speed teleprinters, and stores low-priority messages for later transmission.

International markets: Firm but competitive

Exports by United States electronics companies are expected to top the $1 billion mark in 1965 for the first time. But competition is increasing, particularly from Japan and Western Europe.

Unofficial government estimates put 1964 exports at just under $1 billion, up substantially from $865 million in 1963.

Increases are predicted this year in exports of computers, television transmitting and receiving gear, test equipment such as oscilloscopes and wave analyzers, and some components—high-quality crystal diodes, transistors, capacitors and resistors.

The biggest foreign market for U. S. military electronics equipment seems to be in the air-defense and ground-environmental systems that link national defense networks in various parts of the world. They're used for ground surveillance, aircraft detection, calculation of a plane's speed and direction, and in similar functions.

Brighter markets for U. S. electronics products are seen in the following countries:

- West Germany—U. S. industrial equipment and components that use advanced technology should be especially attractive. Short delivery time is important. West Germany imported $187 million of electronic products in 1963. Of this, $65 million was bought in the United States. Computers and advanced electronic components offer the best prospects for sales to Germany.
- Great Britain—The British government's new 15% import duty could hurt. But Britain lags behind the U. S. in equipment and components and is trying to catch up through licensing agreements. U. S. manufacturers will probably find the best opportunities in the more sophisticated and advanced product areas where quality and reliability are in demand, rather than in standard product areas where local producers have the edge. Britain imports about 10% of her electronic products with U. S. producers competing primarily with West Germans for a share of the market.
- Japan—The government recently liberalized import regulations, and sales of U. S. electronic products are expected to climb. The best prospects seem to be electronic equipment and components that incorporate advanced technology, also color tv receivers. In 1963, Japanese imports from U. S. electronic companies totaled $63 million, largely in commercial, industrial and military electronics. Digital computers led the list with $35 million in imports from the U. S.

President Johnson has announced an interest in liberalizing trade with the Communist countries. The Commerce Department will continue to study ways to pare lists of equipment, especially electronics, that are embargoed by the U. S.

The cover

Hi-fi power amplifier, built with integrated circuits, does work of 8 transistors and fits in a TO-5 transistor can. The one-watt device, built by Motorola, Inc., is part of the invasion of consumer field by integrated circuitry. Inset photos show some future application of integrated circuits in the electronics industry.

Credits for inset photos: industrial control by General Electric Co.; a GE-425 digital computer; color Tv by Philco Corp.; Syncom communications satellite. NASA; electron microscope by Radio Corp. of America.

Reprints of this report are available. See the reader service card at the back of this issue.

Electronics Markets

1965

TOTAL ELECTRONICS INDUSTRY

	(millions of dollars)			
	1963	1964	1965	1968
ELECTRONICS INDUSTRY TOTAL	16,506	17,225	17,600	20,001
Consumer Electronics	2,432	2,550	2,750	3,150
Industrial-Commercial Electronics	3,883	4,131	4,570	6,088
Federal Electronics (incl. military and government adjusted for calendar years)	9,516	9,844	9,580	9,963
Replacement Components	675	700	700	800

Consumer Markets

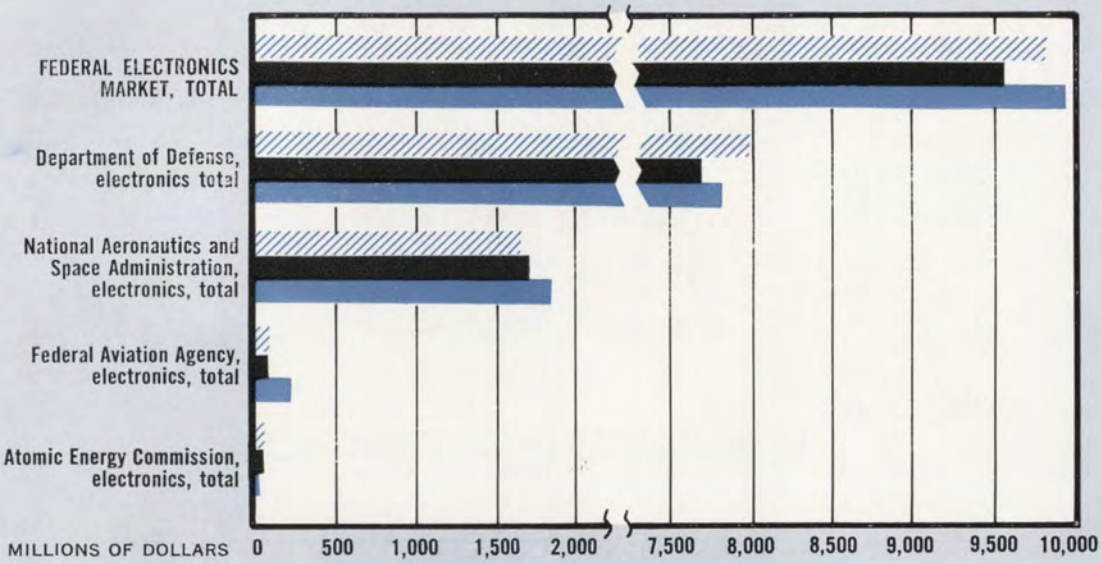
	1964	1965	1968
	(Millions of dollars)		
CONSUMER ELECTRONICS, TOTAL	2,550	2,750	3,150
Television Receivers	1,290	1,379	1,500
Monochrome	860	780	615
Color	430	599	885
Radio Sets	368	358	345
A-M and F-M	174	179	173
Auto	194	179	172
Phonographs	470	480	525
Monaural	40	38	33
Stereophonic	430	442	492
Records & Tape	289	295	301
High Fidelity Components, (incl. tuners, amplifiers, speakers, etc.)	50	52	58
Kits, except toys	50	53	58
Other consumer electronics	33	133	363

Federal Markets

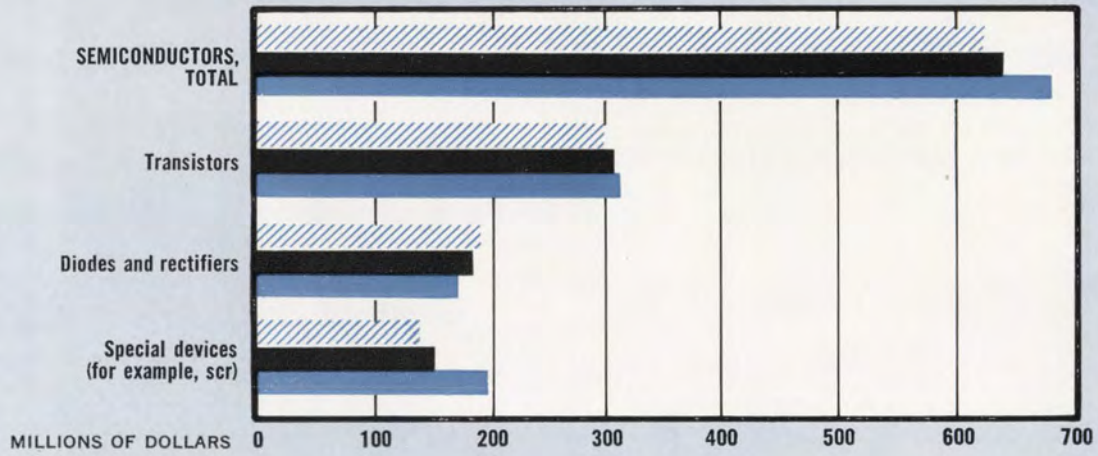
	1964	1965	1968
	(Millions of dollars)		
FEDERAL ELECTRONICS MARKET, TOTAL	9,844	9,580	9,963
Department of Defense, Electronics Portion, Total	8,000	7,700	7,825
Procurement	4,518	4,163	4,023
Communications	1,150	1,100	1,250
Aircraft	1,300	1,360	1,360
Missiles	1,460	1,135	820
Mobile and Ordnance	125	100	100
Ships	483	468	493
Research, Development, Test and Evaluation	2,000	2,000	2,100
Operations and Maintenance	1,482	1,537	1,702
Nat. Aeronautics & Space Adm., Electronics Portion, Total	1,675	1,715	1,850
Federal Aviation Agency, Electronics Portion, Total	103	100	225
Atomic Energy Commission, Electonics Portion, Total	66	65	62.5

The market estimates in this tabulation are based on a mail survey conducted by Electronics magazine. Detailed questionnaires were sent to marketing managers, analysts and planners in all segments of the electronics industry. Estimates obtained are United States factory sales in millions of dollars—projections of output for 1964, 1965 and 1968. The data was tabulated from the questionnaires and analyzed in three ways: obtaining the median, the mode, if one existed, and, in some cases, calculating the mean. But only one number was chosen in each category based on the following criteria: the median was used if the selection was large enough, the mode was used if one existed at or near the median, or the mean was chosen if the responses were limited. Finally, industry, government and trade groups verified the figures in appropriate areas.

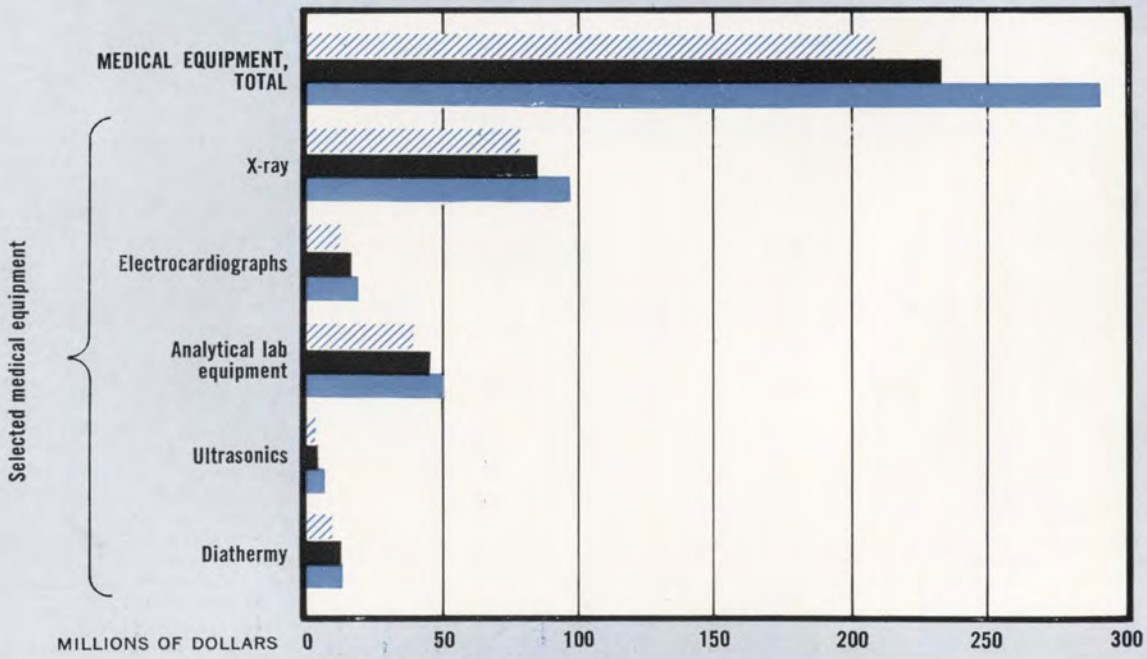
FEDERAL ELECTRONICS MARKET, TOTAL



SEMICONDUCTORS, TOTAL



MEDICAL EQUIPMENT, TOTAL



1964 1965 1968

Industrial - Commercial Markets

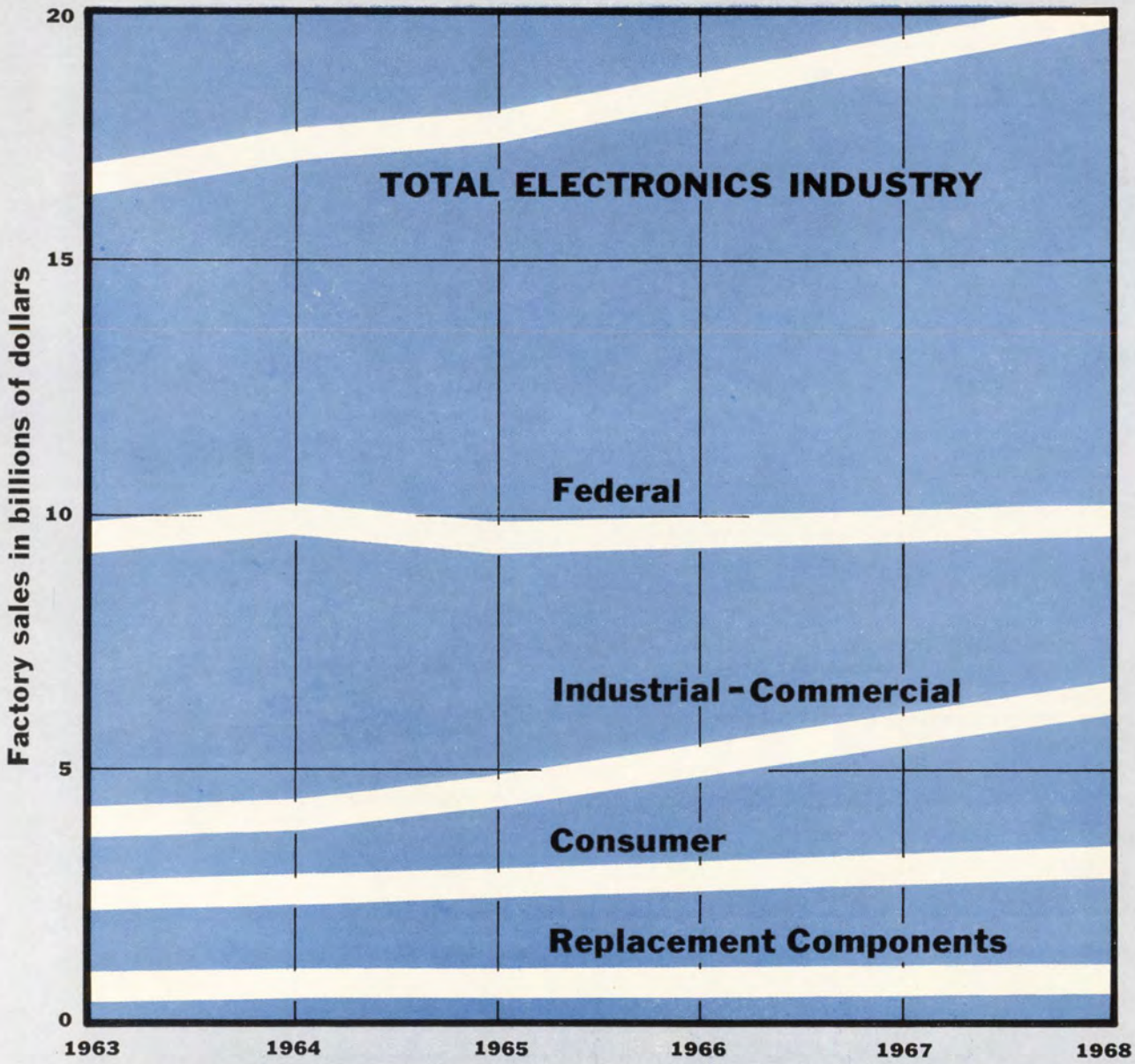
	1964	1965	1968
	(Millions of dollars)		
INDUSTRIAL-COMMERCIAL, TOTAL	**4,131**	**4,570**	**6,088**
Test and Measuring Instruments, Total	**454**	**498**	**622**
Spectrum Analyzers, subaudio to 1 Gc	10	11	12.5
Signal Generators, 100 Kc to 1 Gc	40	42	50
Oscillators, subaudio through video	18.3	20.1	25.5
Waveform Generators, square, pulse and special	9	9.8	11
Waveform Analyzers and Distortion Meters	7	7.5	10.5
Counters, time and frequency, zero cps to 1 Gc	30	35	40
Voltmeters and Ammeters, d-c to 1 Gc	14	15	16
Power Meters, d-c to 1 Gc	2	2.2	3
Digital Voltmeters	20	22.5	25
Calibrators and Standards, active and passive	10	12	14
Oscilloscopes, d-c to 1 Gc	80	92	100
Recording Instruments, digital and analog	44	46	55
Components Testers, (transistor, capacitor, etc.)	19.5	20	21.5
Power Supplies, laboratory type	45	49	60
Amplifiers, laboratory type	5	6.5	11
Microwave Measuring Equipment, 1 Gc to 100 Gc	55	60.5	76
Impedance Measuring Equipment	12	14	18
Power Measuring Equipment	5	5	6
Frequency Measurement and Analysis	10	11	15
Noise Measuring Equipment	10	11	14
Signal Generators	18	19.5	23
Other Test and Measuring Equipment	45.5	47	91
Medical Equipment, Total	**209**	**234**	**292**
Radioactive Tracer Equipment	3	5.1	7.5
X-Ray Equipment	80.1	85.2	98.5
Diagnostic	73	78	91
Therapeutic	7.1	7.2	7.5
Patient Monitoring Systems	7.5	10	16.5
Hearing Aids	41	43	47
Electroencephalographs	2.5	3	5
Electrocardiographs	12	15	18
Electron Microscopes	6	7	9
Analytical Lab Equipment (incl. blood colorimeters)	40	45	50
Ultrasonic (diagnostic and therapeutic)	3	3	5
Diathermy, shortwave and microwave	9.5	10.2	12.1
Lasers	1.5	1.9	3.5
Other	3	6	20
Nuclear Instruments and Equipment, Total	**104**	**113**	**158**
Semiconductor Detectors	2	2.9	3.2
Analyzers	17.6	20.8	24
Pulse Height	15	17.5	20
Other Spectrometers, (for nuclear applications)	2.6	3.3	4
Accelerators	21	23	27
Linear	6.8	7.5	10
Other	14.2	15.5	17
Power Supplies	6	7	12
Amplifiers	8	9.6	11
Pulse Generators	3	3.5	4.2
Radiation Monitoring Instruments	10.5	11.5	12.5
Portable Survey	8.5	8.5	8.5
Fixed Monitoring	2	3	4
Reactor Controls	18	20	38
Other	17.9	14.7	26.1

	1964	1965	1968
	(Millions of dollars)		
Computers and Related Equipment, Total	**1,850**	**2,045**	**2,820**
Digital Computers, except process control	1,462	1,564	1,950
Analog Computers, except process control	75	100	140
Hybrid Computers, except process control	13	16	30
Peripheral Equipment	300	365	700
Converters, A to D	82.5	105	240
Converters, D to A	45	55	88
Converters, Card to Tape	3	4	9
Readers, Paper Tape	25	31	63
Readout Devices	15.5	19	31
Mass Storage Memories	129	151	269
Communications Equipment, Total	**1,121**	**1,241**	**1,633**
Land Mobile	170	185	230
Microwave and Radio Relay	68	76	100
Terminal and Switching	85	93	120
Navigational Aids	70	79	120
Radar	50	55	75
Other	20	24	45
Marine Communications	12	12.5	15
Airborne, including ground links	150	155	163
Carrier-current	16	17	20
Intercom and Sound	225	250	325
A-M Station Equipment	28	30	34
F-M Station Equipment	44	50	65
TV Station Equipment	110	130	225
Citizens Band	31.5	34.5	55
Amateur	6.7	6.3	4
Facsimile	18	18	25
Light Communications, (lasers, i-r)	1.5	2.5	8
Telemetry	70	85	100
Other	15	17	24
Closed Circuit Television, Total	**24**	**29**	**48**
Industrial	14	16	23
Educational	8	10	18
Theater	1	1	2
Medical	1	2	5
Dictating Devices, Total (for office and business)	**35**	**40**	**50**
Industrial Operations Equipment, Total	**334**	**370**	**465**
Motor Speed Controls	30	34	40
Welding	6	6	5
Power Supplies, (complete equipment)	90	94	100
Photoelectric	6.2	6.4	6.9
Infrared	30	35	50
X-Ray, except medical	23	25	30
Lasers	2	3	10
Measurement and Surveying	1	1	3
Welding and Machining	1	2	7
Process Control Computer Systems	49	58.5	89
Analog	18	20	25
Digital	29	34.5	56
Hybrid	2	4	8
Other Process Controls	90	98.5	111
Controllers	12	13	15
Actuators (incl. valves)	23	25	28
Indicators	5	5.5	6
Recorders	50	55	62
Other Equipment	8	10	23

Electronics Markets 1965

TOTAL ELECTRONICS INDUSTRY

	(millions of dollars)			
	1963	1964	1965	1968
ELECTRONICS INDUSTRY TOTAL	16,506	17,225	17,600	20,001
Consumer Electronics	2,432	2,550	2,750	3,150
Industrial-Commercial Electronics	3,883	4,131	4,570	6,088
Federal Electronics (incl. military and government adjusted for calendar years)	9,516	9,844	9,580	9,963
Replacement Components	675	700	700	800

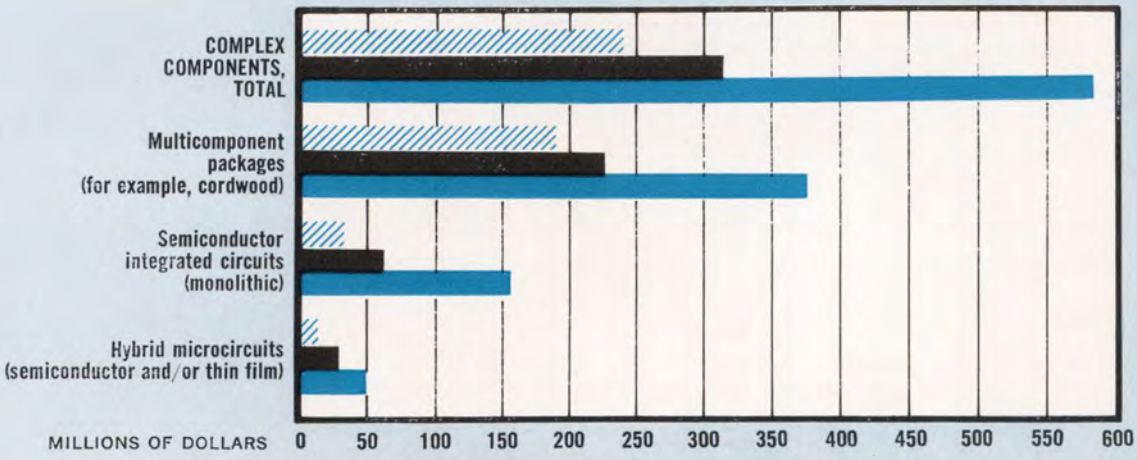


Components Markets

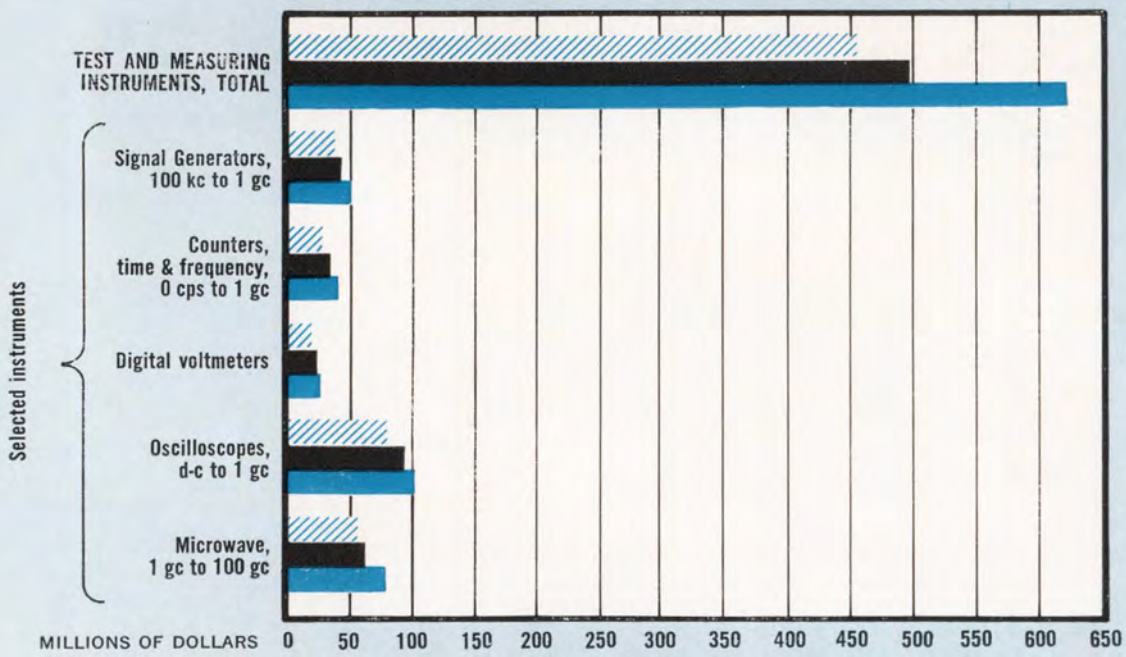
	1964	1965	1968
	(Millions of dollars)		
ALL COMPONENTS, TOTAL	**4,157**	**4,370**	**5,286**
Antennas and Hardware, Total	**45**	**53**	**60**
Capacitors, Total	**354**	**364**	**377**
Paper and Film	104	110	115
Electrolytic	130	135	142
Mica	25	25	24
Glass and Vitreous Enamel	17	17.5	18
Ceramic	47.5	50	54
Variable	30	26	24
Complex Components, Total	**242**	**316**	**585**
Multicomponent Packages, (two or more separate active or passive components in a single package)	193	226	375
Microelectronics	48.5	90	210
Semiconductor Integrated Circuits, (monolithic)	33.5	60	160
Hybrid Microcircuits, (semiconductor and/or thin film components on the same or separate substrate)	15	30	50
Connectors, Total	**243**	**246**	**255**
Coaxial	29	29	32.5
Standard	22.5	22	23
Miniature	6.5	7	9.5
Cylindrical	88	88	90
Rack and Panel	60	62	65
Printed Circuit	30	32.5	37.5
Special Purposes and Fused	36	34	30
Delay Lines, Total	**15**	**18**	**25**
Electroluminescence, Total	**6**	**7**	**10**
Electron Tubes, Total	**832**	**881**	**1,141**
Receiving Tubes	252	236	170
Power and Special Purpose	245	252	273
High Vacuum	60	61	64
Gas and Vapor	18	18	18
Klystrons	45	44	44
Magnetrons	33	32	31
Traveling Wave Tubes, including backward wave osc	40	40.5	47
Light Sensing	20	25	32
Storage, Light Emitting, Display	19	20	23
Other	10	11	14
TV Picture Tubes	335	393	698
Black and White	165	173	198
Color	170	220	500
Ferrite Devices, Total	**20**	**22**	**28**
Filters, Total	**52**	**55**	**85**
Gyros, Total	**300**	**300**	**350**
Loudspeakers, Total	**48**	**50**	**52**
Magnetic Tape, Total	**84.4**	**101**	**173**
Audio	25	30	35
Instrument	52.4	63	123
Video	7	8	15

