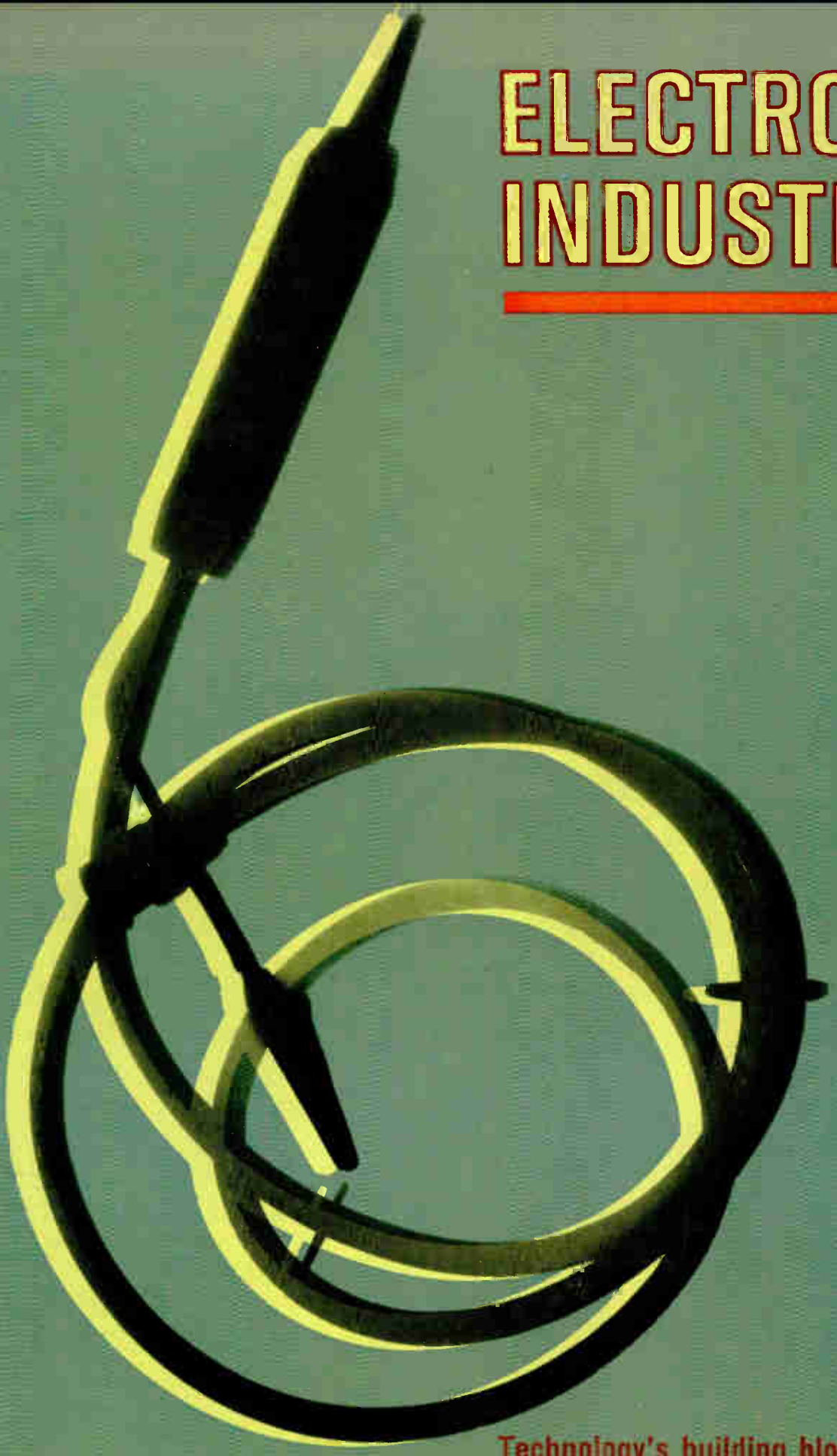
ELECTRONIC INDUSTRIES



Technology's building blocks:–

Measurement • Test • Standards

APRIL 1964

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Check the case dimensions of Dale's new 2100 Series – it's a direct, and competitively-priced replacement for several frequently specified wirewounds with lower power ratings. In both construction and performance, the 2100 is Dale-designed to be the commercial counterpart of RT-11, MIL-R-27208A. Normally an unsealed unit, it can be sealed for just a few cents more – giving you a humidity-proof trimmer equal to the Mil-Spec in all areas except temperature. Right now, you can simplify your design, standards and inventory problems by putting the 2100 Series to work on jobs which you may now be assigning to as many as three *different* trimmers. The price is right – and the delivery is fast.

Write for Catalog B

SERIES 2100 SPECIFICATIONS	
Case Dimensions:	.31 high .28 wide 1.25 long
Standard Models:	2187 – Printed Circuit Pins, 21 AWG Gold Plated 2188 – Stranded Vinyl Leads 2189 – Solder Lug, Gold Plated
Power Rating:	1 watt at 70 C, derating to 0 at 125°C
Oper. Temp. Range:	-65 C to 125 C
Adjustment Turns:	25±2
Standard Tolerance:	±10% standard (lower tolerances available)

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ELECTRONIC INDUSTRIES
The STATE-OF-THE-ART Magazine for Electronic Engineers

EDITORIAL:

THE NEED FOR BETTER MEASUREMENTS

IN THIS ISSUE, ELECTRONIC INDUSTRIES introduces a new section—"Measurement and Test." It is worth taking a few moments to explain why.

The concern of ELECTRONIC INDUSTRIES editorially is with the State-of-the-Art in the many and varied areas of electronic technology. Specifically, we aim to point out the significant problems and what is being done, or can be done, to solve them.

In looking around this industry it soon becomes apparent that in many areas the most important problem is the lack of adequate measuring equipment. The most obvious example is the upper microwave regions, but almost universally there is a demand for more accurate measurements under varying conditions.

Strangely, this is a subject which is sorely neglected in the education of electronic engineers. Engineers are graduating from college with only a passing acquaintance with the basic measuring techniques; hardly sufficient to alert them to the pitfalls that can lead to erroneous data.

In coming issues ELECTRONIC INDUSTRIES will publish articles on proven measurement and test techniques. Some will deal with fundamental measurements; others will cover specialized instrumentation. We shall also include pertinent information on standards and specifications issued by the various government agencies.

One of the editorial goals will be to spell out the limitations of presently available test equipment. It is our experience that too often measurements of circuit parameters are being called for which are impossible at the level of today's State-of-the-Art in measurements. Sometimes it is a matter of the accuracies demanded, other times the conditions under which the measurements are to be made. These problems, and ways of attacking them, will be discussed in this new section.

Parenthetically, it can be pointed out that many military contracts now require not only a statement that the equipment meets specifications, but also a tracing of all measurements, particularly close-tolerance, to approved and certified standards. This type of contract forces designers to guarantee their measuring techniques.

The area of standards needs some clarification, too. Frequently a defense contractor has inadequate standards equipment to meet contract specifications. Engineers then must turn to outside standards laboratories. ELECTRONIC INDUSTRIES will be publishing information on approved laboratory services from time-to-time. We invite those companies with calibration and measurement capabilities "for hire" to notify us of the specific facilities available.

The "Measurement and Test" section begins this month on page 127. It contains two articles, "Scope Adapter for Tunnel Diode Measurements," and "Making Accurate Microwave Power Measurements." Another article, on page 80, discusses Mil-E-6051, on electromagnetic compatibility.

Our cover this month symbolizes electrical and electronic measurement and test. Engineers are constantly "probing" for qualitative and quantitative answers to design problems.

ELECTRONIC INDUSTRIES solicits State-of-the-Art contributions to this new measurement and test section from its engineering readers. Any information you consider pertinent to the solution of problems in the measurement and test area, either general or specific, will be reviewed for possible publication. All published contributions will be paid for. Your suggestions and comments on this section will be welcome.

Did you know Sprague makes...?

MAGNETIC LOGIC DEVICES

Core-diode and core transistor magnetic shift registers and magnetic counters for switching and storage applications in computer and logic circuitry.

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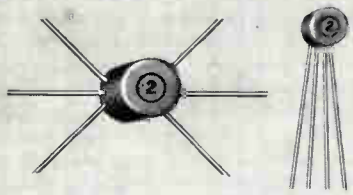

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Designed especially for high-speed, low-power switching up to 100 kc, adaptability with conventional transistor packaging techniques, and performance under MIL-S-21038 environmental conditions.

CIRCLE 135 ON READER SERVICE CARD

ELECTRONIC MODULES TO CUSTOMER REQUIREMENTS

Custom packaging is no novelty at Sprague's Special Products Division, where "specials" are continually being developed and produced with countless variations in electrical characteristics and mechanical configurations.

CIRCLE 137 ON READER SERVICE CARD

For application engineering assistance (without obligation, of course) on any of the above products, write or call the Special Products Division, Sprague Electric Company, 233 Union Street, North Adams, Massachusetts.

485P-111-63 R3

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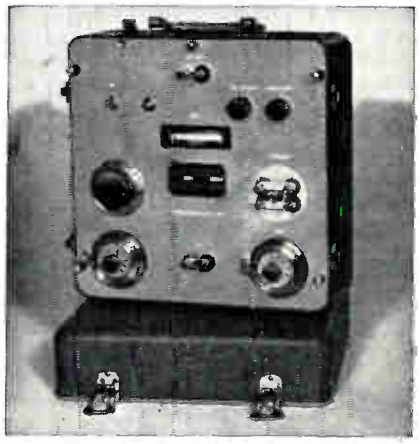
New Bridge Design For Safe, Accurate, Easy Measurement of 'Lytic Capacitors



The Sprague Model 1W2A Capacitance Bridge introduces new, improved technical refinements as well as restyling for added attractiveness and ease of operation. Built *by* capacitor engineers *for* capacitor users, it incorporates the best features of bridges used for many years in Sprague laboratories and production facilities.

Precision Measurements over Entire Range from 0 to 120,000 μF

The internal generator of the 1W2A Bridge is a line-driven frequency converter, and detection is obtained from an internal tuned transistor amplifier-null detector, whose sensitivity increases as the balance point is approached. It has provision for 2-terminal, 3-terminal, and 4-terminal capacitance measurements, which are essential for accurate measurement . . . ±1% of reading + 10μμF . . . of medium, low, and high capacitance values, respectively.

No Damage to Capacitors

The model 1W2A Capacitance Bridge will not cause degradation or failure in electrolytic or low-voltage ceramic capacitors during test, as is the case in many conventional bridges and test circuits. The 120 cycle A-C voltage, applied to capacitors under test from a built-in source, never exceeds *0.5 volt!* It is usually unnecessary to apply d-c polarizing voltage to electrolytic capacitors because of this safe, low voltage.

Complete Specifications Available

For complete technical data on this precision instrument, write for Engineering Bulletin 90,010A to Technical Literature Service, Sprague Electric Company, 233 Marshall Street, North Adams, Massachusetts.

488P-128-63

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April 1964, Vol. 23, No. 4

ELECTRONIC INDUSTRIES

The STATE-OF-THE-ART* Magazine for Electronic Engineers

COVER

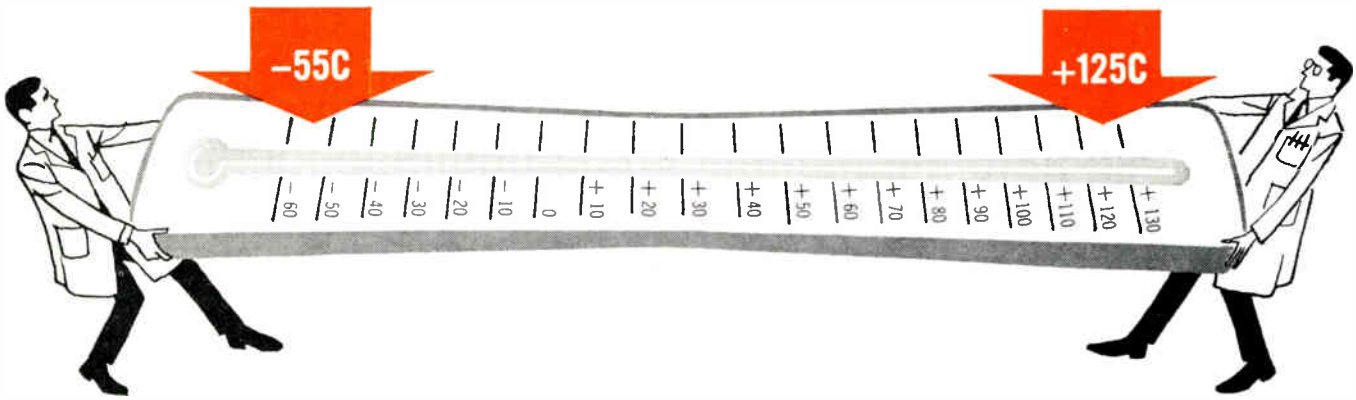
In this issue, we introduce a new section, "Measurement and Test." The probe on our cover, which finds use with so many different types of electronic test equipment, illustrates the wide range of measuring techniques that will be described in forthcoming issues.

*STATE-OF-THE-ART: up-to-the-moment capability in each area of electronic technology

BPA NBP

DEPARTMENTS

New from Sprague!



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VOLTAGE RATINGS TO 150 VDC. unlike other so-called "wide temperature range" aluminum electrolytics with compromise voltage ratings only to 60 volts.

CAPACITANCE STABILITY over entire temperature range. Even at −55 C, capacitance drop is very small.

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ELECTRONIC INDUSTRIES HIGHLIGHTS

THE GOVERNMENT ELECTRONICS MARKET 38

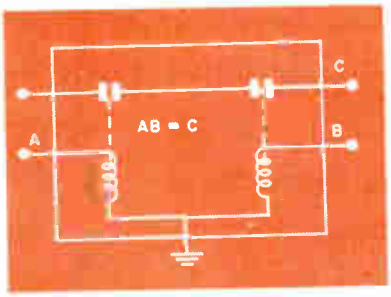
What are the problems involved in obtaining electronic development contracts from the government? What is the proper method of approaching the various Government technical agencies? How are proposal funds obtained? These and other important questions are answered for the engineer.

NEW DEVELOPMENTS IN MICROCIRCUIT PACKAGING 56

The significant progress being made is largely confined to four major types of packaging—Micromodule, Dot, Hybrid, and integrated Systems. The wide range of variations poses problems in choosing which one to use. A possible clue lies in the different construction techniques.

CONVERTING DIGITAL DATA TO VOICE 84

The advent of the dry reed relay greatly advanced the state-of-the-art in switching design. Reed relay logic modules are being successfully used in systems not adaptable to semiconductor or tube logic. The conversion of digital information to voice described here, is a good example.



MAKING ACCURATE MICROWAVE POWER MEASUREMENTS 126

A combination of available calibration services and modern equipment have made possible microwave power measurements with accuracies within 1½% under favorable conditions, and around 3% in worst cases. These services, equipment and the methods used are discussed here.

WHERE ARE ELECTRONIC ENGINEERS GOING? 142

Going back to school is a growing 'must.' A corner of the employees' training division is often a post-graduate classroom. Many electronic engineers are stepping over into management. Others are giving civil service a try. Current job outlook may not be promising. The long-range future may hold a different story.

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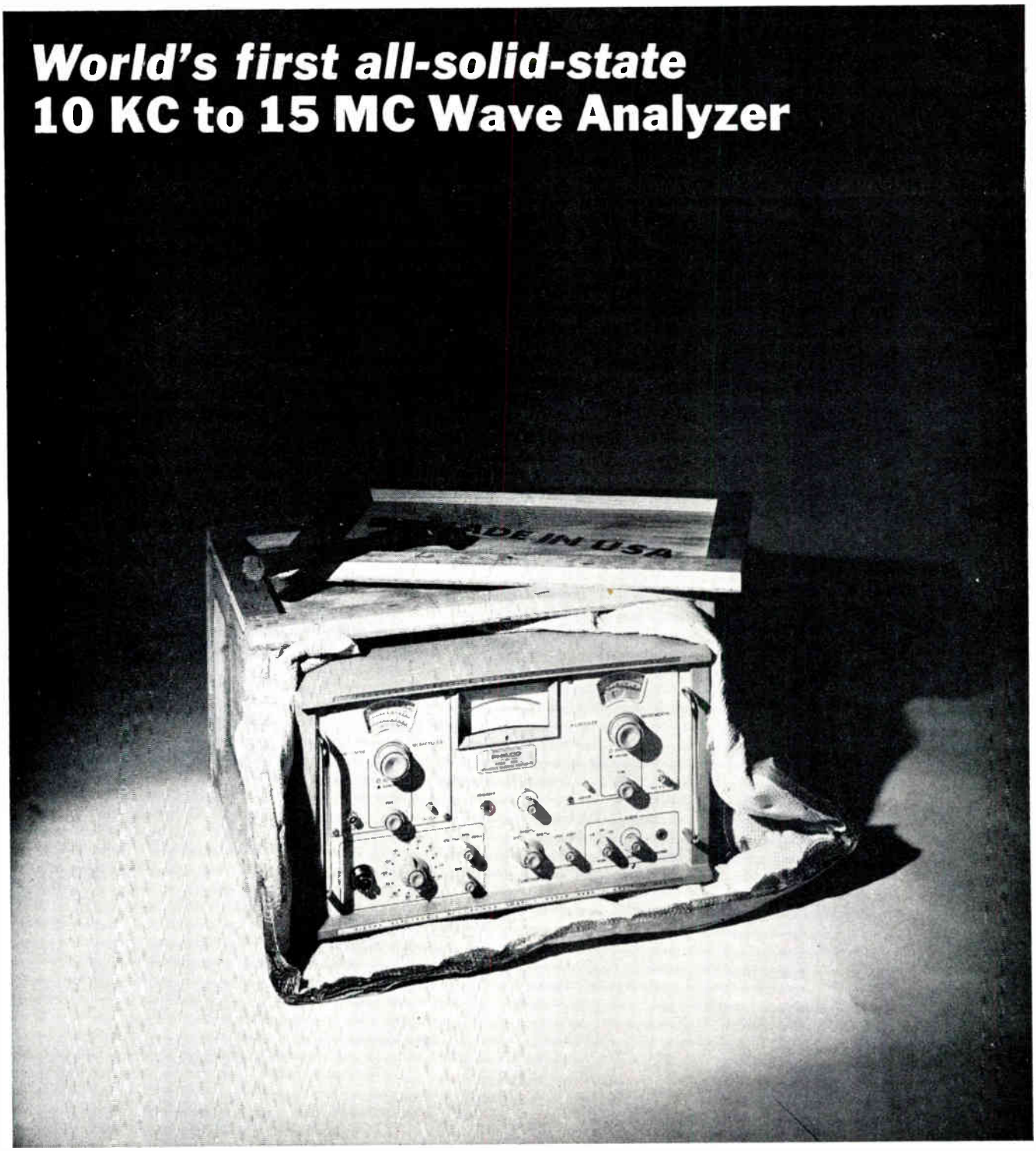

Up to now you had to look outside the U.S.A. for a wave analyzer to fit this billing. Except you'd never find an all-solid-state model. Because there weren't any until Sierra's new Model 128A Extended Range Wave Analyzer came along. □ Now you'll be seeing more and more Sierra Wave Analyzers at work in carrier communications terminals, in microwave repeater stations, and in R&D labs. That's because Model 128A's specs, taken as a view of total performance, exceed those of any other wave analyzer made in the world today. You'll find the specs in a newly published product bulletin, available now from Sierra. Or, a word to your Sierra sales representative could produce both the bulletin and a date for a product demonstration.

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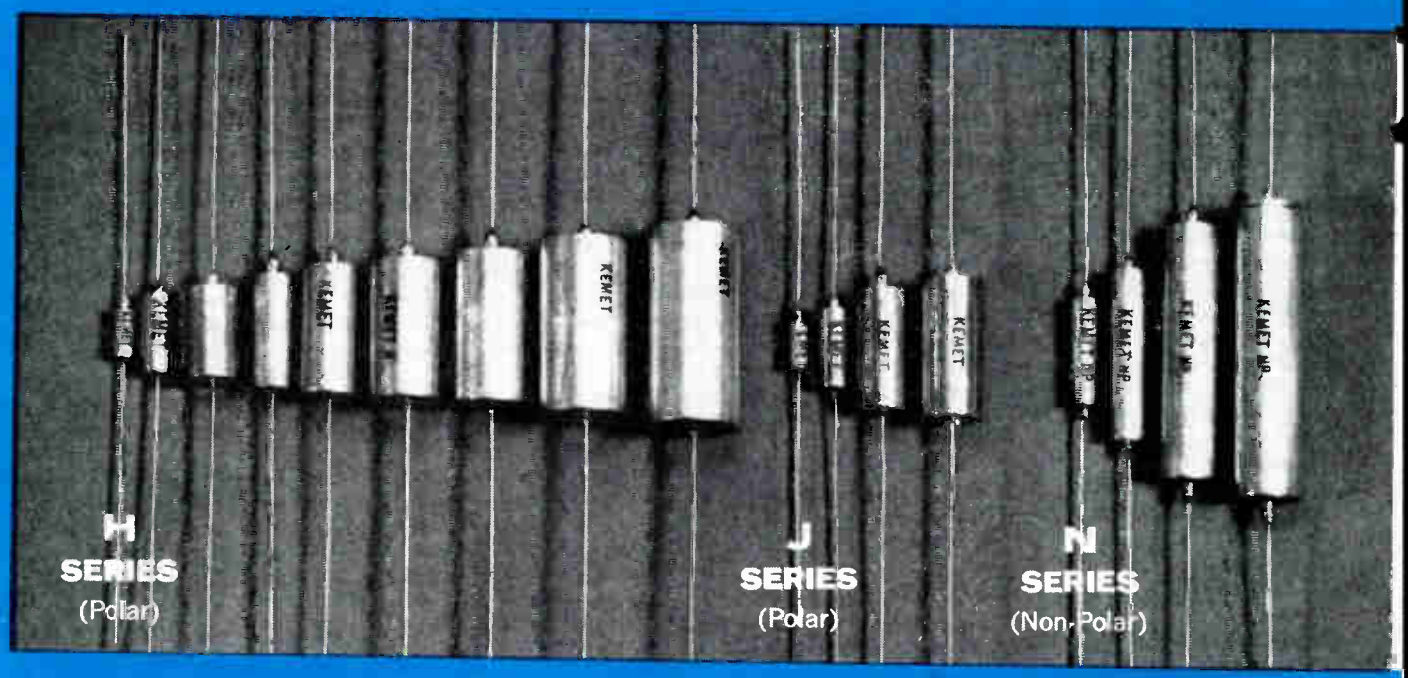

CASE SIZES (Left to Right)	A, B, E, F, G, H, J, K, L	A, B, C, D	AA, BB, CC, DD	
CAPACITANCE RANGE (Standard E.I.A. Values)	0.33 to 330 microfarads (±5%, ±10%, ±20% tolerance)	.0047 to 330 microfarads (±5%, ±10%, ±20% tolerance)	.0024 to 160 microfarads (±5%, ±10%, ±20% tolerance)	
WORKING VOLTAGES	6, 10, 15, 20, 35, 45, 50 (Voltages up to 100 also available on request)	6, 10, 15, 20, 35, 50, 60, 75, 100	6, 10, 15, 20, 35, 50, 60, 75, 100	
OPERATING TEMPERATURES	Continuous from −80°C to +125°C (No derating required at 85°C)	Continuous from −80°C to +125°C (No derating required at +85°C)	Continuous from −80°C to +125°C (No derating required at +85°C)	
DC LEAKAGE CURRENT	Typically $I_L \leqq 0.01$ microamperes per microfarad volt	Typically $I_L \leqq 0.01$ microamperes per microfarad volt	Typically $I_L \leqq 0.01$ microamperes per microfarad volt	
DESIGN FEATURES	Hermetically sealed in nine corrosion-resistant, seamless metal cases with solderable or weldable leads. Meet or exceed MIL-C-26655/1B, Styles CS 14 and CS 15.	Dry, sintered anode encapsulated in ultra-small solder-coated brass case with glass-to-metal end seal. Conform to MIL-C-26655/2C, Styles CS 12 and CS 13.	Each unit consists of two polar J-Series capacitors electrically and mechanically connected back-to-back and supported by an outer corrosion-resistant metal sleeve.	
PRINCIPAL APPLICATIONS	Wide variety of commercial and military uses where dependable performance is a prime requisite, such as: transistor amplifiers, R-C timing circuits, analog computers, triggering circuits, and power supplies.	Miniaturized circuitry; especially suited for power supplies, transistor amplifiers, and R-C timing circuits. Top performance at extreme temperatures and under severe mechanical stresses.	Servo systems, phasing of AC motors, tuning low-frequency circuits, and other applications where reversal of polarity is a consideration.	
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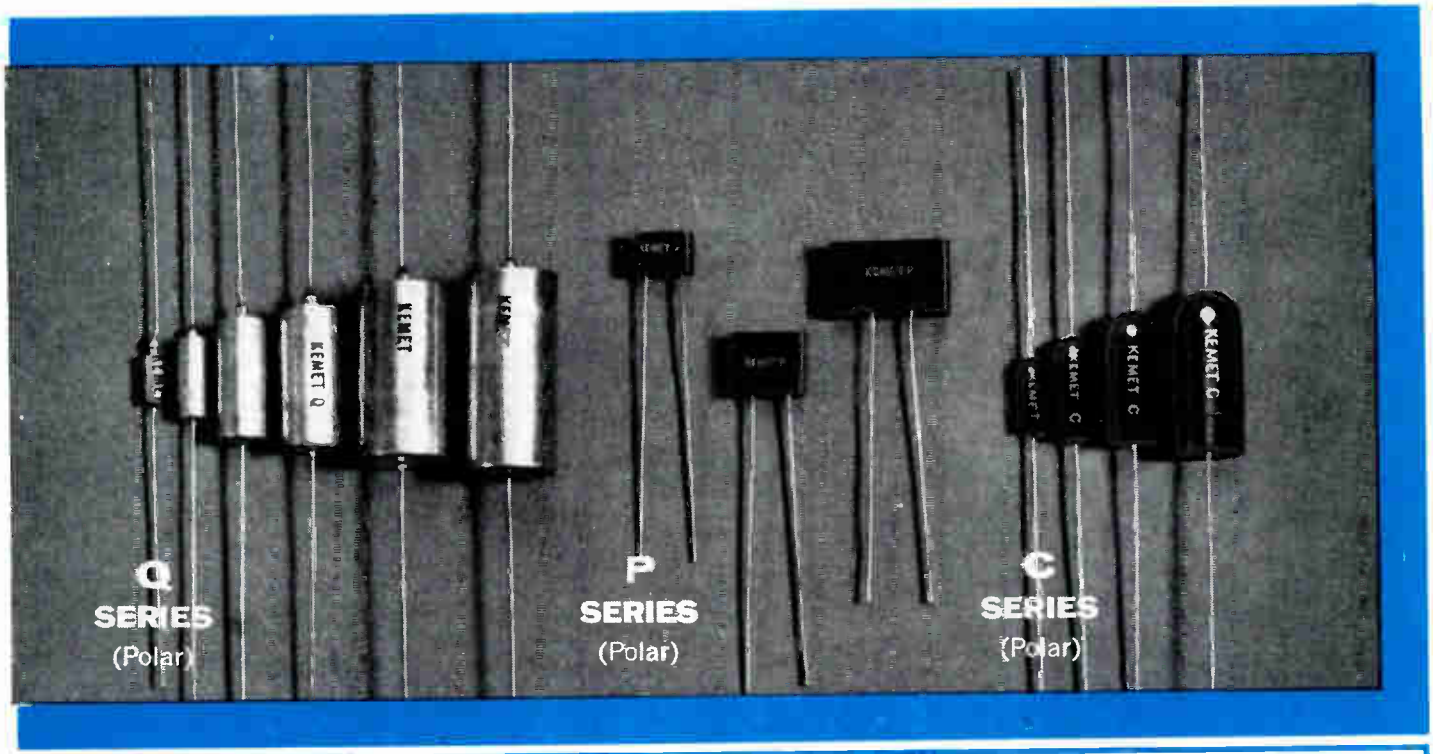

	A, B, C, D, K, L	X, Y, Z	A1, B1, C1, D1
	.015 to 330 microfarads (±5%, ±10%, ±20% tolerance)	.10 to 220 microfarads (±5%, ±10%, ±20% tolerance)	.10 to 330 microfarads (±5%, ±10%, ±20% tolerance)
	6, 10, 15, 20, 35, 50	6, 10, 15, 25, 35, 50 (Voltages up to 75 also available on request)	6, 10, 15, 20, 35, 50, 75 (Voltages up to 100 also available on request)
	Continuous from −80°C to +125°C (No derating required at +85°C)	Continuous from −55°C to +85°C (Without voltage derating)	Continuous from −55°C to +85°C (Without voltage derating)
	Typically $I_L \cong 0.001$ microamperes per microfarad volt	Typically $I_L \cong 0.01$ microamperes per microfarad volt	Typically $I_L \cong 0.01$ microamperes per microfarad volt
	New concept in solid tantalum capacitor manufacture for better reliability—built-in by voltage derating technique.	Compact rectangular-shaped anodes, epoxy-molded. Excellent moisture resistance and dielectric properties. Molded-in polarity symbol. Recessed slots permit easy removal of soldering flux at solder joint.	Economically-priced, epoxy-molded shape adaptable to welded module construction or conventional point-to-point wiring, also automatic insertion equipment. Save up to 88% in capacitor space as compared with aluminum electrolytics of equivalent electrical value.
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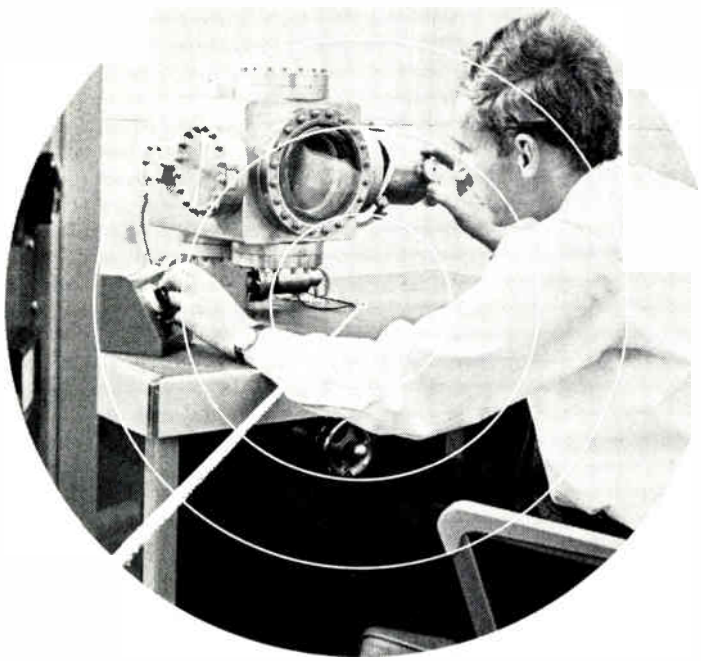
ELECTRONIC INDUSTRIES RADARSCOPE

Analyzing current developments and trends affecting the State-of-the-Art of technologies throughout the electronic industries



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First commercial instrument for low energy electron diffraction studies of the surfaces of solids as oresented by Varian Associates. Heart of instrument is high vacuum chamber, which includes electron source, holder to position study material, and fluorescent screen. The Varian system can maintain pressures as low as 5 x 10^{-10} torr.

MICROWAVE AND LASER TECHNIQUES are not yet practical for flight vehicle power subsystems, Air Force researchers state. The Air Force has just completed a study and has issued a report on the feasibility of using microwave methods and lasers for transmitting flight vehicle power between two points in space. The overall efficiency of lasers must be improved by about two orders of magnitude. Cooling requirements must be drastically reduced before lasers are attractive as a flight power subsystem, researchers say.

COLD TUNNEL CATHODES for microwave tubes have been made by engineers at Stanford Research Institute. Developed for the Air Force, engineers report that the cathodes have longer life and lower noise than any other. Called metal-insulator-metal (M-I-M) capacitor cold cathodes, tests showed no fundamental limit on noise reduction. According to SRI engineers, limits on efficiency and current density are believed to be well understood. M-I-M cathodes should have indefinite life once problems of materials are solved.

NEW PARAMETRIC AMPLIFIER for use on VHF and UHF bands may extend working range of VHF and improve quality of TV from the new 4 and 5-band stations. Developed by Production Engineering Research Association of Great Britain (PERA) the amplifier uses a computer diode as a parametric device and a new type of transistor as a pump source. Instead of a distributed circuit, the unit employs a special lumped circuit. PERA engineers report "excellent results operating in non-degenerative mode at 145 mc. Internal noise factor did not exceed one decibel over a two-mc band width. Gain factor—17 decibels.

POLAR DISPLAY TECHNIQUE can be made more simple and less costly by using Hall effect multipliers, reports engineer Glen H. Smerage, Sylvania Electronic Systems. It could improve reliability of nearly any polar display, including those used in sonar, direction-finding and in plan-position indicators for radar. In standard electro-mechanical systems, a signal must go through lengthly circuits and processing before it appears on the screen. Mr. Smerage said use of Hall effect multipliers will reduce *middle-man* circuitry. It will permit simpler, all-electronic display systems with high accuracy.

REAL-TIME TELEMETRY DATA has been displayed with success at Marshall Space Flight Center, according to engineers of Dynatronics, Inc., Orlando, Fla. Time lapse between transmission from Saturn I and appearance of data on Huntsville X-Y plotters was put at 15 seconds. The entire system at Marshall is made up of combined outputs from receiver equipment built by other firms for NASA plus a Dynatronics PCM receiver station. Combined data was channeled through an on-line real-time display system designed by the Orlando firm for NASA.

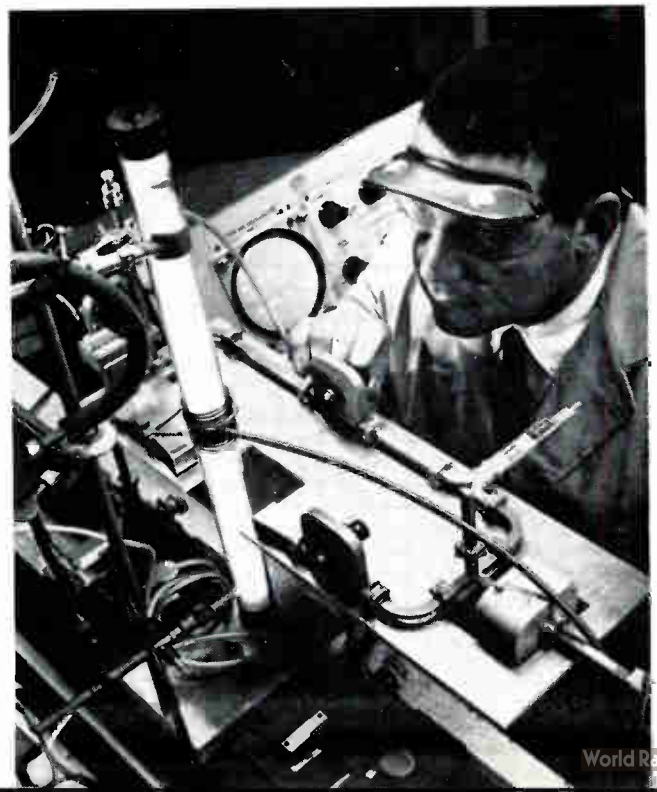
SATELLITE COMMUNICATIONS was the most significant development of 1963 in the field of communications, according to E. William Henry, Chairman of the FCC. Member nations of the International Telecommunication Union saw benefits that could result. They set aside frequencies needed for the success of the program. Comsat, to own and work the American part of the system, is working out technical needs and international arrangements. Further tests with *Telstar, Relay* and *Syncom* show promise toward reliable and economic communications. Mr. Henry noted stepped-up educational TV; more than 80 stations were working by year's end. In non-broadcast radio, the FCC now lists nearly 1.3 million licensees who operate more than 4 million transmitters.