	1964	1965	1968
	(Millions of dollars)		
Quartz Crystals, Total	**43**	**50**	**63**
Resistors, Total	**350**	**352**	**383**
Fixed	176	174	174
Composition	70	67.5	66
Carbon, deposited	22	20	16
Metal Film	33.5	36	45
Wirewound	50	50	47
Variable (potentiometers)	138	141	155
Nonwirewound	59	61.5	65.5
Wirewound	79	79.5	89
Other, (incl. nonlinear resistors as varistors and thermistors)	36	37	54
Relays, Total	**214**	**225**	**238**
Solid-State Relays	1.5	4	7.5
Electromagnetic Relays	114.5	119	124
Contact Meter Relays	6.5	6.7	7
Crystal Can	20	19	20
Dry Reed	10	12	19.5
Stepping	11	10.5	9.5
Telephone Type	28.5	28.5	28
Mercury Wetted	12.5	15	17
Other Electromagnetic Relays	26	27.3	23
Other Relays (except electromagnetic)	98	102	106
Semiconductors, Total	**630**	**641**	**680**
Transistors	300	310	313
Silicon	150	175	185
Germanium	150	135	127.5
Diodes and Rectifiers	191	179	170
Silicon	140	132.5	132
Germanium	32	29.5	19.6
Selenium and Copper Oxide	19	17	18
Special Devices	139	152	197
Silicon Controlled Rectifiers	25	30	37
Microwave and Variable Capacitance Diodes	10.5	12.3	15.7
Tunnel Diodes	2.4	2.5	4
Light Sensitive Devices	60	67.5	84.2
Field Effect Transistors	2.8	5	13.9
Voltage Reference and Regulator Diodes	38.4	35	42
Servos and Synchros, Total	**63**	**63**	**63**
Resolvers	10	10	10
Synchros	27	27	27
Motor Generators, Rate Generators, Servo Motors	26	26	26
Thin Films, Total (resistors, capacitors, but not an integral part of a microcircuit)	**5.5**	**8.5**	**22.5**
Transducers, Total	**150**	**150**	**200**
Transformers and Reactors, Total	**210**	**212**	**220**
Wire and Cable, Total	**250**	**255**	**275**

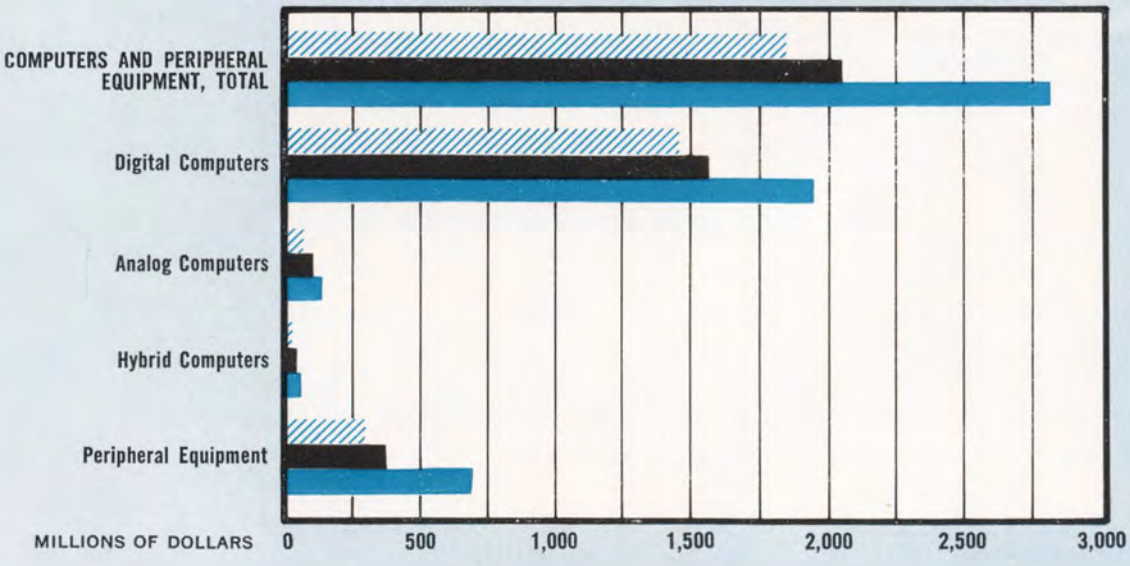
COMPLEX COMPONENTS, TOTAL



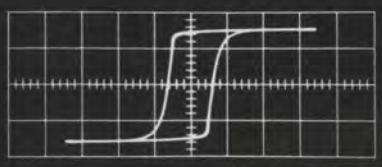
TEST AND MEASURING INSTRUMENTS, TOTAL



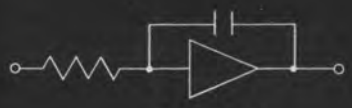
COMPONENTS AND PERIPHERAL EQUIPMENT, TOTAL



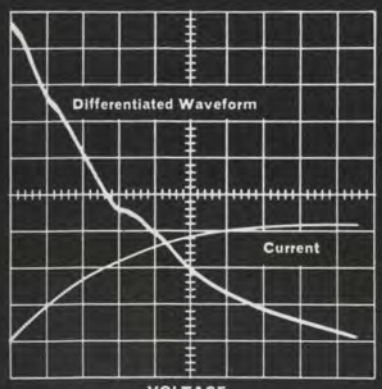
1964 1965 1968



DISPLAY OF INTEGRATED WAVEFORM—transformer secondary voltage integrated and plotted against the transformer primary current—for enabling study of B-H loops of transformer cores.



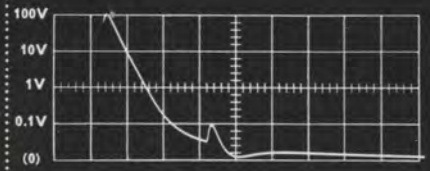
INTEGRATOR



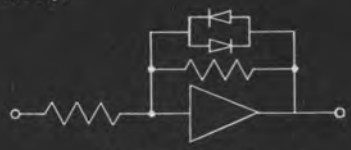
VOLTAGE

DISPLAY OF DIFFERENTIATED WAVEFORM—tunnel diode in liquid helium—for enabling detection of quantum phenomena at low temperature.

DIFFERENTIATOR

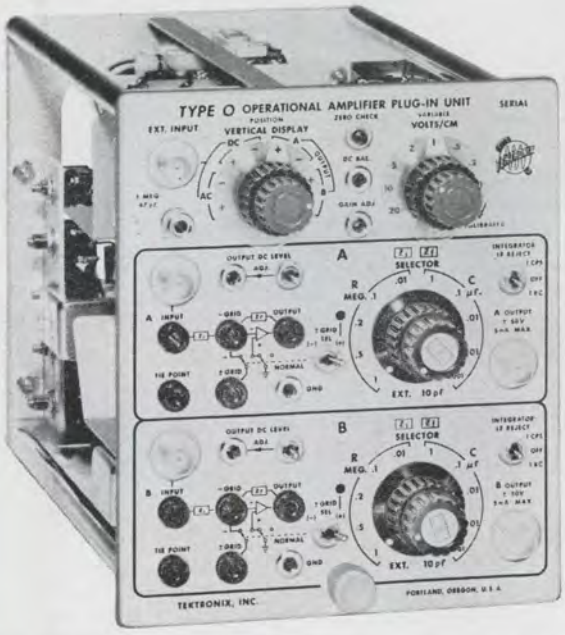


DISPLAY OF LOGARITHMIC RESPONSE—two pulses of widely varying amplitudes—for enabling observation of 100-volt pulse and 0.1-volt pulse in the same viewing area (simplified schematic shown below).



NON-LINEAR AMPLIFIER

Operational Amplifier Plug-In Unit Permits Oscilloscope Measurements Under Dynamic Conditions



Type O Unit $525
Accessory Log Adapter $75

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

For a demonstration—
please call your Tektronix Field Engineer.

TYPE O UNIT—for Tektronix Oscilloscopes that accept letter-series plug-in units.

Using this new Operational Amplifier Unit in your Tektronix Oscilloscope, you can perform precise operations of integration, differentiation, function generation, linear and non-linear amplification.

You can accomplish many of these operations by simply manipulating the front-panel controls—for the Type O Unit features convenient *selection of precision input and feedback components.*

You can use the Type O Unit as a gated integrator . . . as a high-input-impedance amplifier . . . as a bandpass amplifier . . . as a constant-current-drive amplifier . . . as a peak-memory amplifier . . . as a function generator . . . as a capacitance-measuring device . . . as a low-current measuring device . . . and for many and varied other specialized operations—some performed *with* external circuitry and some *without.*

CHARACTERISTICS

The Type O Unit contains two complete operational amplifiers and one complete vertical preamplifier.

Each operational amplifier features 15 mc open-loop gain-bandwidth product, open-loop dc-gain of 2500, selectable input and feedback impedances, drift rejection for ac integration. The output of one operational amplifier can be applied to the input of the other for combined operations.

The vertical preamplifier can be used independently or to monitor the output of either operational amplifier. In a Tektronix Type 540-Series Oscilloscope, the passband is dc-to-25 mc, the risetime is 14 nsec, and the maximum calibrated sensitivity is 50 mv/cm.

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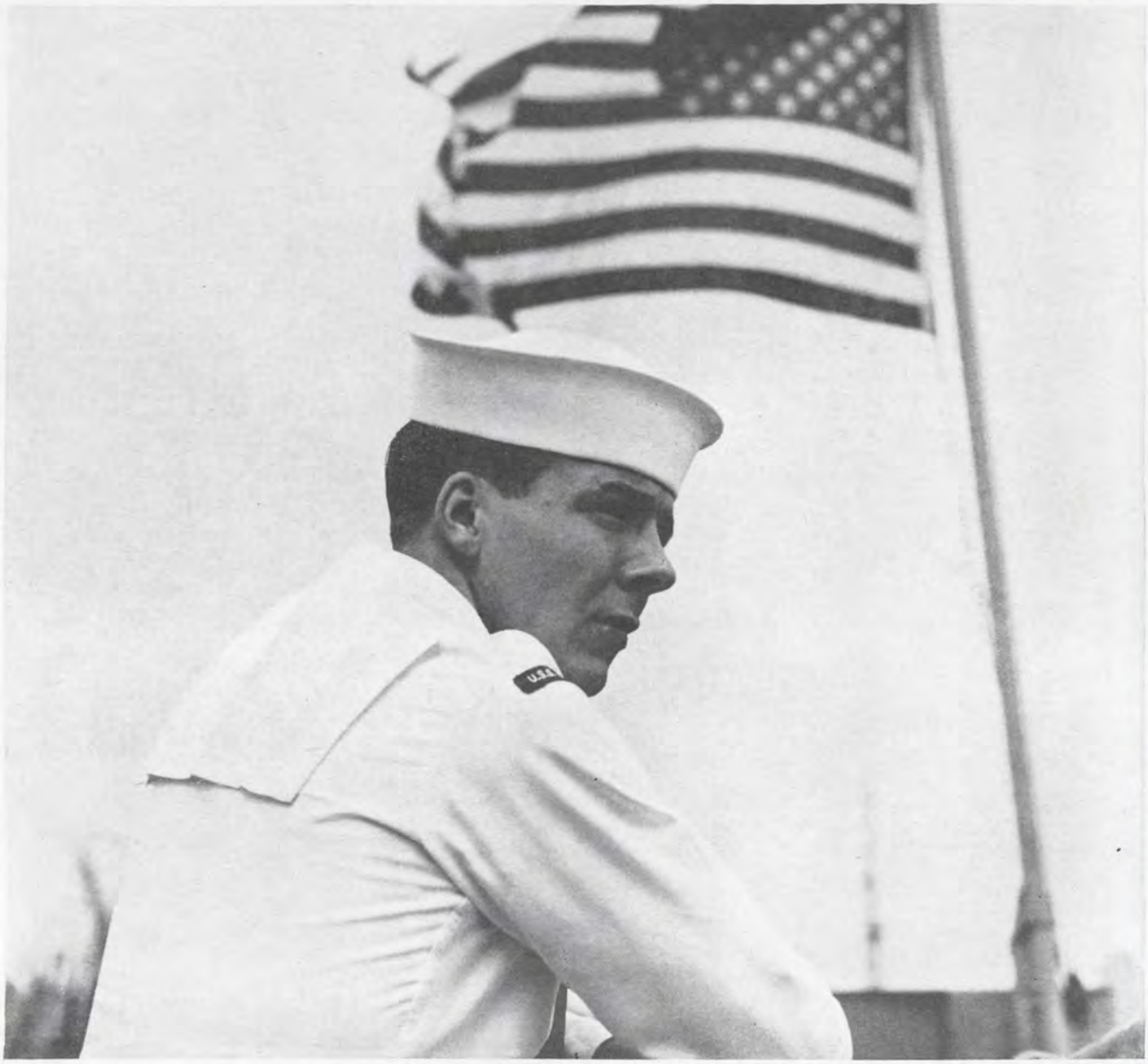

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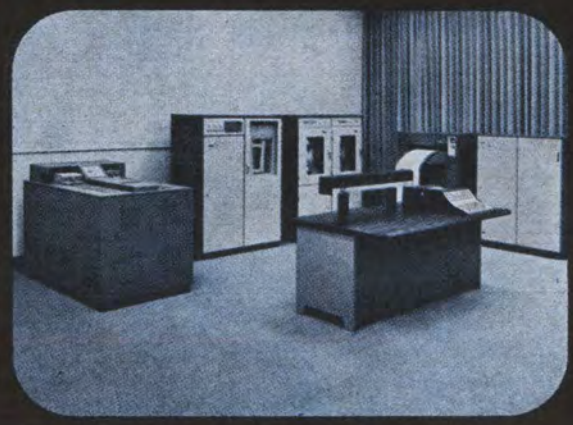

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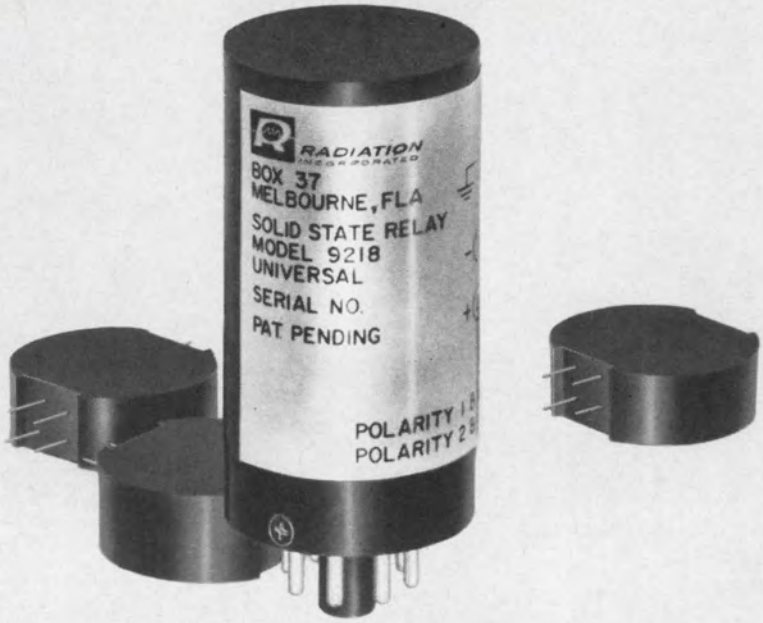
New Modular Telegraph Relays



eliminate up to 54 spare parts

Radiation Solid State Units require only 3 different modules

Eliminate maintenance and adjustment, gain unlimited service life, and carry your inventory in your pocket!

Look inside the case of a new Radiation Solid State Modular Relay. You'll never find more than three different parts. You'll also notice the "checker" construction —a new concept in telegraph relay design. These modules are used in various combinations to duplicate any mode of operation presently handled by electromechanical units.

Inventory headaches are now a thing of the past. With conventional electromechanical units, you have to stock up to 54 parts. With new Radiation Solid State Relays you stock only three different modules. That's all!

Design Features . . .

Welded solid state circuitry is transfer molded to form rugged checkers which are exceptionally resistant to vibration and environmental extremes. Neutral relays consist of one Oscillator module and one Keyer module. Polar relays consist of two Oscillators and two Keyers. Add a Latch module and you have a Universal relay.

The stacked checkers and base are connected with either printed circuit cards or wiring, and inserted into the case. Should a module be damaged, it can be replaced quickly and easily. Pin connections are programmable, and any base wiring can be selected with simple changes.

Electrical Characteristics . . .

New Radiation Modular Relays are completely solid state —there are no moving parts. Thus, they eliminate the need for maintenance and adjustment. Inputs are essentially resistive, and they do not induce transients in the line. The relays operate on current supplied by the input signal, and provide isolation of 50 megohms at 500 v dc. Conductive and radiated RF interference is 30 db better than standard electromechanical types (MIL-I-26,600). Radiation Solid State Relays operate at speeds to 2,400 bits/second with less than 1% distortion, and have been tested to show 56,000 hours MTBF. There are other features!

Radiation Modular Relays are available now in production quantities. Send the coupon for detailed information. We will also be glad to arrange for evaluation samples. Radiation Products Division, Dept. EL-01, Melbourne, Florida. Telephone: (305) 723-1511.

	Base — Model Number — Price		
Relay Type	**Octal**	**202**	**255**
Polar	9228 $ 95.00	9229 $110.00	9230 $110.00
Neutral	9238 $ 56.00	9239 $ 65.00	9240 $ 65.00
Universal	9218 $110.00	9249 $120.00	9250 $120.00
Oscillator Module	Part No. 509972G1		$23.40
Keyer Module	Part No. 509971G1		$27.50
Latch Module	Part No. 509970G1		$23.80

(All prices quoted for quantities of 1 to 49 items.)

RADIATION PRODUCTS DIVISION
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Probing the News

Microelectronics

Integrated-circuit makers are ready for the big buying boom to start

Sales expected to climb to $90 million in 1965 from $48.5 million last year; 1968 volume put at $210 million

In the five years since its birth, the microelectronics industry has been concentrating on finding applications. Now that many markets have been opened, the industry is geared for mass production.

It has taken five years for sales of integrated circuits—monolithic and hybrid—to build up to the present $48.5-million level. Volume should zoom to $90 million this year and 1968 sales are expected to explode to $210 million.

Carving a market. Competition for a market has been so intense that few companies have made profits from microelectronic circuits. Now, although there are more buyers, productivity has increased even faster—and the industry is plagued by overcapacity. Small companies are hanging on precariously, waiting for the expected boom to start. Such relatively small producers as General Micro-Electronics, Inc., and the Molectro Corp. have been forced to seek additional financial help to tide them over this period.

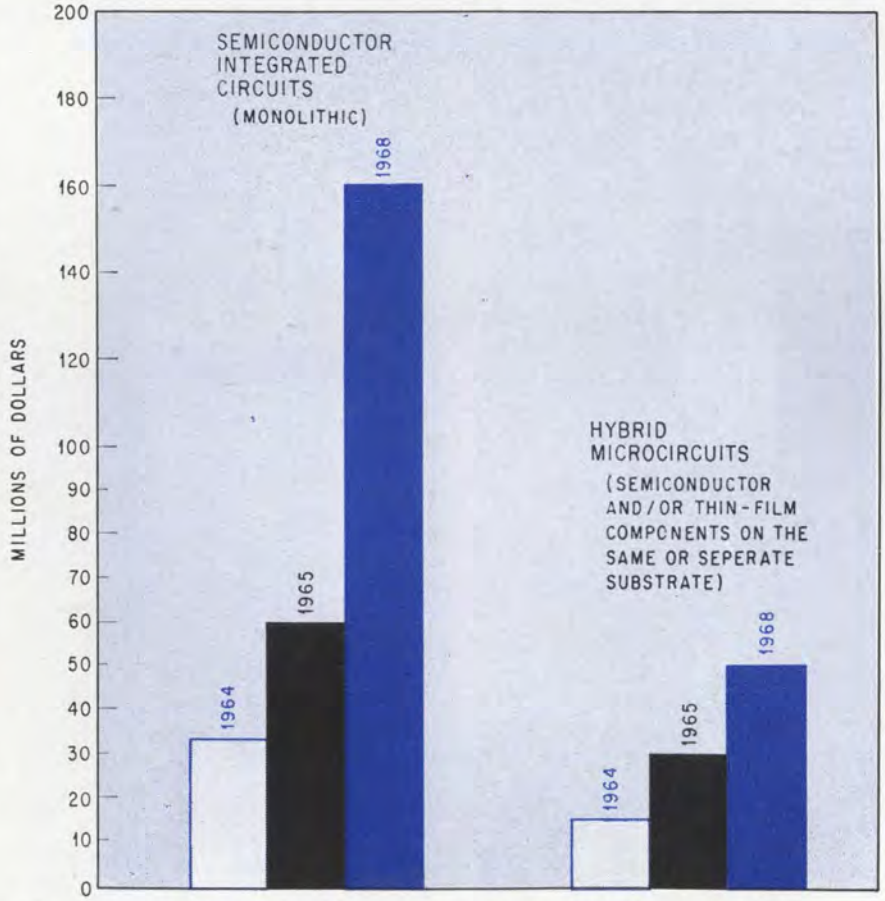
I. Still too expensive?

The biggest buyer of microelectronics has been the military. The Pentagon pushed the use of such circuits primarily because systems made with them are reliable. And there has been an economic bonus.

Some producers of military systems say they have been able to cut equipment costs in half by using mass-produced integrated circuits.

Integrated circuits are considered to be so reliable that a computer being designed to provide navigation and guidance controls for the Apollo moon probe won't have redundancy and the designers are making no provision for mid-flight repairs.

A matter of price. Although the price for integrated circuits seems to be low enough for the military, it's still too expensive for most industrial customers. Computer makers are the exception. Some digital



Microelectronics sales in the U.S. are expected to nearly double during 1965, according to a survey by Electronics magazine. The market for semiconductor integrated circuits should increase almost fivefold by 1968. From $33.5 million in 1964, it is expected to rise to $60 million in 1965 and $160 million by 1968. The hybrid microcircuit market should climb from $15 million in 1964 to $30 million this year. By 1968 it should reach $50 million.

Robert Noyce of Fairchild's Semiconductor division: Too many people in the business.

integrated circuits that are being used in computers are half the price of discrete-component circuits. Because computer companies are aware of these savings, all the major manufacturers are designing microelectronic computers.

Three firms cite profits. Only recently have system manufacturers been buying integrated circuits in large numbers. Among the few companies reporting profits from the sales of such circuits are Texas Instruments, Inc., the Fairchild Camera & Instrument Corp. and the Raytheon Co. Observers of the market estimate that Texas Instruments and Fairchild together control as much as 70% of the market.

Robert N. Noyce, vice president and general manager of Fairchild's Semiconductor division, sees prices going down as production steps up, with some companies forced out of business by the competition. "The business will start getting better when there are fewer people in it," he adds.

Richard J. Hanschen, assistant vice president and general manager of Texas Instruments' semiconductor unit, thinks the shakeout is over. "Its been possible to open up the industrial market nine months earlier than we initially forecast," he says.

C. Lester Hogan, vice president of the Semiconductor Products division of Motorola, Inc., sees the industry on the verge of the explosion. "The industry is now in the phase where everyone is redesigning all kinds of circuits, a lot of engineering is being done, but no customer's volume is up very high," he says.

Trygve Ivesdale, product manager of the Raytheon Co.'s semiconductor operations notes that the use of integrated circuits in military equipment and in commercial computers is on the increase. "Business is coming along very nicely," he added.

II. The custom builder

The early going has been tough because there is not much off-the-shelf business. Custom designers of integrated circuits expect some of their products to be mass-produced some day. But for the most part, makers of integrated circuits must continue to cater to the custom needs of a big potential customer. Comments Motorola's Hogan: "It is difficult and costly to develop integrated circuits for a customer's special needs. Until the customer's buying goes up significantly, we are bound to lose money on him."

One attractive market for the custom builder is in linear circuits. The biggest market is in digital circuits, and the linear-circuit field is less crowded. Besides lower sales, it's more difficult to engineer and produce linear circuits than logic circuits. The digital-circuit orders often can be filled with standard logic circuits, but linear circuits require special tailoring and a special price.

C. Lester Hogan of Motorola: It's costly to cater to the big buyer, but we must.

Jean Hoerni, manager of research and development at the Union Carbide Corp.'s semiconductor division, agrees this is the "best way to compete with the digital-minded industry." One of Union Carbide's first linear-circuit products will be for a differential amplifier.

Another company, Amelco, Inc., says more military money is available for linear circuits than in the past. The company soon will offer a highly stable operational amplifier for guidance control in space vehicles.

Richard J. Hanschen of Texas Instruments: The shakeout in integrated circuits is over.

III. Mass production sought

Even though the custom business is attractive, integrated-circuit manufacturers are striving to develop families of linear circuits that will have a broad range of applications, so they can be produced in quantity at low cost.

Many customers that used to buy conventional linear circuits for military radar and navigation, process control and servo systems, are now asking for digital integrated circuits. The families of circuits needed to produce digital versions of traditionally analog systems are already available.

Companies with a stake in linear integrated circuits figure they have to go after this market with general-purpose linear circuits. If they don't make such circuits available, they reason, somebody else will.

According to Frank Pittman, who heads linear-circuit development at

Integrated circuits being produced at Texas Instruments plant. In the first few years industry searched for applications, now it's geared for mass production.

the Westinghouse Electric Corp.'s Molecular Electronics division, development is concentrating on three lines of circuits: broadband amplifiers, operational amplifiers and power devices.

Westinghouse recently developed a feedback amplifier, called the 1146, that covers the frequency ranges of four earlier circuits in its amplifier line. The amplifier operates at frequencies from direct current to 60 megacycles per second. With a 330-ohm load, the circuit's gain is 23 decibels at 40 Mc. However, gain falls off to 16 db at 60 Mc. The circuit can be used for numerous applications: video amplifiers for radar and television and in intermediate-frequency strips.

This bandwidth, which represents a doubling of the bandwidth of circuits that were produced a year or two ago, has been achieved through size reductions to reduce stray capacitances in the circuits, and by the development of higher-frequency transistors. The oxide isolation techniques that are coming into general use in the industry should achieve the same gain at 60 Mc that is now attained at 30 to 40 Mc.

Operational amplifiers are already being used in systems such as the Minuteman II missile. But Pittman says general-purpose circuits are needed, with the ability to deliver up to 60 db gain at frequencies up to 1 Mc, and with input impedances greater than 100 kilohms.

Drive a speaker. The 1- to 5-watt audio amplifiers appearing on the market are the first linear integrated circuits with sufficient power to drive transducers such as loudspeakers. Integrated-circuit designers are pushing the power level up to 10 watts and at the same time working to make the amplifiers inexpensive enough for use in consumer electronics. They are also working on series voltage-regulator circuits that can handle one ampere, and on circuits capable of driving electromechanical devices in servo systems. For this goal, oxide isolation is considered a key technique; another is the deposition of high-value precision resistors as thin films on top of the semiconductor circuit.

IV. Vying for the computer market

Computer makers are a hefty market for integrated circuitry. The fight for this business has brought on some frantic races for ultrafast circuits. Texas Instruments, for example, says it is working on a circuit with only a 2- to 3-nanosecond delay. And the Signetics Corp., a company controlled by the Corning Glass Works, is putting 25% of its research-and-development efforts into the commercial computer markets.

James F. Riley, the president of Signetics, says: "The industry has gone through its adolescence very quickly. We are just now starting to mature."

Walter W. Finke, president of Honeywell, Inc.'s Electronic Data Processing division says that integrated monolothic circuitry will be standard in virtually all new equipment announced in 1965.

Although most computer companies are interested in monolithic circuits, the biggest one—the International Business Machines Corp.—is the exception. IBM uses hybrid circuits in its new System 360. IBM seems to be stressing hybrids because of their speed and power.

Although IBM now makes all its own circuits, the company is expected to seek outside suppliers of hybrid circuits if computer sales rise fast.

Both used. The Radio Corp. of America, in announcing its new series of computers, the Spectra 70, reported that the upper end of the line would be monolithic and the lower end hybrids. RCA is buying, as well as making, its circuits.