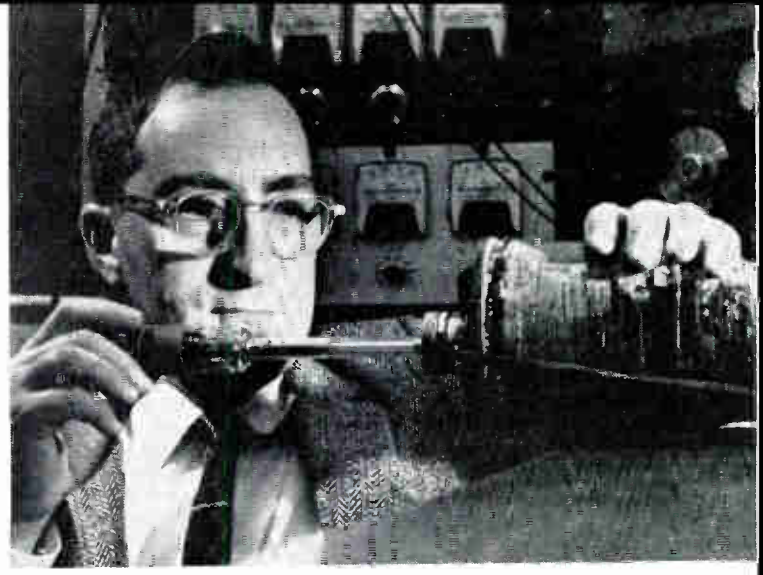
PRECISION TUNING TECHNIQUE has allowed Bell Telephone Laboratories to reach a frequency accuracy of 2/100 of 1% for a tantalum thin film "notch" filter. The filter is a twin-T network of passive components that nearly rejects all of a particular frequency when it is properly tuned. Circuit is made from resistors, capacitors, and interconnections formed by photoetching a tantalum film sputtered onto a glass substrate. Film is anodized to produce capacitor dielectrics and resistor values. Capacitor counterelectrodes are made from evaporated gold. Tuning is done by a series of measurements and precise adjustment of resistance values by anodizing.

REMOTE RADIOMETRY IN METEOROLOGY to improve weather forecasting here and to aid planet probes, has been disclosed by Geophysics Corp. of America. Dr. J. I. F. King, physics research head at GCA, said the principle is a mathematical study of imbedded atmospheric heat sources detected by IR sensors aboard spacecraft. With this state-of-the-art upgrading, meteorological inferences can be taken of atmospheric aspects once hard or impossible to get. Some of these are: concentration of water vapor, carbon dioxide and ozone. Another is, zone of atmospheric instability; also listed is pressure at the surface or tops of clouds. Through use of the principle in MARINER II, we know many things about Venus.

PLASMA-MICROWAVE INTERACTION

Basic research on plasma and interaction with microwave energy is being done at Westinghouse Defense and Space Center. Here argon plasma at 500 μ pressure is maintained by a pulsed discharge between end electrodes of glowing tube. Energy from klystron operating at 35 GC and 20 mw is transmitted through ionized gas.





TECHNIQUE REDUCES STATIC

Dr. Jacob M. Hammer, RCA Laboratories, inserts standard traveling-wave tube, used to amplify microwaves, into magnetic solenoid in new technique that reduces static and noise in such components to the lowest levels ever reported. Development may lead to much improved radar, radio astronomy, communications and counter-measure devices.

FILTER MODULATOR FOR LASERS, variable and compact, has been disclosed by Sylvania Electric Products, Inc. Hold-in-the-hand size, the unit needs less than one watt of power; or 1/250th the power needed for present modulators used in high data rate systems. The broadband device was designed for the Air Force, according to Wilson Boothroyd, Associate Director, Sylvania Laboratories in Buffalo, N. Y.

TWO MICROWAVE DIODES, with high sensitivity, are being tested by the Army's Harry Diamond Laboratories. Intended as electromagnetic radiation detectors, one diode, 1N830, is designed for high level use near 100 mc. The other, 1N833, is classed as a low level X-band detector. Tests were done to determine static characteristic, and measurement of RF impedance at low power levels from 250 mc to 4000 mc. Tests also were conducted to determine tangential signal sensitivity over the same frequency range. Test results, contained in a report supplied by the Department of Commerce, will be used to develop a similar series of detectors.

ENGINEERING AND SCIENTIFIC STAFFS should be retained by Congress as well as by other parts of the government, according to Paul H. Robbins, Executive Director of National Society of Professional Engineers. House Administration Committee is looking for ways to keep Congress better informed on various states-of-the-art in science and technology. Mr. Robbins suggests a Joint Congressional Committee on Engineering and Science. The group would include chairmen of Congressional groups concerned with Federal R&D. Its technical staff would be headed by one of high repute in science or engineering

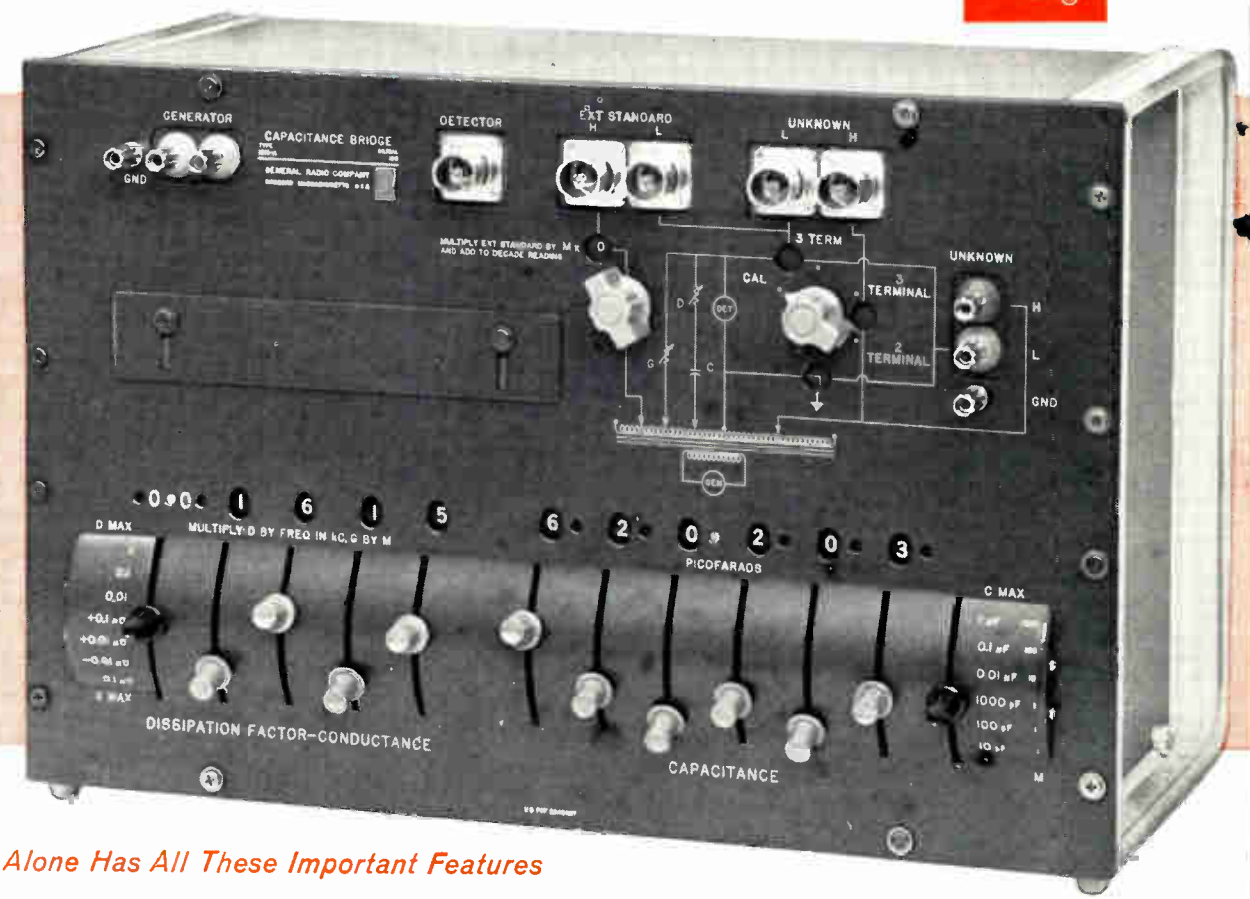
(More RADARSCOPE on Page 13)

The Most Precise Capacitance Bridge You Can Buy

0.01% Direct-Reading Accuracy

TYPE 1615-A Precision Capacitance Bridge Price... $1475 in U.S.A.

Type 1615-P1 Range Extension Capacitor, **$35.**



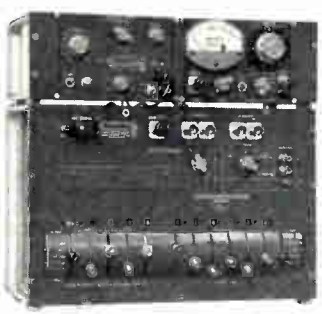
This Bridge Alone Has All These Important Features

1. **Wide Measuring Range** . . . Capacitance; 10 μpf to 1 μf; to 10 μf with plug-in Type 1615-P1 Range Extension Capacitor. Dissipation Factor, 0.000001 to 1 at 1 kc; Conductance, 10^{-6} μmho to 100 μmho.
2. **Excellent Resolution** . . . Six significant figures, seven significant figures with external standards; at least ten times better than any other capacitance bridge.
3. **Wide Frequency Range** . . . From 50 cps to 10 kc.
4. **Excellent Stability** . . . Better than 50 ppm per year. Fixed standards made from low-temperature coefficient Invar alloy are hermetically sealed in dry nitrogen. Temperature coefficient less than 5 ppm/°C.
5. **Easy to Use** . . . Lever balancing controls, digital readout, automatic decimal point location, and units indication. Both coaxial and binding-post terminals with switching for either two- or three-terminal measurements of a variety of capacitors.
6. **Ideal for Intercomparison Measurements** . . . Fast, one-step intercomparisons of three-terminal capacitors differing in value by as much as 10,000 to 1 can easily be made.

NEW **1000-pf THREE-TERMINAL REFERENCE STANDARD CAPACITOR**

Same Invar-alloy construction as in the 1615-A Bridge. Sealed in dry nitrogen to eliminate effects of altitude and humidity. Adjusted to ± 5 ppm of nominal value at 23°C and 1000 cps to NBS calibrated standards. Temperature coefficient is 2 ± 2 ppm/°C from −10° to 60°C. D is less than 1×10^{-5}.

Type 1404-A, $225



Complete **CAPACITANCE MEASURING ASSEMBLY.**

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 1μv; and the new Type 1311-A Bridge Oscillator, with 11 fixed frequencies from 50c to 10 kc. Price for the complete assembly is $2065.

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

IN CANADA: Toronto 247-2171, **Montreal** (Mt. Royal) 737-3673
IN EUROPE: General Radio Overseas, Zurich, Switzerland

NEW YORK, N. Y., 964-2722 (Ridgefield, N. J.) 943-3140 | **CHICAGO** (Oak Park) 848-9400 | **PHILADELPHIA,** 424-7419 (Abington) 887-8486 | **WASHINGTON, D.C.** (Rockville, Md.) 946-1600 | **SYRACUSE** 454-9323 | **DALLAS** FL 7-4031 | **SAN FRANCISCO** (Los Altos) 948-8233 | **LOS ANGELES** 469-6201 | **ORLANDO, FLA.** 425-4671 | **CLEVELAND** 886-0150

Circle 6 on Inquiry Card

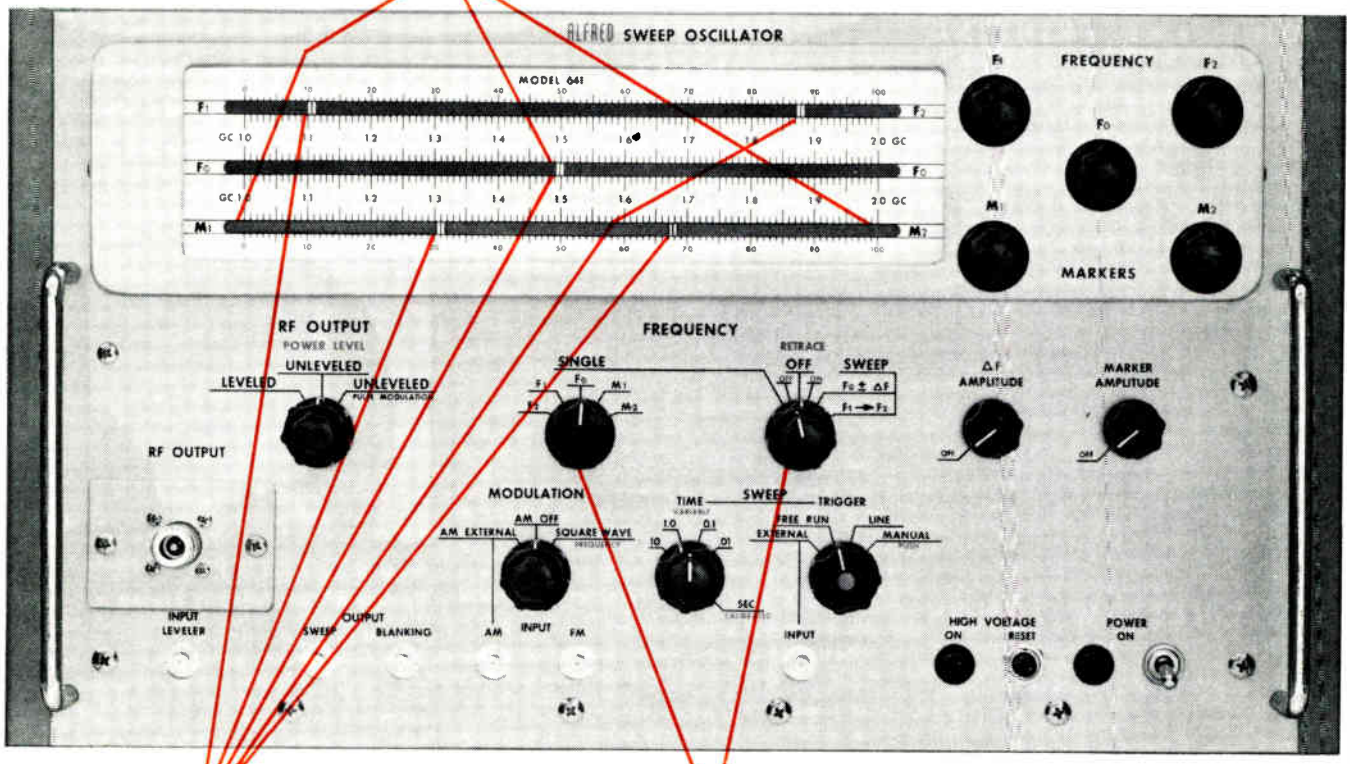
RADARSCOPE

HIGH SPEED PRINTING SYSTEM, using seven million tiny light pipes in a fiber optics faceplate, now makes rocket test data ready in seconds that once took many hours. Designed jointly by General Dynamics and Jet Propulsion Laboratory for the Air Force, the system can put out more than 10,000 words per second, or as much as 71,000 figures per second. Fiber optics faceplate is embedded in the screen of a special CHARACTRON CRT. Beams pass through tube's 64 apertures and take on shape of figures or symbols.

NEW HELIUM - XENON LASER that will penetrate atmospheric absorption and optical interferences adds to laser state-of-the-art. Evolved by Raytheon Co., the gas laser works at 3.51 microns, near middle of IR region. The laser, with power supply, weighs less than 10 lbs. It is powered by 117 rms @ 60 cps. With modulator circuit, voice contacts are possible. Output power is about 0.25 mw. Diverting of beam is only 20 minutes of arc, uncollimated. Bandwidth is 110 mc.

NEW ELECTRON MICROSCOPE TECHNIQUE shown at Britain's Institute of Physics and Physical Society exhibition. Technique includes first Stereoscan Electron Microscope prototype made by Cambridge Instrument Co., Ltd., London. The microscope is said to be suited to examining rough surfaces. It provides consistent resolution of better than 500 Å. Adjustments are reproducible for any object up to 1 cm. across and several mm. thick. Primary electron beam from heated tungsten filament is focused finely on specimen. Beam is made to scan surface by special coils and circuits. A scintillation counter collects electrons from the sample.

Multiple frequency markers allow frequency calibration with 3 markers during broadband sweep and 2 during symmetrical sweep.



Five single frequency settings simplify and speed component evaluation. Choose stable, clean CW or modulated single frequencies at F_1, F_2, F_0, M_1, and M_2. Sweep for qualitative analysis and measure precisely at end frequencies (F_1, F_2) and 3 intermediate frequencies (F_0, M_1, M_2).

Complete sweep flexibility. $F_1 \rightarrow F_2$ sweep for broadband evaluation. $F_0 \pm \Delta F$ symmetrical sweep for expanded display.

Separate F_0 control independent of $F_1 \rightarrow F_2$ allows switching from broadband sweep to symmetrical sweep without "disadjusting controls."

New Sweep Oscillator, 1 to 40 Gc

This is the face of the new Alfred 1 to 40 Gc sweep oscillator. Alfred 640 Series Sweepers offer the cost-conscious engineer the best price-performance ratio.

Features include: internal or external leveling with wide control range, retrace blanking at all sweep speeds for scope or recorder operation, accurate manual sweep, solid state design, 50 to 400 cps operation, ruggedized construction.

Ask your Alfred representative for a demonstration.

	Frequency Range	Power Output	Leveled Power Variation	Residual FM	Price
641	1 - 2	100 mw	*	25 kc	$3,050
641K	1 - 2	70 mw	±0.5 db	50 kc	$3,290
642	2 - 4	70 mw	*	25 kc	$2,850
642K	2 - 4	50 mw	±0.5 db	50 kc	$3,090
643	4 - 8	20 mw	*	50 kc	$2,850
643K	4 - 8	20 mw	±0.5 db	75 kc	$3,190
645	8 - 12.4	20 mw	*	75 kc	$2,990
645K	8.2 - 14.4	10 mw	±0.75 db	100 kc	$3,390
647	12.4 - 18	10 mw	—	100 kc	$3,350
648	18 - 26	5 mw	—	300 kc	on request
649	26 - 40	5 mw	—	350 kc	on request

*Output may be leveled with external Alfred RF Samplers or directional coupler and crystal detector.

Sweeps	Broadband, 2% to 100% of full range. Symmetrical, 0 to ±5% about center frequency F_0. Manual, proportionate sweep voltage with F_0, M_1, and M_2 provided
Sweep Time	10 msec to 100 sec
Sweep Trigger	External; free running; line; manual (single sweep)
Amplitude Modulation	Internal 800 to 1200 cps square wave; external
Single Frequency Control	F_0, F_1, F_2, M_1, and M_2 continuously adjustable, panel switch selected
Frequency Stability	Better than 0.01% per degree C
Frequency Marker	Three markers M_1, M_2, and F_0 adjustable over entire range.

ALFRED ELECTRONICS

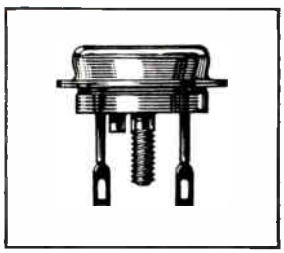
3176 Porter Drive • Stanford Industrial Park • Palo Alto, Calif.
Phone: (415) 326-6496

reliability achievement **99.9999**

reliability requirement **99.997**

.0029

ON THE MATTER OF SURPLUS RELIABILITY



For its participation in the Minuteman program, Delco Radio contracted to produce a high power germanium transistor that was reliable to .003%/1,000 hours.

Twenty months and 54 million transistor test hours later, the failure rate objective was achieved. Ahead of time. The device was being supplied in production quantities.

Delco continued its investigation of the failure modes. High stress tests—pulse life, helium bomb, thermal shock, high-intensity vibration—were intensified. Tons of computerized data accelerated the test program.

Television monitors probed the growth of base material. A new process, surface passivation and ambient control, was developed to stabilize crystal environment.

Currently this power transistor and its family have a failure rate of .0001%/1,000 hours. Also, the device tests favorably at temperatures of 135-150° C.

What we have learned from our experience on Minuteman has been applied to all our semiconductor devices. Car radio transistors, for instance. 3 million a year. And silicon rectifiers, 150,000 daily.

Come to the high volume people for high confidence level reliability.

DELCO RADIO

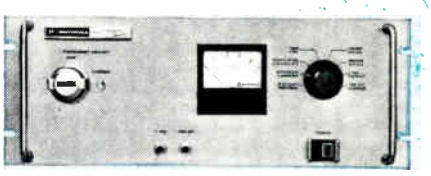
DIVISION OF GENERAL MOTORS, KOKOMO, INDIANA

• Measurement of Parts in 10^9	• Measurement of Parts in 10^{10}	• Measurement of Parts in 10^{11}	• To expand your Standards Lab anywhere in the plant or field.
* VLF Receiver Frequency Std.	VLF Receiver Phase Comparator	VLF Receiver Phase Comparator	Portable Frequency Std.
Frequency Error Expander	1010 Frequency Std.	1011 Frequency Std.	
Digital Counter	Frequency Error Expander	Frequency Error Expander	
*AUTOMATICALLY CALIBRATED FREQUENCY STANDARD	Digital Counter	Digital Counter	
	Strip Chart Recorder	Strip Chart Recorder	

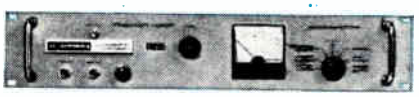
NEW... from Motorola a complete

FREQUENCY STANDARDS LAB

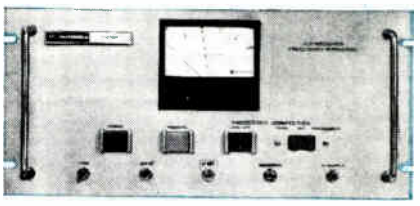
All Solid State MOTOROLA PRECISION FREQUENCY INSTRUMENTS can be assembled to provide a Frequency Standards Lab fitted to your accuracy requirements. The lab contains a high stability oscillator corrected to NBS or Navy time signals by the VLF receiver. These units are coupled to the Frequency Error Expander/Counter combination to allow calibration of your frequency instruments to parts in 10^9 in 1 second or parts in 10^{10} in 10 seconds with direct digital readout. The recorder provides a permanent phase plot of the oscillator vs. the VLF signal to accurately set the oscillator on frequency. The Motorola frequency instruments with guaranteed specifications can be assembled to the lab of your choice as shown in the examples above. **For complete operating specifications on these versatile precision instruments, contact your Motorola Instrument Representative (listed in EEM Directory)—or write for Full Fact Kit, Dept. AEI 414**



Motorola 1011 Frequency Standard
$1x10^{-11}$ Setability. Less than $5x10^{-11}$ Aging Per Day and Short Term Stability, 1 Second Counts • True proportional control double oven construction • Complete oscillator circuitry in inner oven • Selected, pre-aged 2.5 mc 5th overtone crystals • Digital reading **linear** fine frequency adjust • Solid state silicon design • Includes 15 hour internal battery • Model S1065AR $3,950 • Model S1066AR with spectrally pure 5 mc output $4,335

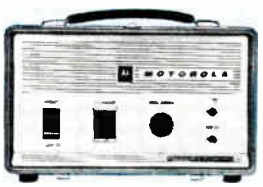


Motorola 1010 Frequency Standard
$1x10^{-10}$ Setability • Less than $5x10^{-10}$ Aging Per Day and Short Term Stability, 1 Second Counts • Proportional controlled double oven • Selected, pre-aged precision 3 mc crystal • Zener regulation • Silicon transistors • Output frequencies: 1 mc and 100 kc at 1 volt RMS • Digital reading **linear** fine frequency adjust • New smaller size—3½" high • Spectrally pure 5 mc output and 10 kc to 1 cps pulse outputs optional • Model S1069AR $1,950 • Internal battery $285.00 • Spectral purity $385.00



Motorola VLF Receiver Frequency Standard
The first and only complete solid state standard that automatically corrects its $1x10^{-9}$ or $5x10^{-10}$ day local oscillator to VLF stations. With transmissions from NBS or the Navy, you get long term stability for lab requirements that otherwise cannot be provided. Precise no-drift standard. Automatic servo phase shifter. Model S1055A $5,850 • VLF Receiver Phase Comparator (to phase plot 1010 or 1011 Standard) Model S1055C $4,250

Motorola Frequency Error Expander
This unit offers the unique ability to multiply the difference between an input frequency and a reference frequency by a factor of 10,100 and 1000, allowing direct, accurate frequency comparisons to be made quickly on a digital counter. On a 1 second count, measuring resolution is parts in 10^9 on a 10 second count, parts in 10^{10}. Use for short and long term stability measurements, and calibration of frequency standards, precision oscillators and frequency counters. Model S1061AR $1,500.



Motorola Portable Frequency Standard
This versatile Frequency Standard operates on battery or AC, serves your instrument calibration needs in the field . . . in production . . . and in the lab • Stability of $5x10^{-10}$ (S1054AH) and $1x10^{-9}$ per day (S1054AL) • 1 mc and 100 kc simultaneous outputs • Completely Solid state circuit • Fine frequency adjustment parts in 10^{10} • Model S1054AL $1,600 • Model S1054AH $1,800 • Model SLN 6076A 24-hour battery kit $300

MOTOROLA PRECISION FREQUENCY PRODUCTS

Motorola Communications & Electronics Inc. 4501 Augusta Boulevard, Chicago, Illinois 60651 • A Subsidiary of Motorola Inc.

COMING EVENTS

APRIL

Apr. 12-17: 95th Tech. Conf. of Soc. of Motion Picture & TV Engineers, SMPTE; Ambassador Hotel, Los Angeles, Calif.

Apr. 13-15: Annual Mtg. & Expos. of Inst. of Environmental Sciences; Sheraton Hotel, Phila., Pa.

Apr. 21-22: Int'l Symp. on Rotating and Static Precision Components, Bureau of Naval Weapons; Washington, D.C.

April 28-30: 12th Annual Nat'l Relay Conf.; Oklahoma State Univ., Stillwater, Okla.

MAY

May 4-6: 10th Nat'l Aerospace Instrumentation Symp., ISA; Biltmore Hotel, New York, N. Y.

May 4-6: Annual Mtg. & Tech. Conf., Region III, IEEE; Jack Tar Harrison Hotel, Clearwater, Fla.

May 5-7: Electronic Components Conf. (ECC), IEEE, EIA; Marriott Motor Inn, Washington, D. C.

May 7-8: S.E. Textile Industry Conf., IEEE; Atlanta, Ga.

May 11-13: NAECON (Nat'l Aerospace Electronics Conf.), PTG-ANE, Dayton Sec., AIAA; Biltmore Hotel, Dayton, Ohio.

'64-'65 Highlights

WESCON, Western Electronic Show and Conv., Aug. 25-28, IEEE WEMA; Sports Arena, Los Angeles, Calif.

Nat'l Electronics Conf., Oct. 19-21, IEEE, et al; McCormick Place, Chicago, Ill.

NEREM, Northeast Research & Eng. Mtg., Nov. 4-6, IEEE; Boston, Mass.

IEEE Int'l Conv., Mar. 22-25; Coliseum, New York Hilton, New York, N. Y.

May 11-14: Design Eng. Show & Conf., ASME; McCormick Place, Chicago, Ill.

May 18-20: Electronic Parts Distributors Show; Conrad Hilton Hotel, Chicago, Ill.

May 19-20: Nat'l Appliance Technical Conf., IEEE; Ben Franklin Hotel, Phila., Pa.

May 19-21: Int'l Symp. on Microwave Theory and Techniques, PTG-MTT; Int'l Inn, Int'l Airport, Idlewild, N. Y.

May 20-22: Pulp & Paper Industry Conf., IEEE; Netherland Hotel, Cincinnati, Ohio.

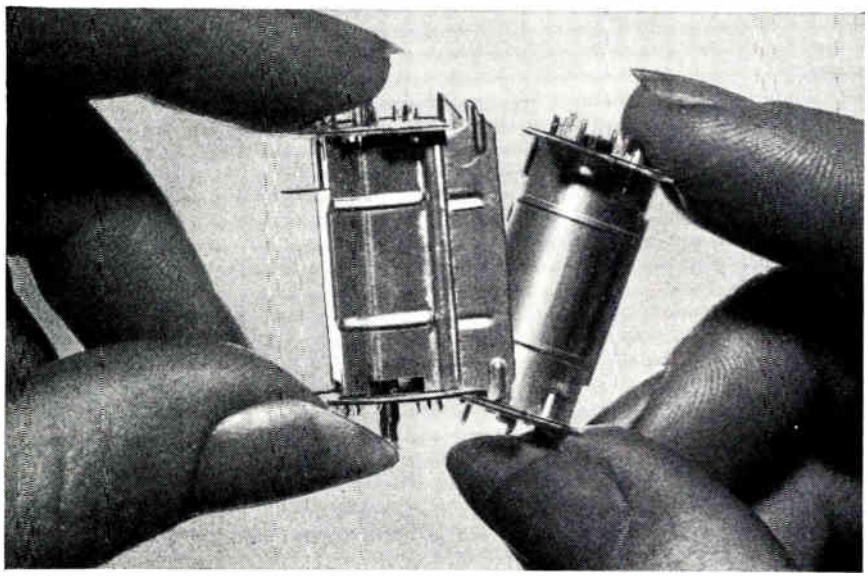
JUNE

June 9-11: 6th Nat'l Electromagnetic Compatibility Symp., PTG-EMC; Los Angeles, Calif.

June 23-25: 6th Nat'l Symp. on Electromagnetic Compatibility, PTGEC/IEEE; Los Angeles, Calif.

TIPS *(Technical Information & Product Service)*

NINE OF THE LATEST NEW



New compactron building block technique helps designers of electronic equipment

G.E.'s new concept in the design of electron tubes promises to be a boon to large and small electronics manufacturers. Termed the "building block concept," it involves the standardizing of basic tube sections—diodes, triodes, pentodes—clipping them together according to the customers' requirements and sealing them in a single envelope.

The building block concept holds these advantages:

1. It exploits the economy of mass production for the benefit of the small volume user.
2. It enables G.E. to offer designers a wider variety of space-saving multi-function tubes.
3. Actually speeds circuit design by use of standardized sections with which circuit designers are quite familiar.
4. Thereby, it eases circuit and product evaluation by equipment manufacturers.
5. It contributes to reliability by employing time-proven tube designs.
6. Retains flexibility so that G.E. may employ modern materials and tube construction techniques to make old designs even better.

Thus, with the standardization of basic tube sections, and the resulting manufacturing economies, the circuit designer and the smaller manufacturer will be freed from the high cost of less common or "odd-ball" tube types.

ZP-1034 metal-ceramic tetrode increases range and capability of electronically-scanned radar

Because of emphasis on the use of negative-grid tubes in broadband circuits at L-band, G.E. has developed the ZP-1034 for use as the final output or driver stage of the amplifier module of a typical steerable array radar. Modern defense systems are trending toward the use of electronically steerable array radar not only to increase range but to provide an active radar capability in a high-density countermeasures environment. Here are some of the features that make the ZP-1034 ideally suited for new applications requiring up to several hundred watts (average) or several kilowatts (peak) output at high duty in bandwidths of 10% in the 1300 mc region:

1. A strap resonance of approximately 1500 mc allows the use of practical $\lambda/4$ circuitry in the vicinity of 1300 mc with resultant benefits in gain, bandwidth and efficiency.
2. A cathode area about 40% greater than that of the only known competitive type improves performance and life.
3. A gain-bandwidth product greater than 4000 gives optimum performance for bandwidth requirements in the order of 10%.
4. Grid-pulsed amplifier service can be used to simplify modulator requirements.
5. An integral water jacket allows dissipation levels to 750 watts average (air-cooled version available).
6. Demonstrated life capability beyond 10,000 hours enhances system reliability.

Circle 12 on Inquiry Card

DEVELOPMENTS FROM G-E RESEARCH

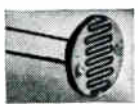
Photoconductive cell developments offer new design opportunities

SIAMESE TWIN: Center tap photocell permits simultaneous control of two separate electrical circuits.

PHOTOCELL-LIGHT COMBINATION: Lamp and photocell sealed together in light-tight package. Variations of voltage on lamp change resistance on photo-cell. Good circuit isolation and mechanically noiseless potentiometry.

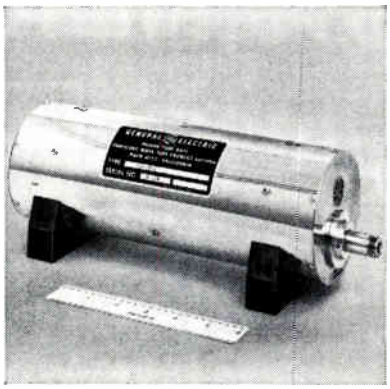
PLUG-IN BASE: Special base eases replacement of cell, eliminates soldering and prevents heat damage during installation. Ideal for metering and control equipment. Now available in ½-inch size.

NEW CONSTRUCTION: Sealing ceramic substrate to base conducts heat more efficiently and reduces need for heat sinks. Tests show over 100% increase in power dissipation: 250 to 500 mw max. on ½-inch cell; 30 to 75 mw max. on ¼-inch cell (TO-3 package).



PLASTIC ENCAPSULATED CELL: Y-1136, available in limited quantities, measures ½-inch dia. x 1/16-inch thick. Max. ratings: 250v; 200 mw; 9,000 ohms @ 2 ft-c; 480 ohms @ 100 ft-c, 6100 ang. max. response.

Circle 13 on Inquiry Card



New C-band single reversal focused TWT's outperform others twice their weight

Now G.E. offers five low-noise, C-band, single reversal focused traveling wave tubes—each less than half the weight of PM-focused tubes.

This new family of TWT's features a unique combination of advantages. They're not only rugged, but give you outstanding performance:

Type	Frequency (Gc)	Noise (db, Max.)	Power Output (mw)	Small sig. gain (db min.)
ZM-3212	4-8	9	5	25
ZM-3235	4-8	8	5	25
ZM-3250	4.4-5.0	6.5	5	25
ZM-3237	5.4-5.9	6	5	30
ZM-3238	5.9-6.5	7	5	30

All five tubes are of metal and ceramic construction, with the same dimensions and weight: 8.2 pounds; 13″ overall length, 4.5″ diameter. The whole family has survived shock of 30 G's for 11 milli-seconds. They're built to withstand severe vibration; altitudes of 100,000 feet; and temperatures ranging from −65°C to +71°C. These rugged little lightweights can improve a lot of designs for advanced radar, countermeasures, and aerospace telemetry.

Circle 14 on Inquiry Card

G.E. cuts 'interface' resistance of receiving tubes—Solves difficult design problem

Critical applications, such as computer and instrument circuits, need stability throughout life, a characteristic that can be upset if unwanted interface resistance develops in the tubes. But to measure this resistance accurately has been a problem—and to measure it in a production test to values less than 1 ohm has in the past been impossible. G.E. solved this problem by developing a special test set that simultaneously measures transconductance at 8 kc and 10 mc. The operator then reads interface resistance, through a bridge circuit.

To reduce interface to heretofore impossibly low levels, G.E. perfected cathode base alloys and coating materials—and refined each detail of tube processing to insure good bonding of the coating to the cathode sleeve. G.E. now can consistently supply tubes free of interface up to at least 2,500 hours of operation—whereas five years ago the best any manufacturer could achieve was to limit the resistance to about 20 ohms at 1,000 hours.

Constant emphasis on improved materials and new processing techniques plus continual refinement—and re-refinement—of receiving tube designs permits G.E. to offer customers the best value for their dollar.

Progress Is Our Most Important Product

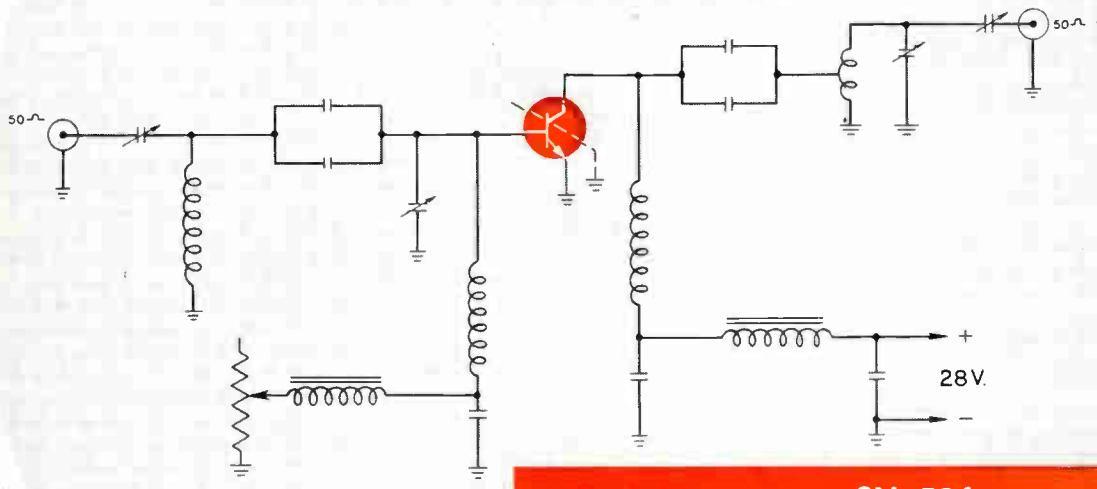
GENERAL ELECTRIC

For more information: Write G.E. Tube Dept., Technical Information and Product Service (TIPS), Room 7002C, Owensboro, Kentucky. Please specify product(s).

Circle 15 on Inquiry Card

NEW NSC VHF SILICON POWER TRANSISTOR DELIVERS 5 WATTS AT 5 db. GAIN

260 MC. POWER AMPLIFIER



Actual Size

Planar SN-526 Epitaxial
MT-31 Isolated Collector

DESIGN CHARACTERISTICS

P_{out} (VCE = 28v, f = 260mc, P_{in} = 2w.)	5w min.
Efficiency (Class C)	40% min.
BV_{CEO}	65 min.

HIGHEST GAIN . . . MOST POWER OUTPUT . . . FROM 28V SUPPLY

• Tiny but powerful, NSC's new VHF device delivers 5 watts at 260 megacycles with a 5-db gain when operating from a standard 28 volt power supply. R-f power leakage is minimal because NSC uses ceramic instead of glass in this device. No forward biasing is required to meet ratings. For complete electrical and mechanical specifications, write for Catalog Sheet SN-526.

Before specifying silicon transistors or integrated circuits in standard or microminiature packages, be sure to investigate NSC's wide product line. Ask for 1964 Composite Catalog on all NSC devices.

NSC
NATIONAL SEMICONDUCTOR CORPORATION
DANBURY, CONN.

WASHINGTON TRENDS

COST-CUTTING A MUST, MUST, MUST—Defense contractors and subcontractors will find that the new DOD cost-cutting drive is a "must" factor in all contract figuring and dickering. Firms that drop the ball on cost savings may find themselves benched. The government up to now simply has been (strongly) *suggesting* cost-cutting to suppliers. Now, it's mandatory. The Pentagon has made it clear that "each company's cost-reduction efforts will be carefully weighed in awarding contracts." Audited savings reports are now required every six months.

U. S. FUNDING FOR CONVERSION — Some Congressmen believe that the government should fund the conversion of military producing capacity to civil purposes. Senator George McGovern (D.-S.D.) is pushing a bill to set up a "National Economic Conversion Commission to plan for the orderly transfer of resources from defense into non-defense production." Firms now receiving defense contracts would be given studies to analyze their civilian production capabilities.

INDUSTRY FIGHTS PATENT FEES — The hassle over maintenance fees for patents is being fought again in Congress. Attempts by the Patent Office to add maintenance fees ranging from $50 to $150 to regular patent payments is strongly opposed by industry and patent lawyers. The Senate Subcommittee on Patents is pondering a bill to increase filing and issuance fees; the bill includes the maintenance fee proposal. Industry leaders do not oppose hikes in regular fees. They assert, however, that maintenance fees would discourage invention and filing of patents. Maintenance fees would be due at the end of the 5th, 9th and 13th year of patent life.

SMALL BUSINESS MYTH—Small Business Administrator Eugene P. Foley asserts that now is the time to dispel the myth that small business is doomed. Addressing the National Newspaper Publishers Association, Mr. Foley felt that small business is essential to the country today and will be just as essential tomorrow. "We must do everything we can to keep it strong, prosperous and growing." He pointed out that the small business strength and durability have already been proven. There has been an average net gain of about 50,000 small businesses each year for the past ten years, although many small firms have been discontinued. "I would hardly call that the record of a weak, unprogressive, or dying segment of our economy."

R&D CONTRACTING QUESTIONED—Separate contract standards soon may be in effect for industry's R&D jobs. The House Select Committee on Government Research is thinking about contracting changes. In its first report, the Committee notes: "Questions have been raised about the wisdom of handling R&D under standard procurement rules." The Committee says problems in R&D payments to private groups especially involve "patent and other proprietary rights, technical data, and published writings.

LAWS TO DE-BUG BUGGERS—FCC has proposed rules (laws actually) to stop or otherwise limit the use of radio devices that invade privacy and interfere with civil liberties. The FCC feels that "with the advent of peanut-sized radio transmitters, use of electronic devices for eavesdropping has become more widespread." FCC states that "eavesdropping, by any means, traditionally has been regarded as contrary to public interest." The Commission adds also that "operation of radio *bugging* devices on unauthorized frequencies is a potential source of interference to radio service."

COMSAT STOCK NEARS MARKET—Some $200 million in Commercial Satellite Corporation stock will be on sale shortly. Price will be quite below the $100-a-share maximum set by Congress. It may even go below $50 a share to meet Congressional orders that the stock has the "widest possible distribution." Half of the stock will go to private communications companies, who had until March 23 to apply to FCC for right to purchase shares. More than 150 firms have been cleared to buy. Meanwhile, COMSAT is expanding. New equipment, that will carry 240 two-way telephone calls at once, will be put into the system this year. It will be operational around-the-clock, rather than just during certain hours.

BUILT-IN WHOLESALE SUPPLY — The Defense Electronics Supply Center is developing into DOD's own *middleman*. DESC, nicknamed *Dessy*, expects to increase its stock to about 550,000 electronic parts worth about $460 million. The Center took over the Air Force stock of parts in March, 1963. DESC expects to complete take-over of electronic components from the Army and the Navy this month. DESC's chief function is to fill requests from the field for replacement parts. For Fiscal Year 1964, the Center expects to buy about $125 million in electronic parts, and *sell* about $115 million worth to the services.

Unit shown 1½ times actual size

Sensitivity · Reliability · Long Life

Over 3 Million Units Sold

SPECIFY RCA—THE INDUSTRY'S WIDEST LINE OF PHOTOCELLS FOR STREET-LIGHT CONTROLS

Is there an RCA Photoconductive Cell in your street-light control? It could be an RCA-SQ2504—a 1"-diameter cadmium-sulfide unit that represents the latest improvements in photocells. It is characterized by high sensitivity, proved reliability, and long life.

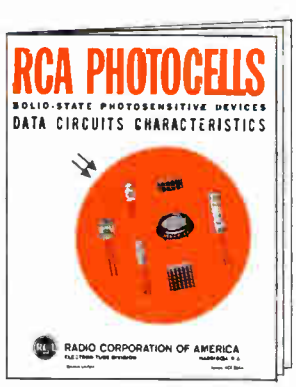
Field experience shows that RCA Photocells in light-operated control, switching, and measurement applications last and last and last! This is why RCA Cells are so often selected by leading manufacturers of street-light controls.

Today, over 3 million RCA Photocells have been sold. More than 70% of these are used in street lighting.

The RCA line of Photocells is designed to provide a wide choice of electrical ratings, cell size, and cell shape. The RCA-SQ2504 (1"), RCA-C70351 (½") developmental type, and RCA-SQ2508 (¼") are good examples. They are compact, with the photosensitive cadmium sulfide sealed in hermetically. You can depend on RCA Photocells to give outstanding performance in diverse environments of humidity and temperature.

So don't take chances with unproven products. Always specify RCA Photocells for proved reliability and performance.

Consult your RCA Representative for your requirements.



RCA's booklet, 1CE-261A, contains technical information on RCA's commercially available line of Photoconductive, Photojunction, and Photovoltaic Cells. For your copy, see your authorized RCA Industrial Tube Distributor or write: Commercial Engineering, Section D-50-Q RCA Electronic Components and Devices, Harrison, N. J.

Also available from your authorized RCA Industrial Tube Distributor.

RCA®

The Most Trusted Name in Electronics

Circle 17 on Inquiry Card

1,000,000 ALL-CHANNEL SETS LEAD TV SALES RISE IN 1963

Distributor sales of television receivers for 1963 totalled 6,828,383, compared to 6,301,340 in 1962, reports the Electronic Industries Association Marketing Services Department. Sales climbed to 759,521 for December, 1963, from 635,973 in December 1962.

Radio sales, not including auto sets, were 1,379,021 in December 1963, down from 1,587,590 for the same month in 1962. Total radio sales reached 9,97[illegible].209 units, also down from the 1962 total of 11,757,093.

TV set production in December 1963 was 690,043 units, compared to 519,799 produced in December 1962. Television production total for 1963 was 7,130,351, compared to 6,471,160 for 1962. The 1963 total of all-channel TV sets was 1,076,282, compared to 598,446 in 1962. The all-channel law becomes effective May 1.

Factory sales of television CRTs were up slightly in numbers and were down in dollar volume for December 1963. Declines in both unit and dollar volume were reported for both picture and receiving tubes for 1963, compared to 1962. Total unit sales for picture tubes for 1963 amounted to 8,955,434, compared to 9,069,643 in 1962. CRT dollar volume for 1963 was $167,268,620, compared to $173,661,723 in 1962.

Unit factory sales of receiving tubes for 1963 was 338,365,000, compared to 361,154,000 in 1962. In dollar volume, 1963 year total was $273,670,000, as compared to $301,453,000 for 1962.

GE EXECUTIVE FORECASTS 1964 COMPONENT SALES

Total sales of electron tubes and semiconductors for 1964 are predicted at about $1.2 billion. The predictor is L. Berkley Davis, vice president and general manager of General Electric's Electronic Components Division.

Behind this forecast are ever-rising price pressures from rising foreign imports, underlined by slightly curtailed defense spending.

The biggest percent rise is expected in functional circuits, up to as much as $35 million in 1964 from 1963's anticipated $15 million. Mr. Davis also sees steady rises in dollar sales of power tubes to $350 million, and semiconductor rectifiers, to $178 million.

The forecast includes decreasing dollar sales in transistors, down to about $285 million, signal diodes, about $90 million, and electronic receiving tubes, $240 million.

ESTIMATES OF U. S. ELECTRONIC EXPORTS

(In Billions of Dollars)

"ELECTRONIC INDUSTRIES" ESTIMATES

	1960	1961	1962	1963	1964	1965
U. S. Electronic Exports to Free Europe and United Kingdom	$.23	.31	.38	.48	.64	.83
U. S. Electronic Exports to All Other Nations and Canada	.24	.30	.38	.50	.66	.87
U. S. Electronic Exports to Common Market Nations* / **	.17	.21	.26	.33	.46	.58
Total U. S. Electronic Exports	.47	.61	.76	.98	1.3	1.7

*Belgium, France, West Germany, Italy, Luxemburg, Netherlands

**Not added to total of Exports

Sources for basic data: Electronic Industries Association; BDSA—Department of Commerce; Stanford Research Institute

FCC IS CONCERNED OVER VHF-TV 'STOCKPILING'

The Federal Communications Commission currently is asking TV set manufacturers to explain reports of VHF receiver "stockpiling" in view of the all-channel receiver deadline of April 30, 1964.

FCC reminds industry that after enactment of the law, the Commission was informed that companies would "do everything possible to achieve the purposes of the law." From a series of discussions the Commission had decided on a "cut-off" date and engineering standards for tuners.

In a letter addressed to TV set makers, spokesmen for the FCC pointed out that April 30, 1964, was "chosen as the 'cut-off' to allow distributors and dealers considerable amount of time to dispose of 1964 sets which do not meet the all-channel requirements."

The letter states that the Commission expected industry to make an all-out effort to fulfill the law. FCC had anticipated industry research on the UHF tuner and an increase in production of all-channel sets before the "cut-off" date. Most important, according to the letter, the Commission stressed understanding that there would be an orderly changeover.

"The stockpiling reports are, if true," reports the Commission, "entirely inconsistent with the basic representations made to the Commission of an orderly transition by industry during the period of December 1963 through April 1964 to the 1965 all-channel models.

Providing the stockpiling reports are factual, the Commission suggests that industry may appreciate the Commission's concern and its desire to evaluate what action to take. FCC feels that the practice conflicts with the public interest, with established Congressional policy, and with the best interests of the set manufacturing industry.

ESTIMATE SOVIET SPACE SPENDING AT $15 BILLION

The cost of the current Russian space program, primarily military, is estimated at 13.9 billion rubles, or about $15.3 billion at the official exchange rate.

Current and recent U.S. defense/aerospace expenditures for electronic equipment and systems average around 20% of the total U.S. defense budget. If this rate holds true for rubles as well as for U.S. dollars, then we may estimate that Khruschev is spending around $3 billion yearly for his electronic equipment.

LESS GOV'T IN R&D WILL RAISE R&D OUTPUT, EDUCATOR SAYS

An educator suggested at the National Assoc. of Manufacturers meeting in New York that "less government concern in R&D might result in more R&D output." The opinion came from Dr. Yale Brozen, professor of Business Economics, Graduate School of Business, University of Chicago.

He outlined some reasons. Taxes to support Federal R&D, for instance, reduce ready capital for private investing in R&D. Then, strong government activity in some fields tends to pre-empt private activity.

Too often government choice of projects results in data, technically significant, yet uneconomical and premature. Dr. Brozen topped it all by stating that talent diverted to well-financed government projects causes talent shortage in some areas. This in turn causes more fruitful R&D to be neglected in these areas.

World's largest selection of adjustment potentiometers

BOURNS TRIMPOT® POTENTIOMETERS

More engineers specify Bourns TRIMPOT Potentiometers because:

TRIMPOT Potentiometer line is complete:
Bourns offers you the largest selection of adjustment potentiometers...33 standard models—4 terminal types—3 mounting styles.

TRIMPOT Potentiometers are small:
Space-saving size and choice of shapes permit the installation of up to 17 units (and sometimes even more) in one square inch of panel area.

TRIMPOT Potentiometers are accurate:
Screw-driver adjustment gives as much as 9000° of rotation ...you can make and repeat the finest adjustments.

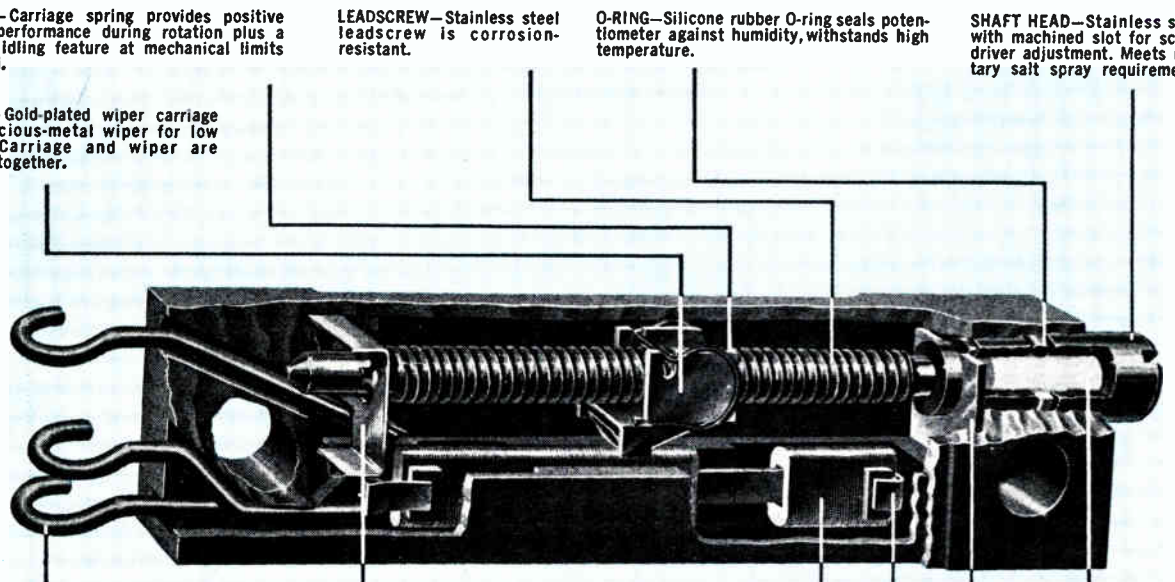
TRIMPOT Potentiometers are stable:
Adjustment shaft is self-locking... settings are virtually immune to acceleration, vibration and shock.

TRIMPOT Potentiometers are fully tested:
All units are 100% inspected before shipment and are checked by Bourns' exclusive Reliability Assurance Program to assure you of reliable performance.

TRIMPOT Potentiometers are proven:
They are backed by over 17 years of engineering know-how and have been specified and used in more military, industrial or commercial equipment than any other leadscrew potentiometer in the world!

REMEMBER—IF IT'S TRIMPOT, IT'S BOURNS

Only Bourns TRIMPOT Potentiometers Give You All Of These Outstanding Features



SPRING—Carriage spring provides positive no-slip performance during rotation plus a reliable idling feature at mechanical limits of travel.

LEADSCREW—Stainless steel leadscrew is corrosion-resistant.

O-RING—Silicone rubber O-ring seals potentiometer against humidity, withstands high temperature.

SHAFT HEAD—Stainless steel with machined slot for screwdriver adjustment. Meets military salt spray requirements.

WIPER—Gold-plated wiper carriage and precious-metal wiper for low noise. Carriage and wiper are welded together.

SOLDER TERMINALS—Tinned terminals are compact, yet large enough for easy soldering. Teflon-insulated leads and printed circuit pins are also available.

SILVERWELD® TERMINATION—This exclusive Bourns feature is unequalled in ruggedness. There is a metal-to-metal bond from the terminal to the resistance wire.

PICK-OFF—Precious-metal, positive-contact pick-off assures wiper continuity.

ELEMENT—Special ceramic element card for maximum reliability is precision wound with low-temperature-coefficient resistance wire.

SHAFT RETAINER—Shaft is locked in place for top performance under extreme shock, vibration and acceleration.

SHAFT INSULATOR—High-dielectric-strength, ceramic insulator isolates shaft head from internal circuits.

This cutaway of Model 224 shows the typical high quality to be found in all Bourns TRIMPOT potentiometers, although some features may vary from model to model.

...longest record of reliability

TRIMPOT® POTENTIOMETERS—UNSEALED

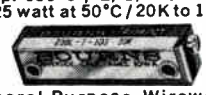
General-Purpose Wirewound Model 200. Max. temp. 105° C / L, S, P terminals / 0.50 watt at 70°C / 10 ohms to 100K.

General-Purpose RESISTON® Carbon Element Model 215. Max. temp. 125°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg.

High-Temperature Wirewound Model 260. Max. temp. 175°C / L, S, P terminals / 1.0 watt at 70°C / 10 ohms to 100K.

TRIMPOT POTENTIOMETERS—HUMIDITY PROOF

General-Purpose RESISTON Carbon Element Model 235. Max. temp. 135°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg.



General-Purpose Wirewound Model 236. Max. temp. 135°C / L, S, P terminals / 0.8 watt at 70°C / 10 ohms to 100K.

Micro-Miniature High-Temperature Wirewound Model 3000. Max. temp. 175°C / P terminals / 0.5 watt at 70°C / 50 ohms to 20K.

Micro-Miniature High-Temperature RESISTON Carbon Element Model 3001. Max. temp. 150°C / P terminals / 0.20 watt at 70°C / 20K to 1 Meg.

Sub-Miniature High-Temperature Wirewound Model 220. Max. temp. 175°C / L, W terminals / 1.0 watt at 70°C / 10 ohms to 30K / Mil-Spec style RT10 and meets MIL-R-27208A.

High-Temperature Wirewound Model 224. Max. temp. 175°C / L, S, P terminals / 1.0 watt at 70°C / 10 ohms to 100K / Mil-Spec style RT12 and meets MIL-R-27208A.

Ultra-Reliable High-Temperature Wirewound Model 224-500. Max. temp. 150°C / L, P terminals / 0.5 watt at 70°C / 100 ohms to 20K. Performance and reliability statistically verified to customer.

High-Temperature, High-Resistance RESISTON Carbon Element Model 3051. Max. temp. 150°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ11 and meets MIL-22097B.

High-Temperature High-Resistance PALIRIUM® Film Element Model 3052. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10K to 1 Meg.

High-Temperature, Low-Resistance PALIRIUM Element Model 3053. Max. temp. 175°C / L, P terminals / 0.5 watt at 70°C / 2 ohms to 100 ohms.

High-Temperature Wirewound Model 3010. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10 ohms to 100K / Mil-Spec style RT11 and meets MIL-R-27208A.

High-Temperature RESISTON Carbon Element Model 3011. Max. temp. 150°C / L, P terminals / 0.25 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ11 and meets MIL-R-22097B.

High-Temperature High-Resistance PALIRIUM Element Model 3012. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10K to 1 Meg.

⅜"-Square Wirewound Model 3280. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K.

⅜"-Square RESISTON Carbon Element Model 3281. Max. temp. 150°C / L, P, W terminals / 0.5 watt at 50°C / 20K to 1 Meg.

½"-Square, High-Temperature Wirewound Model 3250. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K / Mil-Spec style RT22 and meets MIL-27208A.

½"-Square High-Temperature RESISTON Carbon Element Model 3251. Max. temp. 150°C / L, P, W terminals / 0.50 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ22 and meets MIL-R-22097B.

BOURNS® SINGLE-TURN POTENTIOMETERS

5/16"-Diameter Micro-Miniature High-Temperature Humidity-Proof Wirewound Model 3300. Max. temp. 175°C / P, S terminals / 0.5 watt at 70°C / 50 ohms to 20K.

5/16"-Diameter Micro-Miniature High-Temperature Humidity-Proof RESISTON Carbon Element Model 3301. Max. temp. 150°C / P, S terminals / 0.25 watt at 70°C / 10K to 1 Meg.

Sub-Miniature Wirewound Model 3367. Max. temp. 105°C / P, S terminals / 0.5 watt at 70°C / 10 ohms to 20K / meets steady-state humidity.

Sub-Miniature RESISTON Carbon Element Model 3368. Max. temp. 105°C / P, S terminals / 0.25 watt at 50°C / 20K to 1 Meg / meets steady-state humidity.

LOW-COST COMMERCIAL POTENTIOMETERS

Wirewound TRIMIT® Potentiometers Models 271, 273, 275. Max. temp. 85°C / L, S, P terminals / 0.5 watt at 25°C / 50 ohms to 20K.

RESISTALOY® Carbon Element TRIMIT Models 272, 274, 276. Max. temp. 85°C / L, S, P terminals / 0.2 watt at 25°C / 20K to 1 Meg.

Wirewound E-Z-TRIM® Potentiometer Model 3067. Max. temp. 85°C / S, P terminals / 0.5 watt at 25°C / 100 ohms to 20K / Priced under $1 in production quantities.

Carbon Element E-Z-TRIM Potentiometer Model 3068. Max. temp. 85°C / S, P terminals / 0.2 watt at 25°C / 20K to 1 Meg.

SPECIAL-PURPOSE POTENTIOMETERS

High-Power (2 watts) High-Temperature Wirewound Model 207. Max. temp. 175°C / L terminals / 2 watts at 50°C / 100 ohms to 100K. As Rheostat Model 208, available 100K to 200K.

High-Power (5 watts) Humidity-Proof Wirewound Model 3020. Max. temp. 200°C / L terminals / 5.0 watts at 25°C / 100 ohms to 50K.

Dual-Element Wirewound TWIN-POT® Potentiometer Model 209. Max. temp. 135°C / L terminals / 0.50 watt (each element) at 70°C / 10 ohms to 50K.

15 watts, High-Temperature Wirewound Model 3030. Max. temp. 265°C / L terminals / 15 watts at 25°C / 10 ohms to 10K.

Radiation-Resistant, High-Temperature Wirewound Model 3040. Max. temp. 350°C / W terminals / 5.0 watts at 70°C / 500 ohms to 20K.

PANEL-MOUNTED POTENTIOMETERS

Most models are available with panel mounting. Unique design permits quick factory assembly to "on-the-shelf" units. In addition, mounting screws, brackets and clip brackets are available from factory or distributor stocks to meet almost any mounting requirement.

KEY TO TERMINAL TYPES

L=Insulated stranded leads
S=Solder lugs (includes panel-mounting bushing on Models 3367S, 3368S, 3300S and 3301S only)
P=Printed-circuit pins
W=Uninsulated wires (edge-mounting 3250, 3251, 3280 and 3281).

Write **TODAY** for detailed specifications on any model in the large **BOURNS®** Potentiometer and **TRIMPOT®** Potentiometer line **AND** the name of your local stocking distributor.

Remember—
Don't MIL-SPECulate...
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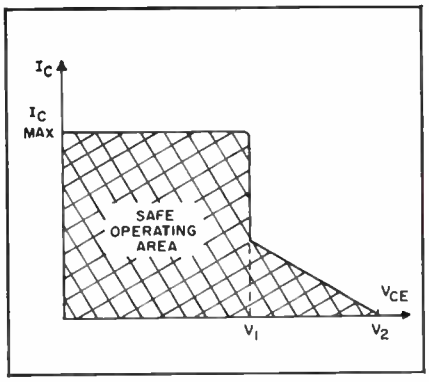
Who put 12 watts at 55°C case temperature in that little, bitty can?

Bendix, that's who.

The shorter height "low dome" TO-5 package makes our 3 amp germanium power transistors perfect for saving space in card and other high density packaging applications. You have a choice of two other packages (the stud nut heat sink or the hexagonal nut heat sink), 48 types and all are SOAR (Safe Operating ARea) specified for applications like audio amplifiers, pulse amplifiers, relay drivers and switching. (SOAR chart↓ and envelope→)

Type Number	V_1 V	V_2 V
2N1038,-1,-2	40	70
2N1039,-1,-2	50	80
2N1040,-1,-2	60	90
2N1041,-1,-2	70	100
2N1042,-1,-2	40	70
2N1043,-1,-2	50	80
2N1044,-1,-2	60	90
2N1045,-1,-2	70	100
2N2552	40	70
2N2553	50	80
2N2554	60	90
2N2555	70	100
2N2556	40	70
2N2557	50	80
2N2558	60	90
2N2559	70	100
2N2560	40	70
2N2561	50	80
2N2562	60	90
2N2563	70	100
2N2564	40	70
2N2565	50	80
2N2566	60	90
2N2567	70	100



In addition to withstanding the environmental and mechanical requirements of MIL-S-19500, MIL-STD-750 and MIL-STD-202, these Bendix® PNP transistors (at 25°C) feature: switching time (t_r or t_f) in microseconds without worry of secondary breakdown; high collector-to-emitter breakdown voltage (reverse biased): V_{CEX} to −100 V; high DC current gain: h_{FE} = 33 to 200 with V_{CE} = −0.05 V, I_C = −50 mA; low collector cutoff current: I_{CBO} = −125 μA maximum at one half of rated V_{CB}; low saturation voltage: $V_{CE(s)}$ = −0.25 V maximum with I_C = −1 A, I_B = −0.1 A; low thermal resistance.

MAXIMUM RATINGS

Type Number	VCEX V	IC A	Pc W	TJ °C
2N1038,-1,-2 2N2552,56	40	3.0	20	+100
2N1039,-1,-2 2N2553,57	60	3.0	20	+100
2N1040,-1,-2 2N2554,58	80	3.0	20	+100
2N1041,-1,-2 2N2555,59	100	3.0	20	+100
2N1042,-1,-2 2N2560,64	40	3.5	20	+100
2N1043,-1,-2 2N2561,65	60	3.5	20	+100
2N1044,-1,-2 2N2562,66	80	3.5	20	+100
2N1045,-1,-2 2N2563,67	100	3.5	20	+100

In case you're involved in military communications, aerospace or underwater equipment design (or if you need absolute reliability), we have eight military qualified types. They're all capable of 12 watt operation at a case temperature of 55°C. For information, contact your nearest Bendix sales office or write us.

MILITARY TRANSISTOR TYPES

Type Number	Case Type	Mil Specification
JAN2N1039	TO-5	MIL-S-19500/89C
JAN2N1041	TO-5	MIL-S-19500 89C
USN2N1039	TO-5	MIL-S-19500 89
USN2N1041	TO-5	MIL-S-19500 89
USA2N1042	MT-6	MIL-S-19500 137A
USA2N1043	MT-6	MIL-S-19500 137A
USA2N1044	MT-6	MIL-S-19500 137A
USA2N1045	MT-6	MIL-S-19500 137A

Bendix Semiconductor Division

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WHAT'S NEW

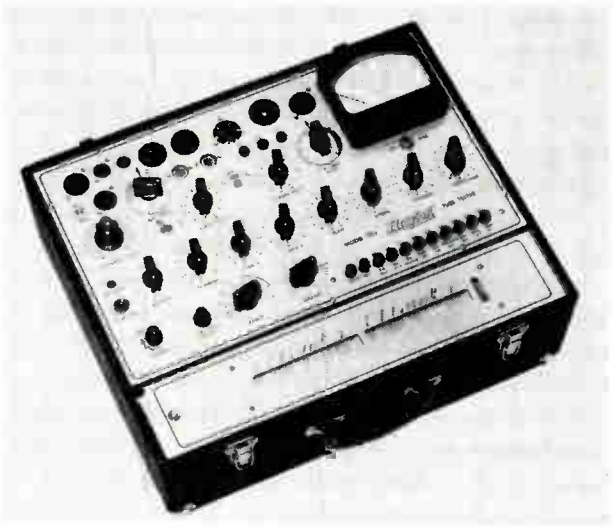
"The changing STATE-OF-THE-ART in the Electronic Industries"

TUBE TESTER

THIS PORTABLE TUBE TESTER, Model 580, is for industrial and laboratory uses. Some features of the unit are: 4μmho ranges to 60K; leakage meter with a 50 megohm sensitivity; a gas-test circuit which detects gas effects to 0.05μa; pushbutton test of dual-section tubes; and an illuminated meter and wall chart.

A complete range of test potentials permits setting test conditions directly from the tube handbook. Gm measurements can be made under a duplication of actual or intended operating conditions.

The tester, manufactured by Hickok Electric Instrument Co., Cleveland, Ohio, accepts 4, 5, 6, 7-pin, octal, and loctal; 7, 9, and 10-pin miniature; 7- and 8-pin subminiature, Compactron, Novar; and 5- and 7-pin Nuvistor.



Cathode life test, which is provided by pushbutton reduction of heater voltage, evaluates cathode reserve.

MICRO-TRANSISTORS

A NEW SERIES OF CERAMIC MICRO-TRANSISTORS, developed by National Semiconductor Corp. of Danbury, Conn., eliminates difficulties in handling and assembling tab transistors. The transistors can be used in subminiature assemblies where normal packages are too large, and as discrete active devices in micro-circuits.

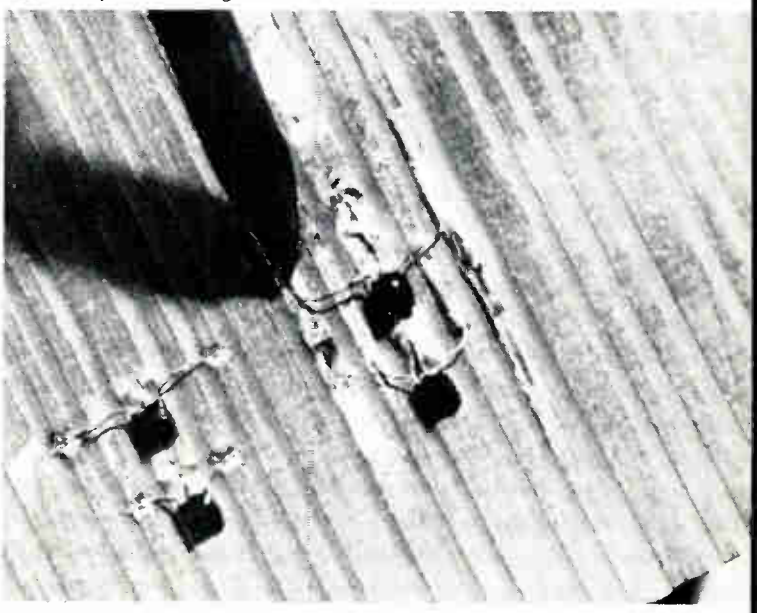
Each micro-package is slightly larger than a tab transistor, yet almost as rugged as a TO-18 which is nearly 50 times their size. The micro-transistors are expected to cut lead breakage and other production losses. They can be picked up with tweezers and handled by the same equipment used for bigger transistors. Micro-manipulation and special nailhead bonding or low-power soldering methods are eliminated.

The 5-mil gold-plated Kulgrid leads are rugged enough to withstand physical handling and can be welded or soldered by standard methods. They can also be unsoldered and resoldered, an important advantage. The 1-mil gold leads of tab transistors are far more fragile and can easily be damaged or destroyed.

The ceramic substrate for each micro-transistor is a tiny block with a center channel or groove. Gold is evaporated and deposited onto the raised surfaces on each side of the channel and onto the face of the channel itself. Gold-plated Kulgrid leads of 0.005 in. dia. are welded to each of these three surfaces. The transistor is mounted on the center channel.