Most computer makers don't expect to be producing computers with 100% integrated circuits for several years. Integrated circuits don't yet have the power required for use in memory and input-output circuits. Integrated circuits are being used in logic sections. But for memory driving, discrete components or hybrid circuits are now used, and for input and output circuits, which have to drive electro-

James F. Riley of Signetics: We are just now starting to mature.

mechanical equipment such as printout systems and tape recorders, discrete components are used.

Although most companies are stressing monolithic circuits, many also maintain a capability for making hybrids.

Despite the shakeout and the struggle of some companies to stay in business, others such as Signetics and Stewart-Warner Microcircuits, Inc., are moving into new facilities.

For as one executive says, "Even though the big-volume market may be a few years off, now is the time to start developing our capability."

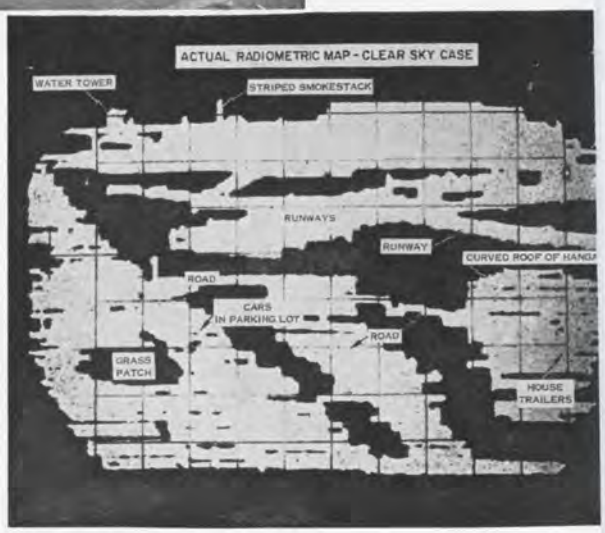
Millimeter-wave research is coming back in style

Renewed interest in millimeter waves is reflected in varied studies and improved equipment

Millimeter-wave research, pushed into the background by interest in lasers, is stirring again.

In 1960, when the first laser was developed, scientists generally shelved millimeter-wave projects, which had run into major technical obstacles, and looked to the laser to provide a revolution in the communications field. But so far, there has been no revolution—only incremental advances in laser technology. And some of the early forecasts of what a laser can do have been toned down, leaving room for millimeter-wave technology to fill the gap.

Back to work. So researchers have been drifting back to millimeter-wave studies. Despite the problems, millimeter waves offer an enormous potential: a capacity that, in terms of cycles per second, is about five times the bandwidth



Ground mapping can be accomplished with millimeter-wave equipment. The Raytheon Co. is developing gear that receives radiation in the millimeter range. The photo above shows the area scanned by the equipment, and the picture at the right is the radiometric image that was picked up.

of the rest of the radio spectrum; ultrahigh resolution radar, and long-range space communication.

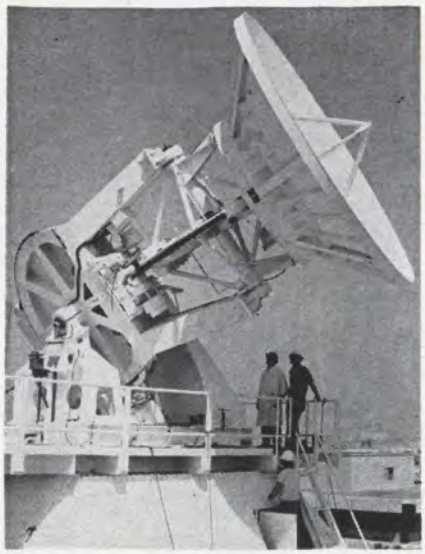
The biggest hurdle to successful millimeter-wave systems is the development of a transmitter with substantial power. Most equipment used so far has been either scaled-down models of longer wavelength transmitters or exotic devices practical only in laboratories. Since most of this gear was inefficient, the major effort, today, is to boost efficiency ratings.

Early manufacturing methods were generally inadequate to meet the high tolerances needed. But precise manufacturing techniques developed over the past few years are helping to provide miniaturized components that will handle millimeter waves as efficiently as standard components now deal with the lower frequencies.

I. Signs of revival

Several recent events point up the new interest in the millimeter-wave field:

- The National Aeronautics and Space Administration recently awarded a contract to the Raytheon Co. to study the feasibility of using millimeter wavelengths for space communication. Experiments will be designed to define channel characteristics of earth-to-space communications.
- The Aerospace Corp., a nonprofit research company, is preparing a 15-foot diameter, 94-megacycle antenna to test tracking of fast-moving objects in space. So far the equipment has been used to study the face of the moon. The company also is exploring the effects of the earth's atmosphere on video transmission [Electronics, Dec. 28, 1964, p. 23]. Researchers have set up a 12-mile line-of-sight television link between their plant at El Segundo, Calif., and a mountain top. Transmissions from local tv stations are picked up on top of the mountain and the video portion is retransmitted on a three-millimeter link to the plant.
- TRG, Inc., is building an experimental communication system that will operate at fixed frequencies between 45 and 80 gigacycles. The project is under a contract with the Rome Air Development Center. TRG will use a new broadband harmonic mixer, which



Millimeter-wave antenna built by the Aerospace Corp. is being tested for possible space-to-earth communications. The 15-inch-diameter antenna operates at 94 gigacycles.

has a sensitivity of −55 to −80 decibels below one milliwatt. Antennas are three feet in diameter. The system will probably be packaged as a mobile unit.

II. Nothing on the shelf

The dearth of millimeter-wave equipment plagues researchers, and many components must be custom-made, delaying studies in the field. However, this problem is slowly being solved, especially in the area of tubes.

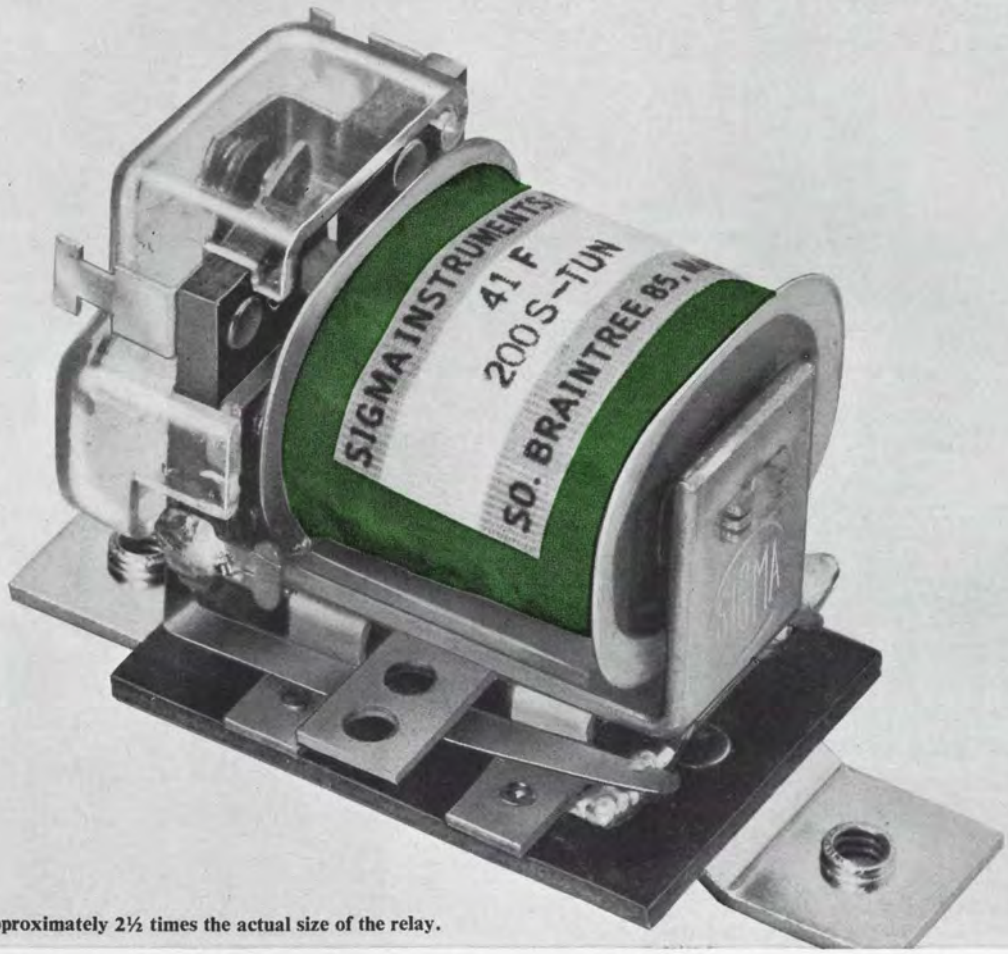
For example, Hughes Research Laboratories, a division of the Hughes Aircraft Co., has made available laboratory samples of its type 814H traveling-wave tube with a continuous output of 100 watts over the range of 90 to 99 gigacycles; the tube has an efficiency rating of 20%. A 30-watt traveling-wave tube operating over a range of 135 to 150 Gc is under development.

And the Watkins-Johnson Co. has developed a high-power amplifier tube with a 1,000-watt output at 35 Gc.

New process. Harmonic generation using varactors hasn't shown much promise because of low power capabilities. However, the Autonetics division of North American Aviation, Inc., is working on a new diode fabrication technique and Hughes also is investigating new diode configurations.

Waveguide, test bench and system components are available from

Insulation of MYLAR® on Sigma relay increases thermal range 50% ...costs remain the same



This photo is approximately 2½ times the actual size of the relay.

Sigma met the problem of increased thermal specifications by switching to insulation of MYLAR* polyester film. With its higher temperature rating, MYLAR upgraded the thermal range of Sigma's Series 41 relay by 50%. This surpassed the specifications required and broadened applications for the relay.

In addition, the switch from acetate film to MYLAR in other relays made by Sigma Instruments, Inc., of Braintree, Massachusetts, also meant:

- **a smaller coil,** since the high dielectric strength of MYLAR permits the use of thinner, more pliable film.
- **longer life** is designed into the coil by the use of MYLAR, which does not dry out or change characteristics with age.
- **insulation costs remain the same,** because less MYLAR is needed for equivalent dielectric strength, as compared with most other insulators.

As a result, relays are now more reliable and versatile and are used in a wide array of applications ranging from furnace flame-out safety controls to automatic traffic and street-lighting controls.

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a few suppliers for use in equipment testing up to 200 Gc.

The limits of scaled-down tubes are stimulating some interest in finding other ways of generating and amplifying millimeter waves. One approach is the attempt to develop a beam-plasma amplifier. Work on this is going on at Microwave Associates, Inc., and at Stanford University. The beam-plasma amplifier would exploit the interactions of electron beams and plasma to get signal generation and amplification.

Receiver sensitivity is also a formidable obstacle to the development of millimeter-wave systems. Autonetics is working on a low-noise parametric amplifier. Engineers there are trying to get the noise figure down to 10 decibels at 94 Gc, but now have to strain to get 15 db, they say. TRG is building a low-noise parametric amplifier for the Signal Corps. It will operate at 94 Gc, with an expected noise temperature of 20° Kelvin, or a fraction of a decibel.

III. Detection systems

Interest in millimeter waves is evidenced outside of the communications field. Some systems are under development for commercial diagnostic purposes. TRG is aiming at the petroleum and chemical companies that use plasma-diagnostic techniques for analysis of flame processes in manufacturing and process control. TRG has built a millimeter-wave interferometer for this use.

Plasma-diagnostic techniques involve transmitting a wave through a plasma. Characteristics of the plasma can be determined by the ways the waves are affected.

At the University of Illinois, research Paul Coleman and his associates have developed a submillimeter wave spectrometer for the 100- to 1,000-micron range for about $100. A commercial unit built around a stabilized klystron could provide accuracy to between ±0.0001%, but the instrument would cost thousands of dollars. The group will use the spectrometer to investigate radiation from various gases and gas mixtures to try to find new lasing lines and to extend the frequency range of lasers.

Used for mapping. A Raytheon group is working on a millimeter

Industrial electronics

Putting zip into mail-sorting

Post Office abandons address-reading machines and seeks one that reads zip codes electronically

By Louis S. Gomolak

Industrial Electronics Editor

The Post Office's zip code is speeding more than the mail. It's also stepping up development of electronic address-reading machines, and competition among manufacturers of these rapid readers.

Next June, four machines will be tested on-line, side by side, in the Detroit Post Office. One, made by the Philco Corp., is alphanumeric —it reads zip-code numbers and the names of cities and states by flying-spot scanning. The other three, which read only numbers, are made by the Burroughs Corp., National Cash Register Co. and Rabinow Electronics, Inc., a subsidiary of the Control Data Corp.

Tests began in '58. Since 1958, the Post Office had been testing a machine that recognizes groups of characters through slit-scanning. But the machine, made by Farrington Electronics, Inc., reads only

radiometry system for mapping that has major military applications. The group says it is able to get precise radiometric measurements of ground targets with no active radiation to betray the operation.

Designers at Raytheon have breadboarded high-gain, noncoherent pulse radars operating at 35 to 70 Gc for search and mapping systems. These high-resolution, continuous-wave radars could obtain radar signatures from moving vehicles or even parts of vehicles, such as scanning radar antennas or turrets. For such work, designers need clean carriers with low noise.

The total dollar volume of the millimeter-wave market for 1964 was between $2 million and $3 million, and in 1965 the market is projected at between $3 million and $5 million.

Additional research in the field is being hamstrung by a lack of money. Industry is generally in a waiting mood and isn't jumping in to subsidize too much basic research, while the military is apparently waiting for industry to come up with more uses for millimeter systems before making additional funds available.

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city and state names. With the advent of a machine that can read zip codes, the government canceled its development contract with Farrington.

The department's goal is a device that automatically reads machine-addressed mail, which comprises 65% of the mail that the Post Office handles.

"We knew slit-scanning worked," says Richard Hessinger, the Post Office's director of research. "The alphanumeric approach, with flying-spot scanning, was still only theory until tests proved the Philco machine far superior to Farrington's."

"Slit-scanning," Hessinger continues, "is limited to a maximum scanning rate of about 1,000 characters per second. We still don't know what the maximum alphanumeric rate is. Also, Farrington's group-of-characters recognition approach can cause ambiguities, in that words such as Sonora and Sonoma are electronically the same. Mail might have been mis-

directed with this method."

Keith G. Huntley, Farrington's vice president of engineering, says, "The Post Office's statements are without foundation. Our chairman of the board will soon have a conference with the Postmaster General. Things aren't what they seem."

Philco's rivals. The Burroughs Corp. is working on a system that uses flying-spot scanning and a best-match technique to recognize the zip code. The National Cash Register Co. is developing a system that uses a flying spot but recognizes the code through the use of a set of photographic plates.

Rabinow uses 540 photomultipliers to read the code, and a best-match technique for recognizing zip-code numbers.

Jacob Rabinow, president, says the Rabinow system, if ordered in a quantity of about 200, would cost about $200,000 apiece. The system uses two stages for reading. The first stage finds the address, the second reads the code. An alphabetic section, for reading cities and states, can be added later," he declares.

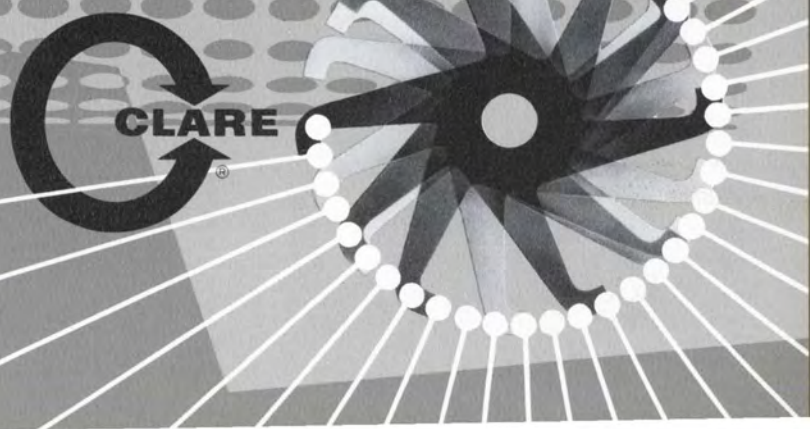
The Detroit test will compare the efficiency of reading only zip code versus reading both zip codes and place names. Joseph Uhland, Philco's project engineer, asks, "What happens when the zip-code is missing or smudged beyond reading? A zip reader can't handle the letter. Our alphanumeric reader, in this case, would read the city and state, then still be able to sort by zip codes that would be stored in the memory. We've got more capability, and the price would be competitive with the zip-code readers."

But Rabinow disagrees. "If the code is smudged, the entire address will probably also be unreadable," he notes.

Burroughs and National Cash both decline to comment on the reading program.

During recent trials by the Post Office the Philco machine sorted 18,000 letters an hour, missing only 90, according to reports. It read 82 different zip codes, 20 cities and all 50 states. An advanced version will go to Detroit. It is reported to be able to sort 36,000 letters an hour and its cost, according to the best estimates obtainable, will be $125,000 to $150,000.

CLARE STEPPING SWITCHES



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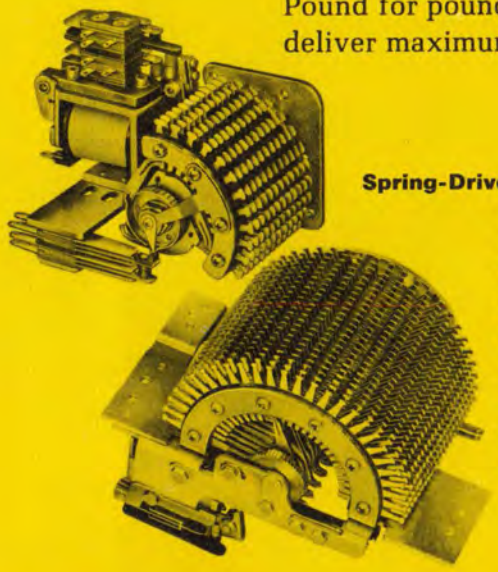

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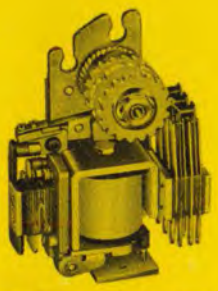
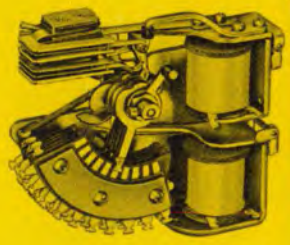


Spring-Driven Cam Switches

The Type 200 Cam Switch is a variation of the basic stepping switch, utilizing the same driving mechanism to rotate cams which, in turn, actuate cantilever contact assemblies. Interrupter contacts available.



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Direct Drive Stepping Switches offer a mode of switching quite similar to that provided by Types 210 and 211 Stepping Switches.

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211	11, 22 or 33	12	132			
20	20 or 40	16	480			
26	26 or 52	16	624			
200	Up to 8 cams with up to 6 contact springs per cam and 30, 32 or 36 steps per revolution					

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At the Rocketdyne Division of North American Aviation, scientists and engineers are continually checking out the most advanced rocket engines. Costly to build, these rocket engines may unexpectedly head for destruction when critical parameters go outside rated limits. To monitor or shut down rocket engines and prevent damage, fast, sensitive, reliable controls are needed. For this job, Rocketdyne is using Carter-Princeton Model 2020 ULTRA-COMPARATOR Dual Limit Controls at five critical points. The 2020 combines two 100K input impedance comparators on one small-size, computer-type, plug-in circuit card. Highly reliable, capable of evaluating low-level electronic signals without pre-amplification, it has the fastest power-relay output yet achieved—5 milliseconds from signal to full 2-ampere output. Here are Rocketdyne's applications:

1. Monitors at "Ignition Start" to pre-determine potential "stall condition," providing fast cut-off. **2.** Monitors an actuator-position signal from a linear feed-back transducer, causing an instant engine cut if engine is not following a pre-determined pattern. **3.** Monitors hydraulic pressure across the piston on gimbal actuators, permitting quick check to see that the load is below safe acceptable limits. **4.** Aids in bleeding air from the gimbal actuators by permitting a constant velocity actuator displacement. **5.** Monitors function generator output for level detection in order to set up logic circuits which give wave shapes for the determination of gimbal patterns.

The Model 2020 circuit is one of a series of new ULTRA-COMPARATOR units offering high sensitivity, compactness, reliability and adaptability at substantial savings. A limited number are available for free trial and evaluation.

For information, details, and specifications, contact Carter-Princeton, Electronics Division, Carter Products, Inc., 178F Alexander Street, Princeton, N.J. 08540. Phone (609) 921-2880.

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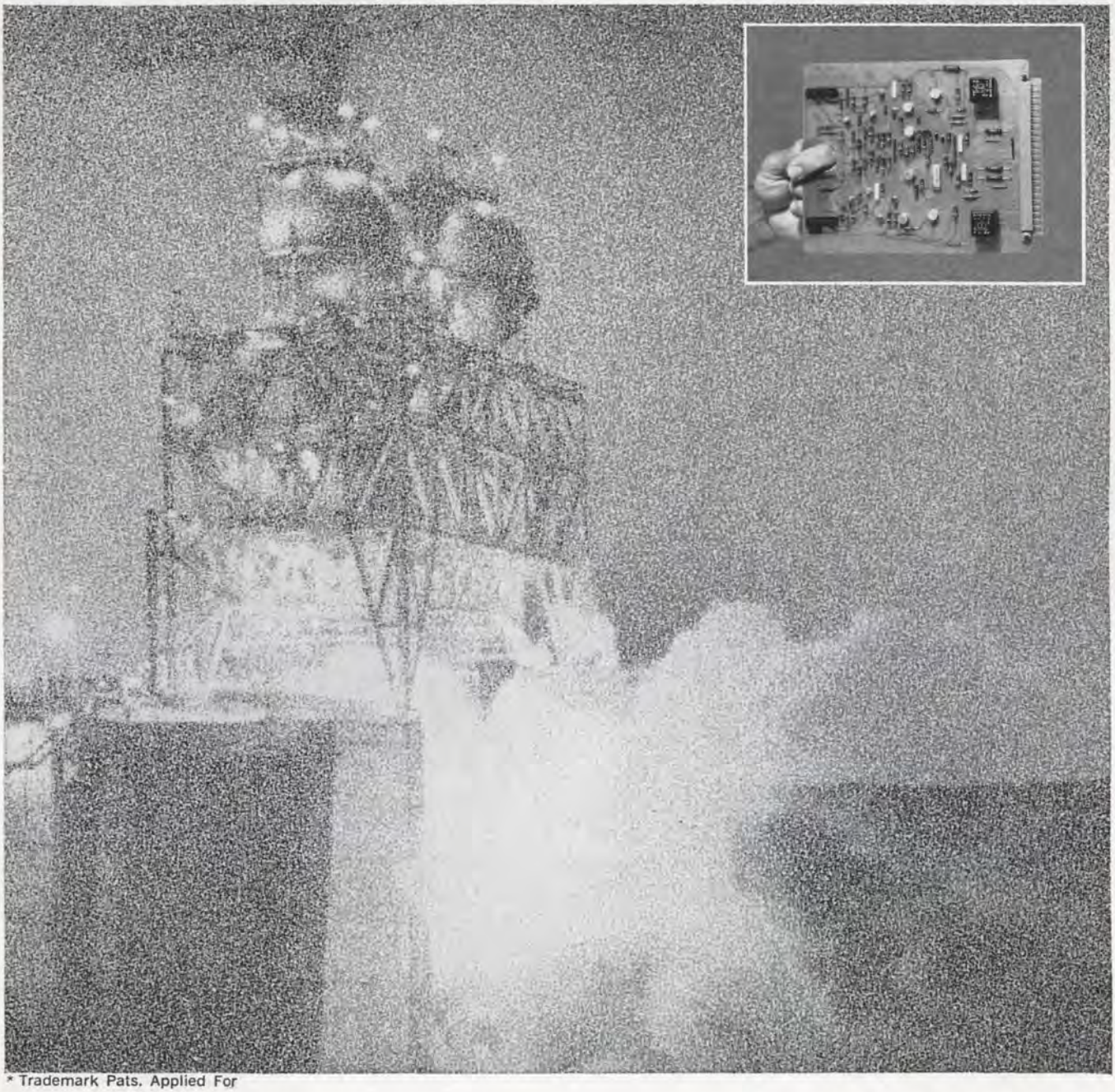

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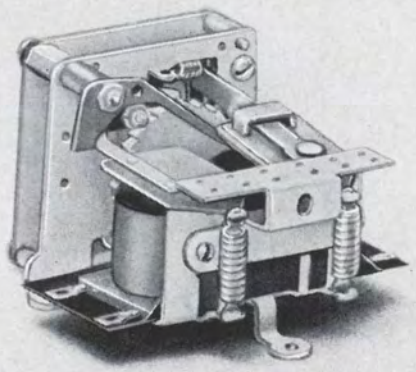

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Microelectronics

The Cermet Story

A Highly Sophisticated Versatile Material
with Unique Features and Varied Applications

Scientists and Engineers at CTS Corporation, Elkhart, Indiana, began over thirty years ago a continuing search for superior resistive materials. Hundreds of basic materials and thousands of resistive compositions have been analyzed, and the search will undoubtedly continue indefinitely. But several years ago a portion of this search was focused on ceramic-metallic compositions. The outcome of these investigations and the resulting applications are "The CERMET Story".

Most mixtures of ceramics and metals are either highly conductive or highly insulative depending upon their percentage composition, but several years ago mixtures of noble metals and glass frits were discovered which were semiconductive over narrow ranges. These early formulations were not commercially useful because of high current noise, high voltage and temperature co-efficients of resistance, and very poor reproducibility. These early formulations could be varied through a range of only a few hundred ohms per square. If formulations varied beyond a critical point, the resistivity of the film often decreased abruptly from a relatively high value to a very low one.

The Discovery

After several years of continuous study the CTS research staff learned to control the relationship between resistivity and the ingredient formulations. Improvements in noise, temperature and voltage stability, and reproducibility were also achieved. By 1958 CTS scientists and engineers had perfected a family of stable, reliable, economic, semiconducting films. This result led to the now famous CTS CERMET product line.

Production Methods

CERMET films are produced by screening formulations of conductive and insulating materials onto ceramic substrates. After firing at temperatures in excess of 600°C, a semiconducting alloy is formed which is permanently bonded onto the insulating substrate. A circuit or component produced in this manner is remarkably rugged and able to resist abrasion, heat-shock, humidity, oxidizing atmospheres, overload, and other environmental stresses.

Applications

CERMET films can also meet the demands of severe economic environments. Screening is a relatively simple process well adapted to automation. Resistors, capacitors and conductive networks can all be applied to a substrate by the same techniques and fired to fuse the components into an integrated circuit. External lead connections can be made by solder dipping the entire unit. (CERMET components are not damaged by the temperature of molten solder.) No costly high vacuum methods or elaborate mask making is required. Thus, many CERMET products are directly competitive with conventional items.

Fig. 1

CTS Corporation initially used CERMET films as resistive elements in potentiometers and trimmers. The dual tandem CERMET potentiometer (Fig. 1) is being used to replace wirewound units in commercial communications equipment for greater reliability and improved resolution.

Fig. 2

The reliability and the stability of CERMET films has been confirmed by the use of CTS CERMET trimmers, (Fig. 2) in electronic pacemakers inserted into the bodies of heart disease patients.