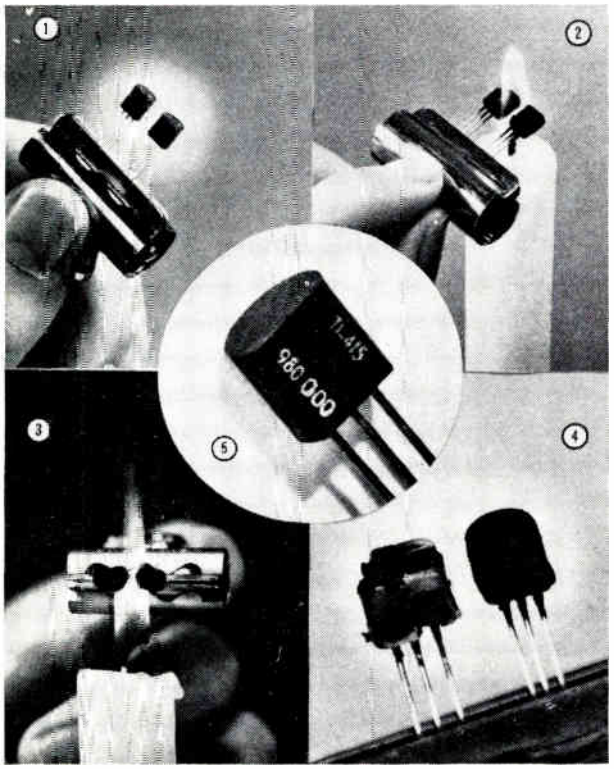
Four micro-transistor packages are available. All are silicon-planar transistors of the npn type and are used in sophisticated microminiature circuits. Three comprise a family of small-signal devices for low-level amplification, while the fourth is a transistor designed for high-speed switching.

Micro-package electrical characteristics can be categorized and performance guaranteed like canned transistors.



WHAT'S NEW

SILICONE ENCAPSULATED TRANSISTORS



THE SILECT® SILICONE-PLASTIC encapsulated silicone transistors replace both epoxy-encapsulated and more conventional types of silicone encapsulated transistors. They are suitable for any application requiring amplification from dc to 30MC, or oscillation to 80MC. Typical noise figure is 1.9db with 15.7KC bandwidth.

The new series, designated TI 415 through 419, are a product of Texas Instruments Incorporated, Dallas, Tex. They use a glass-like silicone plastic, which is a departure from epoxy-encapsulation techniques. The plastic is opaque, thus eliminating problems of light sensitivity encountered in earlier transparent or translucent plastic packages.

Of special interest is the heat-resistant quality of the silicone package. This package can withstand the direct application of a hot soldering iron with no effect. Other types of plastic-encapsulated transistors deform or blister at this temperature. The transistors have a storage temp. of 150°C, as opposed to 125°C for the plastic-encapsulated units.

The glass-like silicone plastic of these devices is a departure from expoxy encapsulation techniques. The transistors withstand high temperatures with no damage.

SMALL GEAR MOTORS

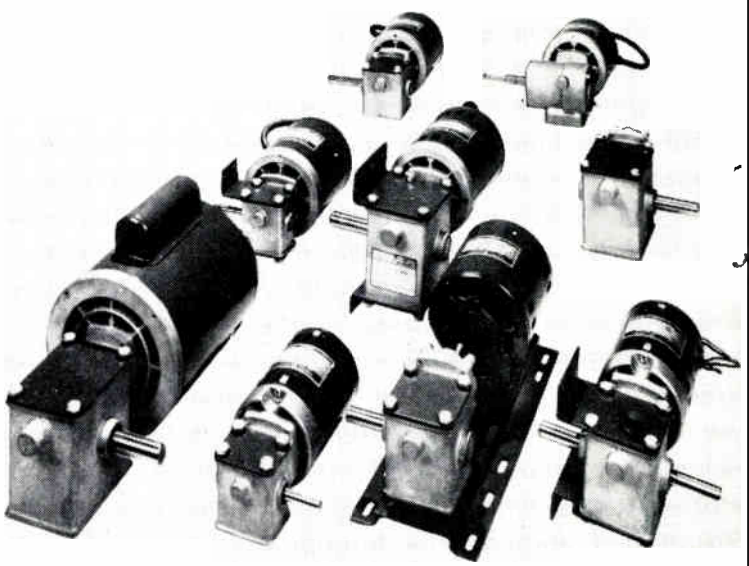
THE MINA-GEAR™ is a complete line of small gear motors with a wide variety of applications. The line includes ac, dc, and series gear motors, separate gear reducers, clutch gear motors and all-motor gear motors. The all-motor unit is a complete package which contains a separate gear reducer coupled to a resilient base motor—all mounted on a common bed plate.

The right-angle design gear motor uses Spiroid® face-type gearing. It is available in models ranging from 1/100 to ½ hp, with output speeds from 15 to 350 RPM. The spiroid gear system can be most closely compared with the hypoid gears in the rear-axle drive of an automobile. The main difference is in the pinion, which has complete threads on its circumference. These threads are similar to a worm-gear pinion except that the pinion's outer diameter is a truncated cone rather than a cylinder. The gear is a face-type with arc-like teeth cut on the side face of the blank, rather than on the outer perimeter as is the case with worm-wheel gears. (This gives the advantage of compactness and high-torque capacity.)

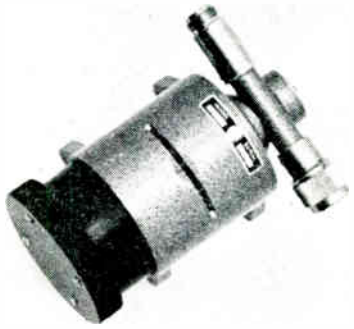
When the pinion rotates, the lead of the thread causes the meshing gear teeth to move by a sliding action. Power can be transmitted in either direction. The relationship of the number of threads on the pinion to the number of teeth on the gear determines the ratio of the speed reduction.

The motors were developed by General Electric's Gear and Transmission Components Section, Paterson, N. J.

Wide assortment of gear ratios offers flexibility of speeds and torques. Reduction ratios from 10:1 to 102:1.



N410A Coaxial, direct reading, 0.1% accuracy, 1-4 Gc



N414A Coaxial, direct reading, 0.1% accuracy, 3.95-11 Gc

FXR offers complete coverage

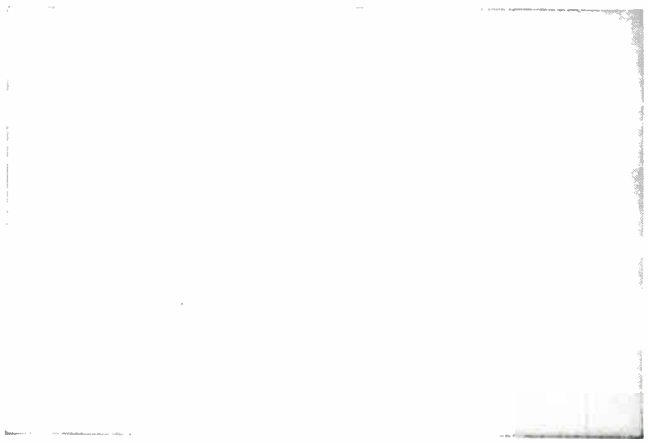
Series 410B direct reading, auxiliary transmission coupling probe, 3.95-12.4 Gc

Series 402A, precision direct reading, .015% accuracy, invar cavity, hermetically sealed, 5.85-12.4 Gc

Series 410A, direct reading, 0.1% accuracy, 12.4-39.5 Gc

Series 410X and 412A, micrometer driven, non-contacting choke tuning plunger, 33-220Gc

in frequency meters



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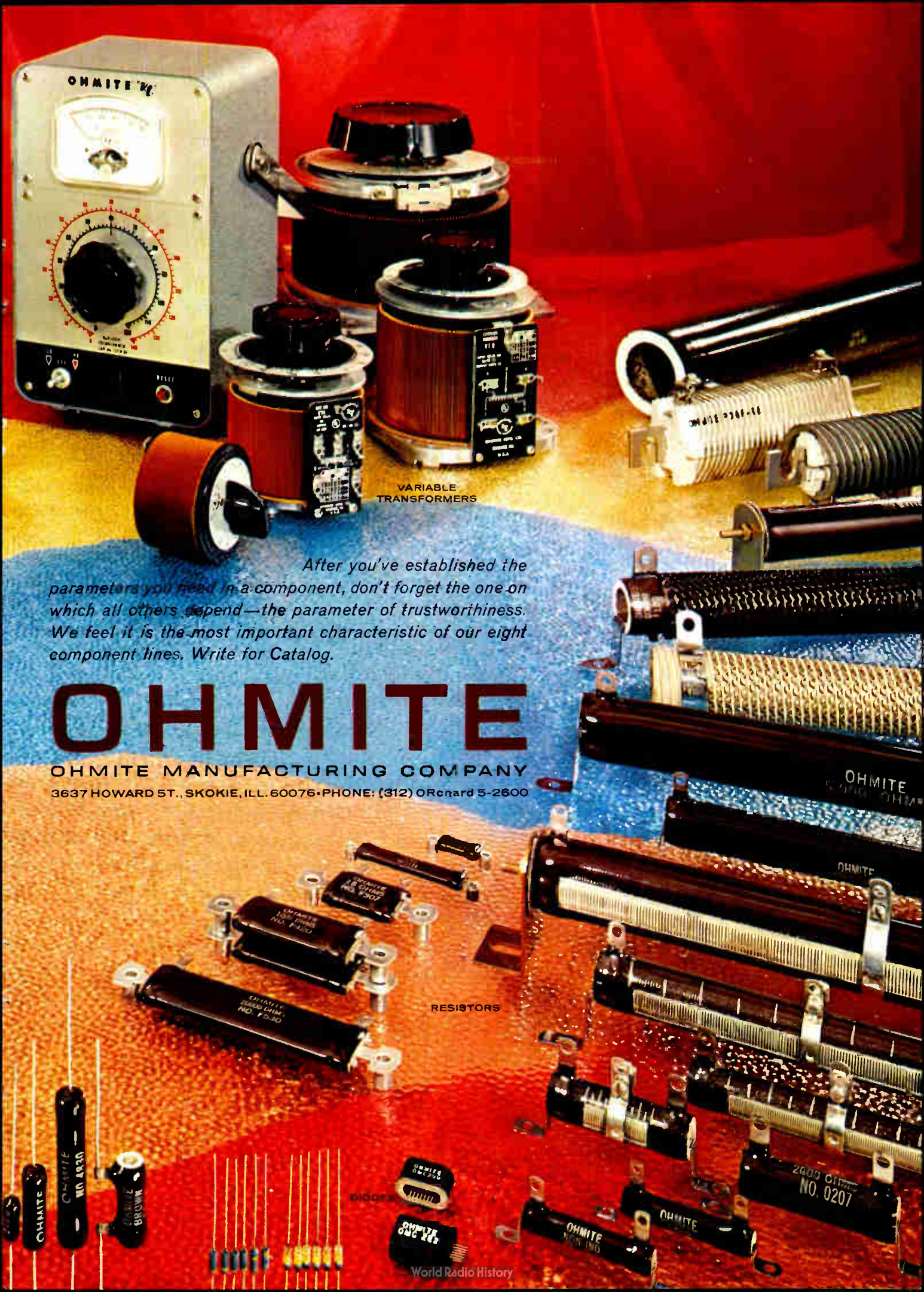

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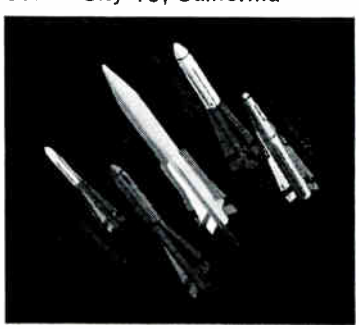

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AN ENGINEER'S VIEW OF

THE GOVERNMENT ELECTRONICS MARKET

What are the problems involved in obtaining electronic development contracts from the Government? What is the proper method of approaching the various Government technical agencies? How are proposal funds obtained? These and other important questions are answered for the engineer.

THIS ARTICLE EXAMINES SOME OF THE PROBLEMS involved in obtaining large electronic development contracts from the Government. A neat "How-To-Do-It" treatise on the subject is impossible; but, it is possible to set forth a number of helpful facts and guidelines.

* * *

There are three facets to the Government electronic market—the industry, the customer, and the product. On the industry side, there are many highly competitive organizations competing for the Government dollar. On the Government side, there is one complex customer made up of many individuals who may sometimes be out of touch with each other.

Industry, in this atmosphere, must live by its ingenuity. The customers with whom industry representatives deal are civilian project managers and section chiefs in various Governmental technical agencies. These people are accustomed to listening to the often exaggerated claims of their constant stream of visitors. These conversations consume so much time, that they are often hard put to keep up with their paperwork. By and large they are hardworking, conscientious, and scrupulous about guarding a company's proprietary ideas. But, unless the proper motivation has been created, they have little enthusiasm for going to lunch with a visitor or delving deeply into the ideas presented.

This situation changes dramatically when one is dealing with personnel with whom he has a contractual relationship. Now everyone is on the same side. All the information that can possibly be made available will be supplied. Detailed evaluations of the work will be provided and both helpful and critical comment will be offered. Both parties to the contract want to see that the work results in a useful output and that effective team spirit is created.

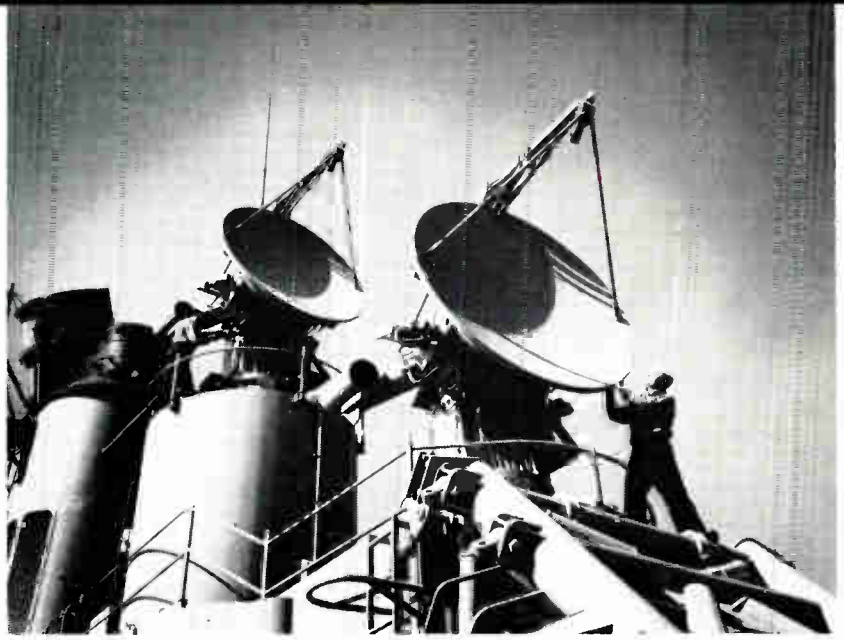
Obtaining Internal Support

In obtaining program support of company technical and financial management, the case is strengthened if it can be shown that the activity is a natural outgrowth of the company's previous and present achievements. Engineers feel a closer sense of identity and financial personnel foresee fewer financing difficulties when there is a close tie-in with past activities. A question which arises is whether the early exploratory work should be conducted as a pre-proposal effort or as part of the company's independent R&D. This matter is discussed here.

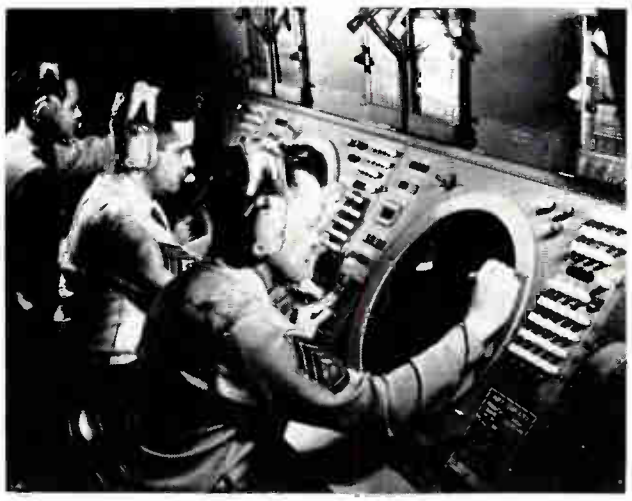
Proposal funds are a part of overhead costs and can be charged against existing Government contracts. Thus, these funds are completely recoverable. But, normally, a defense-oriented corporation runs a continuing proposal activity which, if it rises above a certain fraction of gross sales, threatens the overhead structure and hence the company's competitive posture. Thus, with limited proposal funds, there is keen competition for those which are available. It is unwise to use large parts of those resources in proposal efforts unless much prior preparation has been involved.

Independent development funds of a defense oriented business are recoverable as contract charges, subject to negotiation within the framework of ASPR-15. This quote from ASPR-15 applies: "In recognition that cost sharing of the contractor's independent research and development program may provide motivation for more efficient accomplishment of such program, it is desirable in some cases that the Government bear less than an allocable share of the total cost of the program." Thus, it can be expected, that in a typical defense corporation a percentage of independent R&D costs are recoverable.

By DR. PETER M. KELLY
Director,
Advanced Technology Laboratories,
Philco Corporation,
Blue Bell, Pa.



. . . to 'Never approach the Government agencies with empty hands' is axiomatic . . . It is permissible to say "Here are results of some of our recent work. Let us hear about your activities in related areas."



If it is decided that the work should be part of the independent development program, the engineer and the marketing representative should try to show that the preliminary development work needed to launch a new program can be made to fall within the ASPR definition of independent development. The ASPR regulations are written quite broadly, Table I. Hence, programs of intrinsic merit can be done within the framework of ASPR and the company may recover a large part of the costs incurred.

IRDP programs have the stability and continuity notoriously lacking in proposal efforts. As a technical man, the writer prefers the IRDP approach at the start of a program, since it provides time and resources to obtain technical answers before approaching the customer. As a manager of technical men, the writer prefers the pre-proposal approach, for it requires the engineer to check his ideas with the customer at an early date. There is an inconsistency here, but a pre-proposal effort that gets preliminary answers and that serves as a basis for developing the IRDP program is often a satisfactory compromise.

A third method of financing new efforts is through the use of cost-sharing contracts. Under these contracts the customer, a Government agency, pays part of the cost of a development and the contractor agrees to pay the rest. These costs incurred by the contractor are not recoverable as are proposal and IRDP funds. Hence, they must come directly from profits. This is one reason that corporate management usually has a negative attitude toward cost-sharing arrangements. On the other hand, the method has been used suc-

cessfully over the competition in a newly developing area. There are signs that the Government is increasingly less interested in the cost-sharing relationships because of the favored position created and the criticism it has created.

A second negative factor involved in cost-sharing is their uncertain place in a normally competitive market. The corporate management has questions about the capabilities of his technical people if they must offer cost-sharing. He questions the Government's actual need for the effort if it isn't willing to pay all the costs involved. Further, cost sharing is like a protective tariff which erects a wall to protect infant enterprises. Corporate management wants assurances that the need is legitimate and that the protection is only needed temporarily. In spite of all the foregoing, the author has used cost-sharing and seen it used very successfully.

Table 2 summarizes some of the methods available for internal support of a new program.

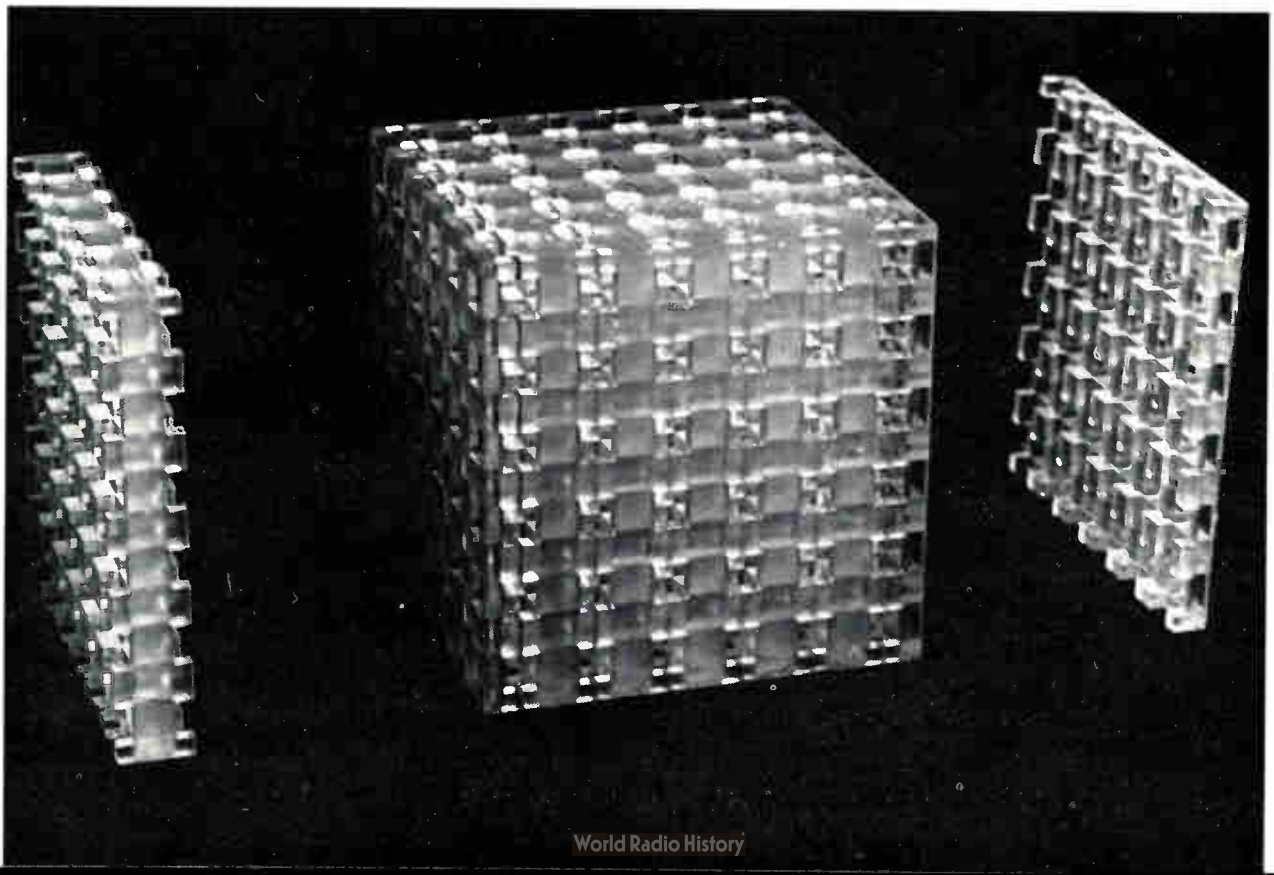
Technical Notes

It is hard to say what the first approach to the customer should be. It is clear what the first approach should not be—it should not be a response to a formal request for proposal. It should be stressed again that the subject here is one involving human institutions so that no rules are inviolable. The possibility of being required to respond to an unanticipated RFP does exist and this problem is discussed later.

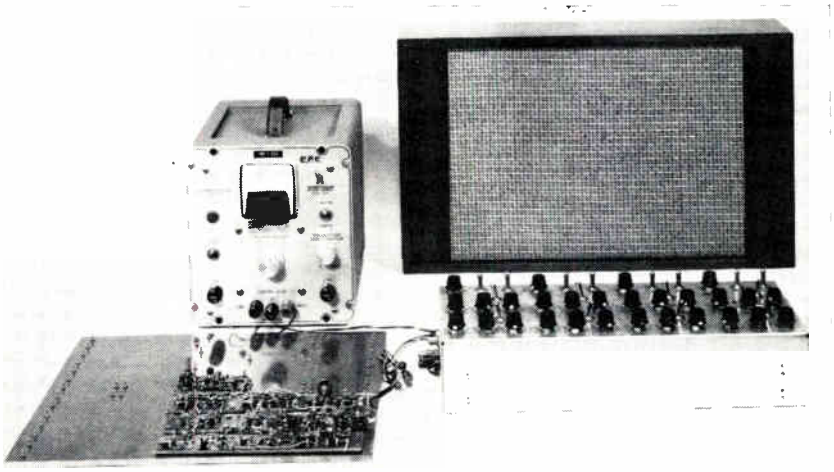
Never approach the Government agencies with empty hands is axiomatic. The old approach of "Tell us your problems so that we can work on them" is outworn and probably useless. It amounts to an admission of lack of knowledge of technical trends and, further, to a request for unpaid consulting services. A straightforward variation of the approach does make it possible to make initial contacts on an exploratory basis. It is permissible to say "Here are results of some of our recent work. Let us hear about your activities in related areas." Industry can't expect the customer to define his problems, for when he can clearly define his problems, he is well on the road to solving them. Successful contact consists of opening of doors and listening to discussions. It is up to the industrial representative to listen well and to say, at the appropriate time: "You have a problem and this is what it is."

Simplest tools for opening doors into Government offices are descriptions, in one form or another, of new technical work. The writer has found it useful to have engineers prepare short technical notes with which their names are identified. These are circulated freely both inside the company and in the proper Government circles. Copies are also circulated to public relations personnel who contact the professional and trade journals on possible publication. Such a system can only work if the original author is given clear and generous credit for his work. Examples are described below:

A program which involved this Lattice Cube Structure for Microwave Lenses was summarized in a technical note.



A speech program which supported the communications groups was described in a technical note. The equipment shown here was used for artificial speech generation.



A program of several years' duration in the study of tunnel diode circuitry was brought into focus by building a demonstration unit. Along with the hardware, a technical note was prepared which later became the basis of an article. It has been submitted for publication.

Advanced and superior technical work had been done in establishing the basic design approach to sync search receivers for communication systems. The work was hard to communicate to customers because of its complexity.[1, 2] A simplified, but technically valid, note was prepared with a provocative title, "The Needle in the Haystack Problem," and a cartoon for the cover page. The light touch did arouse mixed comments, but succeeded in calling attention to the work.

The light touch was also used in preparing a technical note describing the Philco pinch tube laser. The note describing the work was titled "How to Pinch a Laser," had a cartoon on the title page. This work too led to a professional publication.[3]

Another program which was summarized by a technical note involved lattice cube structure for microwave lens systems. The speech program which supported the communications groups was also described in a technical note.

By and large, clever titles and cartoons have been used very sparingly. This method can backfire. Also, the technical work must be of unusual merit if attention is directed to it in such a positive manner.

Many individuals must be informed on the subject before a major new approach is financed. Hence the rule in customer contacts is communicate, communicate, communicate. Further, the message does not really penetrate if it is a complex one or covers many subjects. In order to communicate it is essential to concentrate.

The problem arises as to whether opportunities are overlooked by too narrow a concentration upon subject matter in talks with the customer. But the gain involved usually outweighs the loss. The resource that the industrial concern brings to a developing technology is its team of senior scientific talent. The way of dissipating that resource is to assign to it a variety of tasks and responsibilities. In this way the personnel find it difficult to concentrate long enough in one area to develop significant achievements. The customer tends to realize, too, that if technical personnel are performing well in one area, they can also do well on other tasks. Thus, concentration on one problem does not usually exclude a group from broader consideration. Rather the reverse is true, a good analysis well presented is the best recommendation.

Marketing Probes

The marketing probe consists of a presentation by a small team of engineers and a marketing representative. The group presents the company's recent tech-

This tunnel diode memory demonstration unit brought into focus a program of study concerned with tunnel diode circuitry.

1. C. Gumacos, "Analysis of an Optimum Sync Search Procedure," IEEE Transactions on Communications Systems, Vol. CS-11, March 1963, pp 89-99.

2. J. Z. Grayum, "Optimum Decision and Scanning Technique for Synchronization," Eighth Natl Communication Symposium, Oct. 1962.

3. R. Crompton, J. Hitt, and R. Williams, "Laser Pump Employing the Plasma Pinch," 1964 Internatl Solid State Circuits Conf., Phila., Pa.

nical achievements in a particular field, along with recommendations for future action in that area. Purpose of the probe is to learn the state of the market, the trends in the military thinking, and the present and projected condition of the customer's budget in the technical area of interest.

The poorest possible probe is the well rehearsed one which is interesting, dramatic, convincing, and leaves no time for questions. The writer—to his sorrow—has been involved in such exercises. It sometimes occurs that the complexity of the system under discussion leads the technical man to stress one or two important highlights to communicate his message. If those highlights do not include the features considered to be important by the immediate audience, then a disastrous misunderstanding may occur. The customer may feel that the company representative does not appreciate the problem. The only sure way to avoid such fiascos is to insure that a two-way communication takes place.

A not uncommon feature of well organized marketing probes and presentations is that they may literally be too good and handled by the wrong people. Quite often the key scientific talent in a program will have no gift or inclination toward oral presentations. Thus, the company will often decide to use a less gifted or well trained technical man, but a better public speaker. This course can lead to disaster for a number of reasons. The Government in evaluating a program is always asking not one but two questions:

Does the proposed program have merit?

Can this company carry out the program?

TYPICAL AGENCIES SPONSORING RESEARCH AND DEVELOPMENT

AGENCY AND ACTIVITY	MISSION AND MAJOR FIELDS OF INTEREST
Department of Defense ARPA—Washington, D. C.	Advanced Ballistic Missile Defense and Basic Research in Materials, toxicology, Advanced Energy Conversion, and Solid Propellant Chemistry—(radar methods, decoy discrimination, data processing, guidance and control, range instrumentation, Very Early Warning, nuclear test detection . . .)
Defense Communication Agency—Arlington, Va.	Responsible for World-Wide communications for all services — (Defense Communications System, Communications Satellites, National Military Command System, National Communications System)
Navy Office of Naval Research —Washington, D. C.	Broad Research Program in selected fields having important bearing on Navy problems—(Earth Sciences, Materials, Physical Science, Mathematical Sciences, Biological Sciences, Psychologial Sciences, Naval Applications, and Naval analysis)
Naval Electronics Laboratory—San Diego, Cal.	Research, Development and Tests authorized by Bureau of Ships in fields of Electronics, Engineering, and Science—(radio, radar, sonar, oceanography, Human Factors, Weapons effects . . .)
Bureau of Naval Weapons—Washington, D. C.	Plans, Directs, and coordinates research, development, and production of Weapons and Aircraft for the Navy —(ECM, Electromagnetic Search and Detection, Navigation, guidance, Radar, Communications, Fire Control . . .)
Army Army Electronics Research and Development Laboratories—Ft. Monmouth, N. J.	Conducts continuing Research in all Fields of Physical Science leading to the development of new techniques of interest to Army—(ECM, Communications, IFF, Radar and other sensors, automatic data processing, solid state devices, electronic tubes and components, Frequency Control . . .)
Army Missile Command —Huntsville, Ala.	Directs Army Missile R&D Activities—(Missile guidance and control, Ground support equipment, tracking radar, Electromagnetic studies, anti-tank and anti-aircraft weapons . . .)
Army Electronics Command—Ft. Monmouth, N. J.	Plans, Conducts, and Manages all electronics research, development, production and distribution activities for the Army—(Avionics, navigation, Electronic Warfare, Radar, Communications, data processing . . .)
Air Force Air Force Cambridge Research Laboratories — Bedford, Mass.	Conducts Research of interest to the Air Force in Physical and Environmental Sciences (Mathematic sciences, Microwave Physics, Meteorology, Electronics, Space Physics, Terrestrial Sciences, Aerospace Instrumentation, Optical Physics . . .)
Rome Air Development Center—Rome, N. Y.	Plans, formulates, presents, and executes, for Air Force System Command, exploratory and Advanced development programs in assigned areas (High Power Microwave Components, Command and Control, Signal Detection and Processing, A-J Techniques, ELINT, Communications . . .)
Aeronautical System Division—Dayton, Ohio	Plans, programs, and manages, all Aeronautical Systems and related equipment. Responsible for development and acquisition of all aircraft and non-ballistic systems used by Air Force (Navigation equipment, radar, infrared, electronic countermeasures, data links . . .)
NASA Goddard Space Flight Center—Greenbelt, Md.	Responsible for complete development programs in Space Science and Satellite Applications; Tracking and data acquisition and reduction (Meteorological and Communication Satellites, Planetary and interplanetary sciences, ionospheric Physics . . .)
Langley Research Center—Hampton, Va.	Conducts Research related to problems associated with Space Flight and entry from space into planetary atmospheres; and problems of advanced aircraft (guidance and control, Heat transfer, materials, and aerodynamics and structures . . .)
Manned Spacecraft Center—Houston, Texas	Responsible for carrying out all NASA manned Space Flight Programs—(Space guidance and Communications display, orbital rendezvous, reentry and recovery, astronaut training . . .)

If the presentation is made by good speakers who, however, founder when penetrating questions are asked, then the conclusions may be adverse to those desired. The customer may decide on the basis of the clear and forceful presentation that the proposed program is a good one; but that, proprietary rights permitting, it can be carried forward more efficiently by another company.

The Proposal Document

The proposal document should make it clear that the proposal is only a part of a consistent corporate campaign. In the majority of today's proposals only these three basic statements need to be made and proved:

1. That the industrial concern completely understands the specific Government problem under discussion.

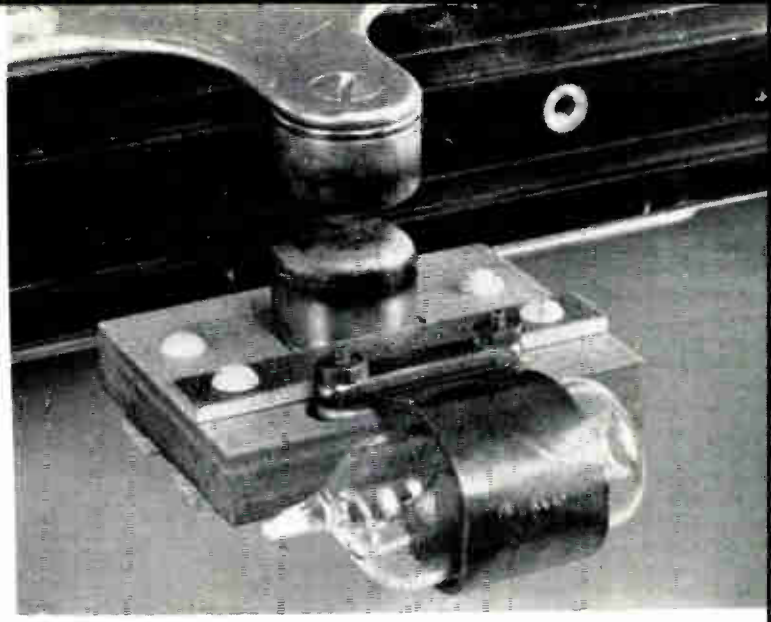
2. That the industrial concern has an approach or a number of approaches, which have the highest probability of successfully solving the Government problem.

3. That because of the particular resources in technical personnel, finances, existing equipment, management, and further because of demonstrated interested and experience, this industrial concern is the best possible choice for the task.

It is easy to say that the three statements above are true. The trick is to convince the customer, knowing that a dozen other industrial concerns are making conflicting statements. Much of the convincing must have already been done before the proposal was prepared. Even so, only a limited number of Government representatives will have been reached in personal contacts. Hence, it is entirely legitimate and quite useful to document in the proposal those pre-proposal contacts and conversations. Thus the marketing effort is described as evidence of the specific interest of company management in the project under discussion.

There is a threshold of good organization and legibility that must be achieved in a proposal document. Beyond the point of simple clarity of presentation, there is little point in attempting to do better. The problem of getting the message across in a proposal document is an exercise in clear straightforward English. The problem of deciding that there is a message which should be put across is more nearly the basic problem. This question, of course, should have been decided long before the request for proposal was received.

Most Government agencies have a proposal scoring system. Table 3 presents a scoring system which has been used at one agency. Generally these same items are used in all scoring systems, but the weightings vary. Thus, a small R&D effort would emphasize the engineering approach; a large systems management task would emphasize general management qualifications. Note further that a proposal may lose not only for over-all low scores but for an unsatisfactory rating on any one critical item.