Fig. 3

CERMET films have also found ready acceptance as a material for manufacturing fixed resistors. The very high resistances available in short straight paths (for example, one megohm in .025″ x .075″ size) have made CTS CERMET films the logical choice for fixed resistors deposited on T05 headers (Fig. 3).

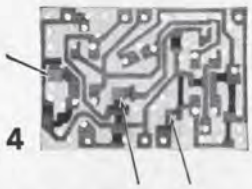

Fig. 4

In 1963 CTS developed a CERMET capacitor which is fully compatible with the CERMET resistance film. The CTS CERMET capacitor can be manufactured by the same inexpensive screening techniques and is fully operable over the same severe environmental conditions as are CERMET resistance films (Fig. 4).

Fig. 5

CTS customers also asked for semiprecision resistor networks deposited onto ceramic blocks which can be automatically inserted into printed circuit boards. The resulting product (Fig. 5) has found extensive use in commercial data processing equipment.

Fig. 6

The most recent chapter of the CERMET story has been written by a family of CTS CERMET hybrid integrated circuits which provide the basic building blocks for digital logic functions. The dual flip-flop (Fig. 6) has 14 diodes and 4 transitors on the upper side and 20 CERMET resistors, 4 CERMET capacitors, a CERMET lead crossover, and a CERMET conductive network on the under surface. A dual nand gate, a bistable flip-flop, a one shot multivibrator, an oscillator, a quad nand gate, and a quad analog gate (Fig. 7) are also being produced. These CERMET hybrid integrated circuits permit the circuit designer to combine the best available discrete active devices with rugged CTS CERMET passive components manufactured to extremely close tolerances. CTS hybrid integrated circuits provide excellent power handling capability, superior high frequency performance, and freedom from parasitics. CTS CERMET hybrid integrated circuits can also be made available in production quantities with relatively short lead times. The Re-entry Systems Department of General Electric Company was recently able to develop and deliver, in only sixteen weeks, a re-entry vehicle using CTS CERMET hybrid integrated circuits.

Fig. 7

What are your requirements for advanced microelectronic components or circuits? Your latest "design headache" may provide the plot for the next chapter in "The CERMET Story".

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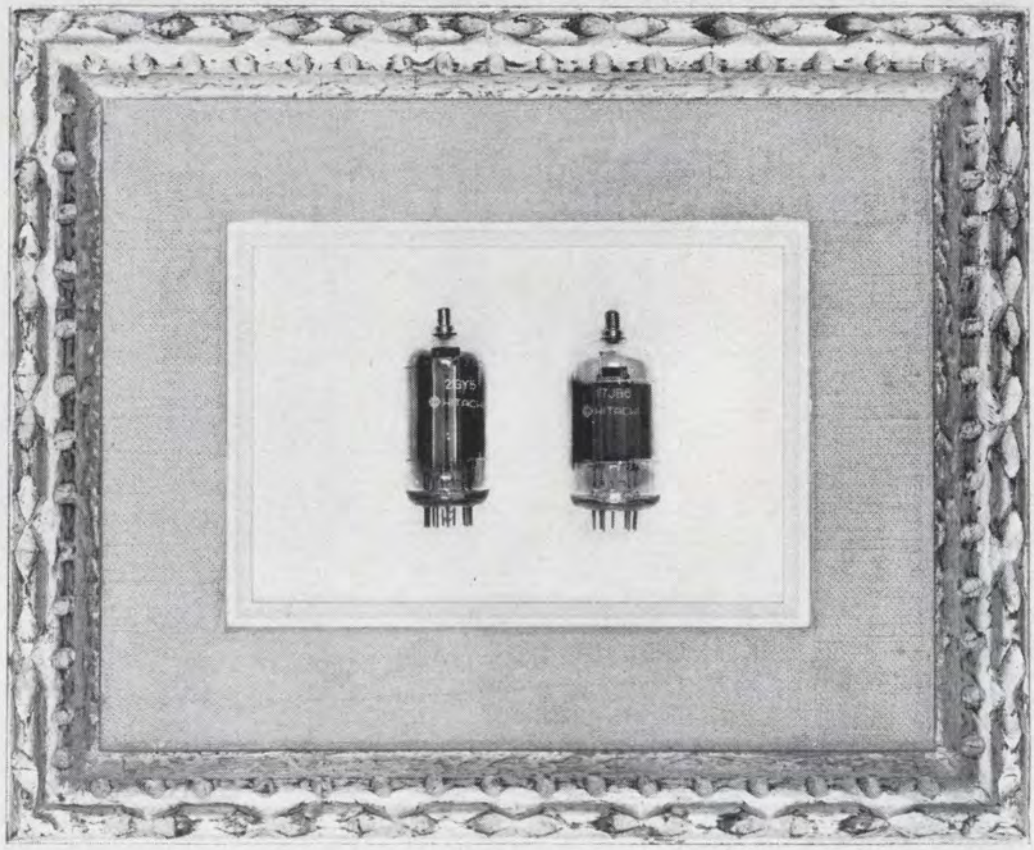

A masterpiece in color

A Tintoretto may be your preference . . . but these nine and twelve pin receiving tubes can bring in a color TV picture that's just as much a masterpiece. They're the latest in the Hitachi receiving tube family.

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That's our message put down as simply as possible . . . we hope you get the picture.

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HITACHI SALES CORPORATION 333, N. Mishigan Avenue, Chicago 1, Ill., U.S.A. 666, 5th Avenue, New York, N.Y. 10019, U.S.A. 12715, S. Daphne Avenue, Hawthorne, Calif., U.S.A. HITACHI, LTD. DUESSELDORF OFFICE Graf Adolf Strasse 37, Duesseldorf, West Germany BUENOS AIRES OFFICE Avenida de Mayo 666 Piso 12, Buenos Aires, Argentina SAO PAULO OFFICE Rua Direita, 250-23 Andar S/5, Sao Paulo, Brazil INTERNATIONAL IMPORTERS, INC. (Agent in U.S.A.) 2242, S. Western Avenue, Chicago, Ill., U.S.A.

Babcock's new BR-10 1/6-size crystal can relay will switch dry circuit to 1-amp loads with the same sensitivity as DPDT types many times its size. Designed for low profile mounting, it exceeds MIL-R-5757D requirements and withstands severe environmental conditions encountered in airborne applications. Available both single pole and double pole.

For 2-amp contact requirements, the Babcock BR-17 (latching) and BR-16 (non-latching) half-size crystal can relays provide the same reliability and, like the BR-10, incorporate the exclusive Babcock Vycor getter to adsorb outgassed organic contaminants after production degassing. Various mounting arrangements and either plug-in or solder hook terminals can be supplied as standard. Write for complete details in our new 24-page catalog.

	BR-16	BR-17	BR-10T	BR-10W
Operation	Non-Latching	Latching	Non-Latching	Non-Latching
Contact Arrangement	DPDT	DPDT	DPDT	DPDT
Construction	All Welded	All Welded	Solder Seal	All Welded
Sensitivity	175mw	175mw	100mw	100mw
Contact Rating	2A @ 26VDC	2A @ 26VDC	1A @ 26VDC	1A @ 26VDC
Size	.131 cu. in.	.131 cu. in.	.046 cu. in.	.046 cu. in.
Weight	.25 oz.	.25 oz.	.15 oz.	.15 oz.
Vibration	30g 30-2000 cps	30g 30-2000 cps	30g 40-3000 cps	30g 40-3000 cps
Shock	50g 11 msec.	50g 11 msec.	150g 11 msec.	150g 11 msec.

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Differential v-m's offer high accuracy

Completely portable, these solid-state instruments may be either line-only, or line-and-battery powered

Two new solid-state differential voltmeters have been developed. Series 871 and 873, d-c and a-c/d-c units, respectively, are available in either 50 to 440 cps, 115/230 v line-powered-only, or combination line-and-battery powered models. Battery life is 30 hours minimum, and the instruments' performance is not degraded in any manner while the batteries are being recharged. One of the great advantages of battery operation is the elimination of measurement inaccuracies caused by ground loops.

Range of the new instruments—0 to 1,000 v a-c or d-c with 10% overranging—is said to be more than twice that of the manufacturer's earlier voltmeters. Sensitivity is ten times as great. Input impedance is infinite at null up to 11 v d-c for true potentiometric measurements, and an excellent 10 megohms above 11 v d-c.

D-c accuracy is ±0.03% + 10 μv. A-c accuracy from 30 cps to 10 kc is ±0.2% of input + 25 μv (0.001 to 1,100 v) and ±0.3% from 0.1 to 1,100 v over the 20 cps to 20 kc range. The manufacturer processes each zener diode reference to prove 0.005% per year stability. Ratio stability of the company's resistors is 0.0025% per year. Temperature coefficient for reference and critical resistors is 0.0005%/°C and 0.0004%/°C, respectively.

A major application for these new voltmeters, and where they do a better job than the 500 v reference units, is to monitor stability of voltages as a function of time.

Model 871AB is a line-and-battery powered d-c differential voltmeter

In analog computers, a reference level, normally 100 v, is established. The accuracy of the computer is dependent on the accuracy and stability of the 100 v. It is common to use a differential voltmeter to monitor the 100 v in conjunction with a strip chart recorder. Thus a 24-hour record of the 100 v can be made with excellent resolution (2 ppm/division). Because of the stable reference in the 871A, voltmeter instability can now be neglected in making measurements.

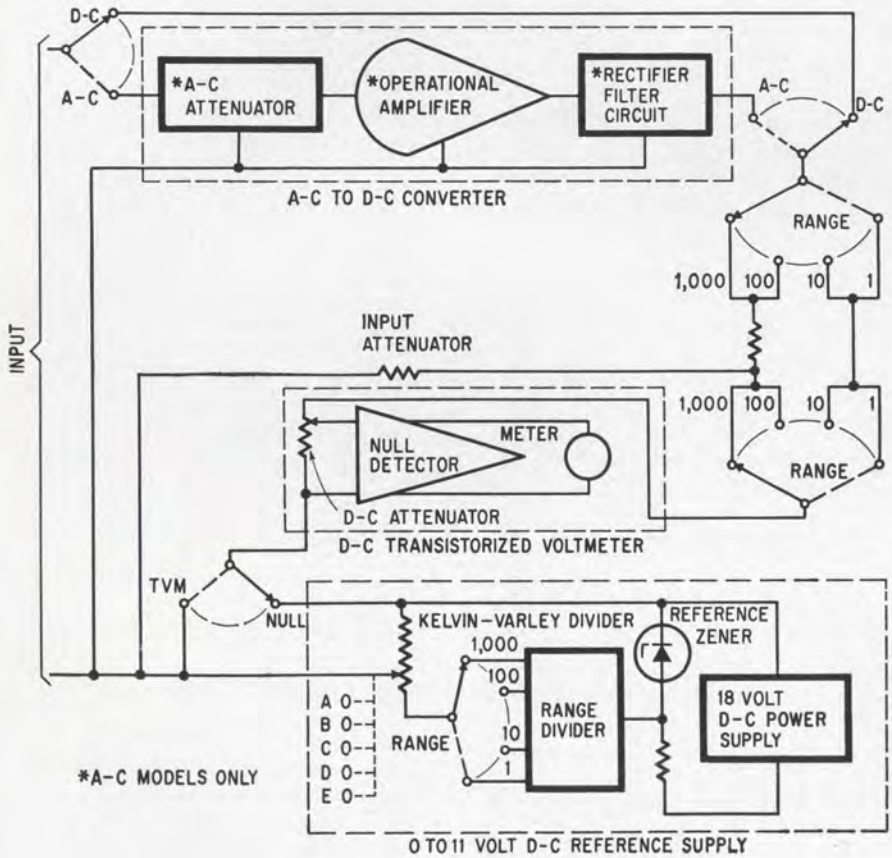
Five-digit readout with automatic decimal point and mode indicator insures quick, accurate readings. Perfect null is obtained by using a precision, single-turn pot at the output of the Kelvin Varley divider.

The completely portable voltmeters weigh 13 lb in the line-power-only version and 14 lb with battery power too. Size is 7 in. high by 8½ in. wide by 11¾ in. deep. Instruments are equipped with resilient feet and tilt-up device for field and bench use. Attaching metal handles allows half-rack or side-by-side mounting. The clean sealed cabinet keeps dirt and moisture out.

Price of the series 871 d-c differential voltmeter is $565 for the line-powered model and $695 for the battery-and-line-powered model.

John Fluke Mfg. Co., Inc., Box 7428, Seattle, Wash., 98133.

Circle **350** on reader service card



Block diagram is valid for either model, with the a-c/d-c converter used in the 873 line-powered model only

Mercury-wetted miniature reed relays

New miniature reed relays with mercury-wetted contacts provide a switching mechanism yielding the ultimate in reliability, according to the manufacturer. They are tested to exceed one billion operations under dry circuit conditions (current passing through the contacts in the microamps). The relays are said to be the ideal combination of high-speed switching with low-contact resistance and high-power capacity. They can be used with other discrete components that have been reduced in size. Measuring only 1.375 by 0.450 by 0.450 in., the relay is transfer-molded in epoxy (blue is standard—other colors are optional). The contacts are conservatively rated at 3 amps 28 v d-c resistive, and there is no contact bounce. Life at full load is 10×10^6 cycles, and at dry circuit a minimum of 10^{12} cycles. Since mercury-wetted reed relays must be mounted within 30° of vertical, the contact pin locations for p-w board mounting have been arranged nonsymmetrically to prevent incorrect assembly.

Grigsby-Barton, Inc., 107 N. Hickory Ave., Arlington Heights, Ill. **[351]**

Vacuum relay adapts to many applications

A high-voltage vacuum relay now in production is available in any of three contact forms, and three mounting configurations. It can be supplied in spst, spdt, and dpdt configurations, and with solder-flange mountings, threaded-base, or 3-hole mountings—all standard. Operating voltage is 20 kv; max current, 15 amps d-c; max switching time, 15 millisec; nominal coil voltage, 26.5 v d-c. Units measure $1\frac{1}{16}$ in. diameter by $2\frac{3}{4}$ in. high. Variations of the aforementioned are supplied with operating voltages up to 30 kv (oil), and a height of $1\frac{3}{4}$ in. with only slightly reduced ratings. Designated model H-8, the unit is used in ecm, communications, sonar, radar, pulse-forming networks, medical electronics, and other high-voltage equipment. Price, 1 to 24 pieces, is $90 to $100, depending on variations.

High Vacuum Electronics, Inc., 537 Mission St., South Pasadena, Calif. **[352]**

Shielded inductors in molded cases

A quality line of shielded inductors is offered in molded cases 0.156 in. in diameter and 0.375 in. long. The inductance range is 0.1 μh through 1,000 μh in standard 10% tolerances. Type 15 shielded inductors are designed to meet requirements of MIL-C-51305C (MS90537) and MIL-C-39010. Axial leads are of oxygen-free copper with 60/40 solder coating. For increased copper

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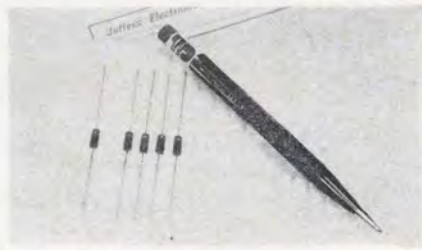


weldability, a pure tin coating can be supplied. The manufacturer can also supply various weldable lead materials.

Jeffers Electronics, a division of Speer Carbon Co., Theresia St., St. Marys, Pa. **[353]**

Metalized Mylar miniature capacitors

A series of miniature, metalized Mylar capacitors—types MDWR and MDW—feature a self-healing capability. Utilizing Mylar film as a dielectric, these capacitors are wrapped in a skin-tight plastic tape with an epoxy resin end fill. This construction offers excellent resistance to humidity and is intended for use where space is at an absolute premium. Type MDWR is a tubular model; type MDW is available as a flat-case unit. Both models are available in 200, 400 and 600 v d-c, in capacitance ranges from 0.01 to 10.0 μf. Capacitors are designed to operate over a temperature range of −55° to +125°C without derating. Capacity tolerance is ±20% at 1,000 cps for units up to 0.82 μf, and ±20% at 60 cps over 1.0 μf; tolerances of 10%, 5% and 1% are available upon request.

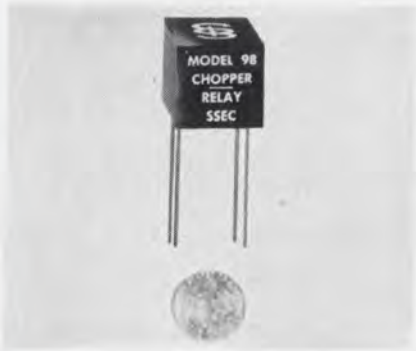
Film Capacitors, Inc., 100 Eighth St., Passaic, N. J. **[354]**

Variable capacitor features high Q

A new variable air capacitor, measuring only 0.220 in. in diameter and 15/32 in. long, features a Q factor of better than 5,000 at 100 Mc. The capacitors are available with printed-circuit terminals (model 4642) or turret terminals (model 4640). The new units also feature

a capacitance range of 0.4 pf to 6 pf. Manufactured in coin silver, gold-plated brass and glazed alumina ceramic insulation, the capacitors are nonmagnetic and extremely rugged. Threaded caps with internal silicone-seal washer provide moisture and dust seal.

Johanson Mfg. Corp., 400 Rockaway Valley Road, Boonton, N.J. **[355]**



Chopper-relay for d-c to 5 kc

The model 98 chopper-relay is said to represent a breakthrough in isolated-switching circuit design capable of creating new versatility of application within electronic systems. It is a completely solid-state inertialess design, employing silicon semiconductors and magnetic components to achieve complete isolation between drive and signal, previously unattainable, according to the manufacturer. Model 98's typical low noise of 25 μv makes it ideal for switching low-level signals. The dynamic range can extend from ± 75 μv to ± 20 v.

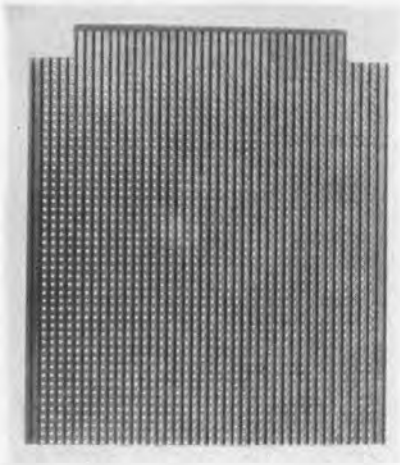
Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. **[356]**

Foil heating elements for space industry

FEP heat-sealable-Teflon insulated foil heating elements are being made as thin as 0.004 in. and having a 1,500-v dielectric capability. They combine the ruggedness of heat-sealable Teflon-coated glass cloth with the superior thermal characteristics of a foil resistance element, satisfying the rigid environmental requirements of the

New Components

space industry. The heat-sealable Teflon insulation eliminates the need for volatile adhesives which in the past have caused contamination in high vacuum applications. The foil elements spread the heat over 97% of the surface of the blanket to permit greater watt densities than possible with conventional wire element types. Alternate insulation materials include: silicone rubber, neoprene rubber, and Mylar. Foil heating elements can be manufactured in practically any size or configuration from 1 in. by ½ in. up to 10 ft by 30 ft.
Thermal Circuits, Inc., Park St., Beverly, Mass. **[357]**



Weldable wiring board cuts production costs

A new weldable Veroboard is announced. The universal wiring board consists of a series of metal strips, each a three-layer composite of nickel, steel and aluminum bonded to an epoxy fiberglass board and then pierced with a reg-

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20 cps – 15 kc (narrow band)

20 cps - 250 kc (wide band)

Model NF-315 Noise and Field Intensity Meter

EMPIRE* Noise and Field Intensity Meter Model NF-315 is a self-contained highly versatile RFI measuring instrument combining both a narrow band tunable superheterodyne receiver and a complete wideband video receiver — plus indicators, pickup devices, and internal frequency and amplitude calibrators.

Narrow band operation covers 20 cps to 15 kc, in a single band, and its two bandwidths (7 and 70 cps) provide faster measurements, more precise signal identification, and optimum sensitivity. As a wideband receiver, the NF-315 simultaneously measures all signals in the 20 cps to 250 kc range.

Solid state circuitry, together with time-tested tuning techniques assure reliable short and long term stability plus complete freedom from instabilities caused by external effects. Highly stabilized circuits eliminate the need for recalibration when tuning to a new frequency. The instrument comprises a single unit completely shielded electrically and magnetically, and filtered to permit operation in areas of high ambient signal level. A built-in nickel-cadmium rechargeable battery and charger contribute to portability for field operation.

Model NF-315 Applications: field intensity measurements, electromagnetic interference measurements in accordance with commercial and military requirements, as a sensitive tunable transistorized voltmeter, a sensitive wideband video receiver, a receiver for acoustic and vibration analysis, a sensitive audio harmonic wave analyzer, a tunable high-sensitivity null detector, and in shielding effectiveness.

SPECIFICATIONS

- Frequency range 20 cps - 15 kc, narrowband; 20 - 250 kc, wideband.
- ±(1% + 5 cps) freq. calib. accuracy
- 50, 600, 100,000 ohms input imped.
- ±0.5 db amplitude accuracy (used as 2-terminal voltmeter).
- Voltage range as a 2-terminal voltmeter:
  0.15 μv-10 v for 100 kΩ, narrowband
  0.015 μv-1 v for 600Ω, narrowband
  0.005 μv-1 v for 50Ω, narrowband
  10 μv-10 v for 100 kΩ wideband
  1 μv-1 v for 50 or 600Ω wideband
- Over 70 db spur. response rejection.
- Average, rms, peak, slideback metering.
- Built-in spot-frequency stabilized amplitude calibrator.
- Recording and X-Y plotting outputs.
- 17" w x 10½" h x 11" d, adapter brackets avail. for rack mounting.
- 3 ft. dia. loop antenna and high-sensitivity flat-response rod-type antenna.

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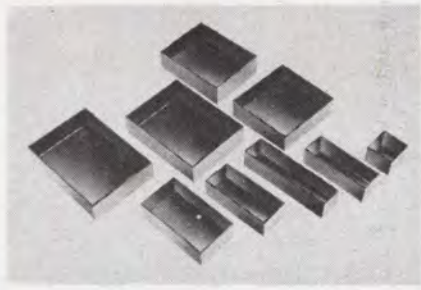
ular hole matrix at 0.1 in. It is also available with 0.156 in. and 0.2 in. matrices. The Veroboard concept allows any circuit to be constructed quickly and easily without expensive art work, tooling or the normal delays in printed-circuit production. It is now available for microelectronic application where welding is used for the high reliability interconnection of integrated circuits and other electronic components.

Vero Electronics, 48 Allen Blvd., Farmingdale, N. Y. **[358]**



Molded plastic encapsulating shells

A broad standard product line of plastic encapsulating shells is announced. Available are more than 60 round, square and rectangular shells molded of flame-proof glass-filled diallyl phthalate meeting specification MIL-M-14, type SDG-F. Shells are designed for encapsulating of toroids, miniature delay lines, capacitors, laminated transformers, resistors, welded modules, pulse transformers, and semiconductor networks. New tooling concepts allow fast, economical production of new shell designs without tooling cost to the customer, based on production requirements.

The Robinson Co., 3636 W. 139th St., Hawthorne, Calif. **[359]**

Transistor holder for Micro-modular units

A transistor holder has been designed to accommodate the new 8-lead, TO-5 can, Micro-modular units. In the RTC-0808-SL the tran-

sistor leads are passed through holes in the Teflon bushing and then soldered to adjacent lugs. Shoulder diameter of the holder is 0.562 in. with a minor diameter of 0.513 in. Height above the chassis is just 0.060 in. Lugs are of brass with gold flash over silver, and the socket body is of 100% pure virgin Teflon for maximum reliability and life. For past positive insertion in the chassis, the manufacturer makes a companion installation tool identified B-42.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. **[360]**

Wirewound resistors rated from 3 to 13 w

Axial-lead, commercial wirewound resistors are announced. The CW series combine all-welded construction with a high-temperature silicone coating. This enables them to offer a ratio of power to size which should be valuable in commercial circuit design. For example, the CW-2, rated at 4.25 w, has a body length of only 0.625 in. and a body diameter of only 0.250 in. At present, CW resistors are being produced in seven different models with power ratings ranging from 3 w to 13 w. Resistance range of the line is from 1 ohm to 273,000 ohms. Standard tolerance is ±5% with a standard temperature coefficient of ±260 ppm/°C. The power rating of CW resistors is based on 100% at 25°C ambient. From this point they derate on a linear basis to zero power at +350°C.

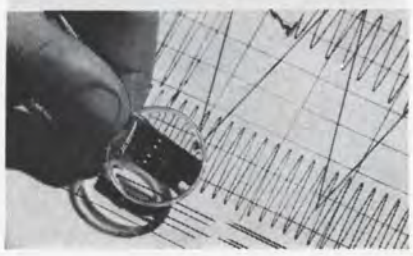
Dale Electronics, Inc., P. O. Box 488, Columbus, Nebr. **[361]**

New Instruments

IR gauge measures water in paper

An infrared back-scatter moisture gauge is available for on-and-off-line measurement of water in paper. The Inframike moisture-monitoring gauge can sense total water content from 0% to 12% for paper with a basis weight in the range of 6 to 70 pounds per 3,300 sq.ft. It is accurate to within ±0.1% moisture. Gauge accuracy is limited primarily by standard gravimetric techniques, but is better than 0.25% moisture. Daily drift is less than 0.1% moisture. The Inframike can be fixed mounted for continuous monitoring of moisture content on a single paper machine, used as a portable unit for trouble-shooting on several paper machines, or as a laboratory test instrument. Principal components of the gauge are the scanning head (left foreground), a hermetically sealed unit containing both the infrared radiation source and a lead sulfide sensing cell, and the control cabinet. The control unit features solid-state circuitry and has three simplified controls for standardizing the gauge for moisture content and setting basis weight compensation. The two disks in the photo are long-term stable standards provided with the gauge for checking calibration and performance.

General Electric Co., X-Ray Dept., 4855 Electric Ave., Milwaukee, Wis. **[381]**



High-speed 10-channel event recording unit

A new ten-channel event recording unit fits into a light beam oscillograph without disturbing existing analog channels. The new accessory unit permits recording of ten channels of high-speed events within a one-half inch space on the chart paper margin. It contains ten pinhead-size incandescent lamps and is situated at the edge of the chart paper with the lamps practically butted up against the chart paper. When a lamp is energized a trace appears on the chart paper. In the conventional light beam oscillograph the standard procedure for obtaining event recording is by converting one of the analog channels to event marking, thus eliminating one of the analog channels. Since one analog channel costs $200, that also is the cost for one channel of event recording in the conventional approach. Cost of the new ten-channel event recorder unit is only $30 per channel, and the full complement of analog channels is retained. Two leads from each lamp go to a connector at the rear of the recorder. Lamps

Kodak reports on:

unspoiled infrared . . . a new flavor in data recording on tape . . . Rapid Access Recording on film

Unclassified gratification

Aerojet-General Corporation informs us of an investigation they have conducted on the image-spoiling properties of the optical materials that are available for transmitting and refracting infrared. Out to 21μ — that sort of thing. Some were found to do grave violence to a collimated infrared beam. The five hot-pressed polycrystalline materials tested acted more like thin air in their effect on the beam geometry. In response to our inquiry, they disclose these to be KODAK IRTRAN 1, 2, 3, 4, and 5 Optical Materials, respectively. We feel pleased.

A copy of their report, which is fortunately not "classified," and extensive data on these materials can be furnished by Apparatus and Optical Division, Eastman Kodak Company, Rochester, N. Y. 14650. We can work them to outlandish shapes, with or without holes.

From the banks of the Genesee

A certain kind of sausage that must have originated in the Italian city of Bologna brings joy to unnumbered millions. Quite a different kind, identified with the Thuringian duchies of olden Germany, also sells very well. Wieners, still another kind of sausage, are loved by virtually every American with little thought to the Austrian capital or its possible rival Frankfurts on the Main or Oder.

Inedible but more up-to-date commodities can likewise be geographically identified, though manufactured by companies instead of guilds. One such is magnetic tape for aerospace telemetry and other raw-data recording applications. One company on the Mississippi and a smaller rival near the Pacific shore have won eminence in the field. Now an unfettered economy further widens the choice that faces the instrumentation-tape buyer. He must now consider tape from the banks of the Genesee in New York State.

For the benefit of his conscience as an engineer, he must be told that while the three principal sources of supply can equally assuage the hunger of his data recorders, their products are no more identical than are wieners, thuringer, and bologna. The engineers of Consolidated Electrodynamics Corporation, a leading manufacturer of recorder/reproducers that use instrumentation tape, have announced their decision to give their preference and "CEC" name to our Rochester-made tape on the following grounds:

• **Smoothness:** Pleasant in shaving, drinking, or riding and essential in recording frequencies up to 1.5 mc. Well known rule-of-thumb says you lose 55 db when oxide surface jumps one wavelength from polepiece. At 1.5 mc and 120 in/sec, a wavelength is 0.00008". Pimples had better be low, few, and far between on "wideband"-class tape. We also do very well by CEC in this respect on the three other classes down to "standard telemetry," which claims only 100 kc at 60 in/sec. Differences come in particle-size distribution. Each of our classes excels in response out to its frequency limit. When you can afford to reduce gain in the amplifier at high frequencies, you are cutting broad-band noise. Signal-to-noise ratio is the cause worth fighting for. In audio tape, which we also make, it's low print-through. The human brain balks at strange echoes. The human ear needs no frequencies above 20 kc and little power above 5 kc. But signal power at high frequency keeps the instrumentation-tape user in business.

• **Straightness of edge:** Wandering out of alignment with the polepiece gap after a few thousand feet can be as fatal as a coating defect. We have slit film to better accuracy than that from time immemorial.

We don't even have to slit in the dark.

• **Uniformity of characteristics end-to-end and reel-to-reel:** CEC, who have tested plenty of tape in their day, say they have never before encountered any so uniform. We think we can do better later.

• **Little things:** Extreme cleanliness is the price of admission to the tape-making game. We had to pay it a generation before magnetic tape came in. It seems a pity to risk sifting dust from paperboard packaging over such a clean product. Therefore we put all our tape for CEC in metal cans and the cans in rectangular cartons that can be stored on edge and marked for identification. On the tape itself we print our name and a code number every few inches. We wonder why the others don't.

Any questions? Ask Eastman Kodak Company, Magnetic Products Division, Rochester, N. Y. 14650.

The time has come to quit kidding ourselves. Beautiful photography is a great art that has virtually nothing to do with the purposes for which physical scientists and engineers justify their heavy consumption of 16mm, 35mm, 70mm, and larger widths of film during working hours. We had better see things their way. We now know they are seldom in a mood to treat film with veneration. All they seem to want are the data—the quicker the better.

The exact nature of these data is really none of our cotton-pickin' business, except insofar as the users care to talk or honor us with reprints some fine day. The best we can contribute to their radar recordings, their studies of bioluminescence or of the stratigraphy of Antarctica, their improvement of sugar-beet pulping machinery or of ignition systems for vernier rockets, their logging of oil wells, their probing of the Saturnine atmosphere, their counting of taxis on the Golden Gate Bridge, and all the other vaguely imagined tasks they perform with film—the best we can contribute is a fierce determination to make them demonstrably better film for their multifarious purposes than anybody else can make.

To this end we are placing upon the market a new line of films. We don't want them confused with films designed for beautiful movies either by us or by our competitors. You will get to know them by a trademark that hardly suggests softness and beauty. It happens to consist of the initials for "Rapid Access Recording."

The five films which will first carry this mark are *primarily* designed for processing at temperatures up to 130°F. Four of the five are on ESTAR Base, tops for dimensional stability in film with strength and thinness. A sixth new one, KODAK 2475 Recording Film, likewise on ESTAR Base, has extended red sensitivity to make it the fastest film you can buy, but it is not yet suitable for hot processing.

Hardly less important than the characteristics of the new films is ready information about said characteristics so that user and maker can sit down together and make the best choice for the work at hand. Get in touch with Eastman Kodak Company, Photorecording Methods Division, Rochester, N. Y. 14650. See what happens. The new trademark, by the way, is:

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

can be energized either externally or internally. External excitation can be obtained through a battery and capacitor. A lamp will be trig gered on or off by 1.5 v at 15 ma. Response is 10 millisec on and 2 millisec off.

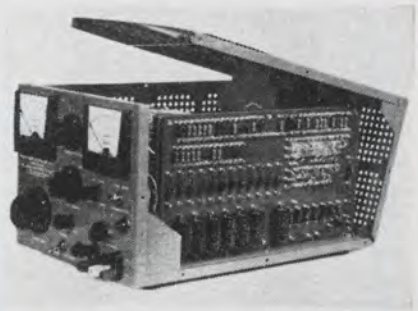
Brush Instruments, Division of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio [382]

Transistor checker has remote connector

The new transistor checker gives a direct dial reading for checking all important transistor d-c parameters, including those in the inverted connection. Featuring a remote connector, the model 9001 permits checking of parameters while a transistor is in an environmental chamber or if the transistor has an unusual case or base style. The remote connector provides unlimited flexibility, according to the manufacturer. For example, small signal beta may be achieved by external insertion of additional base resistance. This resistance may be adjusted to provide any base current the user desires, thus providing beta measurements for any value of base current from 0 to 100 μa. In the inverted connection, the applied voltage is dropped to 1 v. This feature accommodates a maximum tolerable inverse voltage as low as 1 v and permits inverted parameter reading of many transistors that otherwise could not be checked. Because the beta of many transistors exceeds 100, a beta-times-ten scale has been provided to permit accurate indication of betas up to 1,000. The meter's 50-μa movement increases the capability to read I_{co} and I_{eo}. Model

9001 also provides a diode test capability for testing inverse leakage current as well as the forward d-c resistance. The transistor checker is powered by a mercury cell battery, assuring long life at constant voltage.

Spectra-Strip Wire & Cable Corp., P.O. Box 415, Garden Grove, Calif. 92642. [383]



Highly regulated d-c power supply

All transistor, portable model VAS60-5 divides output into 0-6/30/60 v d-c and 0-0.1/0.3/1/3/5 amp and employs multirange meters to improve down-scale reading accuracy over standard 2% single range meters by an order of magnitude as great as 10. Other features include 0.005% full load/line regulation throughout any point on any selected range, ripple 1 mv peak, overload mode selector for either current limit or current trip, and automatic power shut-down in less than 20 μsec for inadvertent range switching. Price is $875; delivery, 4 to 6 weeks.

Space Power Associates, Inc., 161 Brielle Ave., Staten Island, N.Y. 10314. [384]

Data amplifier offers three output terminals

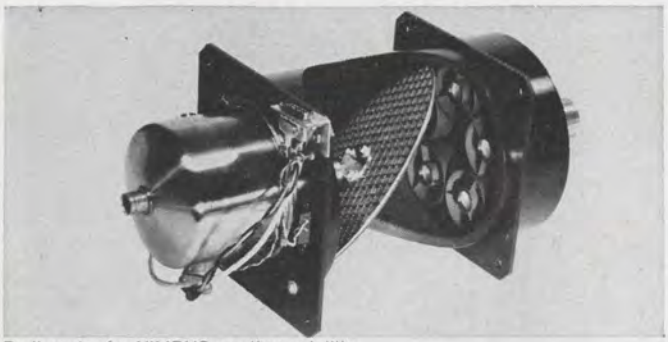
Simultaneous recording of wideband and narrowband data from a single amplifier source is possible with the model 3630 amplifier. This direct-coupled differential amplifier is designed specifically for use in high-precision data gathering and instrumentation systems. It features a total of three output terminals. One terminal is used to obtain a full bandwidth representation of the input signal. The second terminal provides a filtered output

ideally suited to drive narrowband recording or display devices. The third terminal is common to both outputs. In a typical instance, the wideband output would be directed to an oscilloscope for a "quick look" monitoring of the data in real time, while the narrowband output would be fed into a time-shared digitizing and print-out system. The wideband output is capable of handling a full-scale load current of 100 ma. The 3 db small-signal bandwidth of this output signal is 50 kc, providing more than sufficient frequency response for most wideband applications. The narrowband output, which is used primarily with digital devices, has a full-scale load current capability of 10 ma. The bandwidth of the output is determined by a front-panel switch and may be set at 10 cps, 100 cps, 1 kc, 10 kc, or full bandwidth. The amplifier design provides total isolation between the input terminals and both sets of output terminals. Common-mode rejection on both outputs is better than 1,000,000 to 1 with up to 10 v of 60-cycle common mode voltage and 350 ohms unbalance on either input lead. No external "ground return path" is required between the input and output commons.

Dana Laboratories, Inc., Irvine, Calif. [385]

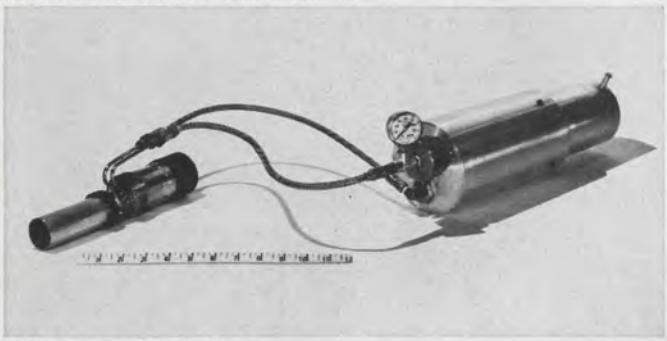
Compact tape recorder for rugged environments

Portable tape recorder/reproducer, model MTR-3200, offers precision instrumentation performance in extreme environments. Weighing only 44 lb, occupying less than 1 cu ft of space, and operating on less than 55 w of power, the unit can be



Radiometer for NIMBUS weather satellite

Interceptor IR installation

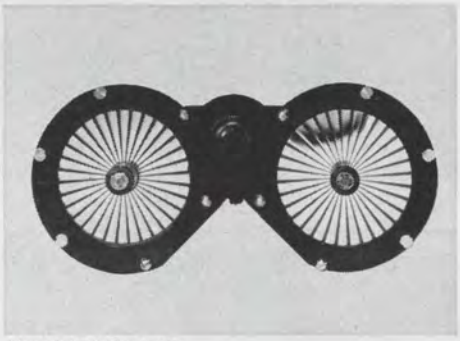


12°K closed-cycle cryostat

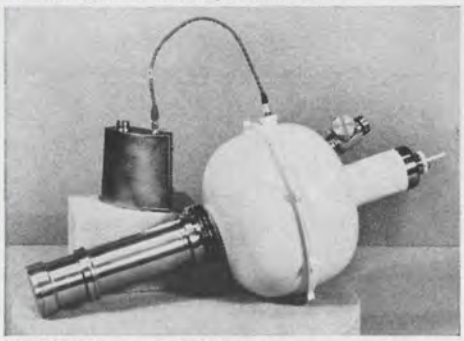
90C IR search/track set

IR multi-channel tracking radiometer

Star tracker for SURVEYOR spacecraft



Modulated IR source



Liquid-helium-cooled IR detector

IR anti-tank missile controller

Expanding Infrared Programs

create new career assignments

Rapid growth of HUGHES Infrared activities in the Aerospace Divisions and the Santa Barbara Research Center has created many responsible positions for qualified engineers and scientists in all phases of IR systems development from conception through production engineering.

Immediately available assignments include openings in such diverse technologies as semiconductor physics, optical design, cryogenics, mechanical engineering, precision electro-mechanisms, electronic circuit design, servo systems...and many other areas.

Current HUGHES IR contracts include advanced systems for space exploration, weather reconnaissance, anti-ballistic missile defense, anti-submarine warfare, interceptor weapon guidance & fire control, bomber defense and tactical weapon control.

Professional experience, an accredited degree and U.S. Citizenship required.

For immediate consideration, please airmail your resume to:

MR. ROBERT A. MARTIN
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 13, Calif.

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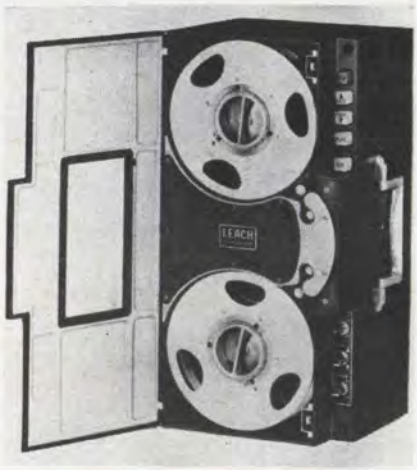
New Instruments



hand-carried to any test site. It can be used in land, sea, airborne or space applications where space and power are at a premium. It offers standard IRIG or extended broadband recording. Electronic components for each record/reproduce method are modularized, and plug in for easy record/reproduce mode selection. Six standard recording speeds ranging from 1⅞ ips to 60 ips are offered in electrically selectable pairs operated by pushbutton controls on front of the machine. Optional speeds from 0.5 ips to 240 ips are also available. A constant speed of 120 ips is used for fast forward and rewind. Using Mil-type components throughout and special tape transport design features such as dual capstan drive, high reliability and accurate data recording are ensured with flutter, for example, held to less than 0.5% peak-to-peak at 60 ips.

Leach Corp., 1123 Wilshire Blvd., Los Angeles 17, Calif. **[386]**

Voltage-controlled signal generators

Models 104 and 105 voltage-controlled generators are announced. They may be frequency-modulated both at very low frequencies and high frequencies without moving parts. Each new unit provides up to 20:1 VCG frequency range, selectable in bands of 3:1 ratio, with the capability of changing frequency on external electrical control without physical movement of the dial.

Reliable remote operation is obtained through solid-state components. Without external VCG control, the new units are versatile, general-purpose generators. Each VCG can do the combined work of several items of test equipment previously used. The units have a frequency range of 0.0015 cps to 1 Mc and generate clear and stable sine, square, or triangle waves with any external modulating function provided. The wide frequency range enables use in l-f applications such as servo and electromechanical systems as well as audio or video amplifier work. Complex oscilloscopes can be completely checked out in the field or

lab with this one versatile, portable instrument. The VCG can f-m a servo, sweep test i-f strips, f-m or sweep a triangle wave, sine wave, or square wave. The ultrafast rise and fall times (as low as 4 nsec) can trigger high-speed computer circuits. Weight is 8 lb and dimensions, 7¾ in. wide by 5⅛ in. high by 7½ in. deep. Model 104 has three power supply options: a-c line, rechargeable nickel cadmium cells with built-in charger, or dry cell battery. Price is $595 to $675. Model 105 (a-c only) incorporates an all-silicon 30 v p-p output. Price is $695.

Wavetek, 8133 Engineer Road, San Diego, Calif., 92111. **[387]**

Instrument measures radiation emission

A newly developed Densiometer includes complete frequency coverage from 200 Mc to 11,000 Mc. Model 1200 is a standard portable, battery operated instrument that provides a simple, positive means for detecting and measuring the amounts of microwave energy radiating from transmitters and re-

New Instruments

lated equipment. With it, even unskilled personnel can check unsafe areas with rapid, easy-to-read detection of the trouble spots. Model 1200, designed for universal use in plants, laboratories or in the field, is normally furnished with seven antennas to cover uhf through X bands.

Ramcor Inc., 190 Duffy Ave., Hicksville, L.I., N.Y. **[388]**

Sweep generator spans wide band

A 500-kc to 1,200-Mc sweep generator has been introduced. Model 890 is expected to be widely used on production lines where accuracy and ease of operation are prime considerations. In two ranges—vhf and uhf—the instrument supplies a sweep signal with center at any frequency from 500 kc to 1,000 Mc and with sweep widths as broad as 200 Mc or as narrow as 100 kc. The r-f output, carefully monitored by matched crystal diodes feeding a two-stage, push-pull, automatic-level-control amplifier, is flat within ±0.5 db up to 800 Mc and ±1.5 db from 800 Mc to 1200 Mc (at maximum sweep width). Because this

instrument is reliable and stable, even semiskilled production line workers can use it to make highly accurate quantitative sweep frequency measurements. Applications of the 890 include measurement of gain, loss, and vswr. The unit can also be used to measure the unloaded bandwidth and Q of cavities and resonant circuits as well as to test impedances in order to determine the degree to which they match a transmission line.

Jerrold Electronics Corp., Industrial Products Division, 15th and Lehigh Ave., Philadelphia 32, Pa. **[389]**

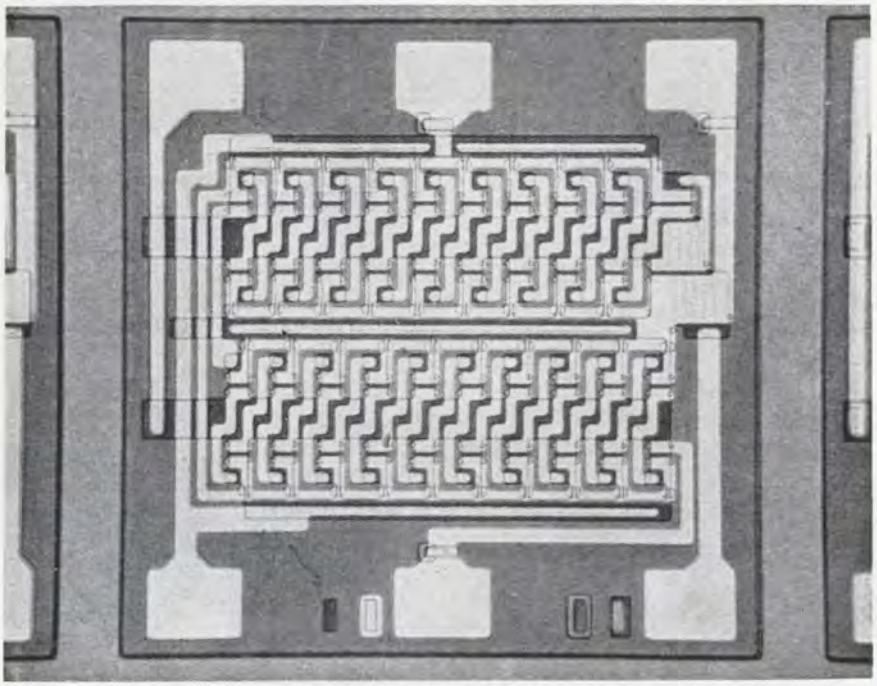
Tri-contact probes for in-circuit testers

Two new tri-contact probes can be used as accessories for all types of in-circuit semiconductor testers. Designed specifically for tests on printed-circuit boards, the probes have pointed stainless steel tips whose vertical and lateral spreads are controlled by two thumb wheels, operable by one hand. The center tip is insulated to prevent shorting. The first of the probes has a three-wire lead cable shielded to prevent stray pickup. Two models are available, one with standard

connectors, and the other with optional connectors to meet MIL specifications. The second, similarly available in two models, depending on type of connector required, is supplied with a shielded five-wire cable, permitting the use of a self-contained snap-action switch for actuating a remote function such as found in testers having automatic lead selection (that is, AEL models 236 and 240). Customers may specify connectors of their choice, in all models. Price is $29.50.

American Electronic Laboratories, Inc., Richardson Road, Colmar, Pa. **[390]**

New Semiconductors



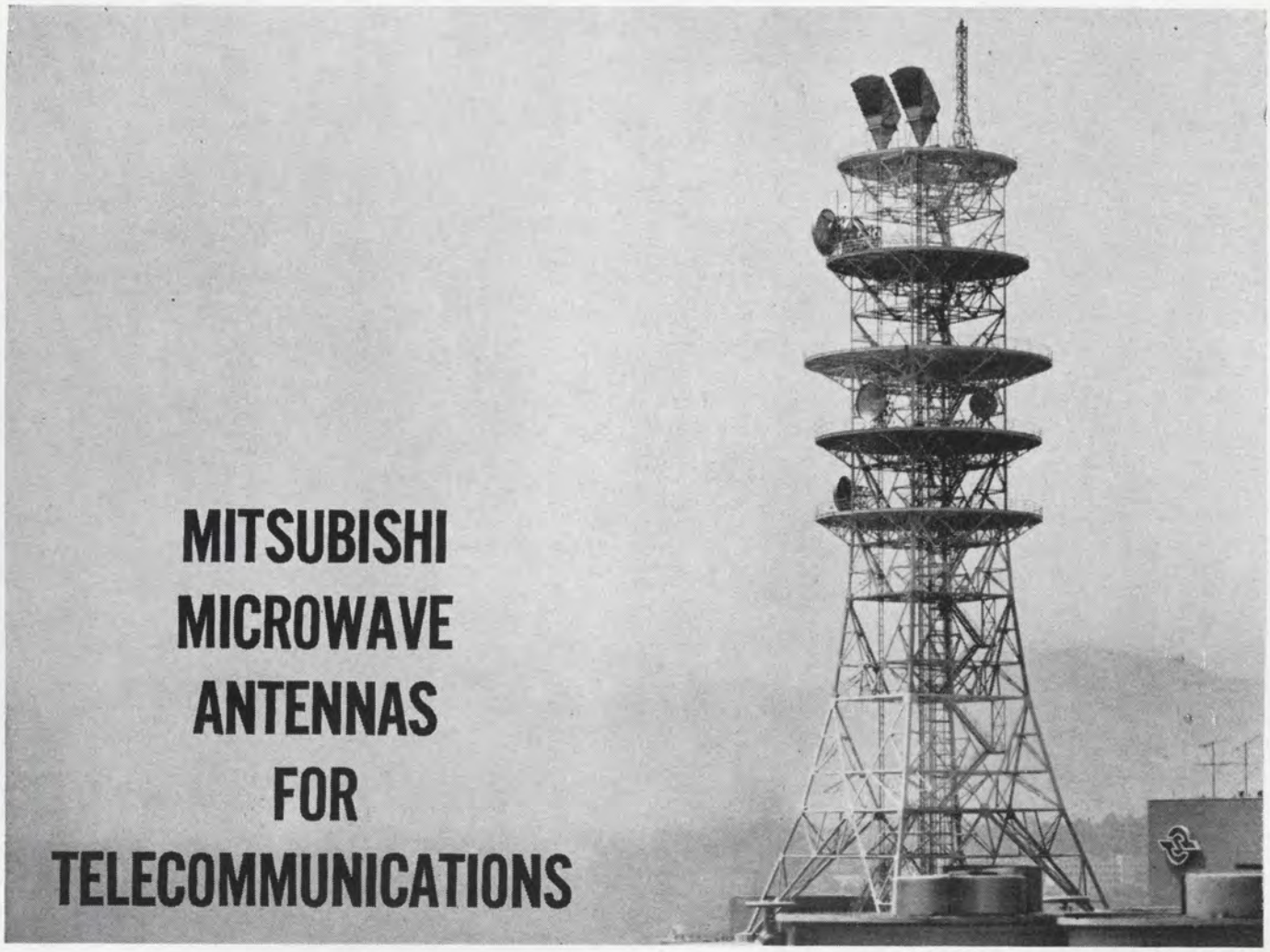
Shift register contains 120 MOS FET's

The pL5000 is claimed to be the first integrated circuit that uses metal oxide silicon technology. This 20-bit serial shift register offers a 20-to-1 increase in functional complexity over the most complex conventional monolithic integrated circuits currently available, according to the manufacturer. The pL5000 is designed to be used in a two-phase clocked sequential digital system. When used open loop, the element provides a 20-bit delay to the input signal. When operated closed loop, the element can be used as a circulating 20-bit memory. Moreover, pL5000 elements can be cascaded to provide longer delays or larger capacity memories. At a clock rate of 1 Mc, the power dissipation is typically 60 mw for clock pulses with a 50% duty cycle. For a constant clock pulse width, the power consumed will be proportional to the clock frequency. At 100 kc the power dissipation will be 6.0 mw or 0.3 mw/bit for a clock pulse width of 500 nsec. The pL5000 contains 120 MOS FET's on a 41 by 41 mil die. This means that there is a possibility of 350 circuits per 1-in. wafer. The register has less metal over the thin oxide (gate electrode) than a conventional DTL capacitor input binary element. It is contained in a die area smaller than the DTL binary, which, in its smaller form, is 53 by 43 mils. Price for 1 to 49 is $250 each; for 50 to 199, $167.50 each.

General Micro-electronics Inc., 2920 San Ysidro Way, Santa Clara, Calif. [371]

Signal diodes offer high reliability

A line of high-speed signal diodes is said to have greater reliability than other commercially available signal diodes. The increased performance of these "double heat-sink" diodes (DHD's) results from their planar epitaxial passivated design. Measuring under $\frac{3}{16}$ in. in length by $\frac{1}{16}$ in. in diameter, the DHD (shown at top) is one-third the size of the company's DO-7 line of signal diodes, and can be substituted directly for DO-7's in most applications. The DHD's can dissi-



MITSUBISHI MICROWAVE ANTENNAS FOR TELECOMMUNICATIONS

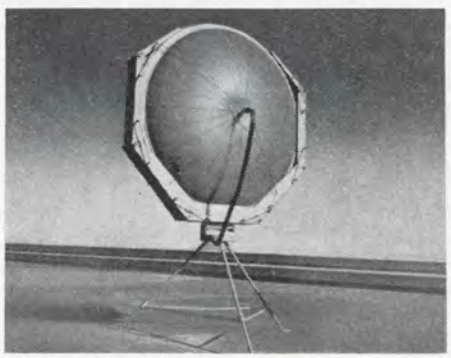
Japan today has the second largest microwave network in the world. Mitsubishi Electric, with the longest microwave antenna experience in Japan, has supplied 90% of the antennas used in the trunk lines of this extensive network. Mitsubishi antenna systems include parabolic, scatter, horn reflector and radar types, as well as a complete line of waveguide components and accessories. Frequencies from 900 Mc. to 24 KMc. are covered. The IU-62, shown above and specified at the right, is typical of the outstanding performance of Mitsubishi microwave antennas. Full technical information on any of these types of antennas is available at your request.