The light touch was used in preparing a technical note describing the Philco pinch tube laser (shown above). This approach calls attention to the work, but it must be used with caution.

National Defense by Contract

Industry-university-Government is a team that has grown to an economic structure that can provide the rapid response of the nation's best scientific brains

Table 1

IRDP Program Activity Definitions From ASPR

Basic Research:	is that type of research which is directed toward increase of knowledge in science. In such research, the primary aim of the investigators is the fuller knowledge or understanding of the subject under study, rather than any practical application thereof.
Applied Research:	consists of that type of effort which (i) normally follows basic research but may be severable from the related basic research (ii) attempts to determine and expand the potentialities of new scientific discoveries or improvements in technology, materials methods, devices, and techniques (iii) attempts to "advance the state of the art"
	Applied research does not include the above efforts when their principal aim is the design, development, or test of specific articles or services to be offered for sale, which are within the definition of the term development.
Development:	is the systematic use of scientific knowledge which is directed toward the production of, or improvements in, useful products to meet specific performance requirements, but exclusive of manufacturing and production engineering.

Table 2

Techniques for Financing New Efforts

SOURCE OF FUNDS	ADVANTAGES	DISADVANTAGES
Proposal Funds	(a) 100% recoverable as charge against existing contracts (b) Large funds available on short notice for intensive efforts	Appropriate only for short efforts with a specific end product e.g., proposal or presentation
IRDP Funds	(a) Large percentage of costs recoverable as charges against existing contracts (b) IRDP programs have built-in security	Funds often more limited or more carefully controlled than proposal funds. (This may be an advantage or disadvantage to the individual concerned.)
Cost-Sharing Contracts	(a) Useful tool for "freezing out" competition (b) Develops direct and close relationship with specific customer	(a) Heavy cost sharing is more costly than IRDP program (b) Surrender of management prerogatives (c) Repels corporate management (d) Costs come directly out of profits

Table 3

Proposal Evaluation Guide Form

ITEM	Score	Weight	Rating
I GENERAL QUALIFICATIONS: (a) Demonstrate ability on similar projects (b) Reputation—for meeting schedules —for production quality			
II FACILITIES: (a) Adequacy of basic plant (b) Adequacy and availability of equipment			
III PERSONNEL: (a) Experience in related work (b) General qualifications (c) Availability for this project			
IV ENGINEERING APPROACH: (a) Understanding of the problem (b) Soundness of approach (c) Simplicity of design (d) Completeness of proposal (e) Unique ideas (f) Ease of maintenance			
Total Rating			

to urgent national problems, without prejudicing the democratic form of Government. The system does have a rough mechanism of checks and balances. Also, in spite of security measures, the system provides for individual contributions that may or may not conform to current group thinking.

In spite of close governmental supervision, there is every intention of retaining and encouraging the free enterprise nature of the military electronic industry. Profits may well be larger in coming years for firms that succeed in this industry. It is still characterized as a high-risk situation. There are fewer pay-offs and they will generally be large. Further, there is no award for second best. One may ask what are the boundaries to the actions of the individual in this Monte Carlo world?

It is possible, in this atmosphere, to make short-range gains by glowing promises and by making commitments known to be impossible to keep. The industry is large and complex enough that by well-timed moves an individual can avoid for some time the problem of performing on his promises. The dangers and long term effects of such an approach should be obvious.

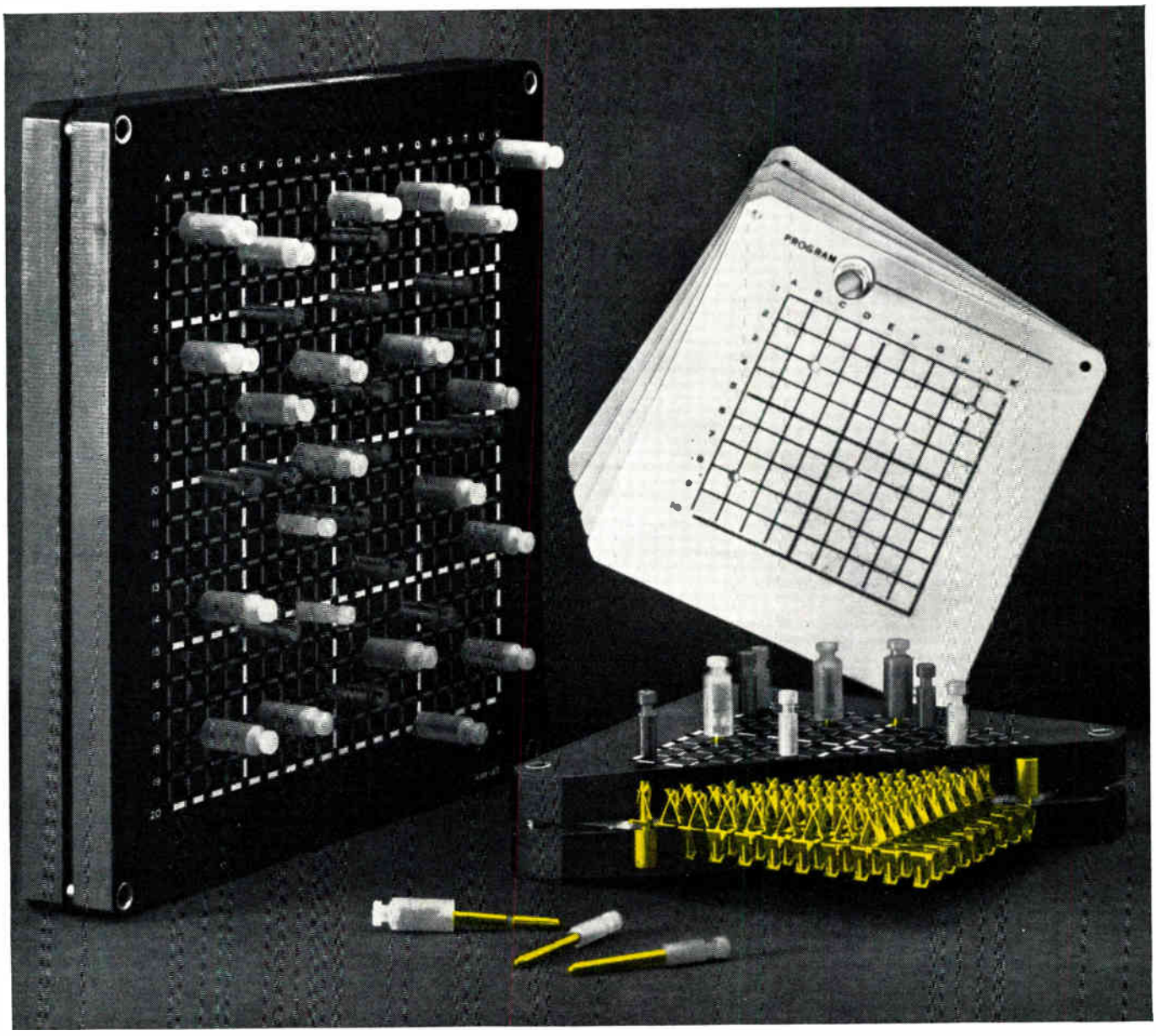
There is a further aspect of the problem, which is sometimes a little awkward to discuss. That is the matter of patriotism. If, in marketing and in developing marketing approaches one is trying to anticipate the leading edge of the problems of the Government, then one is acting as a catalyst to make this industry-university-Government perform as it should. If the slightly different approach is taken of trying to anticipate not the actual needs, but what the customer thinks are the actual needs, then the entire procedure is cheapened in a way difficult to describe. The writer's own experience is that Government personnel do not appreciate this "second guessing" and that the more courageous approach is also more successful.

● **A REPRINT of this article is available from ELECTRONIC INDUSTRIES Reader Service Department**

NOTE: The techniques described in this article are considered to be basically sound and useful although it is known that some of the details of Government procurement policy are currently in process of change. Among the more significant changes are these:

Cost sharing has been prohibited on R&D contracts unless the contracting officer can prove to the head of the procuring agency that substantial commercial benefit will accrue to the company involved.

Consideration is being given to the practicability of lumping development, research, and technical bidding costs into a single pool of allowed expense with an associated ceiling. It would be left to the discretion of individual company management as to the distribution of the effort into the three areas.



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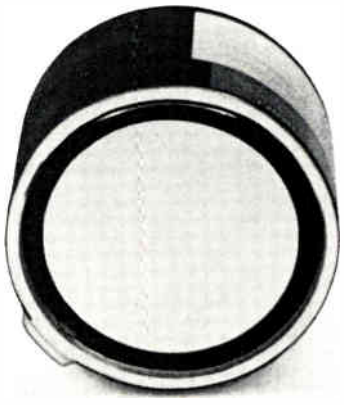

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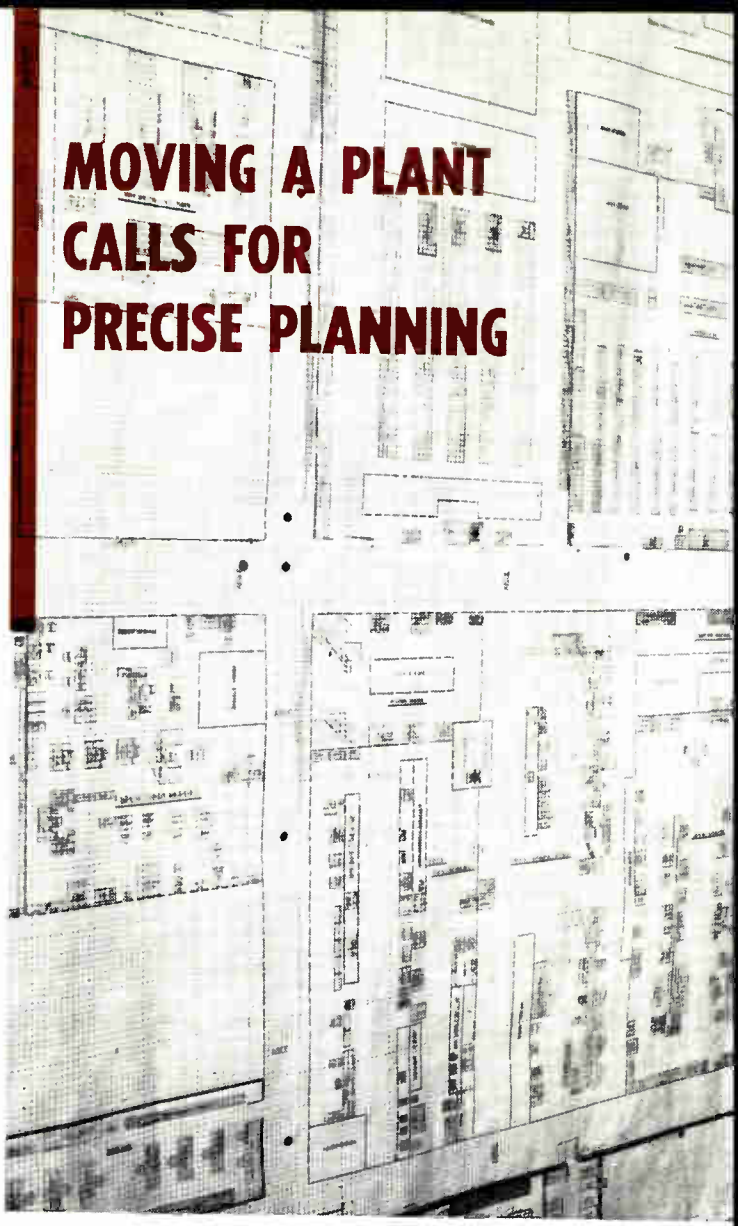
MOVING A PLANT CALLS FOR PRECISE PLANNING

One of the decisions electronic industry managements must face at some time is when and how to expand. Often this expansion means a new, modern plant at another location. The question then is how to move a whole company and minimize the downtime for production machines. Littelfuse tells how they tackled the problem.



EFFECTIVE MANGEMENT usually makes effective decisions. One of the hardest decisions many managements must face at one time is to expand their manufacturing facilities, to build new plants.

Adding to management woes is another task, once the new plant is built—moving men and machines from the old plant with minimum production downtime, the period when machines are idle. Many questions must be answered before the decisions can be made.

Principal questions are somewhat simple. How do we get started? Where do we build it? Who can we get to build it? Do we have the know-how and the manpower to do it ourselves? What plans do we have to make to produce for today, tomorrow and five years from now? What real estate is available and what about prices? How can we avoid costly pitfalls?

Summarized, the big question management asks itself is—"how do we do it?" The decision to expand and build a new factory building is a big task. It is one that requires good planning in the first stages in an overall program based on many decisions; it must have well defined objectives.

Top management of a large electronics firm in the Midwest solved expansion by following basic concepts. It used as the basis for all of its planning and follow-through what the firm likes to refer to as its *4 C's formula*. In its simplest form the formula covers coordination, cooperation, communications and command; it took decision from conception through to reality.

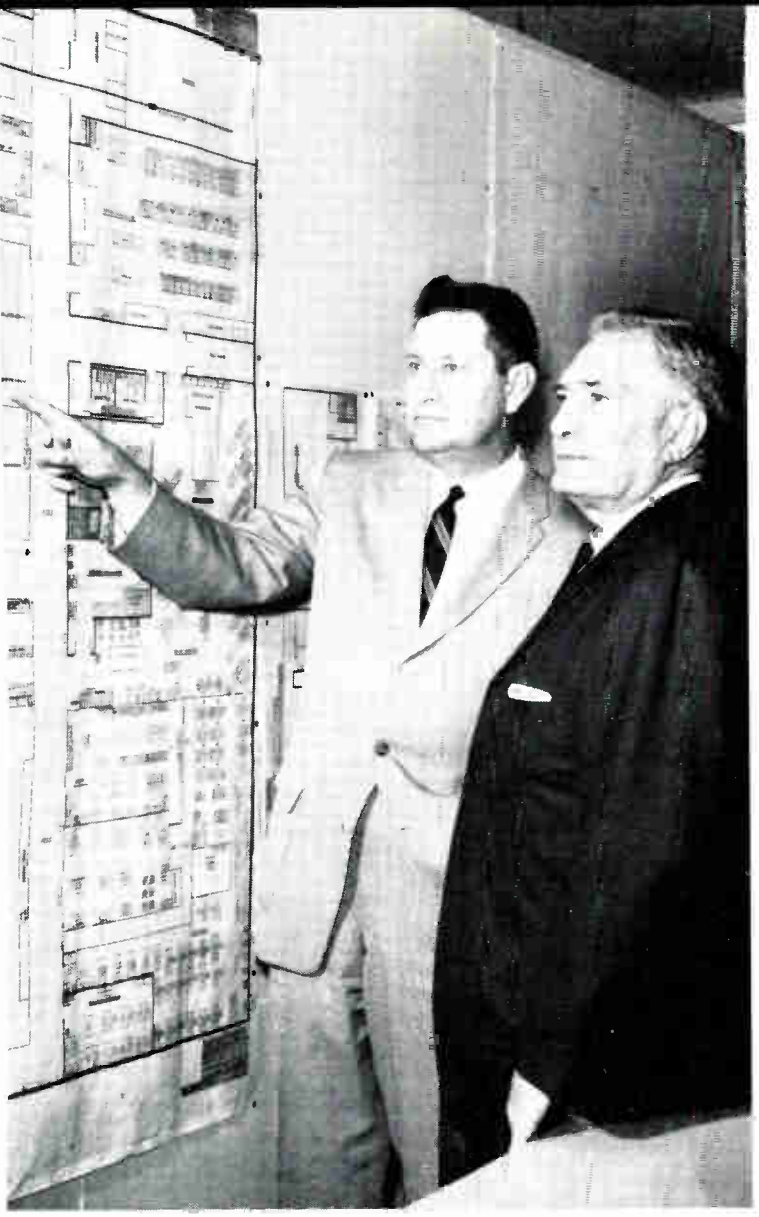
The company, Littelfuse, Inc., of Des Plaines, Ill., broke ground on its new 125,000 square-foot plant in March, 1963. It began moving into the new $1.75 million, all-air-conditioned building eight months later. The building, located on 14.1 acres of choice site, is designed for the future with provisions for growing to double capacity already built-in.

11 Working Steps

Thomas M. Blake, president of Littelfuse, and Jack D. Hughes, executive vice president, broke down their company's approach to the building and moving problem into 11 working steps:

BUILDING STAGE

1. Establish the *need* for a new plant.
2. Bring in an industrial engineering firm; select a proper location.
3. Lay out plot in block diagram.
4. Lay out plant in block diagram.
5. Layout plant in detail (to scale).
6. Work with architect/contractor on building design.
7. Check out details of the architect's drawings and specifications.
8. Check details of construction during building of plant.



Thomas M. Blake (right above), president of Littelfuse, studies flexible mylar sheet layout of floor plan of new plant in ¼" scale as executive vice president Jack D. Hughes points out proposed (before the move) production lines for new fuses and relays. Detailed layout showed exactly where each machine operator and piece of equipment would be placed immediately on moving into the new plant to reduce down-time. "Since all production services such as compressed air, electricity, and water were in place and functioning before equipment was moved, it was possible to connect all machinery and have it operating instantly, especially to produce the millions of piece parts (in photo) for relays."

MOVING STAGE

9. Plan move of machines and men in detail.
10. Plan for adequate inventory to cover down-time of production equipment.
11. Supervise moving and installation of equipment in new plant.

Preliminary investigations were carried out by Littelfuse 1½ years before the first shovel of ground was turned. Management had to decide on what objectives it wanted in going to a new plant and who would be in charge of this task.

"It is vital that one man be chosen to make decisions, and that all activities and expenses clear through him," stressed Mr. Blake. Littelfuse executive vice president, Jack D. Hughes, took on this job. He and Mr. Blake already had much background in planning new buildings; both had been active in building of a hospital and a large YMCA.

To coordinate functions at all levels, a manufacturing engineer was assigned to the job. This latter position must be filled carefully by a man with particular attributes. According to Mr. Hughes, he should be thoroughly familiar with the firm's entire operation. This includes manufacturing processes, engineering, inspection and quality control and administrative organization.

While know-how is vital, he should have certain emotional traits. He must be able to communicate with others and have the "patience of an angel" with those he works with under adverse conditions. He must be capable of making organization out of confusion; he should be able to work well under pressure; he must exhude confidence and make quick decisions with assurance. *(Continued)*

By ARTHUR J. STEELE
Administrative Engineer
Littelfuse, Inc.
Des Plaines, Ill.

EXPANSION (Continued)

Plant Location Vital

Plant location calls forth many factors during early planning. Nearness to markets, sources of materials, transportation access are standard factors. Local inducements such as low-taxes, favorable banking, good city government with progressive minded administration, industrial climate for growth are obvious factors to be considered.

Major aspect, of course, is available labor supply and type needed—skilled, semi-skilled and unskilled. To locate a proper site for Littelfuse, surveys had to be made of vacant properties available in areas that met required factors. Price is almost always a criterion. A budget should be decided upon; it can be based on the values of property available.

During the planning of the new Littelfuse plant, an industrial engineering consulting firm, Eitzen Engineering, of Chicago, was brought in to assist the manufacturing engineer and management. There are two main advantages to this. One, an industrial engineer can take an objective look at your present operation without bias. Second, he can remain on the job as a consistent operation and not be interrupted by regular company routine.

Job Was to Coordinate

In early planning, the consulting firm felt its job was to coordinate. In any firm, as with Littelfuse, there are many management ideas to be coordinated. The consulting engineer can direct, suggest and consult with management and department personnel to determine their needs for today, tomorrow and beyond. Two objectives had to be reached in preliminary planning:

1. Relieve the congested conditions of today. (Production departments had grown, from increased sales, to the point of overflow of personnel, machines and space.)

2. Provide for future expansion (future growth of building including provisions for power, shipping, etc.).

It took about five months for the consulting engineer working with the Littelfuse coordinator to determine the firm's present situation, what it needed, and what its goals were for the next five years (based on % growth per year). Also determined was the ultimate goal of the selected property so that production, machine and personnel data could be known.

Future growth projections from Littelfuse management were added to the old plant layout and from these a new plant layout was made. The percentage of expansion for each Littelfuse department for the next five years was figured with new statistics. A plot layout was also made.

Sought Foremen's Ideas

Throughout early planning foremen and supervisors were asked for their cooperation and ideas. Each had to forecast his future needs so as to space and justify them. A multitude of ideas came from middle management groups. This is essential to the success of such an undertaking. If a foreman participates, usually he will sell it to his employees. He has a feeling of responsibility.

"The success of the move depended on how well each foreman planned it," asserts consulting engineer, Vince Eitzen.

After the growth factor was introduced to each department's square footage, planners made a block diagram to determine basic size of the new plant. The building was designed from the inside out. As with most plant layouts, its purpose was to bring about the best combination of plant and equipment with the highest standards of production and the lowest unit cost.

There are many questions to think about at the first stages of planning. What type of product do we want to assemble or make? What type of organization do we want? Are changes necessary to improve our efficiency?

We found a number of advantages in setting up operations so that fabrication and process work on piece parts was apart from final assembly areas. We set up a pattern so that work would flow from section to section with minimum material handling.

Some departments produce heat in their processes. These had to be properly located so that future expansion could be worked out easily. Expansion included complete air conditioning. Thought was given also to double decking for storage of materials and slow-moving items. The physical image of the new plant emerged on exact paper block diagrams. Littelfuse's approach was a practical one. Department details were added in another layout.

The detailed layout showed exactly where each machine operator and piece of equipment would be placed.

Same for Each Department

The same procedure was followed with each department until the entire factory had been laid out item by item. A similar procedure was followed for offices. When this layout was concluded, Littelfuse contacted the architect and discussed layout in detail. Planners explained needs for factory operation. It saved money and time.

While working with an architect, Littelfuse found

Arthur J. Steele (right above), Littelfuse administrative engineer, with a representative of Eitzen Engineering, Chicago industrial engineer firm. "There are two advantages to consulting assistance. An industrial engineer can look at a firm's operation without bias. He can be a consistent operation and not be interrupted by company routine."

"Thought was given to double decking for storage of stock, materials and slow-moving items. The Littelfuse approach was a practical one." Checking stock are (from left) Jan Janata, Shipping Room Supervisor; Walter A. Clements, vice president, distributor sales; Andrew Kalata, customer service manager.

Statistical data provided by Littelfuse's new processing and storage system permits management to chart business course and trends. From left are: Kurt Schaffert, data processing manager; Jack D. Hughes, executive vice president; and Thomas M. Blake, Littelfuse president.

it necessary to go over needs in great detail. Discuss the scale layout so that it is thoroughly understood by mechanical engineers and the architect. The work can be divided into two general areas:

1. The design and construction of the building itself, including all of the building services needed to make the building function.

2. The process and production services to make the factory operate.

As architectural drawings and specifications are made up it is to the planners' advantage to check drawings *thoroughly*. The architect adjusts the physical structure of the plant. He adds specifics—boiler room, air handling areas, power sources, additional structural beams, changes toward esthetic beauty of the plant. The consulting engineer works with the architect until the final designs are frozen.

Messrs. Blake and Hughes with architect, Carl Teutsch, of Carl Teutsch & Associates, also Chicago, finished the designs of the new plant and presented them to the Littelfuse Board of Directors. The building program was assigned to Jack Hughes.

Other aspects still to be worked out with the architect included: level of the general factory lighting, cutting the amount of noise in production and office areas, heating and ventilating, and air conditioning for the entire plant. Employee facilities had to be weighed such as eating, parking, medical and lavatory. All were measured by "present plant volume" as well as by anticipated volume at some future point.

Services Around Perimeter

The new Littelfuse plant is designed so that service departments are around the perimeter of the building; assembly areas are centrally located. Shipping and receiving are at the rear; as the need arises for expansion, Littelfuse can expand further to the rear, adding production departments so that they completely surround the two departments. This will reduce travel distance for raw material and shipping.

After all drawings are rechecked and approved, construction can begin. Littelfuse found it advisable to have one of its building engineers assigned to the project. His prime job was to work with the supervising construction engineer of the architect's staff, seeing that all original details are built into the plant.

EXPANSION (Concluded)

As construction progressed, it was possible to install process services: electrical power, high pressure air, etc. Because they had been laid out to scale, it was now possible to show exactly where each of these services was to be located.

Littelfuse planners suggest that all services and equipment for services to operating departments be operable and in operation before moving in the first piece of equipment.

Moving to the New Plant

There is much to consider in planning the move of equipment from the old plant to the new. There must be complete coordination of all production and administrative departments. Littelfuse found that breaking the moving into several phases helped a lot. If all of one function within the factory is moved at one time as a first phase, it is advisable to have a period of time between this moving activity and the second phase. This may be classed as a digestion period. It is a period when the equipment that has been moved can be set up and put into operation in the new plant before the next plant function or second phase of moving. The next function to be moved becomes the third phase, and so on. This always reduces confusion at both plants.

The estimated time to move all of Littelfuse was eight weeks. Down-time was estimated at one day per machine. Competitive bids were asked by Littelfuse from professional movers. Each bidder was shown the machinery, how far it had to be moved, type of anchoring, etc. Bids were realistic. Other movers, for stock, boxed inventory, desks, etc., had to provide maximum price estimates and bill on a time and materials basis. Savings from this method were large. Packing was done by Littelfuse personnel. Safety was stressed and liability insurance was taken out to cover accidents.

Jack D. Hughes, center, exec. vice president, at trial run shortly after "plug-in" at new plant. "It was necessary to schedule production cut-offs and parts build-up to reduce down-time."

Since all services were in place and functioning before the move, it was possible to connect all machinery and equipment and have it running right away. This operation was greatly assisted by the marking of the machine's number on the floor exactly where it would be located.

Timetable Necessary

In early planning it was necessary to set up a timetable for cutting off production, building up adequate piece part reserves to reduce down-time, establish good housekeeping methods and eliminate as much old material as possible before the move.

Above all, department heads had to be advised of all planned moves, so their departments could move out one at a time to avoid mixup. Department supervisors acted as coordinators with the superintendent in charge of the moving. The success or failure of the moving depended on how well each department head organized his work.

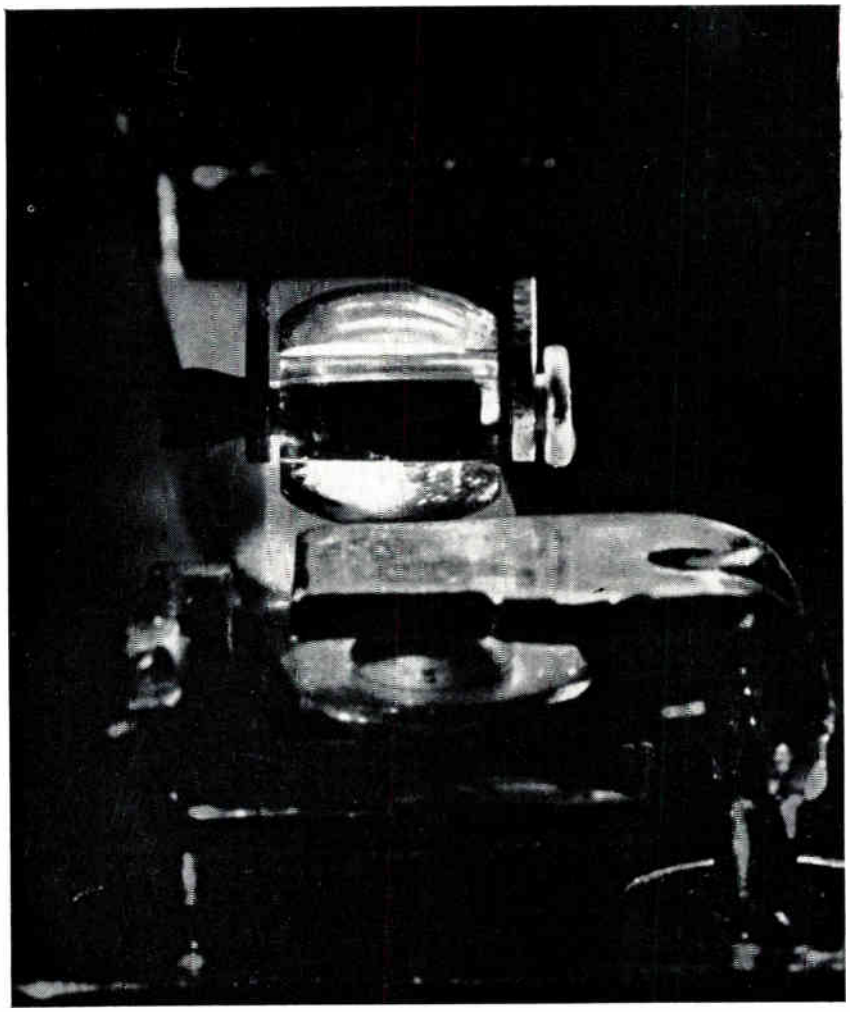
Before moving, machine repair or maintenance might be done during a machine's down-time. Littelfuse set aside a staging area for all equipment and machinery. Each unit was thoroughly cleaned and spray-painted. After the move, employees were not only in a new factory, they were, in effect, using *modernized* equipment.

To facilitate moving, a color code is a good idea. Littelfuse assigned a color to each department; tags or sticker labels were issued in this color. If more than one department at a time is moved, materials from each can be identified merely by color designation.

When material or equipment arrives at a department, location is then by number which also appears on the colored tag. Equipment can be positioned in its proper place without any secondary moving and loss of time.

By moving in this fashion, it is possible to move a large factory over a several-week period. However, Littelfuse suggests no more than one day down-time for any piece of equipment. The aim for minimum down-time is the main reason for basic planning before the move begins.

The building, the moving, when reduced to common denominator, is people in action. How they plan, coordinate, communicate, cooperate and command is the secret to any successful undertaking.



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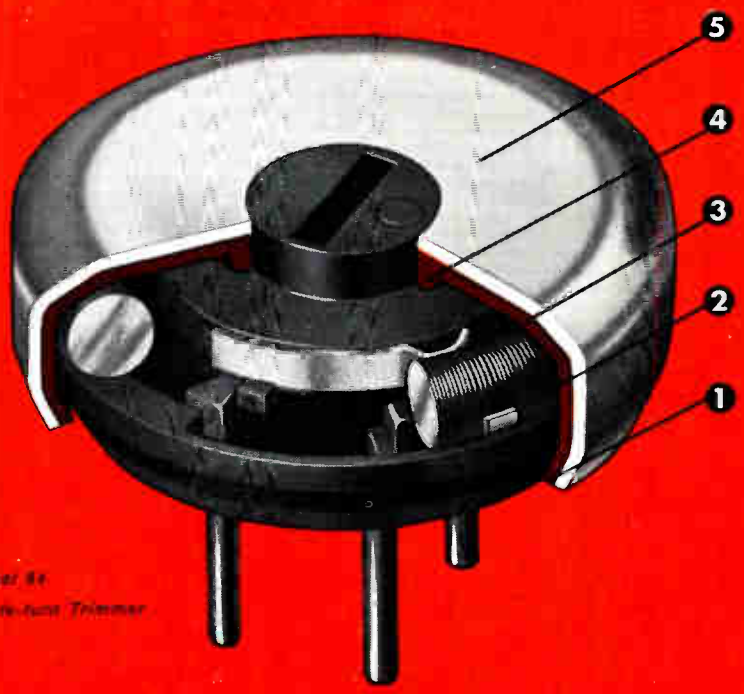

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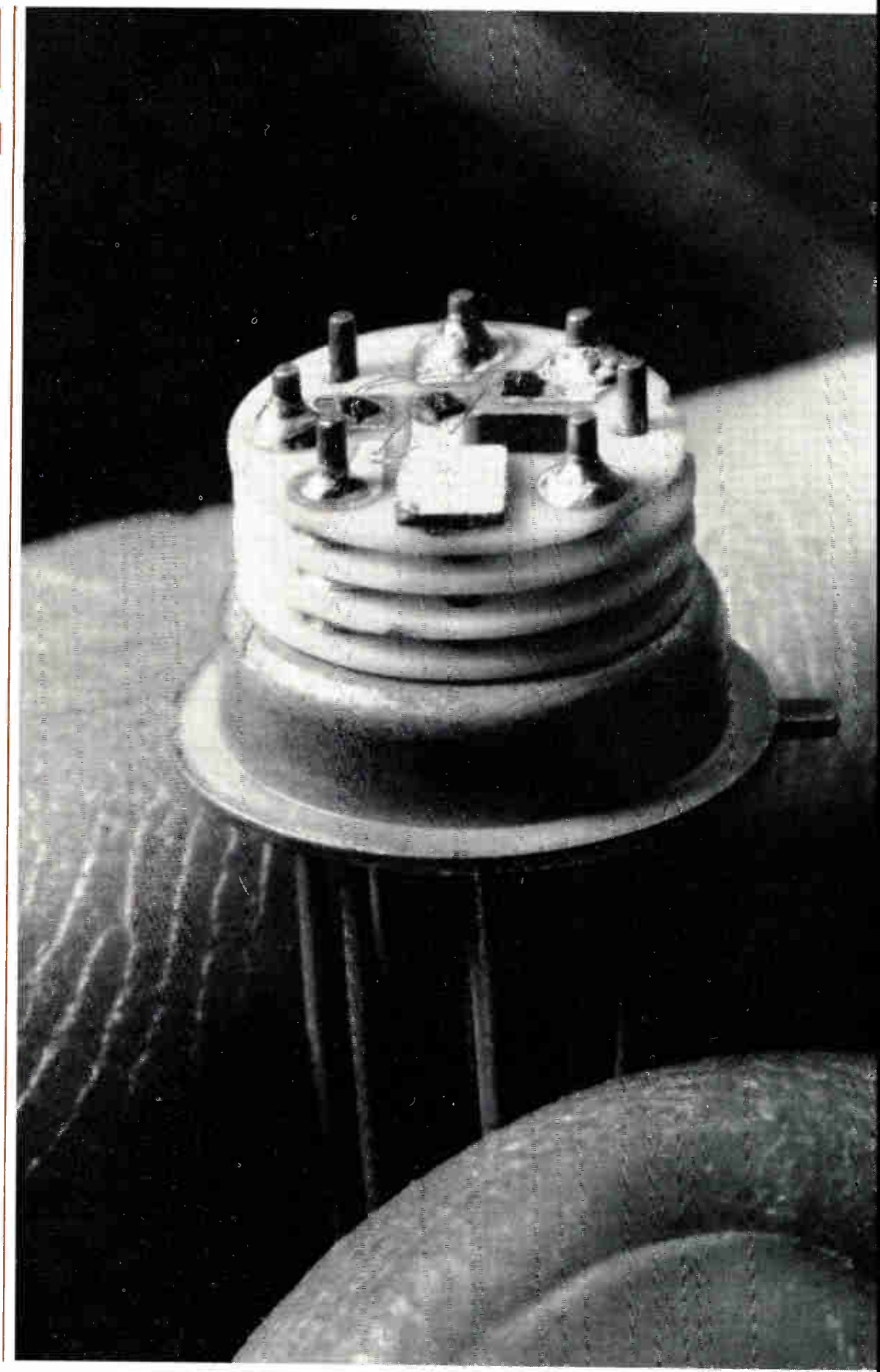

The significant progress being made is largely confined to four major types of packaging—Micromodule, Dot, Hybrid, and Integrated Systems. The wide range of variations poses problems in choosing which one to use. A possible clue lies in the different construction techniques.

NEW DEVELOPMENTS IN MICROCIRCUIT PACKAGING

THERE HAVE BEEN MANY STEPS in the evolution of microcircuit packaging; notably, "Tinkertoy," "Cordwood," and the simultaneous microminiaturization of discrete components.