IU-62 Horn Reflector Antenna

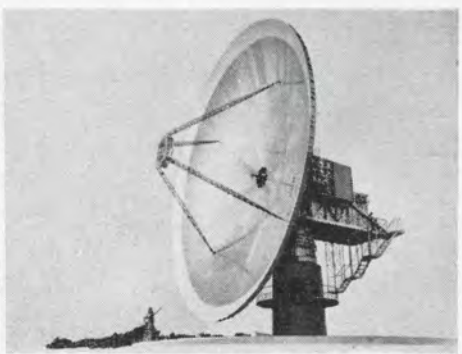
Frequency Range	3,000-12,000 MC
Aperture	9m²
Max. width	4,050mm
Max. depth	2,560mm
Max. height	7,418mm
Gain at 3,900MC	V 41.5 db
	H 41.2 db
Gain at 6,100MC	V 44.9 db
	H 45.0 db
VSWR	1.01
Front/Back (over 60 degrees)	67-70 db
Discrimination of cross polarization	V 57 db H 78 db (at 3,900MC)
	V 45 db H 37.5 db (at 6,100MC)
Guaranteed wind velocity	140 miles/hr

MITSUBISHI ELECTRIC CORPORATION
Head Office: Mitsubishi Denki Bldg., Marunouchi, Tokyo. Cable Address: MELCO TOKYO

■ IU-61 parabola antenna

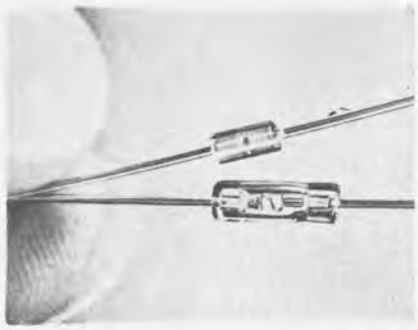


■ Air inflated parabola antenna



■ 20 meter diameter antenna for satellite communication

New Semiconductors



pate up to 700 mw at 25°C when properly heatsinked. Their design meets and exceeds mechanical testing requirements of MIL-S19500C. Samples have withstood over 3,000 hours of life tests without significant change in parameter values. Leads are anchored. A lead pull of approximately 1 lb for each of three 90° arcs of the case will not dislodge the leads. The construction provides for the uniformity of electrical parameters for large-scale production. Single-pellet DHD's may be used in low-level limiters, computer logic, core drivers, hammer drivers and a large variety of general-purpose applications covering the broad spectrum of diode usage. Multipellet DHD's, called stabistors, are designed for use as low-voltage regulator diodes, amplifier nonlinear bias elements and as a level shifting diode in diode-transistor logic circuits. The DHD offers high breakdown voltage (up to 125 v), low leakage current (as low as 100 picoamps) and capacitance under 1 pf. Prices of the DHD's, including stabistors, range from 35 cents to $3.65 in lots from 100 to 999.

General Electric Co., Semiconductor Products Dept., Syracuse, N.Y. **[372]**

Alloy-diffused scr's rated to 16 amps rms

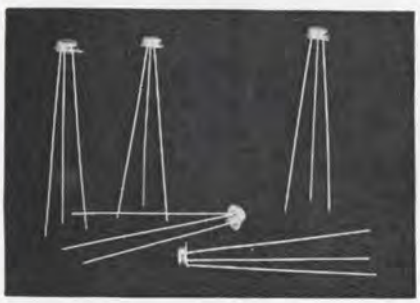
A series of alloy-diffused silicon controlled rectifiers have been developed with continuous current ratings to 16 amps rms, 10 amps average. The 2N1842 series offers 12 transient peak reverse voltage ratings from 35 to 960 v. This rating is the maximum instantaneous value of the reverse voltage across

the scr, including all nonrepetitive transient voltages. Peak 1-cycle surge current for the series is 125 amps. The rectifiers are manufactured in an all-welded TO-48 case with glass-to-metal hermetic seals. All internal joints are hard-soldered for maximum resistance to thermal stress. All units in the 2N1842 series deliver 16 amps rms forward current for all conduction angles, a peak gate power of 5 w, peak forward gate voltage of 10 v, peak reverse gate voltage of 5 v, and peak forward gate current of 2 amps.

Tung-Sol Electric Inc., One Summer Ave., Newark 4, N.J. **[373]**

High-voltage silicon transistor

A new pnp silicon transistor is available. The 2N3527 is a 30-v unit that has a typical d-c current gain of 60 at 0.1 μa of collector current, and maximum leakage current of 0.1 na. The device requires

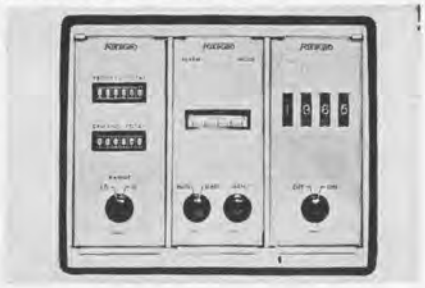


only nanowatts of d-c operating power. The 2N3527 is manufactured by the epitaxial junction process, which combines the advantages of alloyed, epitaxial, and planar techniques, and provides extreme ruggedness and parameter stability. Unit price is $12 in 1-99 quantities.

Crystalonics, Inc., 147 Sherman St., Cambridge 40, Mass. **[374]**

New Subassemblies and Systems

Automatic pacing component blender



A new digital, in-line blending system keeps all product components at correct ratios, regardless of a reduction in flow. The system is expected to be used to process chemicals, foods and petroleum; and to manufacture fertilizers. Featuring new M/98300 automatic pacing digital controllers, the system blends either liquids or solids and is particularly useful for short runs involving relatively small total quantities. The advanced system operates on the principle of pace setting, that is, allowing the lagging component to set the pace for the other streams. With the system in operation, a master demand module paces the blend, sending a pulse signal, whose frequency is proportional to total blend rate, to the new digital controllers. One controller is on each component line. As long as the component flows satisfy this particular demand, the blend rate is maintained. However, if one component falls behind—which is likely to happen at start-up, or when a strainer clogs, or a pump cannot meet flow requirements—the controller on that line takes over, slowing all feeds in proportion to the troublesome one so that the blend is on spec at all times. A typical system consists of a master demand module, measurement transmitters control valves or speed control devices, and the component control stations, which include a standardizer, the new automatic pacing digital controller and a ratio module.

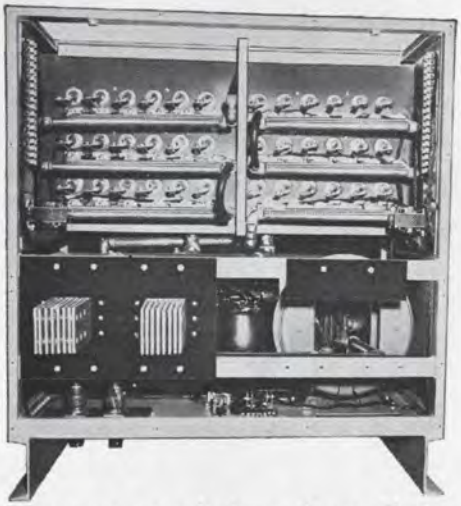
The Foxboro Co., Foxboro, Mass. **[401]**

Compact, logarithmic computing instrument

This compact electronic computer can be used on desk tops or tables. The LOCI-1 is designed to extend the personal computing power of the scientist and the engineer. With its storage registers and keyboard, it performs all of the operations found in ordinary calculators. However, its logarithmic principle of operation enables it to function with a unique flexibility and unparalleled power, according to the manufacturer, reducing the number of steps needed for many types of complex calculations. For example, square roots and reciprocals of square roots may be computed with one-key strokes. Exponential and logarithmic operations are accomplished with equal ease. LOCI-1 has a logarithmic register which accumulates the logarithms of numbers much as an ordinary accumulator stores the result of additions and subtractions. The logarithms are automatically generated when the appropriate function keys are pressed. The anti-log of a number in the logarithmic register is also obtained upon a single key command. Careful construction from completely solid state components is said to assure the most reliable and long-term performance. Answers of 8- to 10-digit precision are instantly available at electronic speeds upon the clearly legible Nixie display. Simple to operate, the LOCI-1 is more flexible than

WHAT WILL Acme Electric GET INTO NEXT?

THIS RECTIFIER HAS INTEGRAL WATER-COOLED CONDUCTORS



Instead of solid copper conductors, Acme Electric engineers employed hollow copper conductors for both transformer and reactor to reduce size and control temperature rise. All semiconductors and even the outside covers were water cooled.

As a result of this ingenious construction, this 45,000 watt static power rectifier, rated for 7500 amperes at 6 volts, was compressed in physical size, delivering 1200 watts of power per cubic foot; 36 watts per pound of physical weight!

Acme Electric engineers have an accumulation of experience for almost twenty years in building static power rectifiers and power supplies for applications that require out-of-the-ordinary performance. Acme Electric is ready to help you.

SPECIFICATIONS OF WATER-COOLED CONDUCTOR RECTIFIER

INPUT: 460 volts, 3 phase, 60 cycles

OUTPUT: 6 volts D.C., 7500 amperes

SIZE: 48" high x 44" wide x 30" depth

WEIGHT: 1250 lbs.

Acme Electric

SAA3815-3120

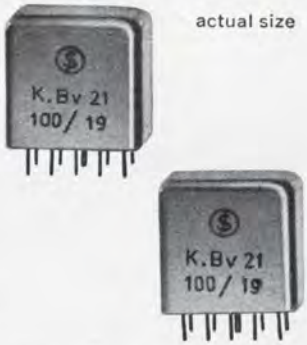
Engineers and Builders of...

REGULATED POWER SUPPLIES
STATIC POWER RECTIFIERS
VOLTAGE STABILIZERS
VOLTAGE REGULATORS

311 WATER STREET, CUBA, NEW YORK
Canadian Representative: Polygon Services, Ltd.
50 Northline Rd., Toronto 16, Ont.

Circle 211 on reader service card

POLAR RELAY TYPE 21



This subminiature polar relay of advanced design is widely applicable in small-size, light-weight communications equipment and control equipment for telephony, carrier telegraphy, data transmission in telemetry, automatic control, data processing, etc. It features extremely efficient magnetic circuits, unique chatter-free contact mechanism, and long-life contacts. Advanced hermetically sealed design is combined with long life (100 million operations), high sensitivity (0.7 mw), high speed (1.5 ms), and high stability against external magnetic fields.

MICRO RESONANT REED SELECTOR

This radically miniaturized micro resonant reed selector of the single-reed, plug-in type finds widespread use in diverse types of tele-controlling systems, portable equipment, and other transistorized circuits. It is composed of a composite cantilever vibrator, driving system, contact, and their supporting structures, all accommodated in a metallic case. In addition to its small size and light weight, since the vibrator is mechanical, its selectivity is sharp, and since variation of the resonant frequency due to changes in ambient temperature or aging is very slight, a high order of stability is obtained.

FUJITSU LIMITED
Communications and Electronics
Marunouchi, Tokyo, Japan

THE NISSHO AMERICAN CORP.	80 Pine St., New York 5, N.Y. Phone: WHitehall 3-7840
THE NISSHO PACIFIC CORP.	120 Montgomery St., San Francisco 4, Calif. Phone: YUkon 2-7901~7908
NISSHO (CANADA) LTD.	100 University Avenue, Toronto Phone: EMpire 2-4794

Circle 167 on reader service card

a slide rule and more accurate than most mathematical and engineering tables. Price is $2,500.
Wang Laboratories, Inc., 836 North St., Tewksbury, Mass., 01876. **[402]**

Millivolt-controlled subcarrier oscillator

An inexpensive oscillator, model 238, is designed for f-m telemetry systems where a number of millivolt-level, high-frequency transducer signals must be transmitted simultaneously over some distance or recorded for later data reduction. As f-m record electronics, the unit offers performance an order of magnitude better than conventional tape-recorder electronics, according to the manufacturer. Model 238 features high voltage-to-frequency conversion gain: a 10-mv input produces full-scale deviation of ±40%. The oscillator incorporates an internal mixing network and provides an output of up to 2 v rms, permitting a number of model 238's to be operated in parallel without a buffer amplifier. It is available for use in proportional-bandwidth and constant-bandwidth systems. Plug-in channel selectors provide operation at frequencies between 300 cps and 1.6 Mc and deviations of up to ±40%. Design features include: ±0.1%-of-bandwidth linearity, 100-db common-mode rejection at 60 cps, 1-meg-

ohm input imepdance, less than 10-μv equivalent input noise, and less than 1% carrier distortion. Price is $590.
Electro-Mechanical Research, Inc., Sarasota, Fla. **[403]**

Pulse generator with 1.5-amp output

A new pulse generator, model SP, features no-droop output waveform, with rise and fall times of 1 and 10μsec, respectively. Output is 1.5 amps, resistive or inductive. Input voltage is 18 to 30 v d-c.

Frequency range is 0.01 to 5,000 cps, and its on/off duty cycle limits are from 2% to 98%. Its applications—as a controller—include stepping motors, relay cycling, solenoid actuators and relay life testing. Units are priced from $88 each.
Crane Electronics Corp., 1401 Firestone Road, Santa Barbara Airport, Goleta, Calif. 93017. **[404]**

High-speed solid-state arithmetic processor

A new rack-mounted arithmetic processor is a high-speed, solid-state device with capability ranging from single instruction arithmetic operations including square-root to complex function subroutines. Its features include three arithmetic registers, three memory registers, and an optional keyboard and crt display which can be remotely located. The unit is specifically designed for use as the arithmetic element of on-line systems in applications where larger scale computers are economically impractical. This central processor

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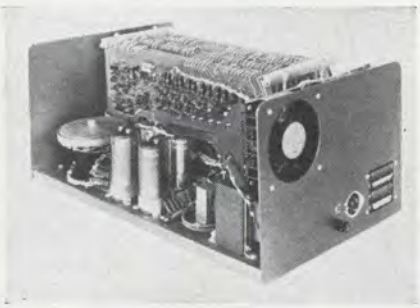
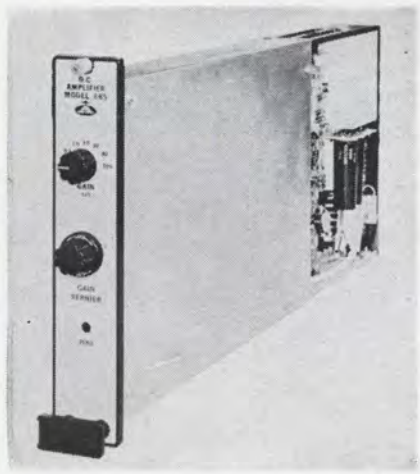
New Subassemblies



can communicate with a wide variety of input/output devices such as paper tape, punched cards, plotters, keyboards, crt displays, or d/a converters. Problem areas where the arithmetic processor is directly applicable are linearizing, conversion to engineering units, limit comparisons, repetitive computations involving more than one variable, and real-time statistical analysis on input data. Priced at $3,450, the processor is said to provide for the first time an economically feasible digital computation facility for the single control loop or small instrumentation system.
Wyle Laboratories, 128 Maryland St., El Segundo, Calif., 90246. **[405]**



Wideband amplifiers for data and systems

A line of low-cost wideband amplifiers is announced. Especially designed for data and systems, the models 884-101, 885-135 and 885-235 are all-solid-state and contain their own internal power supply. Chopper stabilization without me-

New Subassemblies

chanical choppers is achieved through the use of newly-developed field-effect transistors. This new circuitry provides chopper stabilization to obtain low drift rates previously found only with mechanical choppers. The amplifiers' input circuits are floating and guarded and isolated from the output and power ground circuits. The output is also isolated from the input and power ground circuits. Common mode rejection of 160 db at d-c and 120 db to 60 cps is achieved with up to 1,000 ohms source resistance unbalance in either input lead. Common mode voltages may be as great as ±300 v d-c or peak a-c.

Astrodata Inc., 250 E. Palais Road, Anaheim, Calif. [406]

Uncoated laser optics have high reflectivity

A series of uncoated laser optics, known as resonant reflectors, are in production. They are said to upgrade the reliability of laser systems with which they are used through their ability to withstand peak power densities orders of magnitude greater than those which destroy commonly used dielectric coatings. Peak powers over 10^8 w per sq cm have been successfully and repeatedly handled. The resonant reflectors are broadband in operation. They have a high reflectivity from 0.4 to 4.0 microns. The manufacturer describes the units as assemblies of parallel sapphire or quartz plates which have been polished and positioned to interferometric tolerances. The assemblies are being made available with both a choice of reflector materials and in the number of elements, thus offering a wide range of reflectance values. Reflectivity peaks are separated by ap-

proximately 1 angstrom. An additional benefit gained through the use of resonant reflectors is that they have intrinsic mode selection properties which significantly improve laser beam divergence.
Lear Siegler, Inc., Laser Systems Center, 2320 Washtenaw, Ann Arbor, Mich. **[407]**

Low-frequency low-pass filters

New low-frequency low-pass filters are announced. These stable units are engineered to perform with an unvarying frequency response over extended periods of time and usage. Designed to pass signals from d-c to 1 cps, the response to this filter is flat to within 1 db for signals up to 0.75 cps and is within 2 db to 1 cps. At frequencies above 2 cps, the filter has an attenuation of at least 40 db. The source and load impedances are 10,000 ohms. The filter is manufactured and guaranteed to MIL-F-18327B. It is hermetically sealed and ruggedized being MIL type FR4RX11LB. It measures $4\frac{5}{16}$ by $3\frac{11}{16}$ by $4\frac{1}{2}$ in. and weighs 6 lb. The unit fills requirements frequently found in medical electronics, geophysical and similar low-frequency applications.
United Transformer Corp., 150 Varick St., New York, N.Y. 10013. **[408]**

Rear-projection readout device

A new rear-projection readout device will display a 2-in.-high character. This satisfies the basic human engineering requirement as to the ideal character height for a display that must be easily read from a distance of up to 50 ft away. Designed as the series 360, the

New Subassemblies

unit is 3 in. high by 2 in. wide by 7¾ in. long. It may be used wherever visual data display is required and is capable of displaying anything that is photographically reproducible. Each series 360 is capable of displaying up to 12 different messages, which are on film inside the unit mounted in front of an assembly of 12 incandescent lamps. When one or more of the lamps is lighted, the corresponding film message or character is illuminated, focused through a lens system and projected onto the viewing screen at the front of the unit. Series 360 is said to be the smallest rear-projection readout device capable of displaying a 2-in.-high character. It is priced at $33 in 1 to 9 quantities with a decreasing price scale for larger quantities. Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, Calif. [409]

Module displays luminous captions

This caption-display module presents luminous captions or symbols to describe the data read in the numeric portion of the readout. It is equipped with a film transparency which is lighted from the rear by four neon or incandescent lamps. The module can be mounted on a common bracket with the series R-100-T numeric readouts and is available for operation on 14 to 160-v circuits. The display area may be divided horizontally into upper and lower sections, or vertically into left and right sections, each lighted by two lamps and capable of being switched for alternate display. By further subdivision, there may be four areas, each lighted by one lamp, that can be selectively displayed. The four dis-

play areas are suitable for symbols or abbreviations.
Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y., 11237. **[410]**

Computer system for process use

A new high-speed computer system for process use has been announced. Model 97600A is described as the fastest medium priced industrial computer system

available. It is designed for a full range of industrial applications and is especially suited for involved process calculations which are time-shared with production scheduling and direct digital control. The computer features 10 Mc silicon circuitry with a memory cycle time of 1.75-μsec. The fast cycle speed enables many subroutines transferred from bulk storage to be completed without interruption. Options available are a high-speed arithmetic unit and wired-in double precision circuitry. Because the 97600A computer is program-compatible with its predecessor, the 97600, the new machine can be provided with a library of industrial programs already tested in on-line applications. In addition, the

New Subassemblies

97600A can perform on-line compiling in Fortran II language. The new computer will utilize the manufacturer's data bus input-output system, which has been successfully applied to the power, steel and food processing industries. This data bus concept is described as industry's first totally buffered input-output system. It provides simultaneous reading of analog process measurements, contact closures and priority interrupts. It can, at the same time, provide outputs to valve actuators and computer set point stations. In addition, the system communicates with operator consoles, prepares punched tape records and typewritten logs.

The Foxboro Co., Foxboro, Mass. **[411]**

Voltage-controlled crystal filters

New active crystal filters provide adjustable and controllable bandwidth. The CF series was developed especially for use in spectrum analyzers and frequency synthesizers. It can be used in other applications where bandwidth must be adjustable and controllable. Standard center frequencies range from 100 kc to 1 Mc; specials up to 10 Mc are available. Bandwidth can be controlled by d-c or a-c (sawtooth) control voltage. Ratio of maximum bandwidth to minimum bandwidth is approximately 40 to 1.

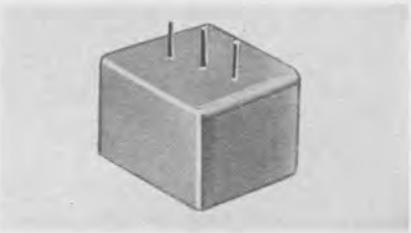
Polyphase Instrument Co., Bridgeport, Pa. **[412]**

Ultrasonic delay lines store digital data

New ultrasonic delay lines are

available for digital data storage. The series 150 offers advantages in size, cost, environmental stability and provides improved pulse timing and fidelity through low dispersion, wider bandwidths; low temperature coefficient and high signal-to-noise ratio. Working over a wide range of bit rates and delays, the series 150 lines are capable of storing 10 to 2,000 bits at rates from 2 Mc to 50 Mc for RZ operation with delays to 800 μsec. Over-all loss varies from 10 to 80 db dependent upon total storage and type of transducer used. Size, environmental stability, and costs as low as a few cents per bit storage are said to make this delay line memory superior to drum and core memories for many applications.

Richard D. Brew and Co., Inc., Airport Road, Concord, N.H. **[413]**



Voltage-controlled crystal oscillator

Model 643 voltage-controlled crystal oscillator is a 1-cu in. unit available at a fixed frequency between 170 and 500 kc. A frequency swing of $\pm 0.008\%$ can be accomplished by applying a 0 to 15-v bias voltage. Input is 26 v d-c with output of 10 v peak-to-peak into a 5,000-ohm load. Wave form is square with 0.2 μsec rise and fall time. Operating temperature range is 0 to 70°C. The unit measures 1 by 1 by 1.06 in. seated and has three 0.1 in. grid spaced wire leads for p-c board mounting. The oscillator meets the vibration requirements of Mil Std 202, Method 204A (10 to 500 cps, 10 g); rfi of Mil-I-6181; environment of Mil-E-5400; and is suitable for in-flight missile applications.

Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif. **[414]**

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P.O. Box 430, Hightstown, N.J. 08520

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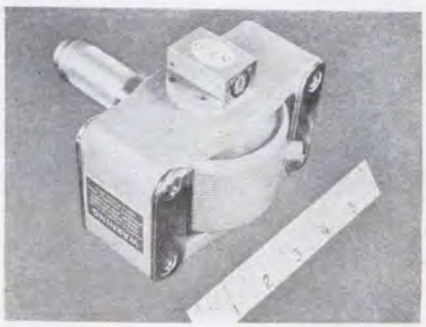
All solid-state tv relay receiver

Model MA-8512 is a solid-state microwave relay receiver of rugged, lightweight design for reception of television video and sound in the 11.7-to-12.2 Gc or 12.7-to-13.2 Gc tv relay bands. No tubes are used. A major feature of this design is crystal-controlled channel selection. The receiver is a superheterodyne and is used with the latest klystron transmitters using low-drift klystrons. The all-weather chassis and solid-state electrical design permit full receiver performance in vans, helicopters and other remote locations where conventional receivers are not suitable. Full crystal-controlled local oscillator output assures excellent performance in high-signal environments. Metering circuits are provided to monitor receiver agc voltage, discriminator d-c voltage and internal line voltages. Total weight is approximately 23 lb., and the size is 8¾ in. by 12 in. by 8 in.

Microwave Associates, Inc., Burlington, Mass. **[421]**



Coaxial magnetron delivers 125 kw peak

A new high-power, Ka-band coaxial magnetron has been introduced. The compact SFD335 delivers 125 kw peak power output at a fixed frequency in the range 34.5 to 35.2 Gc. Production fixed-frequency tubes are normally supplied to within ±50 Mc of the customer's designated center frequency in that band. The tube weighs only 8.9 lb and offers the inherent long-life capability of the inverted magnetron. A tunable version, designated the SFD338, is also available across the band indicated. The tube is ideally suited for airborne, ground transportable, and mobile system applications because of its rugged construction and high efficiency. It is warranted for 1,000 hr, and life test data to date has shown typical life expectancies of 3,000 to 4,000 hr. Output is in circular waveguide (WC-59). Transformation into RG96/U rectangular waveguide, if desired, may be accomplished by the use of the SFD 803 or 805 transitions. Standby heater voltage is 16 v; standby heater current, 5 amps; peak voltage range, 17 to 19 kv; peak current range, 15 to 30 amps. Dimensions are 6 in. by 6¼ in. by 3¼ in.

S-F-D Laboratories, Inc., a subsidiary of Varian Associates, 800 Rahway Ave., Union, N.J. **[422]**

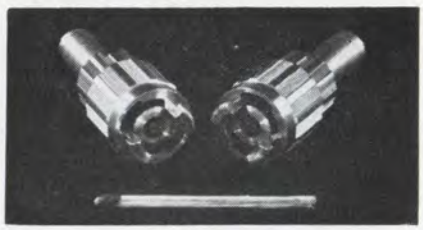
Coaxial attenuator spans d-c to 1 Gc

A coaxial power attenuator has been designed to dissipate a full 50-w energy in the frequency range of d-c to 1 Gc. Model FA-815 may be used as a dummy load for a transmitter, or to reduce transmitter output. It is particularly useful for isolating measuring devices such as bolometers and couplers from higher powered transmitters and other signal sources. The vswr is no more than 1.3:1 over the frequency range while accuracy is

New Microwave

within ±0.5 db of the attenuation. Model FA-815 is available in values of 3, 4, 5, 6, 10, 12, 15 and 20 db. Connectors furnished are normally type N, and other types are available on request.

Electro-Metrics Corp., 88 Church St., Amsterdam, N.Y. **[423]**



Coaxial connectors for use to 18 Gc

A line of high precision coaxial connectors is available for microwave applications up to 18 Gc. They offer additional freedom to the microwave system engineer, permitting the use of smaller, lighter precision coaxial cable and rigid transmission lines with electrical efficiency approaching waveguide performance. The bayonet-type coupling is standard. Screw-type and bolted flange-type couplings are also available. The connectors are sexless, so identical units will mate. The connector size, based on the inner diameter of the outer conductor is seven mm. Over-all size will vary with the type coupling used. The connector is available in two versions —ultra-high-precision units labeled LPC-7 or GPC-7 for lab test equipment applications, and high precision FPC-7 units for field applica-

Circle 223 on reader service card

tions. Lab connectors range in price from $27 to $35 each, depending on the quantity. The field precision connectors sell for about half the price of the lab units.
Amphenol RF Division, Amphenol-Borg Electronics Corp., 33 E. Franklin St., Danbury, Conn. **[424]**

Sampler-attenuator in five new models

This sampler-attenuator precisely levels the output of a sweep oscillator and provides 60-db power control. With the model 1150 series, the output from sweep oscillators may be leveled and attenuated at the load, thereby eliminating perturbations caused by interconnecting cables and components. Power variation with frequency from maximum power down at least 20 db is ±0.5 db and at minimum power is typically less than 1.5 db. Insertion loss is less than 5 db. Five models are available in the series covering the following ranges: 1 to 2, 1.4 to 2.5, 2 to 4, 3.5 to 6.75, and 4 to 8 Gc. Price is $570.
Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif. **[425]**

Ku-band signal source has 700-Mc tuning

A new Ku-band signal source consists of an oscillator multiplier assembly. Outstanding characteristics, according to the manufacturer, are tuning range, r-f power output and small size. It has ideal capabilities for use as a parametric amplifier pump or local oscillator application because of low power input requirements, low spurious noise and long term stability. It can be modified to cover frequencies as high as 18 Gc. Part number is 9507-1000; output frequency,

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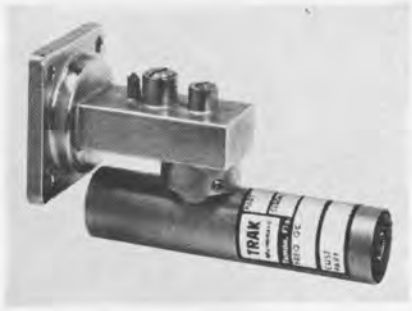

16.05 to 16.75 Gc (c-w); manual tuning range, two screw 700 Mc, one screw 100 Mc; r-f power output is 50 mw, typical, at band edges. A guaranteed 50 mw minimum can be supplied at band center for frequencies up to 18 Gc. Power input requirements are 175 v d-c at 30 ma, 6.3 v at 250 ma nominal.
Trak Microwave Corp., Tampa, Fla. **[426]**

Solid-state microwave switch

Model 02-62 is a spdt diode switch designed for operation at 300 Mc over a 10% frequency band. Features include: nanosecond switching; less than 1 db insertion loss; greater than 35 db isolation between terminals; less than 1.3:1 vswr in both on and off conditions. The switch can handle up to 4 w of average power and requires no negative bias potential. Size is 7½ by 4¼ by ⅛ in. less connectors; weight, 10 oz.; price, $375.
Advanced Development Laboratories, Inc., 24 Simon St., Nashua, N.H. **[427]**

Broadband, high-power coaxial circulators

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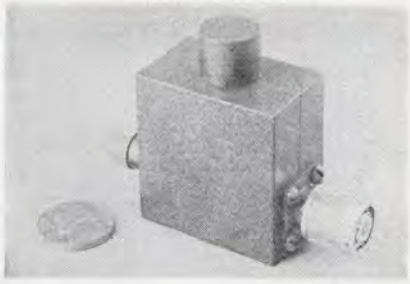
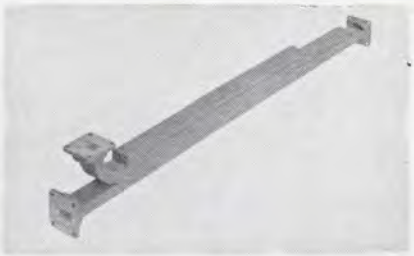


axial circulators are three-port devices. The T-563L has the third port terminated internally to realize isolator operation. Frequency range is 2.0 to 4.0 Gc (any 22% band). With the proper connectors and high power load this unit is capable of handling 400 w c-w. Over the temperature range —55°C to +85°C, the device exhibits the following characteristics: isolation, 20 db minimum; insertion loss, 0.5 db maximum; vswr, 1.20 maximum. Connectors are TNC; weight, 6½ oz; size, 1⅝ by 1¾ by $1\frac{1}{16}$ in. (excluding connectors).

Ferrotec Inc., 217 California St., Newton 58, Mass. **[428]**



Precision waveguide directional coupler

A new series of waveguide directional couplers are designed with an extremely flat (±0.2 db) coupling characteristic. Fifteen standard versions are available to provide coupling values of 10, 20, or 30 db over the frequency range of 3.95 to 18.0 Gc. The new couplers are essential for precision measurement work at any power level where ultimate flatness of coupled output is required over the full waveguide operating frequency range. A new design concept provides for a flat compensated response with an extremely high directivity characteristic. Minimum directivity is 40 db. Main line vswr is 1.10 max; secondary line vswr, 1.20 max.

Waveline Inc., Caldwell, N.J. **[429]**

New Production Equipment

Arc-torch system speeds brazing

Rapid brazing of small ferrous and nonferrous parts is now possible using a highly stabilized arc-torch method. This arc technique of brazing is said to combine the best features of induction heating and protective furnace atmosphere systems with the low cost of gas-torch operation. Also, the rate of heat transfer to the work is three to four times that of oxygen-gas heating methods. One important feature of the arc torch technique is that no toxic fluoride salts or other metal salt flux is required for brazing many metals. Clean brazes have already been achieved with tungsten to copper, tungsten to nickel-flashed or plain stainless steel, brass and bronze to Monel metal, carbon steel to Hastelloys as well as on the more common joints of copper to brass and copper to copper. Mildly reducing atmospheres of helium-hydrogen, argon-hydrogen, nitrogen-hydrogen, or CO_2 have also been used successfully. Even ETP copper can be brazed without significant loss in tensile strength. The correct combinations of gas in the new arc systems offer exceptionally high temperatures, good oxide reduction and a suitable atmosphere for most brazing jobs. The brazing operation also can be carried out in a simple glass enclosure or in a vacuum flushed inert gas chamber.

Dynamic Controls Co., 2225 Massachusetts Ave., Cambridge, Mass. **[451]**

Space winder assures accurate repeatability

A linear/non-linear space winder has been designed with very high accuracy for repetitive windings because of all ball-bearing and ball-bushing movement. Possibility of coil rejects is eliminated by positive cam reset. Model 918-PM winds all types of variable pitch (nonlinear) or linear space windings up to 3½ in. maximum length. The machine also winds many types of tuner and similar single layer multi-wound coils in a great variety of spacings and number of turns in one operation instead of in several operations. Open work area in front permits faster, easier handling by operator. Possibility of clutch slippage is eliminated by a powerful clutch torque feature. Automatic cam return reduces operator fatigue, speeds production and saves up to 20% of operator's time. Wire sizes wound are 18 to 46, winding speeds are variable up to 2,100 rpm, and set-up time is only 5 to 10 minutes for complete job change-over. The machine is furnished with tension, one winding set-up, motor, self-adjusting

magnetic brake and automatic stop feature.
Geo. Stevens Mfg. Co., Inc., 6001 North Keystone Ave., Chicago, Ill. **[452]**

Projection welder for semiconductors

A new machine is announced for general semiconductor welding applications. Model 2400 projection welder is available with integral dry box for controlled atmosphere welding. It offers the ability to encapsulate semiconductor and transistor components by resistance welding over a wide range of sizes—diameters ranging from 0.3 in. to 1.25 in. Specifically, this capacity range is realized through use of twin 75 kva transformers coupled to the welding head through balanced secondary circuits and a new welding head design unique with the model 2400. Welding force may be varied from a minimum of 300 lb to a maximum of 2400 lb energized by 80 psi air. The two-column construction assures that electrode parallelism is accurately maintained. Production rate for projection welding TO-3, TO-5 and TO-8 transistors with ring projections up to and including 1¼ in. diameter is up to 1,000 per hr.
Thomson Electric Welder Co., Inc., 161 Pleasant St., Lynn, Mass. 01901. **[453]**

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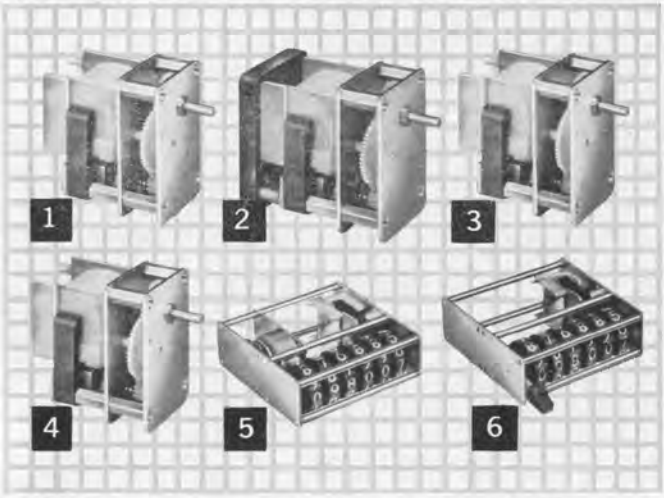

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NO. 2 – Brushless D.C. Motor
NO. 3 – 3-Wire Stepper Motor
NO. 4 – A.C. Synchronous Motor
NO. 5 – Planetgear® Pulse Counter
NO. 6 – Planetgear® Digital Stopclock

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Now, a Brushless D.C. Motor – almost any desired speed accuracy – no brushes or contacts.

Now, a 3-Wire Stepper Motor – compact size – high pulse rate – integral gear train for any step angle – 360° rotation per pulse.

Now, an A.C. Synchronous Motor – ½ watt input and 100 oz./in. at 1 RPM. Integral gear reducer.

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Globe Industries, Inc., 2275 Stanley Avenue
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Weltek's new MODEL 800 Molecular Bonder makes diffusion bonds of fine wire to thin films, integrated circuits, semiconductor devices, and crystals. Process is similar to conventional thermocompression bonding but more controllable since it requires *no heat column*. Accommodates gold, palladium, platinum and aluminum wire from .0007″ up to .004″ diameter. Will do repeatable wedge and stitch bonding as well as regular nail head bonding. Suited for either lab or production operation. Send for literature.

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1701 S. Main Street, South Bend, Indiana, U.S.A.

Circle 186 on reader service card
Circle 228 on reader service card

Polyolefin tubing is heat-shrinkable

An all-purpose, irradiated, polyolefin, heat-shrinkable tubing is available with a 2:1 shrinkage ratio. Within 7 seconds after it's applied at 135°C, Alphlex FIT-221 shrinks to half its original diameter, forming a permanent, tight-fitting mechanical bond, even over irregularly shaped objects. Because of this ability to shrink 50% when heated, it is ideally suited for insulating components and cables with a wide variation in shape and size. The expanded diameter also enables the tubing to be easily slipped over the material to be covered. Longitudinal shrinkage has been minimized at only 5%. FIT-221 is thermally stable and will not cold-flow or melt; it retains form stability throughout its temperature range, —55°C to 135°C. High dielectric and mechanical strength, plus resistance to fungus growth and moisture absorption, add to its value as an insulating material. The use of a hot air gun is recommended as the easiest heating method. However, satisfactory results may be achieved by the use of an oven, radiant heat, dipping in hot liquid, soldering iron or open flame. Alphlex FIT-221 is marketed in standard packages of 4-ft and 6-in. lengths and small quantity assortments of 6-in. lengths. It is available in sizes from 3/64 in. to 4 in., and in 6 colors.

Alpha Wire Corp., 180 Varick St., New York, N.Y. **[441]**

Compound provides r-f shielding

A one-component caulking and sealing compound has been developed to insure r-f integrity of structures, where the shielding requirements are such that the cost of high performance sealants, such as Eccoshield VX or Eccoshield VY is not justified. Eccoshield CO is of a grease-like consistency, and easy to apply either by trowelling or with a gun type applicator. It does not harden with time. It has proven particularly useful and economical in providing an r-f shield in joints of large structures, where the joints are periodically taken apart for access. It is also useful in filling large gaps in an assembly where an r-f shield is required. The volume resistivity of Eccoshield CO is in the range of 75-125 ohm-cm, but in structures where there is a sizeable overlap of metal faces that require r-f integrity, insertion losses in excess of 50 db have been achieved. The compound is priced at $4.70 per lb in small quantities, and in the $2 to $3 per lb range in quantities of 100 lb.

Emerson & Cuming, Inc., Canton, Mass. **[442]**

New Books

Electronic theory

Physical Electronics
G.F. Alfrey
D. Van Nostrand Co.
1964, 220 pp., $8.50

In a descriptive way, this volume deals in considerable detail with the basic mechanisms of present-day electronics. The electronics engineer will find here a readable and valuable introduction to the physics behind semiconductor devices, plasma applications and electron optics. All these, and other, recent advances in the electronic art tend to involve more physics than the average engineer knows. This book fills in some of the gaps painlessly.

The book opens with a historical chapter about the electron, and continues with an explanation of the present-day theory of the atom, with special emphasis on the electron.

Forces between atoms are covered in the next chapter, followed by a detailed treatment of electron emission from solid materials.

After a chapter on electron optics, which also deals with the various forms of the cathode-ray tube, the book goes into a consideration of electron current flow, space charge, and velocity modulation. Electrical conduction in gases and plasma is covered next, with references to magnetohydrodynamic power generation, nuclear fusion and nuclear reactors.

The next group of chapters deals with semiconductor theory and the nature of the transistor. The final few chapters are on magnetic properties of matter, dielectric materials, electrical noise, and molecular amplification—the concept on which the laser and maser are based.

Frequent reference to useful devices and new developments gives the book great practical value.

Pulse networks

Pulse Circuits
Raphael Littauer
McGraw-Hill Book Co.
1964, 530 pp., $12.75.

This volume, written by a Cornell University physicist, uses a novel approach to introduce pulse cir-

cuits. It attempts to develop an intuitive method of combining circuit elements so that their functions can be readily visualized; a rigorous circuit analysis is undertaken only after this visualization, rather than the more usual other way around.

The book begins by describing pulse signals, information coding and basic circuit theorems such as Thevenin's and Norton's. It then discusses simple linear filters made up of inductance, resistance and capacitance, and transient response of their combinations.

Next, all aspects of modern diodes are examined. The use of junction, point-contact and thermionic diodes, in circuits for clipping and d-c restoration, among other applications, is explained.

Active components are covered in the next group of chapters, starting with vacuum triodes and their applications in pulse circuits, and continuing with the triode junction transistor. In each case, specifications of typical components are given with examples of actual pulse circuits.

The following chapters deal with biasing considerations, the pentode tube and the more unusual triode circuits such as followers, cascodes and difference amplifiers. Nonlinear circuits, negative- and positive-feedback circuits are dealt with next. Then comes a group of chapters on bistable, monostable and free-running trigger circuits and their applications.

The blocking oscillator configurations, ramp generators, time coding and sweep-voltage sources are considered next, as is time-amplitude conversion. A separate chapter deals with coincidence and transmission gates, including the diode gate, emitter-coupled gate, saturating and bridge gates, and tunnel-diode applications in this class of circuits.

The final chapter discusses register circuits, ring counters, transfer circuits and decoding matrices.

The circuit-oriented approach will make this book a highly practical addition to the engineer's bookshelf. Actual practical examples of working circuits are given as illustrations throughout. Each of the 18 chapters also carries a set of problems for the reader. There is also a bibliography of recent literature on pulse circuits.

Technical Abstracts

Thin-film memory

A 16k-word, 2-Mc, magnetic thin-film memory*
Eric E. Bittmann, Burroughs Corp., Defense and Space Group, Great Valley Laboratory, Paoli, Penn.

This new thin-film memory operates with a 0.5-microsecond cycle and a 0.3-microsecond access time. It represents a significant achievement in a program of magnetic thin-film development for computer storage begun at the Burroughs laboratories in 1955. The 16,000-word capacity and the half-microsecond memory-cycle speed clearly indicate that magnetic thin films have become the best storage elements for reliable, nonvolatile, fast-access memory.

The storage cells are planar ferromagnetic thin films, produced by vacuum deposition of Ni-Fe alloy onto glass substrates. The film elements are deposited 768 per substrate, in a 32-by-24 array. Five substrates in a row provide storage for 32 words of 120 bits each. A single five-substrate film word stores two 52-bit computer-language words. Four such rows (128 words on 20 substrates) make up a plane. A plane, along with associated circuit cards and connectors, is assembled as an integral plug-in unit called a frame. Thirty-two frames constitute a 4,096-word stack. Edge-board connectors on the frames permit easy insertion, or removal.

The memory module has a total capacity of 16,384 words. The 52-bit word contains 48 data bits, 3 control bits, and 1 parity bit. The control bits act as tags to tell the program whether or not the instruction has been executed.

The 6-bit address is decoded at the input of every word driver word switch by a diode-transformer matrix that contains 4,096 transformers. A reference bit was included in each 104-bit film word because the sense readout signal is only 50-60 nanoseconds wide, and the delay in the stack can vary as much as 70 nsec for different address locations. To generate a variable-time strobe pulse, a strobe reference bit, which is always a ONE, is the 105th bit in the stack. The 15 spare bits in each 120-bit word can be used to replace weak or faulty bits.

The bit current flows parallel to the sense conductor, and induces noise in the sense lines. This noise is reduced by transposing each sense line with the corresponding bit line by a crossover connection in the middle of the memory plane; the connection is made after the glass substrate has been sandwiched between the printed-circuit boards. Some noise (as much as 5 millivolts) remains, because of mechanical imbalance between each sense-line/bit-line pair; this can be reduced by manually adjusting the small sense end-around loops on the plane.

To further reduce noise in the sense lines, the flow of bit current is restricted to a single memory plane during a write cycle, rather than being permitted to flow through the entire stack.

The films are 1,000 angstroms thick; the glass measures 70 by 43 millimeters, and is 0.2 (8 mils) thick. The 786 rectangular cells on one substrate measure 30 by 80 mils each, spaced on 50-mil and 100-mil centers. The glass substrates of each memory plane are sandwiched between two printed-circuit-board assemblies 20 inches long and 9 inches wide. Three conductors address every memory cell: a word conductor 20 mils wide; a 10-mil-wide sense conductor, which has on each side the split bit conductor, each half of which is 20 mils wide, separated by 50 mils.

By reducing the total sense delay and eliminating the bit recover pulse (which is selectively applied to bit lines to eliminate magnetizing energy that would otherwise remain stored in the pulse transformers used in the bit circuits) it is possible to get a shorter memory cycle. Pulse transformers would be replaced by active solid-state devices. A reduction of 150 nsec (50 nsec from a shorter sense delay and 100 nsec from elimination of the bit recover pulse) makes a cycle time of 350 nsec, or 3-Mc operation.

* Presented at the Fall Joint Computer Conference, San Francisco, Oct. 27-29.

Electronics index

Technical articles

Volume 37, 1964

Technical articles

A

ADVANCED TECHNOLOGY

AMPLIFIERS

ANTENNAS

AVIONICS

C

CIRCUIT DESIGN

This abridged index lists only technical feature articles. A separate, complete index is available to readers and libraries for $1.00. Attractively bound, the complete 1964 index catalogs all articles—technical features, newsletter items, Electronics Review, Electronics Abroad, and Probing the News stories — manufacturers mentioned in these articles, and advertisers.

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Amplifier improves peak voltmeter response p. 73 Apr. 20

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MIT MODEL 3 PULSER

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New Literature

Relays. Universal Relay Corp., 42 White St., New York, N.Y., 10013, has issued its 60-page 1965 catalog that includes over 2 million relays in approximately 40,000 types.
Circle **461** reader service service card

Lighted pushbutton switches. Oak Mfg. Co., a division of Oak Electro/Netics Corp., Crystal Lake, Ill., 60014. New design possibilities available to the engineer whose circuiting requirements include lighted pushbutton switches are described in catalog SP-165. **[462]**

Power fans. Dynacool Mfg. Co., Inc., West Hurley, N.Y. A two-page bulletin illustrates and describes a series of fourteen 8-in power fans capable of delivering 200 cfm to 1,000 cfm (nominal). **[463]**

Cable shielding. Metals & Controls Inc., a corporate division of Texas Instruments Inc., 34 Forest St., Attleboro, Mass. Technical data bulletin IND-5 describes copper-clad stainless steel shielding material for communication cable. **[464]**

Solid-state preamplifiers. Applied Technology Inc., 3410 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif., has available a technical application bulletin on its series of solid-state preamplifiers. **[465]**

Angle-repeating instruments. Theta Instrument Corp., Saddle Brook, N.J., 07663, has published its 1965 engineering catalog giving full details of digital instruments for repeating precise angular position. **[466]**

Subminiature indicator lights. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y., 11237. A 12-page catalog presents a complete line of subminiature indicator lights that meet or exceed the environmental and operational requirements of MIL-L-6723 and MIL-L-3661. **[467]**

Counter data file. Computer Measurements Corp., 12970 Bradley Ave., San Fernando, Calif., has issued a complete data file on its 600 series of all-silicon solid-state electronic counters and universal counter-timers. **[468]**

Cryogenic x-ray equipment. Materials Research Corp., Orangeburg, N.Y. A brochure describes a cryogenic x-ray attachment for x-ray diffraction studies at temperatures from 4.2° K to room temperature. **[469]**

Fixed-head drums. Bryant Computer Products, 850 Ladd Road, Walled Lake, Mich. Data sheets describe two of the company's lower priced fixed-head drums—C-105 and C-675. **[470]**

Silicon-rectifier multiple circuits. Edal Industries, Inc., 4 Short Beach Road, East Haven, Conn. Bulletin 109 offers details on series K silicon-rectifier multiple circuits. **[471]**

Analog/hybrid computer. Comcor Inc., 1335 South Claudina Ave., Anaheim, Calif. A six-page brochure describes the all-solid-state model Ci-5000 analog/hybrid computer. **[472]**

Electrometer. Keithley Instruments, 12415 Euclid Ave., Cleveland 6, Ohio. An engineering note describes the model 610B electrometer—almost a complete d-c laboratory—that measures over 79 ranges. **[473]**

Transfer lettering. Chart-Pak, Inc., One River Road, Leeds, Mass., has available literature citing the vital characteristics and applications of Deca-Dry transfer lettering. Included is a section devoted to a new electronic marking kit. **[474]**

High-voltage reference elements. U.S. Semcor, 3540 W. Osborn Road, Phoenix, Ariz., 85019, has published data sheets on three new series of epoxy-encapsulated, high-voltage reference elements in a total of 10 different packages. **[475]**

Component packages. Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. A four-page brochure describes applications and the component complement of typical servopackage assemblies. **[476]**

Digital logic modules. Wyle Laboratories, 128 Maryland St., El Segundo, Calif. Catalog GLM-G covers a line of germanium solid-state logic cards and accessory equipment. **[477]**

Memory unit. Andersen Laboratories, 501 New Park Ave., West Hartford, 10, Conn., offers a bulletin on its 20,000-bit, 10-millisec, 2 Mc NRZ delay line that is designed for use as a serial memory unit. **[478]**

Servo system. Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill., 60638. Descriptive bulletin 343A illustrates a highly precise electronic servo system with graphs and photographs. **[479]**

Encoder-readout display system. Guidance Controls Corp., Plainview, L.I., N.Y., offers a brochure on an encoder-readout display system that combines highly accurate position sensing in a high-speed, low-cost package. **[480]**

Readout line. Burroughs Corp., Electronic Components Division, Plainfield, N.J. A 28-page, illustrated brochure presents full information on a line of readout devices, support modules, and readout systems. **[481]**

Photoconductive cells. Clairex Corp., 8 W. 30th St., New York, N.Y., 10001. A single-page bulletin contains technical data on the CL5M series of small, high-wattage photoconductive cells. **[482]**

Tunnel diode mixers. Aertech, 250 Polaris Ave., Mountain View, Calif., has prepared a two-page data sheet discussing parameters of tunnel mixers, and listing various models together with specifications and prices. **[483]**

Aerospace facilities. The Aerospace Division of Haveg Corp., Wilmington, Del., has issued a 12-page brochure that describes in detail the equipment and facilities available for aerospace programs. **[484]**

8 AU 13 AVRIL 1965 - PORTE DE VERSAILLES - PARIS

salon international des

COMPOSANTS ELECTRONIQUES

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PUBLISERVICE PARIS

April in Paris...

SPRINGTIME FOR ELECTRONICS

April is without a doubt the month when Paris is at its fairest. Gentle breezes, evenings growing longer, trees in full bloom everywhere—along the avenues, in the squares and by the Seine, where the first *"bateaux-mouches"* are carrying sight-seers down the river—and flowers everywhere, even in the ladies' dresses.

April—dazzling-bright stone—for the recent renovation of Paris' monuments and palaces has restored her buildings to their original glory.

Le Louvre, la Place Vendome, la Place de la Concorde, l'Ile Saint-Louis—all the places of Paris are waiting to be seen.

For electronics experts, the pleasure of rediscovering, in all of her spring finery, one of the most beautiful cities of the world will only add to the interest that is ever increasing in the *International Exhibition of Electronic Components,* in Paris, April 8-13.

Created in 1934 and elevated to an international stature in 1958, only for manufacturers, it now constitutes the *greatest worldwide assembly* in the field of electronic parts and accessories.

Its success is growing every year. The total number of exhibitors has more than doubled in the course of the last seven years. Its international spirit was established in 1964 by the presence, out of 772 exhibitors, of 346 foreign exhibitors belonging to 15 different countries. Throughout the world 50 technical and international periodicals cover this event. The number of foreign visitors to the Exhibition is constantly growing. In 1964, 65 countries were represented.

The Exhibition is truly a *crossroad* where manufacturers and technicians alike from all countries meet, exchange views on materials and techniques, and work out together what will be the innovations of tomorrow.

In 1965 the Exhibition will be more important than ever. Bringing together 800 exhibitors, it will hold forth for the first time in the *Hall Monumental* of the *Parc des Expositions de la Porte de Versailles,* in a setting worthy of the scope of this specialized presentation of superior technicality.

Along with it, and at the same time, the First International Exhibition of Audio Equipment will take place—new professional meeting of a branch of electronics which is in full growth.

And from the 5th to the 10th of April, in UNESCO's Salles de Conferences, the first *International Symposium on Techniques of Memories* will get under way. Users and producers will be brought up to date on the actual data of a problem and on the evolution of techniques whose applications are proving to be more and more important.