In shrinking the package, various connecting methods have been used. The most popular has been soldering; though welding has aroused much interest among packaging experts. However, if welding offers any superiority over soldering, it is still to be proven. From a cost standpoint alone, using similar methods, soldering can be 30% less expensive. One reason is that welding is slow when compared to the number of connections that one solder dip can make.

Packaging methods now receiving the most attention are the Micromodule, Dot, hybrid, and integrated systems.

* * *

Dot System

In the Dot system,[1] all elements are pellet shaped, Fig. 2. Available elements include resistors, diodes, transistors, and capacitors. The diameter of these pellets or discs, ranges from 0.050 in. to 0.250 in.; thicknesses are 0.062 in. and 0.030 in.

To assemble, pellet-diameter-sized holes are punched or drilled in an insulating board which is as thick as the element being used. The pellets are placed in holes and held there by force fit or adhesive. A conductive pattern is screened onto the boards and elements to form the completed circuit.

Another method mounts the elements on flat wire matrices which are punched to provide the desired interconnection system.[2] The element is then soldered to one of the wire patterns. Next the second pattern is affixed to the partial assembly. Encapsulation completes the fabrication.

Advantages of the Dot system are that it permits automation; replacement of individual elements, at least in board-pellet form; and, selection of substrates to provide maximum heat conduction for high heat dissipating elements. Disadvantages are the present limited source of element suppliers, plus the cost of these components.

Micromodule

One system that has strived for automatic production, coupled with reliability, is the Signal Corps' Micromodule, Fig. 3. The basic elements in the assembly—wafers—contain one or more of a specific component, i.e., only resistors would be on one wafer; capacitors, on another; etc. These wafers are tested and the suppliers approved prior to use.

To assemble, the wafers needed to form the desired circuit function are stacked in a prescribed order. Spacers between the wafer control the separation. Connection between wafers and to external sources is provided by riser wires, placed in contact with the conductive pad areas on the wafer edges. Soldering completes the interconnection. The circuit is complete when specific risers are cut to eliminate shorts caused by soldering the risers to all available conductor pads.

Possibilities for automating this system are good. The wafer types for a variety of circuits can be reduced to standard groupings for reduction of direct labor costs. Assembly operations have decreased as a result of fixturing and testing.

Two variations have undergone testing: electron beam welded joints in place of soldered connections; and, Dot components mounted in the wafers.

(*Continued on following page*)

Fig. 1: This enlarged view shows an assembled hybrid circuit comprised of discrete components prior to being enclosed.

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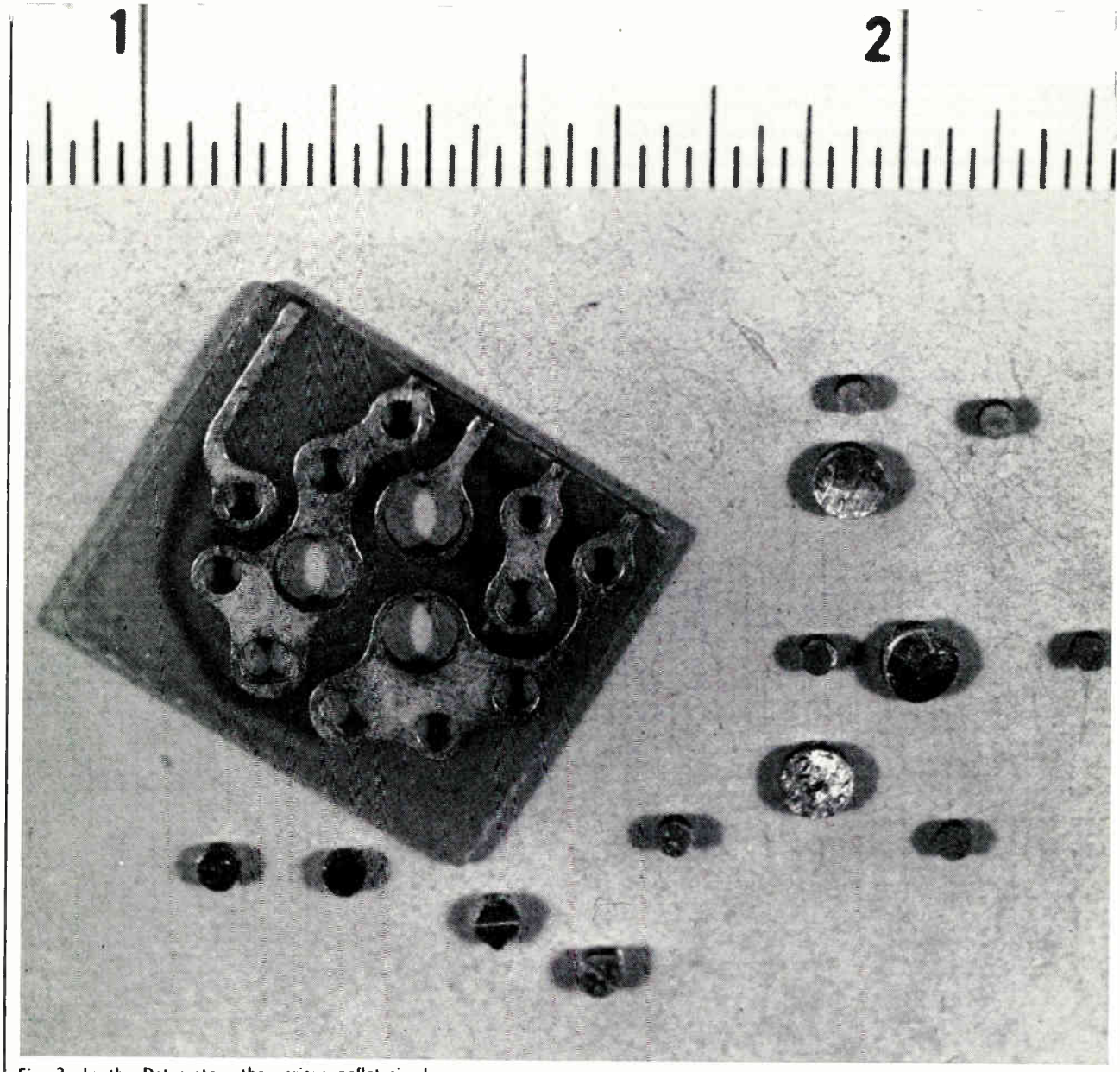


Fig. 2: In the Dot system the various pellet-sized components are inserted into an insulated board.

Fig. 3: The Signal Corps/RCA Micromodule units use a standardized wafer outline.

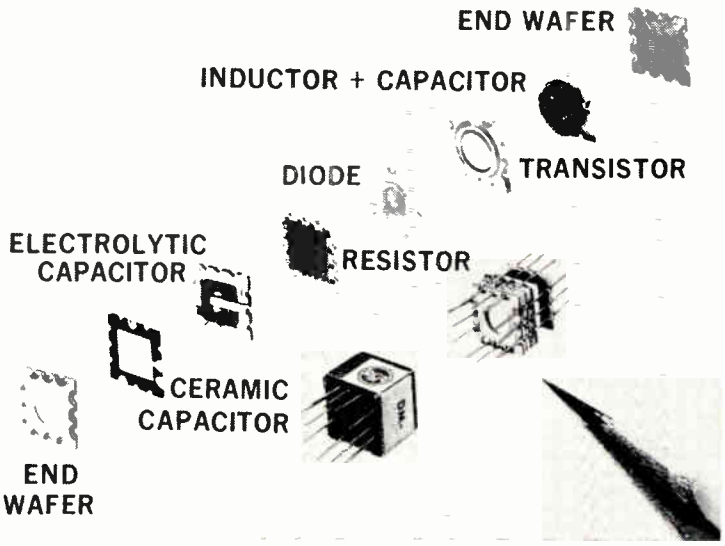
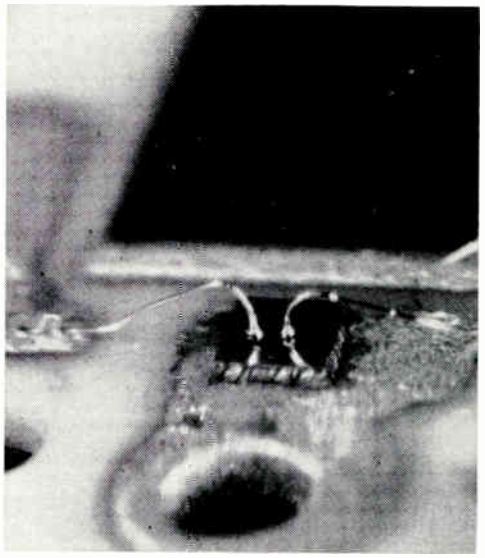


Fig. 4: Ball bonds provide a large area of bond—here, contact is 4 to 5 mils.



Hybrid Circuits

Hybrid circuits contain film and discrete elements. The film components are resistors and, sometimes, capacitors while the diodes and transistors are discrete. The substrate upon which the film elements are applied is usually glass or ceramic. The conductor pattern, like the resistors, is applied to the substrate as a film.

The unit in Fig. 1 was designed mainly for mounting in a TO-5 can. It uses stacked wafers, each wafer containing a portion of the circuit. Diodes, transistors and capacitors are discrete chips; resistors and conductors are fired, glaze films. The chips are bonded to the conductive patterns with a high temperature gold alloy solder.

The other contacts from the chips to the wafer are gold wires bonded by thermal compression. The bond is effected by forcing the gold wire onto the item to be bonded at a temperature above 300°C, but below the gold-silicon eutectic temperature of 370°C.

Two basic types of bonds are made, one is called a ball, or nail head, bond; the other, a wedge or stitch bond. For ball bonding, the gold wire is fed through a capillary tube with a hole diameter slightly larger than the wire diameter. The ball is made by cutting the wire with a hydrogen flame. The diameter of the ball formed from a 2 mil wire would be between 4 and 5 mils. The ball, held at the end of the capillary tube, is positioned over the bonding pad; then pressed firmly onto the metallized pad. The ball should be deformed about 50%.

Fig. 4 shows two ball bonds and the metallized pads to which they are adhered. Ball bonds provide a comparatively large area of bond. Therefore, they have a higher absolute adhesion strength than the wedge bond.

In wedge bonding, the wire itself is placed against the bonding pad, then compressed with a "wedge" tool to form the bond. This method is often called stitch bonding because two such bonds are usually formed. The result resembles a stitch, Fig. 5.

This bond offers two advantages. First, because two or more bonds can be made in series, a number of elements can be interconnected with one length of wire. Second, the bonding area is small; thus connections of small metallized widths—as often occur in the base connections of high speed transistors—are possible.

The magnified view of a 12-hole alumina wafer, Fig. 6, shows a conductive pattern, one resistor (the large black area), and one capacitor chip. The plates of the capacitor are electrically connected by high temperature solder bonding one surface and wedge bonding a gold wire to the other surface.

In assembly, the required wafers are mounted on a TO-5 header having 8, 10 or 12 leads. Spacers are used between wafers. All wafers are then soldered to the header leads. If necessary, after soldering, certain leads are cut to prevent shorting. After cleaning, the unit is sealed. This system provides a rugged, reliable, low-cost unit.

The circuits that can be produced are quite varied because there are relatively few limitations on the elements used. Element selection is based on data obtained by testing individual elements under a variety of conditions. Final approval is based on the individual data, plus performance in specific test circuits.

(Continued on following page)

Fig. 5: Microphotograph shows a gold wire wedge bonded to one plate of a capacitor.

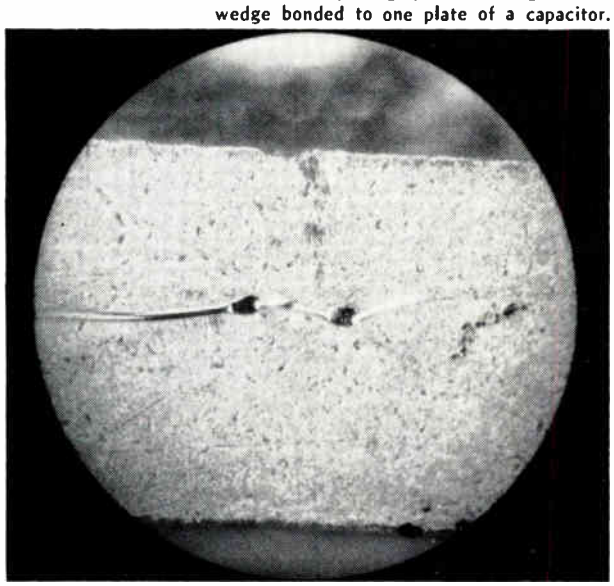
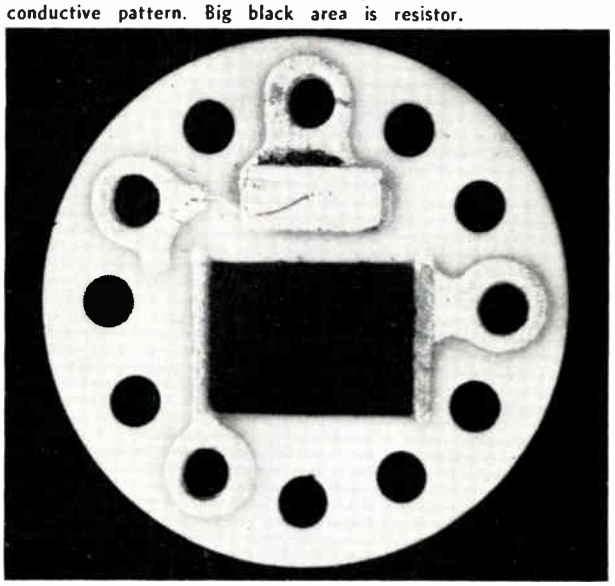


Fig. 6: Gold wire wedge bonded to capacitor and conductive pattern. Big black area is resistor.



MICROCIRCUIT PACKAGING (Concluded)

Integrated Circuits

Physically, the smallest circuits available today are integrated circuits. These are single blocks of silicon material, each of which provides complete circuit functions.

Potentially, integrated are the most reliable circuits—if we assume that reliability is inversely proportional to the number of connections. Eventually, they will probably be lower in cost than comparable devices.

Their disadvantages are circuitry restrictions, lack of passive element close tolerance control, difficulty of testing individual components, and high tooling costs.

This circuit form first appeared in 1959. One of the earliest problems, especially since packing density has been a criterion of progress for many years, was how to package to protect elements but not substantially increase the overall component volume.

The ultimate in size would be the device plus leads; next best, leads plus a conformal coating of, perhaps, glass; third, the flat-type package now used by some producers; and last, the existing basic transistor package—but with more leads.

Fig. 7 shows a 12-pin TO-5 header with an integrated circuit attached. The circuit measures 0.050 in. x 0.050 in. Header pins located on a 0.200 in. diameter circle, have a center - to - center distance slightly greater than 0.050 in. An eight-pin header would have 0.078 in. between pins. The gold wires are nail head bonded to the termination pads and wedge bonded to the header pins.

This package satisfies the requirements of (1) chemical inertness, (2) imperviousness to gases, fluids, etc., (3) low cost and ready availability, (4) adaptability to production process, and (5) interconnectability with other similar packages.

The package being used most widely today is the flat package, Fig. 8. It normally consists of an insulated glass, or ceramic, body bonded to a kovar frame. The cover is also kovar. The cover can be sealed to the frame by soldering, brazing, or resistance welding. Packages made by Corning Glass are all-glass construction, sealed with a Pyroceram cement.

This glass package offers the most space reduction and provides the same degree of protection as other semi-conductor cases; but, the cost is quite high.

Package lateral dimensions are usually in increments of ⅛ in. They range from ¼ x ⅛ x .035 in. to ⅜ x ⅜ x 0.040 in. The leads, located on 0.050 in. centers, are flat kovar ribbons 0.010-0.015 in. wide, 0.033-0.055 in. thick.

The integrated component is mounted and connected like other types of semiconductors. If the mounting base is solderable, a gold alloy bonds the integrated element to the substrate. If the base is an insulator, then a high temperature adhesive, such as Pyroceram cement, is used. Gold wire, thermal compression bonded to the component conductor pads, provides connection to the external leads where it is usually stitch bonded. The latter bond, especially in the case of TO-5 leads, may be a weld.

1. Bender, B. G., and Dreyer, R. W., "Swiss Cheese Method of Circuit Packaging" presented at Electronic Packaging Symposium, Boulder, Colorado, August, 1962.

2. Huetten, C., and Sweany, L. P., "Electronic Networks from Pellets" presented at Third International Electronic Symposium, Boulder, Colorado, August, 1962.

Fig. 7: Chip in the center of this TO-5 header is an integrated circuit. Note connections used—ball bond on chip and stitch bond on header pins.

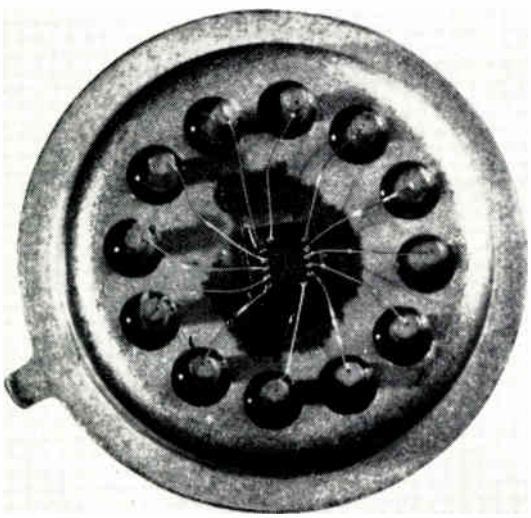
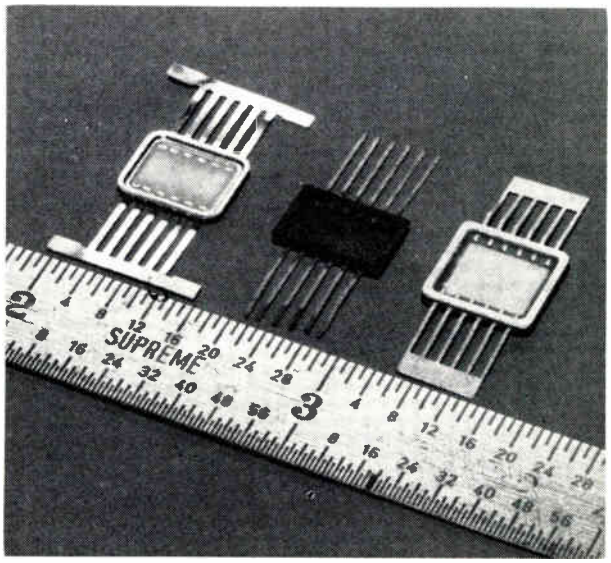


Fig. 8: Samples of various flat packages being used to house integrated circuits. Dark unit is glass, others are glass or ceramic bonded to kovar.



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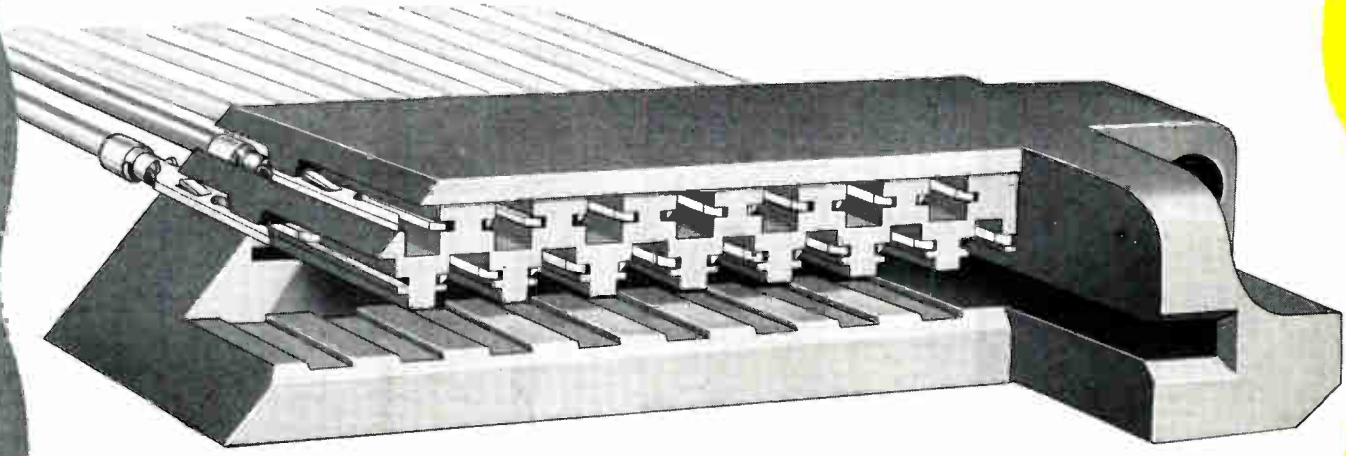

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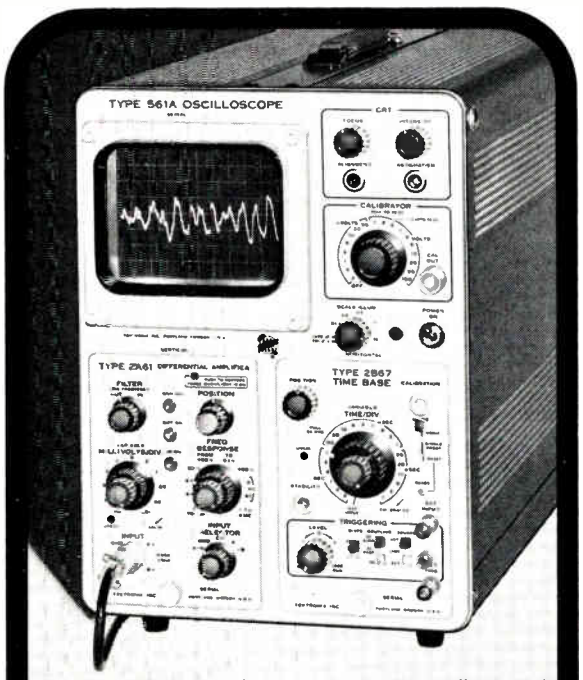

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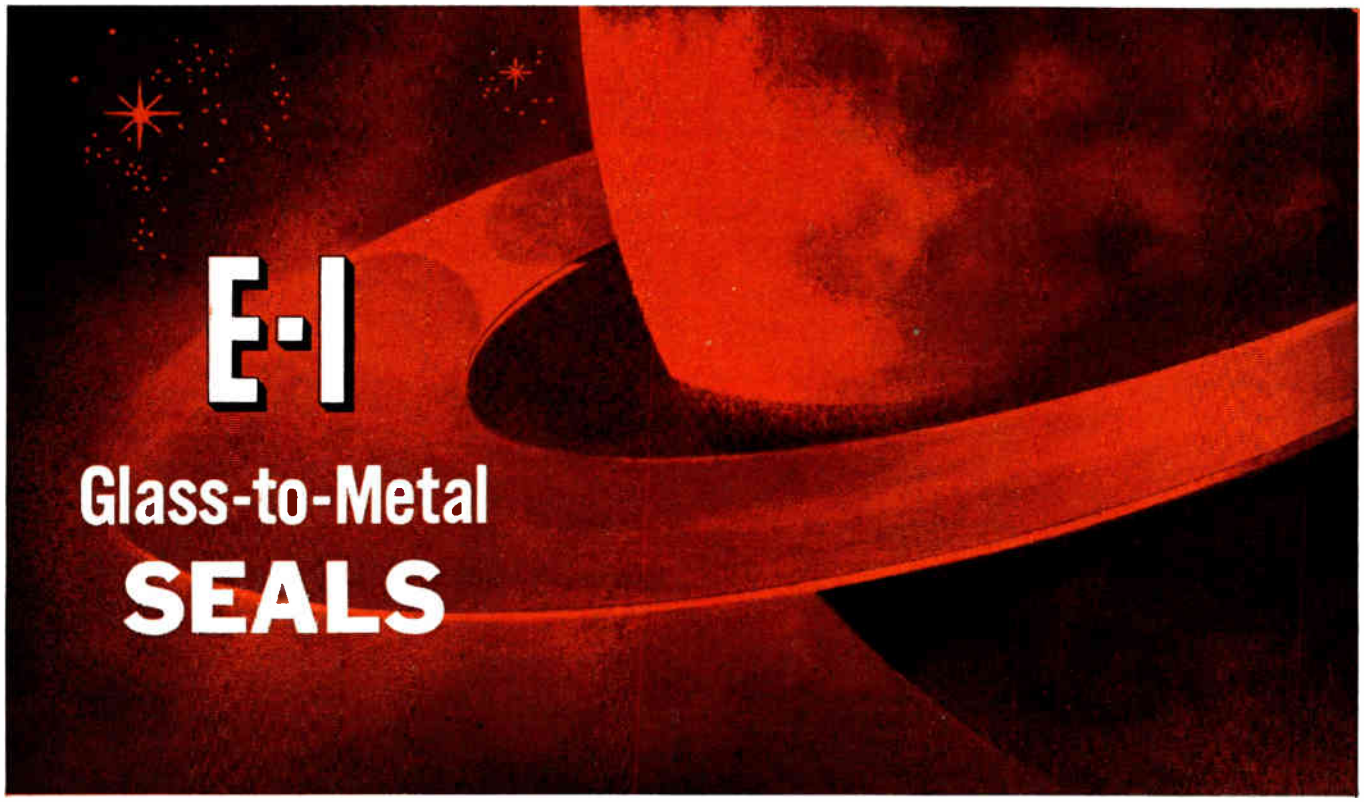

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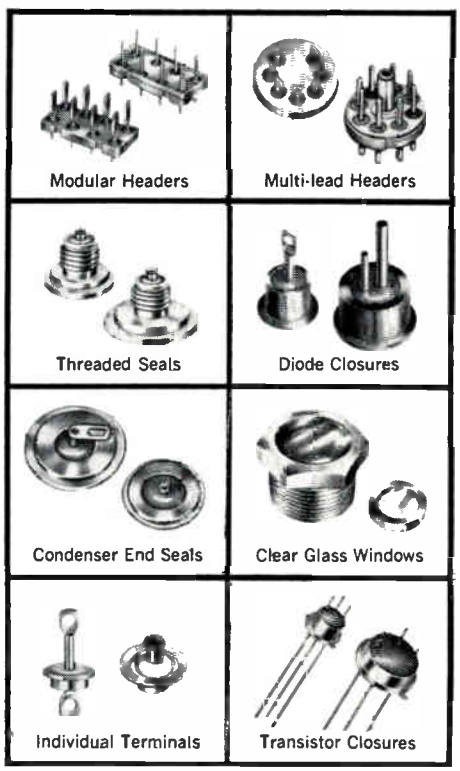

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Advancing electronic technology has created a need for precision display systems of many kinds. An important component of these systems is the high resolution CRT. The systems designer must have a knowledge of the state-of-the-art and also an understanding of design theory. This article will supply him with both of these.

HIGH RESOLUTION CRT'S FOR PRECISION DISPLAY SYSTEMS

By HILARY MOSS
Advisory Engineer
Westinghouse Electronic Tube Div.
Box 284
Elmira, N. Y.

"STANDARD" STATE-OF-THE-ART is a spot diameter of about 1 mil, at up to 5 μa beam current, at 10-20 kv. Dynamic focussing is needed to maintain this focus quality over a 4 x 4 in. raster. Ultimate state-of-the-art represents about a 0.3 mil spot diameter at 2-3 μa and at 20 kv. Three separate but time-synchronized, dynamic, correcting waveforms are needed to maintain this spot size. And, utmost care must be taken in all aspects of tube environment. Useful and substantial further advances seem unlikely.

* * *

In Fig. 1 the space between P and S of length βz is generally an equipotential region. Here the electron volt-velocity is V.

The conical electron beam in Fig. 1 is generated and focussed by an "electron gun" (to the left of P). Electron gun theory is an intricate subject. But, it can be largely ignored here, since by whatever details of gun design the beam is produced, quantities I, V, βr_i, r_s, βz are still connected by certain physical laws which define overall performance.

Before discussing these we must note that the beam in Fig. 1 cannot be usefully divorced from the deflection system. Gun and deflection device are intimately linked by the need that in deflection through a defined angle λ corresponding to an absolute deflection x, the spot must not be excessively deformed. We cannot obtain high overall resolutions by simply achieving a low value of r_s at the screen center only. Thus intuitively we see that all else being constant the "best" pencil of rays from the gun must be as narrow as possible. Unfortunately this process collides head-on with the physical limitations referred to.

All the art of tube design is involved with the resultant compromises. We will now outline the problem.

Limiting Resolution Program

The ultmate limit of resolution—as in all optical devices—is set by diffraction. But, because of the short De Broglie wavelength associated with the electron flow, it is easy to show that this limit lies in the region of $r_s = 10^{-4}$ mil. It is thus far below the present achievements which are therefore set by other considerations.[1] It's easy to show that in high resolution CRT's the spot size limit due to the space charge in the beam is much less than the limit due to thermal ejection energy of the beam-forming electrons at the cathode.[2] Physically this arises since high spot densities can be achieved with only relatively small total beam currents, and it is the total beam current which primarily determines the space charge forces. Hence we may usefully consider only the limit due to electron emission velocity.

Analysis of the mechanism of deflection defocussing[3] shows that the increase in spot size can be expressed roughly as

$$\delta\,(r_s) \sim \lambda^2 z\,\theta \qquad (1)$$

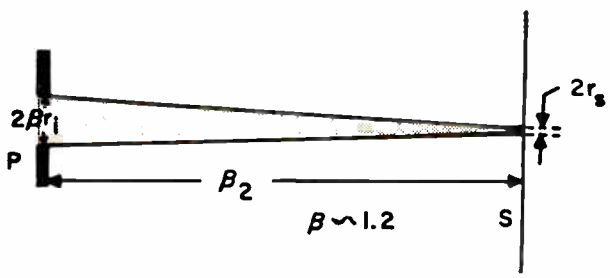
Langmuir's analysis[4] on the consequence of thermal disturbances in electron beams gives

$$\rho_o \cong \rho_c \cdot \frac{eV}{kT} \cdot \theta^2 \qquad (2)$$

provided θ is small and $\frac{eV}{kT} > > 1$ (conditions which are always met in our context)

ρ_o is the maximum possible peak spot density. ρ_c is

Fig. 1: The conical electron beam is generated and focussed by an "electron gun" located to the left of P. The beam cannot be usefully divorced from the deflection system.



the average cathode ejection density for the used electrons. T is the cathode temperature (e and k are electronic charge and Boltzmann constant respectively).

From the simple geometry shown in Fig. 2

$$\theta \cong \frac{r_i}{z} \tag{3}$$

$$\lambda \sim \frac{x}{z} \tag{4}$$

Furthermore, since the spot density is closely of Gaussian shape, if we define r_s as the spot radius at the e^{-1} ordinate, it follows[2] that

$$\frac{I}{\pi r_s^2} = \rho_o \tag{5}$$

Finally, recognizing that writing speed is proportional to the quotient of beam current and spot size we may write

$$\frac{I}{r_s} = K \tag{6}$$

A sensible definition of resolution, and the one used here is:

$$\text{Resolution } (R) = \frac{\text{screen area}}{\text{average spot area}} = \frac{16x^2}{\pi\,[2r_s + \delta\,(r_s)]^2} \tag{7}$$

Substituting from Eqs. 1 to 6 in Eq. 7 gives

$$R = \frac{16x^2}{\left[\frac{2K}{\rho_c} \cdot \frac{kT}{eV} \cdot \left(\frac{z}{r_i}\right)^2 + \frac{\pi x^2}{z^2} r_i\right]^2} \tag{8}$$

Eq. 8 has the form

$$R = \frac{x^2}{[A + B x^2]^2} \tag{8a}$$

which is sketched in Fig. 3 for $0 < x < \sqrt{\frac{A}{B}}$ which is the only region having physical significance in our analysis.

For small values of x we see that the resolution rises nearly as x^2. This is to be expected as here the Bx^2 term, representing defocussing, is negligible. But as x increases, the defocussing causes an increase in *mean* spot size and resolution increase is less marked. Finally, for still larger values of x, defocussing predominates and we reach a limiting resolution.

For any value of x we see the essential necessity for compromise in design. For in Eq. 8a an increase in r_i will reduce A but will increase B. This is the math of the well known juggling of central and edge focus needs. Eq. 8 shows that an indefinite increase in resolution can, in principle, be obtained if simultaneously $r_i \to 0$ and also $\rho_c \to \infty$ or $K \to 0$. The operation $K \to 0$, by virtue of Eq. 6 leads to no useful result but the alternative of increasing ρ_c is practicable. To a large extent this is the essential method used in practice. But it has definite limits. These are now being reached due to the practical impossibility of raising ρ_c beyond some 5-10 a/cm² for CW loading) and also, more fundamentally, by the neglect of space charge limitations in the simple analysis given here.[2] A fuller treatment, in which space charge is fully allowed for, has been made by the author.[3] It shows that the space charge problem can be avoided only by suitably raising V and ρ_c. Aberration limits are eliminated by reduction of beam angle. If V and ρ_c can be arbitrarily high then the ultimate resolution limit is set only by diffraction. But, long before attainment of diffraction limits, insuperable mechanical difficulties arise. Also arising are problems such as light scattering in the recording medium, screen graininess, etc. We shall return later to this matter of "ultimate" resolution.

Need for Dynamic Focussing

This can be shown by consideration of Eq. 8. Entering typical values for a high resolution tube; V = 20 kv, (kT/e) = 0.1, z = 7 in., r_i = 0.05 in. I = 5 μa, r_s = 0.0005, x = 2 in. shows that the resolution is

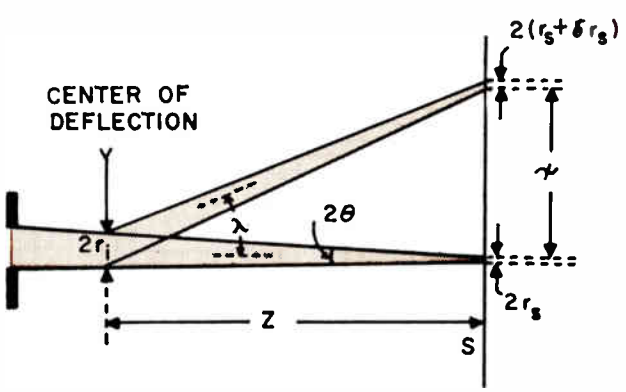
$$R = \frac{64 \times 10^8}{(3.9 + 128)^2} \sim 368{,}000$$

This is low—hardly better than a normal TV tube.* Clearly the reason is the very large defocussing term, Bx^2 = 128, in the denominator. If there were no defocussing, then the resolution would be

(*Continued on following page*)

*This figure—given to show the importance of deflection defocussing—can be raised above 10^8, without dynamic focussing, by using the method of adjusting focus for best *mean* value between edge and center.

Fig. 2: The spot density is close to Gaussian shape.



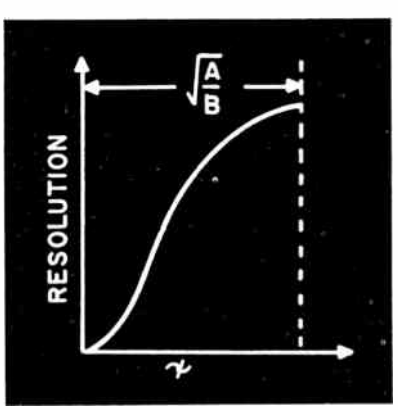


Fig. 3: Sketch of Eq. 8 for the region which has physical significance in this analysis.