To be in Paris in springtime, to be there when so much that is important in the world of electronics is going on, *is a date not to miss.*

INTERNATIONAL EXHIBITION OF

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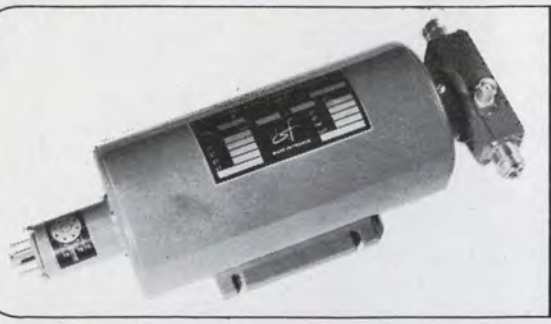
PARIS 8th to 13rd APRIL



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F 4065 (TPO 301)	8.5 - 9,6	7.5

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F 4102	7 - 11	13	35

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F 4134	1 - 2	10
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F 4017	1.7 - 2.7	10
F 4050	2.7 - 3.3	10
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F 4135	2 - 4	10
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F 4056	5.9 - 7.4	10

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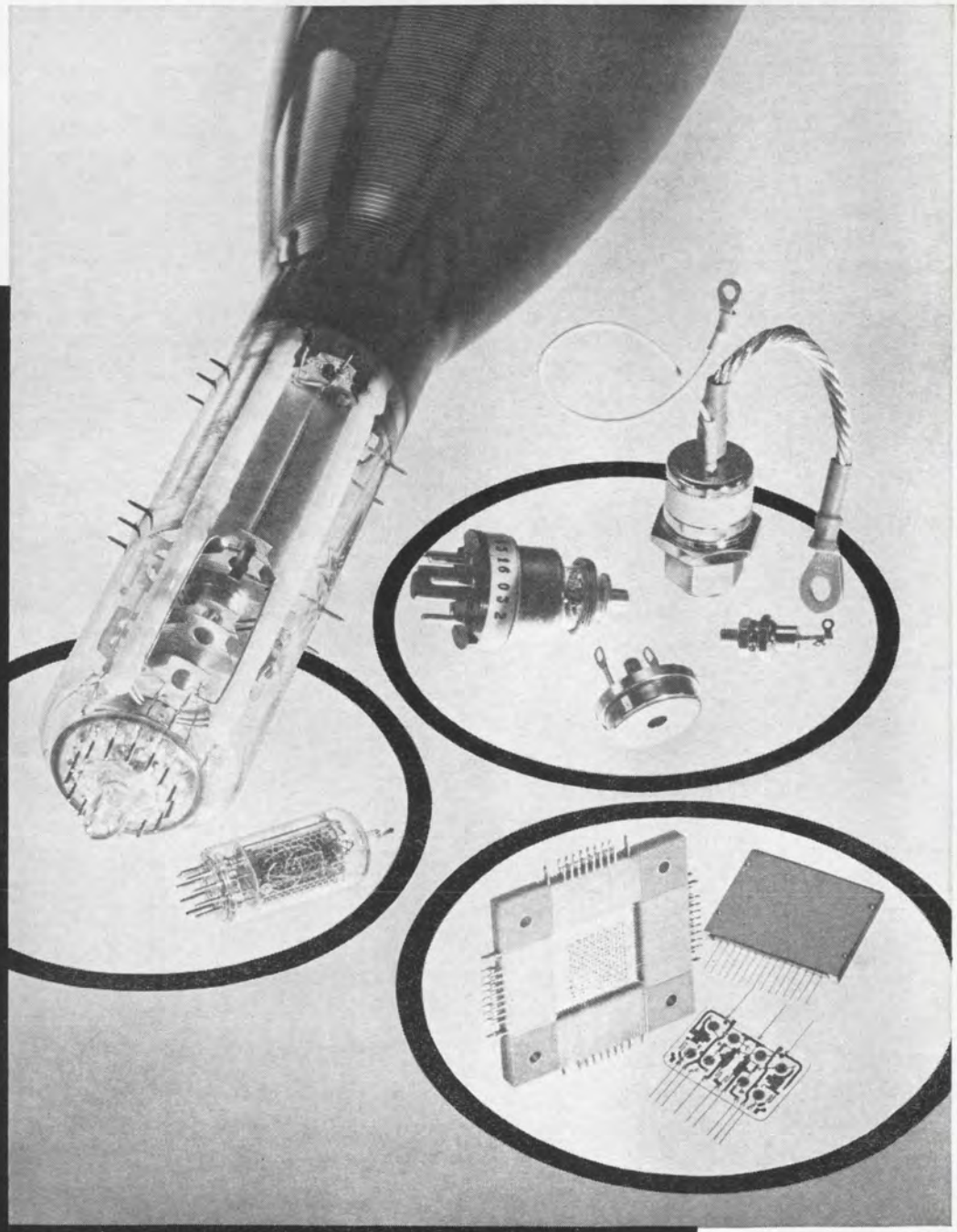

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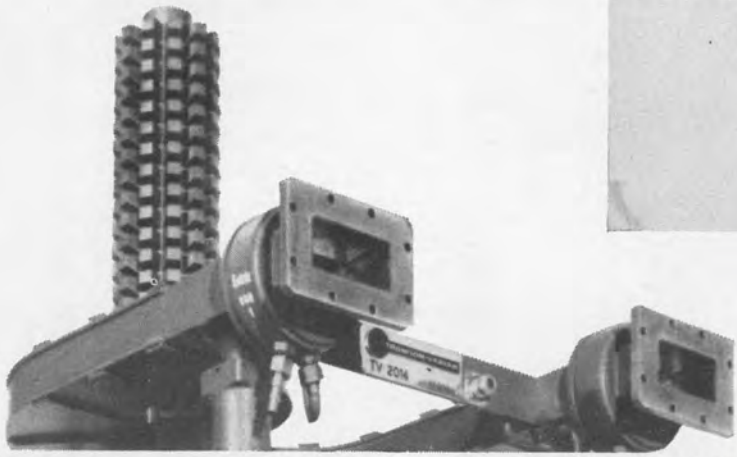

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January 11, 1965

Electronics Abroad

Volume 38
Number 1

Africa

Mapping Liberia

A rebuilt World War II attack bomber, custom-fitted with electronic equipment, is crisscrossing tiny Liberia on Africa's west coast. Its immediate mission is to make a mineral and mapping survey for the United States Army Map Service. Its long-range goal is to help the U.S. get a healthy share of about $3 billion a year that's expected to be spent soon for roads, power plants, dams and other facilities in Africa.

The Douglas A-26 began its flights near the end of 1964. Its owner, the Los Angeles engineering company of Daniel, Mann, Johnson and Mendenhall, calls it "the most sophisticated survey aircraft in Africa." It's equipped with $100,000 worth of electronics: gravitometers, doppler navigation equipment, high-precision short-range navigation gear, computer-linked photogrammetric gear and ground-based geodetic transponders to go with it.

Oil hunt. When the weather prevents mapping, the gravitometric equipment goes to work seeking offshore petroleum for the Gulf Oil Co. The oil survey and some of the mineral survey work employs continuous magnetometers developed by Gulf.

Jess Thompson, electronics chief at Daniel-Mann, says the instruments are self-orienting, with continuous readout, and are capable of resolution "better than 0.25 gamma."

International race. But it's the other electronic survey gear on which the engineers think U.S. hopes for African business rest. Barry F. Mountain, vice president of Daniel-Mann and a member of the foreign policy committee of the U.S. Chamber of Commerce, explains: "If we're going to get our fair share of the African market we've got to get in there first and specify U.S. equipment and standards."

Barry F. Mountain sees rich markets in Africa.

Mountain says engineering survey firms like his are the narrow end of the wedge that can open up the African market to American business. Competition is coming from many countries, chiefly Britain, France, Canada and West Germany.

Continuous measurement. The Douglas A-26's electronic gear includes a precision RC5A aerial camera in the bomb bay, linked to a straight-line computer to take automatic overlapping photographic maps of 4,000-square-mile strips of country at a run. The computer is made by the Vectron division of the Itek Corp.

The Hiran navigation equipment is geared to continuous-distance measurements between the aircraft and transponders at mountain-top beacon stations. The transponders, made by the Radio Corp. of America, receive pulsed radio signals from the plane, amplify them and transmit them back. Distance measurements are said to be accurate to within six inches in 250 miles.

For navigation over known terrain, Hiran can hold the plane automatically on a course within a 35-foot tolerance.

For rough-control reconnaissance in the absence of ground checkpoints, the plane employs doppler radar navigation equipment linked to preprogramed flight paths.

Price of apartheid

South Africa, the continent's most prosperous country, may be one of the last to get television service. Tv seems to be another victim of the government's effort to maintain apartheid, or segregation, of the four million white citizens and the 12 million blacks.

Tv has been vetoed again by the minister of posts and telegraphs, Albert Hertzog, who controls all communication in the country. In his latest speech on the subject, he explained that South African tv would be "mainly dependent on British and American films which are drenched with liberalistic and demoralizing propaganda."

White against white. Among the white population, there's another schism that Hertzog fears would be aggravated by tv. That's the split between British and Dutch settlers. Afrikaners, settlers of Dutch descent, comprise 60% of South Africa's white population. But they're afraid their language would be completely submerged by English if tv were introduced.

South Africa's radio system offers two services, in English and in Dutch, and there's increasing pressure for a service for the country's black majority, which speaks a variety of native dialects. The same would be true of tv.

Election issue? There are some indications, however, that public pressure may one day force the government to adopt tv. The segregated school systems are consider-

ing closed-circuit tv. When enough people come into contact with the medium, the demand is likely to extend into tv for the home. This could become an irresistible groundswell by the time of the next general elections in 1968.

Technically, the South African Broadcasting Corp. is ready to begin television service quickly. F-m towers throughout the country have provision for tv antennas and transmitting equipment.

When Philips Gloeilampenfabrieken, N.V., of the Netherlands, opened its newest electronics plant in South Africa, there were reports that the facility was capable of making tv equipment. That rumor was quickly spiked by Philips. Nevertheless, many observers suspect that Philips, and other companies, are ready to get into tv production whenever the government approves, but that the companies won't talk about it.

Radio-controlled elevator

Now electronics makes it possible to operate a push-button elevator in a mine shaft in Zambia, formerly Northern Rhodesia.

The Anglo American Corp. of South Africa uses a radio-controlled winding device at a 1,585-foot-deep shaft in a copper mine.

The system was developed by Associated Electrical Industries, Ltd., of Britain. It eliminates the need for a cable that carries electrical control signals to and from the elevator cage.

Shaft-long antenna. A transmitter, mounted on the cage, feeds a continuous signal into an antenna mounted in the cage. A receiver antenna, extending the length of the shaft, receives the signal and passes it to a receiver in the elevator-control room.

Each pushbutton in the cage modulates the carrier with a different selected frequency. In the engine room the signal is demodulated; then it operates a frequency-sensitive relay that initiates the correct circuit to control the winder as instructed from the cage.

The cage controls both vertical and horizontal movement.

3-D radar picture is an image of a transparent cube representing airspace being controlled for air traffic. Within the cube, aircraft appear as luminous spots.

Great Britain

Display in 3-D

Now radar screens are turning to three-dimensional displays.

EMI Electronics, Ltd., is testing a system that converts raw radar video data into a 3-D picture on a cathode-ray tube. The approach, utilizing the technique of variable parallax, produces an impression of depth and of relative position. An air-traffic controller, using this display, could introduce graticules into any of the three planes and get a clear picture of the density of plane traffic.

Two operations. A conventional 21-inch cathode-ray tube can be used in the EMI system. A picture is painted on the tube's face in two operations. First the radar beam traces the outline of a cube and, by transforming coordinates, places airways, geographical features and any graticules that may be required. Then it paints the aircraft echoes by sequentially interrogating a computer memory bank and converting the digitally stored aircraft-position information into analog form.

Twenty pictures a second are painted on the display tube.

The picture's size can be changed at will, thereby also enlarging or contracting the area viewed.

Sweden

Spy scare

An electronics dealer is responsible for Sweden's latest spy scare.

The 50-year-old businessman was scheduled to be indicted Jan. 9 on espionage charges. If convicted, he could be imprisoned for life. He is identified only as "Mr. Zebra," the code name by which the police referred to him during a year's surveillance.

Specifically, he is accused of sell-

ing integrated circuits, micromodules and transistors to an unnamed Eastern power, presumably the Soviet Union. He is also accused of delivering microelectronics information.

Another electronics dealer was quoted in a Stockholm newspaper as saying that if sales of these components to Russia now means espionage, at least a dozen businessmen in Sweden "have one leg in state prison."

Top secret. As in all security cases, the police are releasing no information. The trial itself may be held in secret if the judge agrees that disclosure of the testimony could jeopardize the national security.

An amendment to the espionage law, which took effect Jan. 1, places certain business transactions in the same class as direct military espionage, and permits a sentence of life imprisonment. There's some question as to whether the new law is retroactive. Mr. Zebra was arrested Nov. 30 and arraigned Dec. 5; both actions were taken in secret. Under the old law, the maximum penalty is 10 years.

Sven Andersson, Sweden's defense minister, says the case is "not of great consequence."

In search of sales. The microspy, as he's called by Swedish newspapers, is said to have dealt for a year with a technical expert attached to the Soviet trade mission in Stockholm. Mr. Zebra reportedly was trying to increase his business with the Communist bloc. To get in the Russians' good graces, according to this report, he delivered information on the use of integrated circuits in Swedish equipment.

Sweden is not aligned in the cold war, but buys highly sophisticated circuits and components from the United States for her defense organization. She is believed to be anxious to demonstrate to the West that she can be trusted with classified military equipment.

Officials have indicated that the microspy case is not connected in any way with Air Force Col. Stig Wennerstrom, who received a life sentence as a spy for Russia.

West Germany

Jet-noise monitor

Frankfurt's Rhine-Main Airport, the busiest in Germany, has enlisted some electronic innovations in its war on jet noise.

A salvo of complaints from residents of five nearby towns led the airport administration to call for help from Rohde and Schwarz, a manufacturer of meters and instruments.

The airport wanted monitors of sound vibrations at six different checkpoints. It also wanted the sound to be interpreted automatically, and the results recorded in a form that would prove to an offending airline that there was excessive noise. The system also was supposed to check whether pilots observed proper flight paths and altitude requirements.

Elevated microphones. Rohde & Schwarz came up with a system that uses raised microphones [photo at right] in nearby residential areas. The signals are amplified and transmitted along commercial telephone lines at 300 to 3,000 cycles per second.

At the monitoring center in the airport administration building, a classifier channels all data into five categories. These range from 10 decibels below to 10 decibels above a reference level that corresponds to the average noise that comes from aircraft observing speed and altitude regulations at each checkpoint. Noise levels at or near the reference level are indicated by signal lamps, a different color for each checkpoint. A printer records these levels on a continuous tape, together with the time of day. The printer correlates this data with preprogramed flight numbers and times of takeoff or landing for each flight.

Planes that cause excessive noise can be identified from the data. Cumulative noise-level printers record the period during which the reference level was exceeded, and print the sum every hour.

Monitoring systems have been in service since 1963 in various cities, including New York. But there is no system in the United States similar to the Frankfurt network, according to the Federal Aviation Agency and the Port of New York Authority, which operates the John F. Kennedy International Airport.

The roofs have ears in towns surrounding Frankfurt. This microphone picks up aircraft noise which is then analyzed to determine whether plane was off course, flying too low or too fast, or creating excessive noise in another way.

Soviet Union

Electronics market

Soviet reactions to several Western trade missions and exhibitions give some new clues to the state of the electronic art and of the potential market in Russia.

Last July, Elliott-Automation, Ltd., of Britain, demonstrated $3.5

million worth of computers in Moscow's Sokolniki Park. Now Elliott reports that the Russians bought them all. Included were Elliott's new 503 digital machine for industrial control and an industrial modular process-control computer system. The Soviets also ordered another Elliott modular unit for on-line control of an ammonia plant.

These sales increase Elliott's total behind the Iron Curtain to nine industrial computers: five to the Soviet Union, two to Rumania and one each to Czechoslovakia and Bulgaria.

Disbelief. The latest exhibit in Sokolniki Park is a United States communications show, which already has appeared in Leningrad and Kiev. In Moscow, for the first time on the tour, the Russian-speaking guides are getting a verbal workout in questions from Soviet engineers and scientists.

Many Russians at the exhibit express disbelief at what they see. In the Soviet Union, the purpose of such a show is to preview the future, not depict the present. Spectators openly declare that Americans don't really have tiny television sets or Princess telephones. They also doubt that airplane tickets are sold by computers, as shown in the pavilion.

But they enjoy being dazzled by the electronics fairyland. At their peak, lines at the exhibit are two hours long.

Shopping list. In recent meetings with businessmen from the United States, Soviet officials for the first time have named specific electronic equipment they would like to buy. Most of the gear seems to be on the U.S. Commerce Dept.'s embargo list, but the Russians—like many American businessmen—expect that list to be reduced soon.

The Russians expressed strong interest in high-speed computers such as the IBM System 360. They said they'd like to buy either the hardware or licenses to manufacture it themselves.

Soviet officials also have suggested exhibitions in Russia of some U.S. equipment that can be used in data-processing and information-searching. They have even asked American newsmen to help persuade U.S. companies to set up such exhibits.

Here's some other equipment that the Russians would like to obtain: spectrometers and spectrographs of high resolution for the visible ultraviolet and infrared parts of the spectrum, radiospectrometers of nuclear magnetic resonance in the 100-megacycle range, mass spectrometers, x-ray spectral analyzers, chromatographs and sensitive elements for chromatograph detectors.

Japan

Colorful new year

For the Japanese the year ended in red, blue and green. Viewers were treated to a record 31½ hours of color television programing during the holiday weekend.

A highlight was a 2½-hour colorcast on New Year's Eve featuring Japan's most popular singers. This program marked a technical milestone: the first indoor broadcast in Japan using the new two-image orthicon camera developed by NHK, the Japanese Broadcasting Corp. It's the same system that televised the 1964 Olympics outdoors for Japanese viewers.

Although the New Year's Eve program was broadcast in color, viewers at black-and-white sets noticed practically no degradation of the picture. That's because the black-and-white luminance channel is separated from the color channels. The black-and-white image was sharp, with none of the fuzzy focus that's often caused when the three image orthicons in conventional cameras are slightly out of register.

Sensitive camera. The Japanese system generates the same NTSC color signals that are used in the United States. The camera [Electronics, June 7, 1963, p. 28] uses highly sensitive image orthicons of magnesium oxide, and requires only 1,000 lux of illumination. This is far below the 2,500 lux usually needed for color tv and 500 to 1,000

lux common for black and white.

Incoming light is split in two by a half-silvered mirror directly behind the camera's front lens. Half of the light falls on the luminance channel's 4½-inch image orthicon; the other half goes through an optical filter with vertical stripes of red, blue and green, then strikes the color channel's 3-inch image orthicon.

Sales charts. Increased color programing dovetails with the Japanese tv industry's plans to produce more color sets. The Yaou Electric Co. expects to begin selling its nine-inch transistor set this month or next in limited quantity. The Sony Corp. plans to begin sales of its 19-inch chromatron set in April. The Toshiba Electronic Industry Co. is completing an expansion that will double its monthly capacity of color-tv output to 10,000 sets from 5,000.

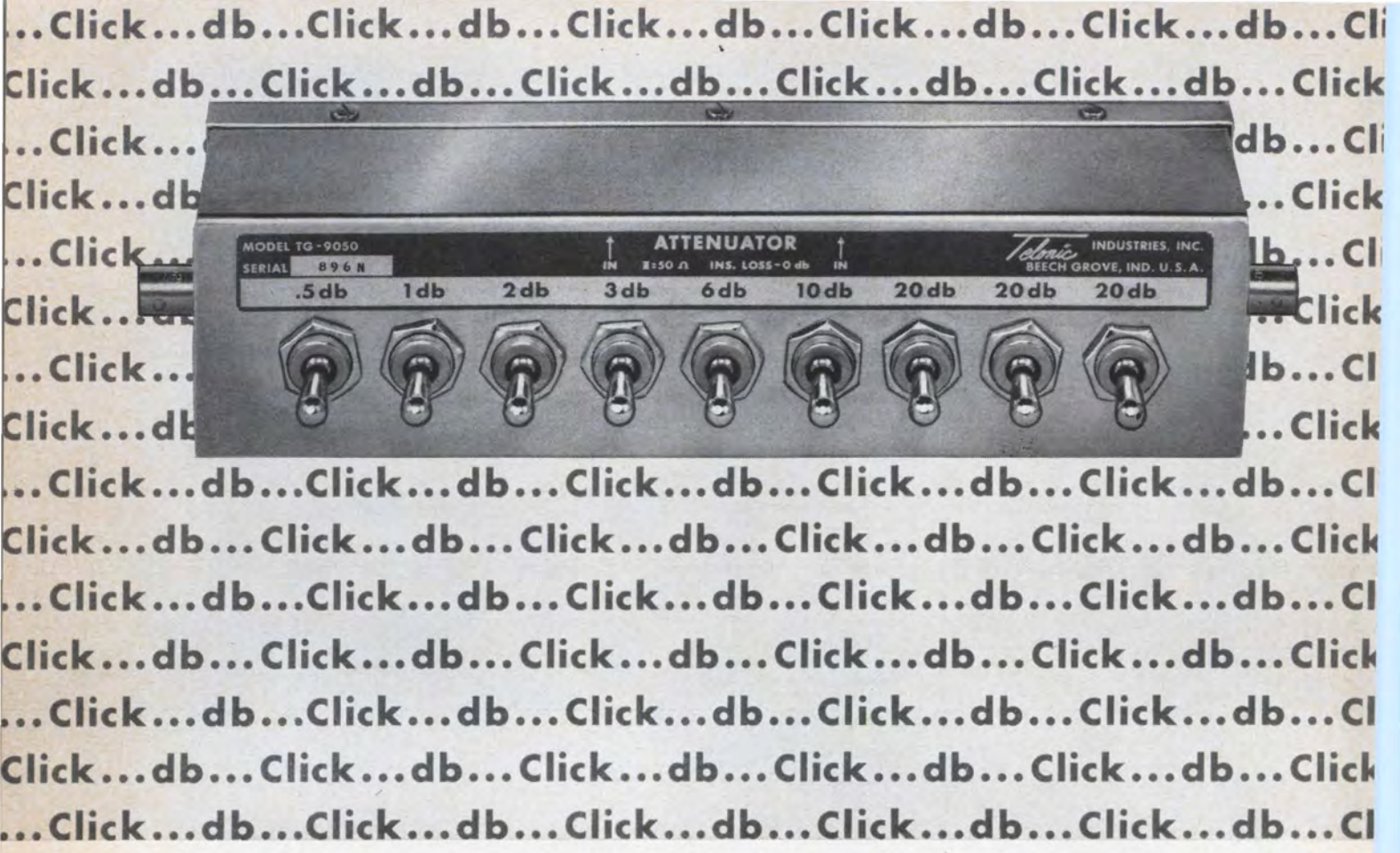
Foreign markets play a big part in Japan's color-tv plans. More than one-half of Toshiba's output now goes to Sears, Roebuck and Co. in the United States. Yaou concedes that its prime market will be in the U.S. initially. Sony, on the contrary, will sell only in Japan in the beginning.

Manufacturers of standard 16-inch shadow-mask sets are watching Sony, whose chromatron units will have the same list price, about $550. If Sony produces in quantity, the other Japanese manufacturers may lower their prices by about $100 and start production of 19-inch shadow-mask sets.

Japanese industry produced about 50,000 color-tv sets in 1964, while 1.25 million were turned out in the U.S.

Tax cloud. The only cloud on the color-tv horizon is a doubling of taxes, from 10% to 20%, scheduled to take effect April 1. The increase would add nearly $30 to the retail price of an average set.

However the Diet, Japan's parliament, is expected to scrap the one-step tax boost in favor of three smaller annual increases. The new plan, which is gaining acceptance in the ruling Liberal-Democratic party, would increase the tax to 13% this year, 16% in 1966, and 20% in 1967.



Telonic Toggle Switch Attenuators Keep Repeating Themselves

KEEP db CLICKING

Because of its straightforward, simple mechanical design the Telonic Toggle Switch Attenuator has an exceptionally long life. It's made for bench or panel mounting, requiring a minimum of set-up time. Everything about this attenuator is rugged except the price. The switch controls are double knife edge and the self-wiping action assures excellent repeatability. The pads are individually shielded to prevent leakage and allow the maximum attenuation to be used. A double shielded box further prevents leakage.

The attenuators are available with attenuation steps of 0.5, 1.0, 2.0, 3.0, 6.0, 10 and 20 db. Six-step units of 0 to 42 db in 1 db steps and 9-step units of either 0 to 102 db in 1 db steps or 0 to 82.5 db in 0.5 db steps are currently available from stock. Other combinations are available on request. They can be furnished in 50 or 75-ohm characteristic impedance.

Telonic® INDUSTRIES, INC.

60 North First Avenue, BEECH GROVE, INDIANA

Representatives in: Baltimore, Boston, Chicago, Cleveland, Dallas, Dayton, Denver, Huntsville, Indianapolis, Los Angeles, New York City, Orlando, Philadelphia, San Francisco, Seattle, St. Louis, Syracuse and principal cities throughout the world.

• SWEEP GENERATORS • RF ATTENUATORS • CW OSCILLATORS • COAXIAL SWITCHES

Circle 248 on reader service card

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January 11, 1965

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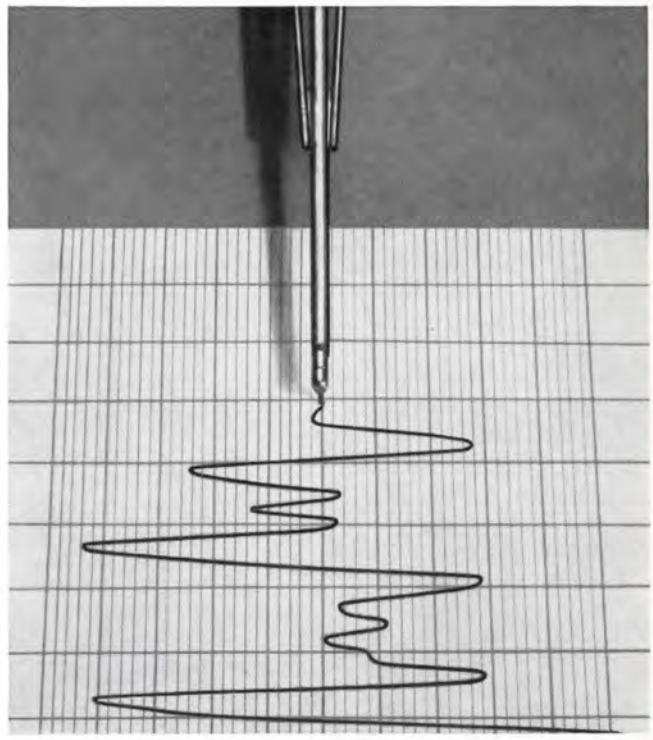


This is a brush Angular Position, Contactless Transducer with 0.1% Accuracy.

It keeps this pen honest.

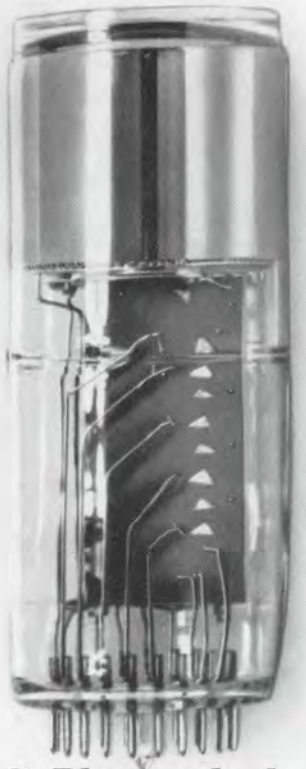
(modern oscillography will never be the same)

This super-sensor is one of several Brush innovations that change previous notions about today's direct writing recording. It's called the Metrisite and helps produce permanent Mark 200 chart records . . . so accurate, so crisp, so readable, so economical . . . you'll never believe it unless you see for yourself. The Metrisite continuously senses the pen position. If the input signal is not precisely matched, instant self-correction is applied . . . and no springs attached! Add a unique pen-linkage that converts rotary motion to a straight line that's 0.1% accurate (this is *true* rectilinear motion) . . . a pressurized ink system that forever eliminates spatter or smear . . . and you'll understand why the rule book of oscillography is changing. Many models are available for many jobs. Your letterhead request will bring the complete, exciting story.

brush INSTRUMENTS

DIVISION OF CLEVITE 37TH AND PERKINS, CLEVELAND 14, OHIO

Circle 901 on reader service card



RCA-C31000 Bi-Alkali Photocathode...2 Nsec Rise Time

UNPARALLELED QE...24% (Typical) @ 3850 Å

10 $\frac{\text{electrons}}{\text{Cm}^2\,\text{Sec}}$ @25°C

RCA now offers a heretofore unobtainable combination of highly desirable photomultiplier characteristics in one tube. Foremost of these attributes are unparalleled high speed and low noise characteristics coupled with high quantum efficiency.

These are just a few of the exciting benefits of RCA's new Photomultiplier—the developmental RCA-C31000. A "universal" type of tube for pulse applications, this 2" photomultiplier has a rise time of less than 2 nanoseconds. In addition, the improvement in the noise characteristic has been demonstrated by the measurement of thermionic emission values as low as 10 electrons cm^{-2} sec^{-1} at 25°C from the photocathode.

This new phototube offers unexcelled QE. For example: RCA-C31000, with its bi-alkali photocathode, has a typical quantum efficiency of 24% at 3850 angstroms. Many S-11 types with CS_3Sb cathodes have a QE of only 16% at 4200 angstroms. And of high importance, its dark current values are improved by as much as three orders of magnitude over S-11 types.

RCA-C31000, already finding application in liquid scintillation counting, time-of-flight measurements, medical equipment, and coincidence counting, has as among its numerous features: Low residual radioactivity envelope • 50 ohm output line to eliminate ringing • Teflon socket supplied, to accommodate base of rigid-pin construction • Uniform collection efficiency • CuBe substrate for stability • 8% (max.) Pulse Height Resolution • Freedom from shock excitation • No after pulse.

For more information on RCA-C31000, or other RCA Photomultipliers, including versions with semi-flexible leads, or potted voltage dividers, see your RCA Representative. For technical data, write: RCA Commercial Engineering, Section K31Q, Harrison, New Jersey.

RCA Electronic Components and Devices

The Most Trusted Name in Electronics