4.15×10^8. This shows how the deflection problem dominates high resolution tube design.

Eq. 1 is based on simple geometric considerations[3] that can hardly be refuted. Thus, the only way to reduce this error involves the use of dynamic focussing. A full analysis of this process is not yet available. But, observation shows that it can reduce $\delta(r_s)$, defined by Eq. 1, by about an order of magnitude, even without using cylindrical field corrections.

Hence

$$R = \frac{64 \times 10^8}{(3.9 + 12.8)^2} \sim 23 \times 10^6$$

which is typical of good present day performance.

What is Available

Catalog Items

Specification methods for high resolution tubes lack uniformity among manufacturers. And, there is an element of vagueness in definition of some parameters.

Usually the maker specifies the spot size, or resolution in lines/in., which in the absence of any specific statement to the contrary is the optimum value at the screen center. Even this statement lacks uniformity of basis. Sometimes it is measured by the shrinking raster method and sometimes by scanning an optical image of the spot over a fine slit or set of slits in association with a photocell.[5] It is occasionally measured by sine wave response methods.

Statements on the degree of defocussing are always vague but it must be recognized that this is indeed a difficult quantity to define. On deflection in a double axis system, a circular spot is deformed in an irregular manner at the edges so that the resolution becomes "direction-dependent."

Finally, it is not always absolutely clear at what beam current the spot size is measured. But the following statement is broadly true.

Tubes are readily available with center spot diameters down to about 1 mil at beam voltages in the order of 10-20 kv and at corresponding beam currents of 5-10 μa. Normally these have nominal 5 in. dia. screens of which about a 4 in. dia. circle is the useable area. Deflection is invariably magnetic; focussing may be either magnetic or electrostatic. Overall length will be about 16-18 in. With dynamic focus adjustment,[6] the increase in spot area at the edges of the 4 in. dia. circle can be expected to be about 30%. Overall resolution reaches up to about 20×10^6. Various screens are available but the choice is restricted by the need for very smooth, thin, texture. Usually a high actinic screen of the P11 type is specified as the recording is almost always photographic.

Experimental Tubes

To special customers tubes are available in limited quantities with spot diameters ranging down to about 0.3 mil. Typical beam currents are in the order of 1-4 μa at beam voltages around 15-20 kv. Such tubes will not yield a corresponding edge focus without elaborate dynamic focussing. This must correct the main rotationally symmetric focussing lens. It must also provide two axes of cylindrical field corrections (anti astimatism). Ultimate resolution reaches about 10^8 picture points. The overall method is elaborate and the correction systems will occupy much more space than the tube itself. G.E. has described a tube of this type and has been active in other complex methods such as aperture imaging and spiral optical devices.[7, 8] Such development demands great ingenuity but the cure may be worse than the disease. And, it is early to say what impact such methods will have on the overall problem.

Ultimate Limits

With no restrictions on operating voltage, the ultimate resolution is limited only by diffraction. It theoretically reaches staggering figures of the order of 10^{14} picture points. But to get within even two or three decades of this value would involve immense difficulty and expense. Problem areas would be those of achieving enough electrical drive stability and otherwise near-perfect "environment."

It is also worth remembering that the scanning time is equal to the number of displayed picture points divided by the modulator bandwidth. At resolutions of 10^{14} the minimum scan time would be in the order of 10^6 sec.

Before even dreaming about achieving anything along these lines it is important to be critical about the real need for such performances. It is no use recording information if the ultimate analyzer (the human being) cannot extract the relevant data within a reasonable time. Much more fruitful approaches involve the concept of machine controlled data analysis followed by selective display only of what is needed. Huge rejections of irrelevant information can usually be thus effected and only modest resolutions may well be called for in the final display device.

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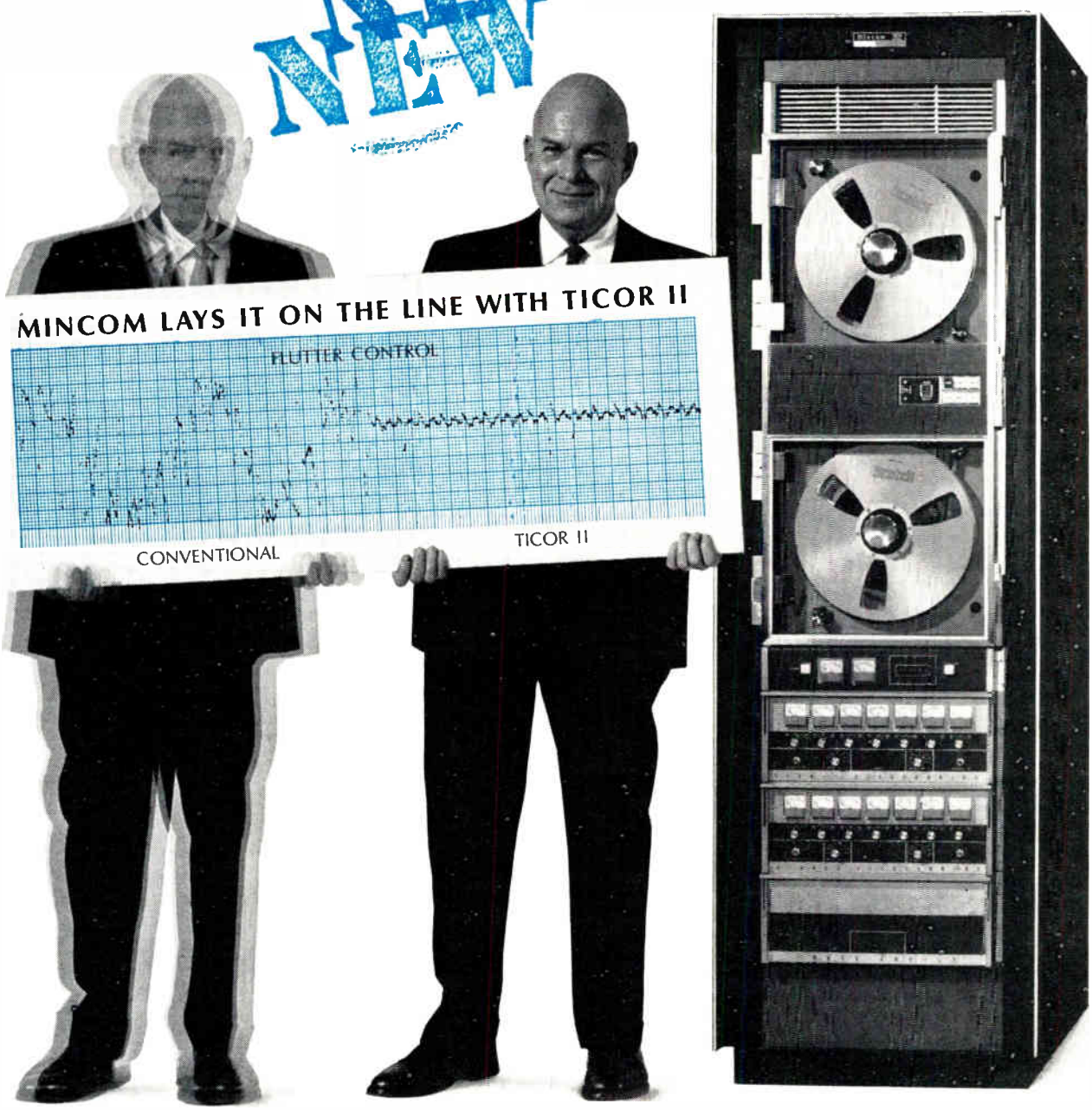

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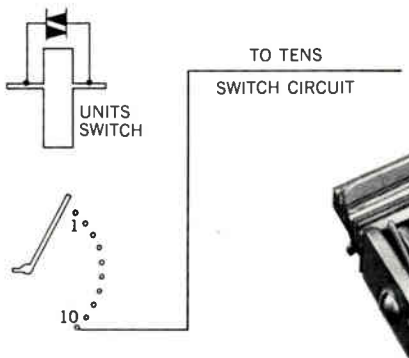

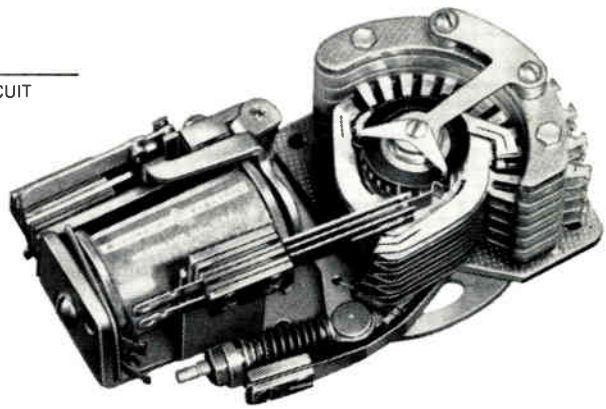

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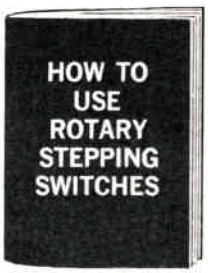

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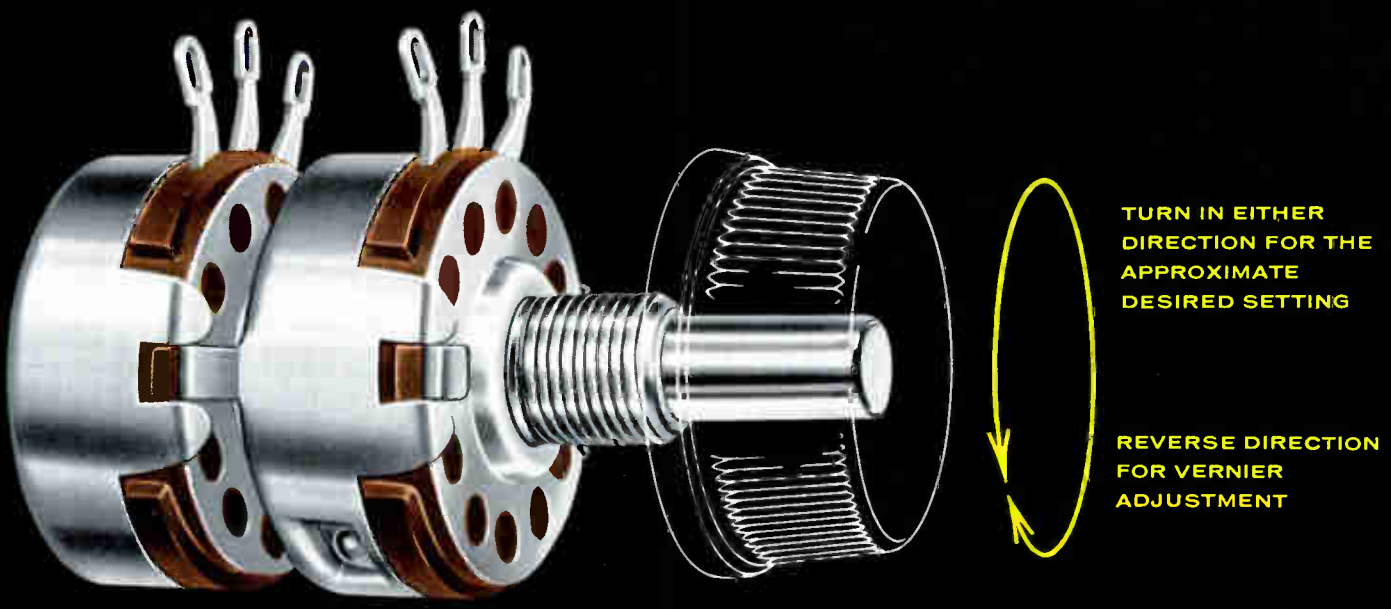

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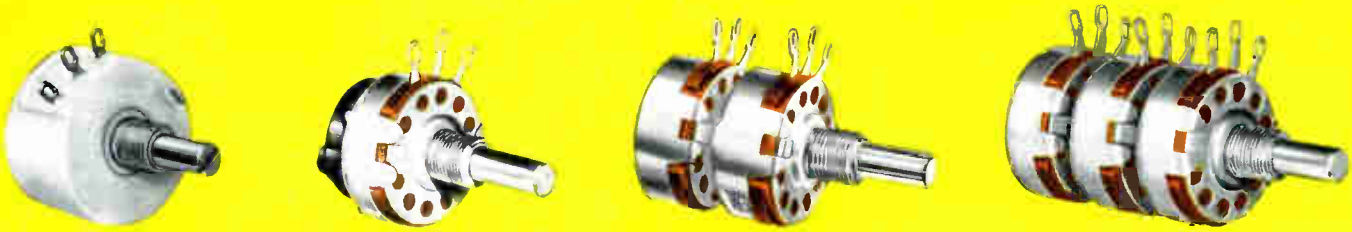

Type J
with encapsulation

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Type JJ
standard dual unit

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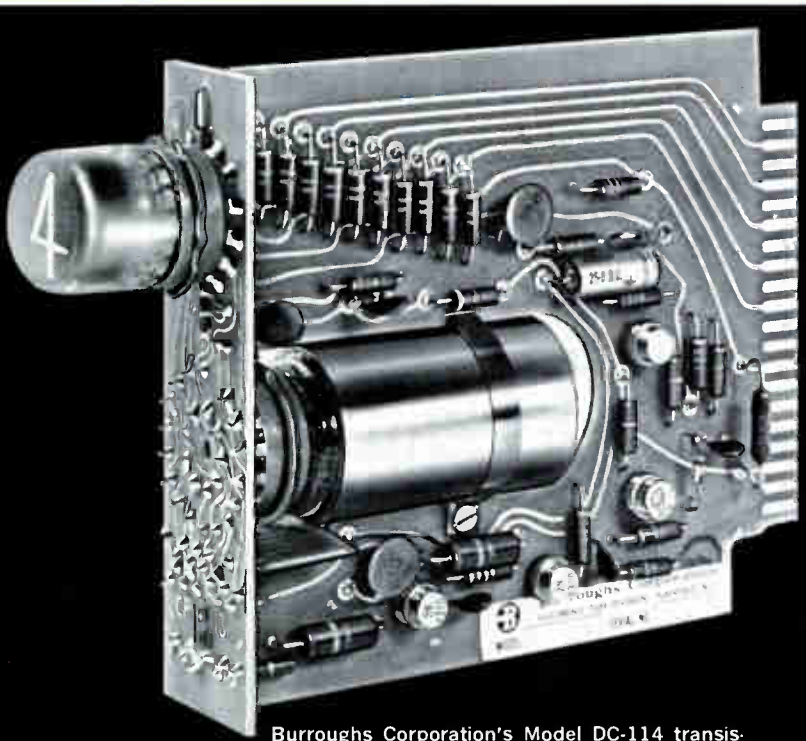

Burroughs Corporation's Model DC-114 transistorized decade counter with Nixie* tube readout, showing use of Allen-Bradley hot molded resistors.

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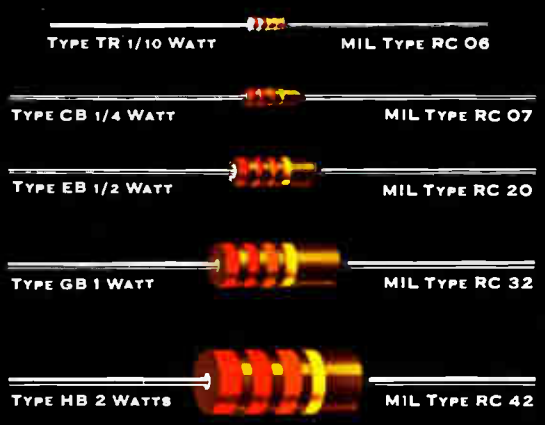

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They use two approaches to the State-of-the-Art.

The first is a complete description of the State-of-the-Art. The article "The Laser Field . . . Where We Stand Today" (Feb. 1964) by Dr. Theodore Maiman, who developed the first laser, is an example of this approach. He evaluates the various types of lasers, their properties, problems and indicates present and future uses. A companion article, in the same issue, "Modulator Crystals for Lasers" deals with the latest methods of modulation.

A second approach to State-of-the-Art is to concentrate on a single problem which may limit the advance in a field. An example of this type of article is "Field Effect Transistors Under Nuclear Radiation" (Mar. 1964). This article reveals for the first time a new parameter of field effect transistors which designers need to know about.

Sometimes materials limit progress. Tunnel diodes failed to measure up to early estimates because of gallium arsenide impurities and lack of processing knowledge. Our editors did a staff report, "Gallium Arsenide: What is its Status?" (Feb. 1963) which reported the State-of-the-Art on both tunnel diodes and the material from which they are made.

In today's world of engineering it is not enough to see the problem alone; the engineer must be aware of the total fabric of which his problem is a part.

It may be necessary to bring in the economic factor. When silicon controlled rectifiers cost more than $150.00 each, a designer could not consider them for his equipment. Today they are used widely, because they are much cheaper. So we can say that while the "State-of-the-Art" is essentially a technical level of development, it may also be affected by costs, availability, production, or reliability.

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An important key to design of transistor devices is a clear understanding of semiconductor noise behavior. This article covers the various types of noise and their origin. It then shows how minimum noise figure can be secured for transistor circuit design.

NOISE BEHAVIOR IN SEMICONDUCTOR DEVICES

By EDWIN G. FONDA
Member of Technical Staff
NASA*
Ames Research Center
Moffett Field, Calif.

WE KNOW THAT TRANSISTORS offer advantages in certain low-noise circuits. Apart from the obvious advantages of freedom from "hum" and "microphonics" of vacuum tubes, now some transistors have better noise performances than tubes, especially in low-impedance uses.

Transistors have begun to compete effectively with and to replace vacuum tubes. Their advance had been held back by two unfavorable characteristics; their high noise in comparison with vacuum tubes, and their unfortunate noise spectrum which showed a drastic increase of noise amplitude with decreasing frequency. But, much progress is now being made in this area. For instance, devices such as tunnel diodes and field-effect units show great promise.

Tubes remain better at high source z levels but the point of crossover is roughly a source impedance of 10k.

It is thus our intent to briefly show the different types of noise, and their origin, and then show how minimum noise figure can be secured for transistor circuit design.

* * *

The usefulness of any system that handles very small signal inputs is limited at some point by the Guassian, white, thermal, random or Johnson noise.

Now, whenever the noise level is fixed by operating conditions and thus if the signal input is small, it follows that the S/N ratio will also be small. Noise phenomena in semiconductor devices has received much attention in the past, but it is still much of a state-of-the-art study. A good example of the minimum S/N ratio is the snowy picture of a TV set in a fringe area.

Before going into noise details, let's briefly review transistor conduction. We can show this device as two diodes connected (in a sense) back-to-back, Fig. 1.

For dc conditions D_1 is biased in the forward direction (low R) and D_2 is reverse-biased by V_{cc}. The transistor transforms the low signal current from the low-resistance junction to the high-resistance junction, causing a power gain, supposedly without any loss of signal through the solid-state device.

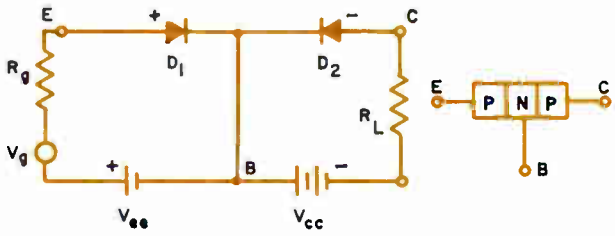

Fig. 1: Analysis of pnp junction Q (grounded base).

Later we will attempt to analyze how a zero or low reversed-bias potential across the collector-base junction establishes a special low noise "hushed transistor operation." (see appendix)

A phenomenon not yet fully explained is the increase of noise with operating time. This has been absorbed in many "noisy" junction transistors, and in a small percentage of low-noise units, as observed.

It has also been observed that the greatest change in RMS noise level occurs within the first few hours of operation after which the level remains fairly constant.[2]

Tunnel diodes show great promise as low-noise devices due in part to their high-impurity concentrations (5×10^{19} cm^3 for Si). Also, they are less insensitive to surface changes; minority carriers produced by ionizing radiation, and the resistivity doping is constant and easily controlled.

*Article was prepared while the author was at Philco's Western Development Laboratory, Palo Alto, Calif.

Noise in Conductors

Basic concepts disclose that every conductor produces an irregular varying voltage across its terminals as a result of random motion of free electrons in the conductor caused by thermal agitation.[2] This effect is referred to by such names as shot, thermal resistance, and/or Johnson noise, among others.[4] The magnitude of this means squared noise voltage associated with the resistance becomes:

$$e_m^2 = 4\,KT \int_{f_1}^{f_2} R_{df} \text{ (expressed as an integration)} \quad (1)$$

Assuming R (of the total Z) is constant over the frequency range of interest, this reduces to the more familiar special case.

$$e_m^2 = 4\,KTR\,(f_2 = f_1) = 4\,KTR\,BW \quad (2)$$

where

e_m = AVG noise voltage in volts (peak values are about 8 times higher).
K = Boltzman's constant (1.38×10^{-23} joules/°K).
T = absolute temperature, °K.
R = resistance across which thermal effects occur.
BW = effective bandwidth of system.

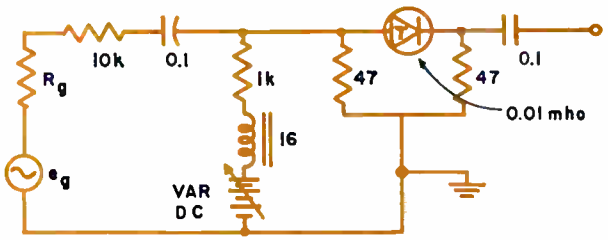

Fig. 2: Basic configuration for tunnel diode audio amplifier.

Note that Eq. 1 shows that the mean squared noise voltage e_m is proportional to the BW. Also, in practice, one is confronted with noise distributed in frequency in accord with the response characteristic produced either by the amplifier response, or by the curve of the equipment used in obtaining the reading, whichever is the factor limiting the BW.

Hence we have found that cathode emission noise in vacuum tubes can be substantial. Common resistors even develop contact noise at solder joints. Those devices are rated from poor to good in the following order:

TYPE	NOISE LEVEL	
Composition	50μv/v	
Deposited carbon	0.5μv/v	(attach noise
Metal film	0.2μv/v	resistor
Wire wound (non-inductive)	0.02μv/v	pictures here)

Equivalent Transistor Circuit

It is interesting to note that the mechanisms for noise generation in junction transistors are described using similar terms as those acting in tubes, viz., "thermal," "shot" and "partition noise."

Noise figure is about the same for all three configurations. Thus we will show only the common base "Tee" equivalent circuit using the R parameters and include noise generators.

The more important sources of transistor noise potentials are summarized as follows[4]: These provide clues for manufacturers to develop clean units.

Thermal noise emf,

$$\overline{v^2_{th.\,b}} = 4K\,T\,rb\,df \quad (3)$$

contributed basically by base resistance internally.

Shot noise emf,

$$\overline{v^2_{sh.\,e}} = 2\,e\,I_e\,df \quad (4)$$

Associated with the base-emitter junction.

Shot noise emf,

$$\overline{v^2_{sh.\,c}} = 2e\,I_{co}\,df \quad (5)$$

Associated with the "leakage flow" across the base-collector junction.

Partition noise current,

$$\overline{i^2par} = 2e\,\alpha\,I_e\,(1-\beta)\,df \quad (6)$$

Contributed by the random distribution of hole current between acceptors through the collector and base region.

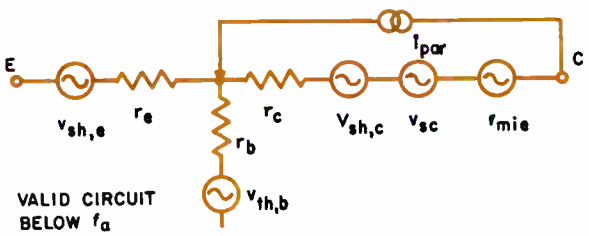

Fig. 3: Common base "Tee" equivalent circuit.

Semiconductor noise emf,

$$\overline{v^2_{sc}} = K_c\,V^d\,R_e^{\beta}\,f^{-\gamma} \quad (7)$$

This equation provides a clue to the frequency-dependent factor of the material. The bracket or bar in the equation indicates an average or mean value.

Noise Figure as a Function of Frequency

Some of the important properties of transistor noise can be shown by its frequency spectrum, Fig. 3.

Here the NF behavior is quite different in different frequency ranges. In the low range $F < f_1$, the NF increases at about 3db/octave slope as the frequency decreases according to a $1/f$ relationship. This is also referred to as the semiconductor or $1/F$ noise phenomenon. It is composed mainly of surface and leakage effects of the semiconductor material itself.

Experimental results[2] disclose that F_1 varies from

NOISE BEHAVIOR (Continued)

50KC to 1KC for many junction transistors. Most low-noise transistors have a "turning point" near the 1KC point or lower.

In the mid-frequency region, $F_1 < F < F_2$, the NF remains about constant. It is known as the white or thermal noise level over the frequency spectrum. In the h-f range $F > F_2$, the NF increases at about 6db/octave slope. Experimental data indicates that f_2 varies from 100KC to 500KC for many junction transistors. Here as was discussed before, alpha cutoff frequency $F\alpha$ assumes importance.

In most transistors "excess" noise is lower above 1KC. In this center frequency region, the NF decreases to a minimum around 3-10db. It is essentially constant in this region (unless the excess noise is so large that the curve becomes V-shaped). Finally, at higher frequencies (h-f) the NF increases because as the frequency is increased the accompanying decrease in alpha causes the collector noise voltage to rise. At extreme h-f alpha approaches zero and the collector noise equation approaches the expression for full shot noise.

Definition of Noise Figure

One test necessary to classify transistors properly

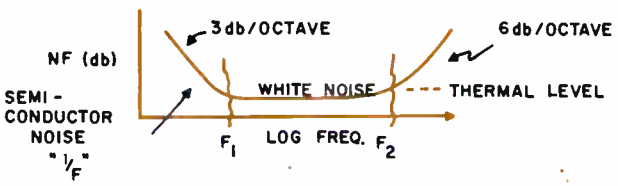

Fig. 4: Some of the important properties of transistor noise can be illustrated by the frequency spectrum of the transistor.

and to find the effects of different materials (Ge-Si); doping methods, and various manufacturing processes (grown, alloy, drift, mesa, field effect, etc.) is the measurement of the noise figure.

This is a good reliability check as the excess occurrence of "erratic" "popping" or "batting" noises in either P.C. or junction transistors is an indication of an abnormal unit. Very high noise makes the unit questionable. Such units have often been found to be short-lived[2]. A current noise measurement as a failure analysis tool for film resistors reveals a similar axiom in that a discrete noise level divides maverick performers from normal resistor units[9].

S/N ratio, while implying what is desirable system-wise, is not much help in finding ways to improve sensitivity. A more useful term is noise factor, which is defined as the factor by which the S/N power ratio is degraded when the signal passes through a network. Or, expressed in another manner, noise factor is the ratio of S/N at the input of the network to the S/N at output of network.

$$F = \frac{S_i}{N_i} \Big/ \frac{S_o}{N_o} \qquad (8)$$

This is normally given as a power ratio. This term F can be used to describe any 4-terminal network regardless of whether it amplifies by tubes or transistors, or whether it is passive.

Noise factor can be expressed in db's as noise figure.

$$F\ (db) = 10 \log_{10} F \qquad (9)$$

Here we see if it were possible to have a perfect network having no internal noise, the S/N would be the same at input and output; hence noise factor F would be unity and $NF = 0$ db, where e_N^2 would equal $4KTR_g\ BW = 1$.

Consider Fig. 4.

Here we have a 4-terminal network with an additional generator to represent the external noise source for the source resistance (R_g). Since the mean squared noise voltage inherent in any resistance is

$$E_n^2 = 4\ K\ T\ R_g\ BW \qquad (10)$$

we can calculate the S/N at the input of the black box of Fig. 4; the available input signal power is:

$S_i = E_g^2/4\ R_g$ while the available input noise power is (11)

$$N_i = E_N^2/4\ R_g \qquad (12)$$

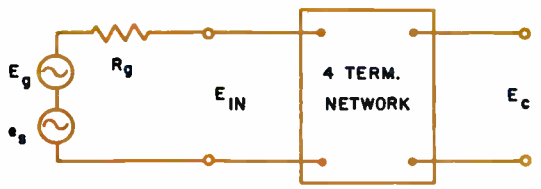

Fig. 5: Symbolic 4-terminal net with an additional generator to represent external noise source for source resistance (R_g).

but $E_N^2 = 4\ K\ T\ R_g\ BW$ hence (13)

$$N_i = \frac{4\ K\ T\ R_g\ BW}{4\ R_g} = K\ T\ BW \qquad (14)$$

Note that noise power available from R_g is independent of the R's magnitude but directly proportional to BW.

S/N power ratio at the input to the network is:

$$S_i/N_i = \frac{E_g^2/4\ R_g}{KT\ BW} = E_g^2/4\ K\ T\ R_g\ BW \qquad (15)$$

Since Eq. 8 defines,

$$F = \frac{S_i}{N_i} \Big/ \frac{S_o}{N_o}$$

and combining Eqs. 15 and 8 yields,

$$F = \frac{E_g^2}{4\ K\ T\ R_g\ BW} \Big/ \frac{S_o}{N_o} \qquad (16)$$

Output S/N ratio S_o/N_o is a power ratio, but for convenience, it can also be expressed as voltage ratio,

$$\frac{S_o}{N_o} = \frac{E_o^2\,(s)/R}{E_o\,(n)/R} = \frac{E_{os}^2}{E_{oN}^2} \text{ thus} \qquad (17)$$

$$F = \frac{E_g^2}{4\,K\,T\,R_g\,BW} \Big/ \frac{E_{os}^2}{E_{oN}^2} \qquad (18)$$

Eq. 18 shows that for a given fixed generator voltage equation, the noise factor F is inversely proportional to the square of the S/N voltage ratio obtained. Eqs. 16 and 18 are the basis for many methods of finding NF. Hence the NF is best defined as the ratio of the total noise power in the output to that portion of the output noise resulting from thermal agitation in the source resistance (R_g)[6].

Representative values for NF, measured at a frequency of 1000 CPS and $R_g = 1\ K$ are 40-60db for point-contact and 5-25db for junction transistors.

Transistor NF Specs per Data Sheets

Many manufacturers determine their low noise transistors by referring the effective input noise to an arbitrary reference level. If the level is high, the NF given would be low and in one case is specified in negative db's.

The IRE standard on electron devices[7] for measuring noise refers the effective input noise to the thermal (Johnson) noise generated by the source resistance.

Let us examine this in detail, i.e.:

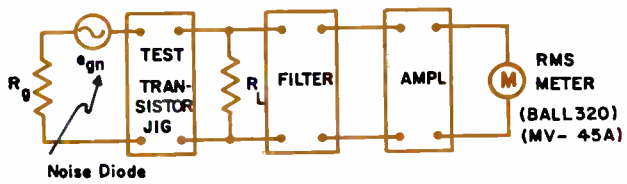

Fig. 6: Noise-diode method is fundamental. It permits simplification and rapid reading but needs a calibrated noise source.

One maker specifies NF = −2db with R_g = 1000 Ω.

However, this is referenced to a 1μv level with a noise BW = 2800 CPS.

By comparing reference voltages we can show the Johnson reference RMS voltage to be:

$$E_N^2 = 4\,K\,T\,R_g\,BW$$

$$E_N = \sqrt{(1.656 \times 10^{-20})\,(2800)\,(10^3)}$$

$$E_N = 21.5 \times 10^{-8}\text{v at } 17°\text{C}$$

Hence the ratio of these reference voltages is:

$$\frac{E_N}{1\mu v} = \frac{21.5 \times 10^{-8}}{10^{-6}}\ 21.5 \times 10^{-2}$$

db-wise

$$10 \log 21.5 \times 10^{-2} = -13.4\ db$$

In conclusion, this 1μv level is actually 11.4db above the accepted equivalent IRE Standard for NF. Hence designers must evaluate the conditions used to find the NF given when selecting low-noise units. Also, an integrated BW value for NF is much better than a spot or single frequency reading because of the semiconductor $1/F$ law and surface leakage effects over the spectrum.

This NF can range from 12db down to 3db depending on the transistor selected and on the position in the spectrum of the frequency interval[10].

Many manufacturers now use a narrow or spot BW which only enhances their product, and only indicates a relative NF for comparing transistors in their family series.

NF Measurement

Basically two methods are available, using a noise diode or generator source or a sinusoidal signal generator.

The noise-diode method is quite basic, permits simplification and rapid reading, and is in general more accurate. But, it needs a calibrated noise source, Fig. 5.

Here the noise generator is connected in series with R_g to the input of the transistor under test. With the generator off, the noise power at output is measured. Then with diode turned on, its voltage level is adjusted so that the power at the output of the

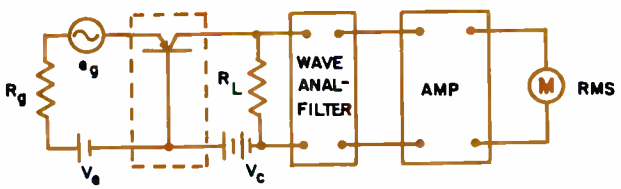

Fig. 7: This procedure involves the use of a wave analyzer. The analyzer will confine frequency response to a desired BW.

transistor is doubled. From the corresponding RMS voltage of the noise generator (e_{gn}) the NF can then be calculated as:

$$F = e_{gn}^2 / 4\,K\,T\,R_g\,BW$$

The second test procedure involves the use of a signal generator. Here the voltage amplification

$$AV = V_o/V_g$$

of the transistor stage is measured. Then with the generator turned off, the RMS value of the noise voltage across the load at a given frequency is recorded, Fig. 6. Use of a wave analyzer will confine the frequency response to a desired BW.

If the mean-square value of the noise voltage across R_L is v_{Nc}^2, then total noise power in output is:

$$P_{No} = v_{Nc}^2/R_L$$

Thermal noise in rg may be represented by a noise voltage in series with R_g:

$$e_n^2 = 4\,K\,T\,R_g\,BW$$

NOISE BEHAVIOR (Continued)

Noise power in output due to this thermal noise in R_g is:

$$P_{No}' = \frac{4\,K\,T\,R_g\,BW}{R_L} \times A_v^2$$

Hence the NF is:

$$F = P_{No}/P_{No}' = \frac{v_{NC}^2}{4\,K\,T\,R_g\,BW\,A_v^2}$$

Proper test instrumentation and facilities are needed for accurate measurements. Solid ground connections will provide truer noise readings.

Some possible problems include: (1) hum pick-up by test gear through the line-operated units in immediate vicinity, (2) operating scope coupling a signal from CRT screen through personnel into test fixture, (3) power lines near test bench, major source for noise pickup, (4) modulation problems caused from paging system i.e., "vibra call."

Also, calibration discrepancies can and will be found between VTVM's which measure full wave average signals, and those which measure half-wave averages, half-wave peak and/or RMS.

Conditions for Minimum NF

Amplifier NF can be minimized by suitably chosen transistor parameters and operating conditions. Obviously, use of a low-noise device is essential. In the absence of "excess" or semiconductor noise, the NF as a function of frequency for the three configurations is constant up to

$$\sqrt{1 - \alpha_o F_a}$$

Here α_o is the low frequency alpha and F_a the alpha cutoff frequency. Above this limit, the NF increases with an asymptote of 6db/octave.

Calculations show that for minimum NF, the base resistance and emitter current should be small; α_o should be close to one; $F\alpha$ should be large; and if possible, a driving source resistance with an optimum value[8] should be selected. It is interesting to note that these requirements on α_o, $F\alpha$ and rb, for minimum NF are also desirable for wideband amplifiers.

The curves of NF as a function of source resistance show that the minimum NF is obtained when a R_g between 400-1000 Ω is used at low dc operating conditions.

For "noisy" transistors, operation at as low a V_c as possible is recommended (less than 4v). Also, the I_E should be kept at as low a value as permissible. NF is constant at about 0.5ma. Below this, the NF increases slightly. This is caused by the decrease in alpha at low currents and the importance of reverse saturation currents, surface and leakage.

Here the dc leakage must be held to a few tenths of a μa. Select transistors having low I_{Co} and high Beta ratings, as transistor NF's greatest change with temperature occurs if high-leakage noise is prominent.

The accepted method for measuring NF of a tuned amplifier using a noise diode source calls for the matching of the noise source's output impedance to the input impedance of the amplifier under test ($R_g = R_{in}$).

In measuring the NF, it is sometimes necessary to operate transistors under unmatched conditions. This case requires modifications to the equations used per the commonly known matched condition.

We don't have space here to fully explore this, but the author directs your attention to the March 1958 issue of the Proceedings of the IRE, Page 619 for a more detailed review.

Conclusions

Semiconductor excess noise, transistor noise is assumed to arise from diffusion and recombination fluctuations across the base region and from thermal noise in the base resistance.

This noise is represented by noise generators connected in the legs of a "Tee" equivalent circuit. Emitter and base noise sources are assumed independent of frequency, but the noise represented by the collector generator increases with frequency. This causes the transistor NF to increase at the slope of about 6db/octave for frequencies above the "break point" $\sqrt{1 - \alpha_o F_a}$.

NF for the three transistor configurations is about the same, except above the alpha cutoff frequency. Here the C.E. and C.B. NF's continue to increase with increasing frequency, but the C.C. noise figure theoretically becomes constant.

For all configurations at low frequencies (1-f), the R_g giving the minimum NF is about the same as that which gives maximum C.E. gain. This makes the C.E. setup optimum for maximum gain and minimum noise at 1-f.

For a source resistance close to the optimum, the NF varies slowly. It will not be degraded by more than 0.5db by a source resistance that is a factor of two away from the optimum, nor more than 2.5db for a factor 5 away.

In any event, the quality of a low-noise transistor unit is its ability to withstand increases of V_c and Δ temperature without showing a large increase in the NF. These are also the devices having: (1) <1000 CPS NF below 3db; (2) same integrated NF over the band as at a spot NF, say recorded at 1KC; (3) ability to tolerate wide input—mismatch without large increases in NF.

Appendix

Hushed Transistor Operation [10, 11, 12]

Transistor noise, according to the authors, W. K. Volkers and N. Pedersen, is mainly a matter of voltage and voltage distribution rather than current and current distribution.

Noise in their concept, is caused by a chain reaction. In this reaction, carriers liberated by their own thermal energy and by an external electrostatic field, are lumped together after a first carrier, and having been liberated cause a field disturbance. They then induce other carriers to rapidly become liberated.

This hushed circuitry provides less than 0.5μv RMS noise output over a 60KC passband. Other specs include:

gain—db	10—80 (10db steps)
Bandwidth—CPS	2 CPS—180 KC (adjustable)
Input impedance	10k, 100k Ω
Max. output (volts)	0.5v.

Transistor amplifiers have low input Z. Hushed transistors are no exception. But, according to the designer, by taking advantage of another property, that is, their high transconductance (H_{oc}), it became possible to design an unhushed emitter follower input which would provide an input impedance in the order of 100k.

Circuit Description

Fig. 8 shows a portion of the complete circuit for the Millivac Instruments MV-45A VTVM.

It has two cascaded 5-stage amplifier units, one being the preamplifier and the other the main amplifier. These units are interconnected by a 5-step output divider for the preamplifier.

Basically, four transistors in the preamplifier (Q_2, Q_3, Q_4, Q_5) are directly coupled, which according to the designer is particularly advantageous in a hushed transistor circuitry because then the voltage drop across the collector junctions operating in hushed condition, are essentially zero.

In this dc arrangement it is thus not necessary to provide the customary "dc pedestals" for each emitter to make per said direct coupling possible.

But, it will be noted that in each "quadruplet" the first three emitters are directly interconnected while the fourth emitter has the customary resistor in the emitter circuit to provide the usual dc pedestal needed in normal direct-coupling. The reason given for this is that the first two transistors operate in hushed condition which means that the base and collector of Q_2 and the base and collector of Q_3 all have about the same potential to ground. This is in

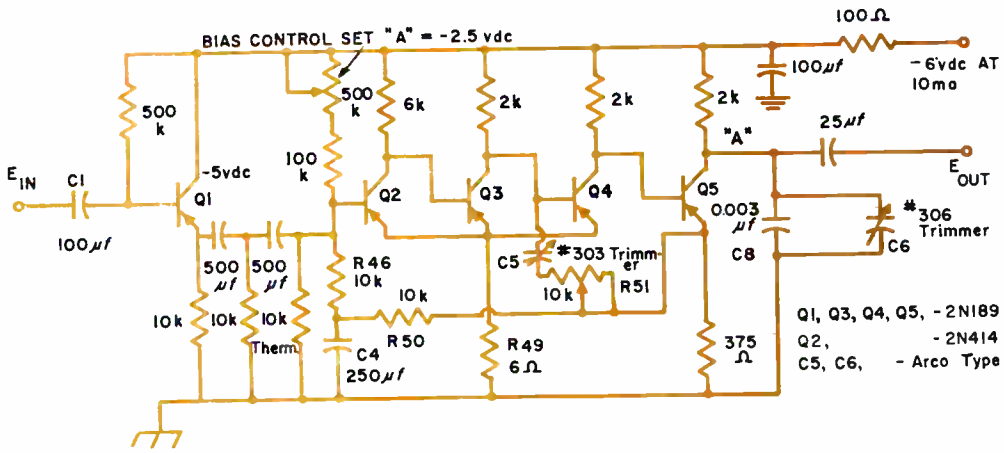

Fig. 8: Preamplifier for the MV-45A, ac VTVM using hushed transistor operation. It is one of two amplifier units used.

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Also, due to this high conductance ratio in the emitter follower stage, the output signal voltage can range between 98% and 99% of the input base voltage. Of course, by having a comparatively large collector junction voltage (about −5v.) this emitter follower develops a large amount of noise in its emitter junction area.

However, the 30-40db internal negative feedback which the emitter follower develops due to its high transconductance, "de-amplifies" nearly all of this noise.

Of course this output impedance of the emitter follower is low so that it can be easily coupled to the next stage of the actual preamplifier.

the general order of −180mv. Q_4 has a much higher collector voltage, in the order of −800mv while Q_5 is even less hushed, having a collector voltage in the order of −2.5v. This is adjusted by the 500k pot bias control located between the first and second stage.

While the preamplifier is directly coupled within itself, it is in reality an ac amplifier having capacitive input and output coupling while being equipped with a dc feedback loop consisting of R_{50} and R_{46}.

This dc feedback is taken from the emitter of the output stage (Q_5) and is fed into the base of the second transistor (Q_2). Since signals are in phase-opposition at these two points, a vigorous dc self-

NOISE BEHAVIOR (Concluded)

biasing action is produced which counteracts effectively bias-drifts liable to occur due to room temperature changes.

Also, this dc feedback path has a bypass condenser (C_4) which absorbs the ac components of the output signal thereby preventing negative feedback of the ac output signal into the base of the second stage (Q_2).

Additional temperature drift correction is provided by a 10k thermistor in parallel with the input of Q_2.

A second feedback loop, handling both ac and dc signals and serving a dual purpose of gain stabilization and bandpass extension, is provided by the common emitter resistor (R_{49}) for the Q_2, Q_3 and Q_4 stages.

Due to phase-inversion between later stages, this common emitter resistor has a slight regenerative effective between neighbor-transistors, i.e., between $Q_2 = Q_3$ and $Q_3 = Q_4$. But, it has an overruling degenerative effect upon the first three stages together.

The local regenerative effect described raises local stage gain and thus indirectly increases the overall degeneration since the latter is directly proportional to local stage gain. Gain of the fifth stage (Q_5) is current stabilized by a large unbypassed resistor in its emitter lead.

The preamplifier is designed with frequency-response compensating networks. They prevent an undesirable gain peak near the upper cut-off point of the bandwidth due to phase shifting. Trimmer C_5 and R_{51} in the third stage provides both an amplitude reduction and phase correction in the BW region in which such an undesirable rise would otherwise occur. Arco type trimmer C_6 and fixed condenser C_8 serve a similar purpose.

The 500k bias control functions as a dc centering adjustment through feeding an adjustable bias current into the base of the second transistor and should be set for -2.5vdc at the collector of the Q_5 output stage. Proper setting of this voltage is important to avoid overloading or clipping.

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CIRCUIT-WISE

SWITCHING INTERMITTENT LOAD

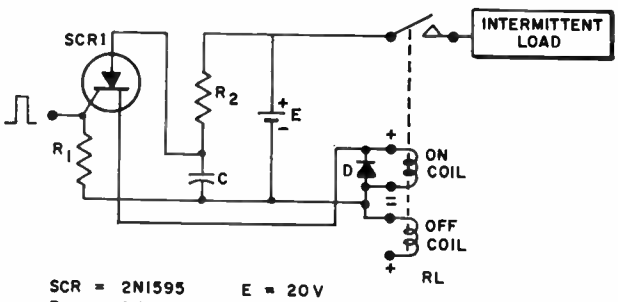
LOADS DRAWING INTERMITTENT CURRENTS from the power supply cannot be latched "On" by low power triggering an SCR switch unless holding current for the SCR is shunted around the load. This loss of battery power is frequently unacceptable.

A solution is to employ the SCR in combination with a latching relay. Energy to operate the relay is stored in a capacitor. The capacitor is charged from the load power supply through a resistor. The resistor must be large enough to hold the capacitor charging current below the minimum holding current of the SCR.

The SL11DC relay shown in the diagram has a sensitivity of 230 mw. at 25°C. If the sensitivity is assumed to be 500 mw. as a safety factor, the energy required is 0.0025 joule. For a 50 μf capacitor, using a 20 volt source, $W_c = \frac{1}{2}(50)10^{-6}(20) = 0.010$ joule.

Reliable operation is obtained with the capacitor at 14 volts.

These relays have two windings, so that a similar circuit can be employed using the second winding to switch the load off. One precaution though, the windings are inductively coupled. When the coil connections are such that positive pulses are applied for turn "On" and turn "Off" a positive pulse applied to one input results in a negative pulse at the input terminal of the second winding. If this winding is connected to an SCR cathode the SCR may switch "On." This is prevented by connecting a germanium diode across the winding to clip the negative pulse.



SCR = 2N1595 E = 20V
R_1 = 2.7K Ω D = 1N90
R_2 = 100K Ω RL = SL11DC (POTTER & BRUMFIELD)
C = 50mfd

Submitted by C. S. PEPPER, University of California, San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, Calif. 92152.

THE ENETRON— A NEW LIGHT SOURCE

The high-peak power, pulse-modulated source makes practical many of the proposed uses in which the laser failed. Applications encompass missile guidance to stop-motion studies.

In the February issue of Electronic Industries (pages 73-74), we previewed a new non-coherent light energy source called the Enetron®. This device is a source of radiation for the ultraviolet, visible, and infrared regions. Now that patent problems have been cleared up, we can present a detailed description of how the Enetron works.

Background

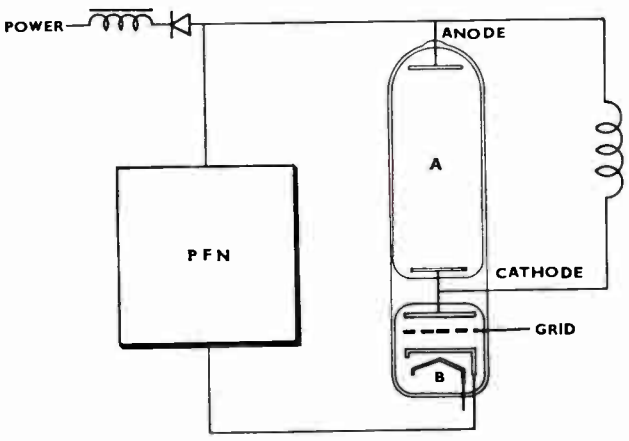
To help understand the operation of this device, we shall analyze a conventional photoflash tube and firing circuit. In this circuit, energy is stored in a capacitor to a value less than the tube's holdoff voltage. If ionization of the tube's gas can be induced at a potential below the holdoff voltage, an arc discharge occurs because the electrical resistance of the gas is reduced. To induce this ionization, a fine wire is wrapped around the periphery of the tube and connected to a high-voltage pulse. When the pulse is applied to the wire, an electrostatic field is created around the tube and gas ionizes. The reduced gas resistance starts an arc discharge with an accompanying drain on the storage capacitor. The optical energy output rises to peak value in a few μsec. and then drops off like an R-C time constant. If more energy is needed, more must be stored for discharge. However, this does not produce all the desired results, particularly if short pulse operation is desired.

High-Energy Pulses

The Enetron was designed to produce magnetron-like pulses. To do this, the stored electrons had to be of higher levels than conventional holdoff voltage. The higher the electron's energy level as they enter the gas, the more efficient the optical energy at discharge. The holdoff voltage is raised by raising the gas pressure. However, the increased gas intensity tends to slow the electrons entering the gas and reduces the effective energy level.

While the high-energy electron is desirable, it presents a problem in control of the discharge arc. The Enetron overcomes this. As shown by the illustration, the Enetron consists of two tubes in one. Section A is a conventional positive discharge tube containing the gas which radiates in the desired spectral region. The holdoff characteristic is low, while the stored energy is comparatively high. Section B is gas filled and similar to a thyratron. The choke coil placed across section A establishes the same voltage at the plate-cathode and the anode by presenting a dc path for the potential between these electrodes. Applying a small trigger pulse to the grid of section B produces conduction through the gas and the plate becomes grounded. With this, the choke becomes inductive and impresses the entire voltage drop across section A where an arc discharge occurs. The modulating circuit is improved by replacing the common storage capacitor with a pulse-forming network. As a resultant, the radiant-energy output becomes a square pulse of enormous peak power.

Segment A generates the energy; segment B is used for control. The output is a square pulse of enormous power.



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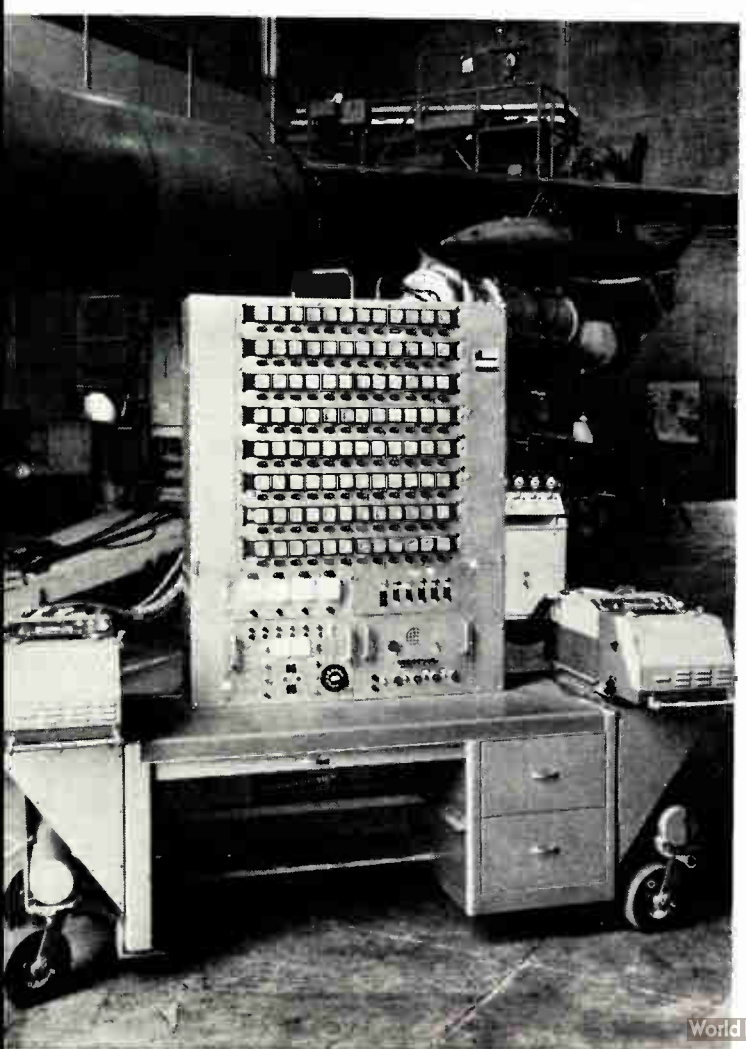
For electromagnetic compatibility tests to be realistic, certain testing techniques must be used. Test procedures and monitoring equipment must allow a system to be operated as an integrated system. How this is accomplished is discussed here.

ELECTROMAGNETIC COMPATIBILITY TESTING TECHNIQUES

THIS ARTICLE DISCUSSES MIL-E-6051 electromagnetic compatibility (EMC) testing concepts and the instrumentation methods necessary for the tests. For compatibility tests to be realistic, test procedures and instrumentation must be designed to complement and be compatible with both the test specimen system and test program data needs. Procedures and monitoring equipment must permit the system to be operated as an integrated system through a sequence that reflects the intended tactical operation as far as is practicable. AGE and other use site facilities capable of contributing to the total EMI environment must be considered a part of the system under test.

* * *

Fig. 1: Prototype integrated EMI instrumentation console.



Specification Mil-E-6051 establishes the compatibility needs for a weapon system, based mainly on unacceptable response, no malfunction, and margin of safety criteria. Unlike other Mil specs dealing with control of EM interferences, the test procedures and instrumentation needed to conduct realistic EMC tests are not defined by the spec. They are instead the system contractor's responsibility. There are three basic approaches that may be followed in setting up compatibility demonstration tests. These approaches, which may be used singularly or collectively, are:

1. Injecting interference at critical system points at a level 6db higher than predetermined system levels. Appropriate system points are then monitored for malfunction.

2. Sensitizing the system to raise its susceptibility (level) to interference by 6db while monitoring for malfunctions.

3. Measuring the susceptibility of key subsystem and system circuits for comparison to existing interference levels to determine if a 6db margin exists.

Concepts and Techniques

EMC needs of Mil-E-6051 are essentially that all elements of a weapon system operate properly, individually, and collectively, with a (S/N) ratio of 2 to 1 in the EMI environment resulting from the operation of the total system. S/N ratio is herein defined as the ratio of the desired signal level needed to produce a desired action to the level resulting from the summation of all extraneous undesired EM effects.

Any and all elements of the system must operate as designed with twice the noise level that actually exists within the system. This must be done regardless of the system's frequency, duration, modulation,

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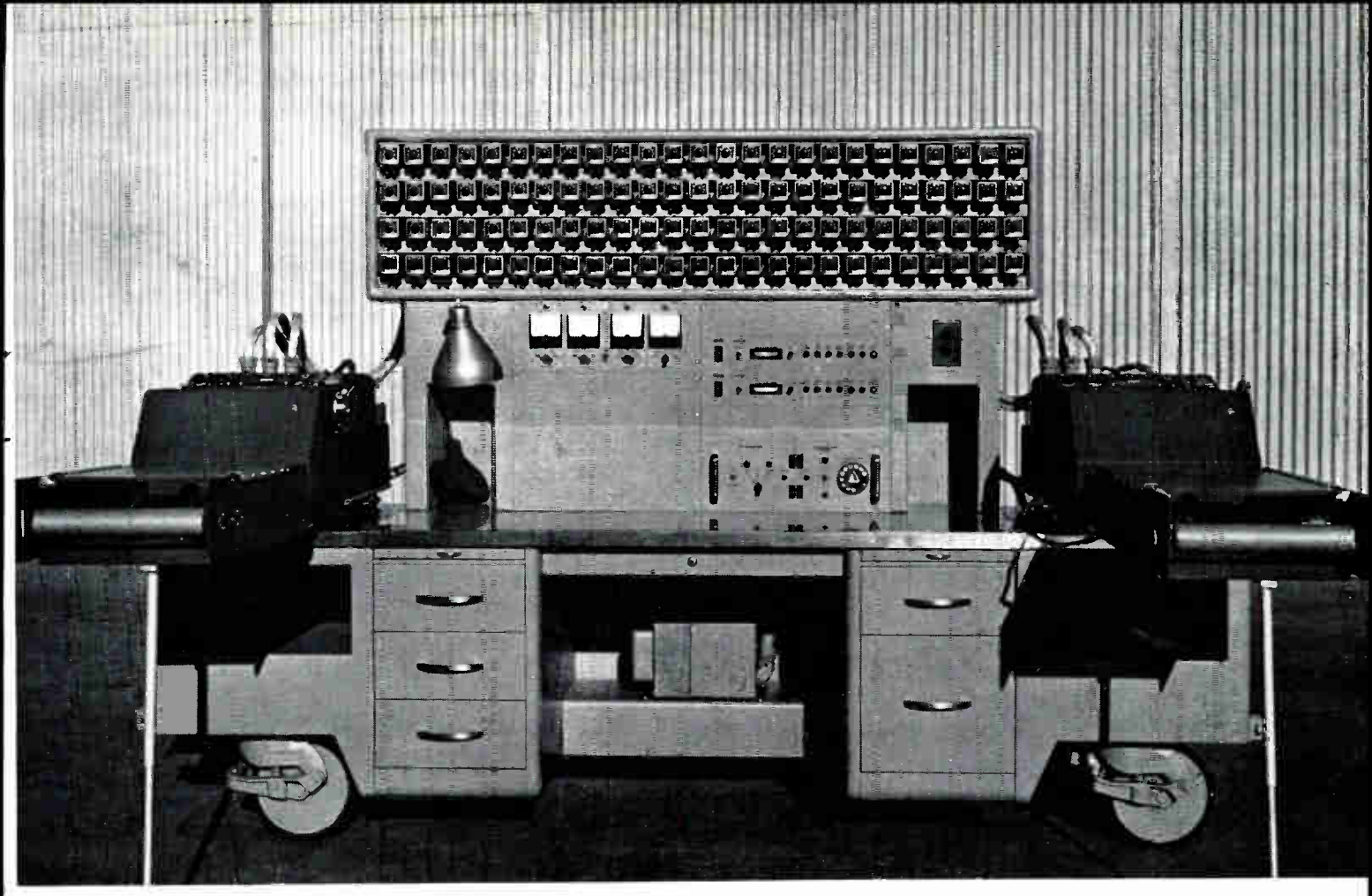


Fig. 2: Integrated system compatibility test console.

waveform, repetition rate, duty cycle, sequence, time, or amplitude, or any other characteristic that may be used to define noise. Primary concern is how it affects system operation. It is reasonable to expect a given element of a complex system to see (be affected by) a burst of noise differently than would a voltmeter, a noise meter, etc. It is also reasonable to presume that susceptibility characteristics (sensitivity, bandwidth, etc.) would change as a function of time, signal level, or other programmed change so that the effect of noise would not be constant. These effects may or may not have a synchronous relation; transients may, or may not coincide with clock pulses. Random transients would thus find random coincidence with periodic ON gates for example.

Many cases could be cited to show the differences between the value placed upon any given type of noise by measurement devices and by elements, circuits, or subsystems within a weapon system. Thus, EMC instrumentation should be able to evaluate existing noise levels in terms of how the system under test would see the noise. This can often be done by measuring the effect of noise upon functional elements and loops within the system.

Total system noise level is a summation of all the EM effects created by the system. This level and the system's detailed sensitivity to this noise both vary as a function of time. They also vary as a function of the operational profile of the weapon in its use environment. Thus, to find by test whether or not the system can operate as designed with the needed safety margin will require test methods and instrumentation that will permit close and accurate time and event correlation of all the quantities measured. Other equally important test methods and procedures are:

1. Instrumentation must include the capability to measure the effects of noise on critical elements and subsystems.

2. It must be possible to analyze all data on a time and event basis.

3. Test procedures must include system support equipment where the support equipment is capable of contributing to the EM environment. Many items of AGE have this capability and must be tested along with the primary system.

4. Test procedures must encompass the total operational profile of the weapon system and ensure that all loops and subsystems are exercised through their total dynamic range.

(Continued on following page)

COMPATIBILITY TESTING (Continued)

Due consideration of these basic needs has led to the formulation of the following guidelines. These have been found to be useful in writing compatibility test procedures and instrumentation specs:

1. All elements of the system under test must be on and operating in a manner approximating normal tactical usage to the extent possible.

2. The use of AGE as items of test instrumentation is to be avoided, instead AGE is regarded as an element of the test specimen.

3. Test instrumentation should be capable of monitoring all critical circuits simultaneously, and of accepting event and time correlation inputs as needed to properly identify and correlate the resulting test data.

4. Because of the importance of noise transients in systems using digital devices, all data channels must be full time. Time sharing to reduce test equipment complexity is not permitted.

5. Monitor those equipments and circuits capable of showing the effects of system noise, thereby, in effect, using elements of the system as noise measuring devices.

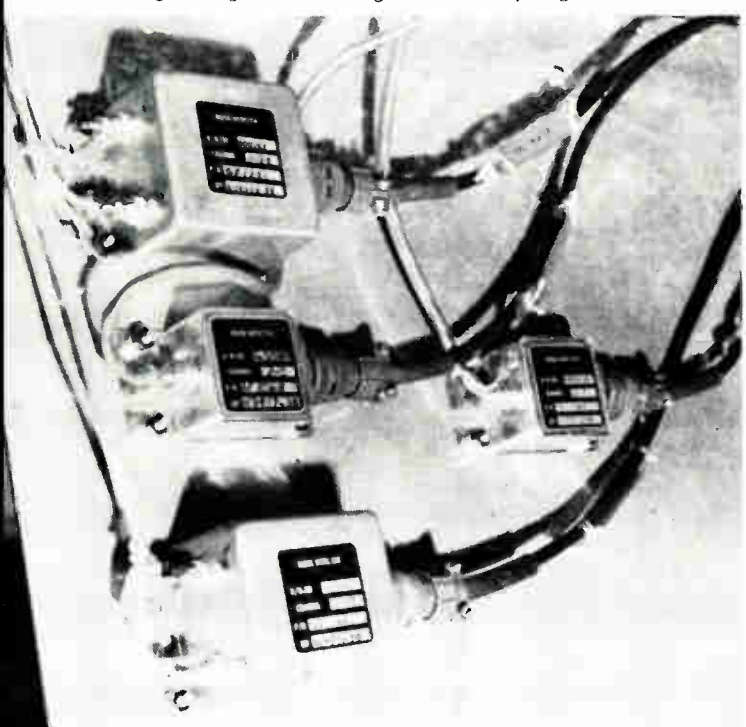
Oscillograph Recorders

Due consideration of the above guidelines dictates the use of multi-channel oscillograph recorders as the basic element of the test setup. Various recorders are available; but, the types using light beam galvanometers provide the widest range of galvanometer selection and provide widest range of record speed and run time capability.

Biggest problem found in using the recording oscillograph is the upper frequency limit of the galvanometer. Response of the highest frequency galvanometer is about 5KC at the upper 5% down point. This limit would seem, at least initially, to limit the usefulness of the recording oscillograph in modern system testing. This is especially true when one considers the fact that the useful direct writing frequency is further limited by resolution of the recorded line. High record velocity is needed to fully use the 5KC galvanometer's capability. For example, a record velocity of 100 in./sec. is needed to resolve a 5KC sine wave; as can be seen, slower record speeds are desirable, and indeed are necessary to make the recording approach practical.

But, when considered as a voltmeter that automatically and continuously records its reading, rather than as a cathode ray oscilloscope to display waveforms, the range of use of the recording oscillograph becomes greatly enlarged. In most uses the galvanometer need not be capable of directly recording a high frequency ac or r-f signal. Instead, it need only follow the rate of change of the information conveyed by the ac signal. Using this method, the relatively low frequency galvanometer can be used to advantage. The problem then becomes one of providing the proper signal conditioning.

Fig. 3: Signal conditioning units (400 cps signal).



Signal Conditioning Devices

The signal conditioning devices needed to make the oscillograph galvanometer compatible with the wide variety and frequency range of the signal sources found in weapon system instrumentation, have been developed to cover a wide range of signal types. The following table lists 9 types that may be considered as typical, but by no means a complete listing.

1. Convert r-f to a dc analog.
2. Convert ac voltage and current to a dc analog.
3. Convert ac of complex waveform to a dc analog of the true RMS value.
4. Convert mechanical position to a dc analog.
5. Convert temperature levels to a dc analog.
6. Convert light intensity to dc analog.
7. Subtract a predetermined voltage from the total signal voltage so that the remainder is recorded in an expanded scale type of presentation.

8. Provide for line to line voltage recording where both lines are above ground.

9. Enable separated signal recording where the desired quantity is:

a. Noise component on a dc voltage.

b. Noise and harmonics on ac power lines.

Signal conditioning units are self contained and miniaturized to facilitate mounting at the signal source. Mounting the signal conditioning unit at the source allows short signal input leads thereby eliminating much of the signal transfer problem. The long cable run, signal conditioning unit to recorder, carries the dc analog voltage only, and thus is not critical. In practice the cable may vary from 10 to 100 ft. in length without needing recalibration of the channel involved.

A relatively wide frequency range is practical through use of the method of placing the signal conditioning circuit at the point of signal origin as noted above, and by using passive detection circuits which avoid the use of amplifiers and their attendant drift, noise and bandwidth problems. The high sensitivity of the light beam galvanometer combined with high efficiency detection circuits makes possible usable deflections with as litle as 25mv of signal using completely passive circuitry. Response up to 400MC has been obtained through the use of high speed diodes and optimized layout geometry.

COMPUTER MASS MEMORY SYSTEM

A COMPUTER MASS MEMORY SYSTEM with a data capacity of 5.4 billion characters has been announced by RCA.

Called RACE (Random Access Computer Equipment), the system can electronically retrieve a number, letter or other data character in a fraction of a second.

Its rental price is about seven cents a month for 10,000 characters of capacity, generally lower than magnetic tape. It permits random or "direct" access to specific data without searching serially through a file.

RACE can handle a full range of daily data processing tasks, update files on a real-time basis and answer priority inquiries in a fraction of a second—all concurrently.

The system operates under the command of the RCA 3301 Realcom computer or the smaller RCA 301. It handles a two-way flow of data by means of electric typewriters, printers, punched cards or tape, CRT's and other visual display units. It can communicate with remote inquiry and input stations via telephone or telegraph lines.

The memory consists of a bank of removable magazines each holding 256 flexible magnetic cards on which information is recorded. A single card contains 166,000 characters of data on a flat magnetic surface 16 in. long and 4.5 in. wide.

The card has 128 recording channels, separated into addressable blocks. Specific records are called for by a computer-command specifying the appropriate magazine, card, channel and block. Each card is edge-notched for purposes of selection.

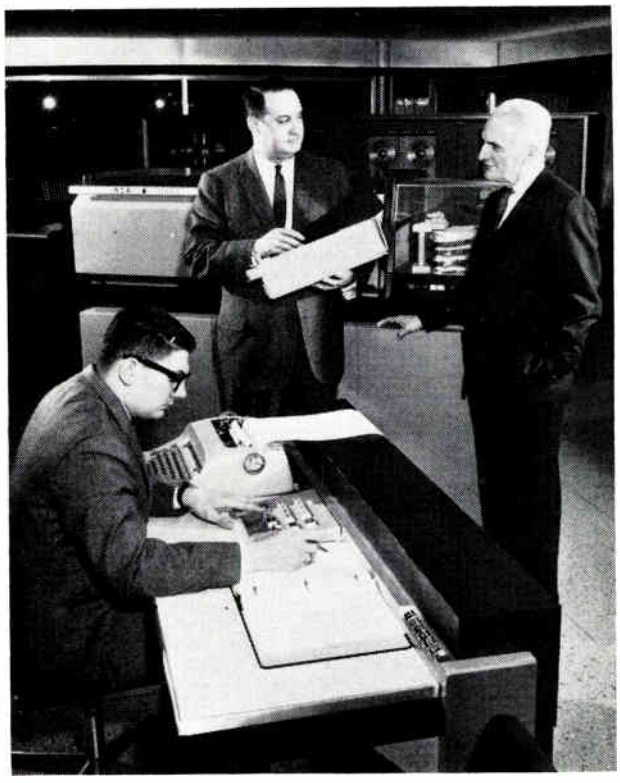
When signaled by the computer, a card is removed from its magazine, entered into a raceway and onto a spinning drum, where it is electronically sensed by a battery of "read-write" heads, in thousandths of a second.

There are from one to 16 interchangeable magazines per read-write stations, and from one to eight RACE units per total system.

This makes RACE expandable from 340 million to 5.4 billion characters.

Transport of the cards from the dust-free magazines to the read-write station and return is completely automatic.

RACE memory consists of a bank of removable magazines each holding 256 flexible magnetic cards on which data is stored.



The advent of the dry reed relay greatly advanced the state-of-the-art in switching design. Reed relay logic modules are being successfully used in systems not adaptable to semiconductor or tube logic. The conversion of digital information to voice, described here, is a good example.

CONVERTING DIGITAL DATA TO VOICE

A VERSATILE DIGITAL-TO-VOICE CONVERTER can be built using reed-relay logic modules.

The advantages of a voice readout to supplement existing instruments are numerous. In aircraft, for example, the amount of instruments to be monitored is increasing to the point where other-than-visual readout methods are becoming a necessity.

Digital logic techniques, although ideally adaptable to such a device, cannot be used throughout the unit because the actual voice must be transferred, thus eliminating the standard two level logic circuits. This audio switching also requires a high degree of isolation not found in common logic modules. The reed, since it is a mechanical switch, fulfills both switching and isolation needs very well.

* * *

The device must scan a digital readout display and convert the visual information to voice. (The display will consist of some combination of numerical digits, along with descriptive symbols or words such as 10 miles, 19.6 degrees, 62.3 CPS, etc.) The conversion is done with a multi-track audio tape drum and associated reed logic circuits.

Scanning

The scanning, usually done with a step relay, can use a reed relay ring counter, thus making the entire units with reeds.

Here we will describe the operation of such a digital-to-voice converter, with an example of a specific unit programmed for conversion of a digital voltmeter readout display to audio.

The heart of the voice-read-out unit is a multi-track tape drum that runs continuously at a constant speed. Each track contains one word or a group of words. The information on the tracks constitute all possible aural interpretations of the digital display. Every instrument will contain the ten numbers (0 to 9), one number per track. Other tracks are usually needed for descriptive words such as Volts, Cycle per Second, Degrees, etc.

An individual read-head constantly scans each track. All read-heads are connected to a common audio amplifier through *separate* AND gates. The read-head AND gates receive information from the digital display, thus, allowing the correct audio signal to reach the amplifier.

The numerical positions on the digital display must be sequentially scanned from left to right. Each numerical digit on the display has zero to nine possible states. Each of these ten possibilities is connected to an AND gate in the voice converter. A group or bank of such AND gates will exist for every position on the display. The necessary serial sampling action is carried out by applying an enabling potential to each bank of AND gates in proper sequence. Of the ten possibilities, only one voltage level will be present at the output of each gate, allowing that particular number to be amplified.

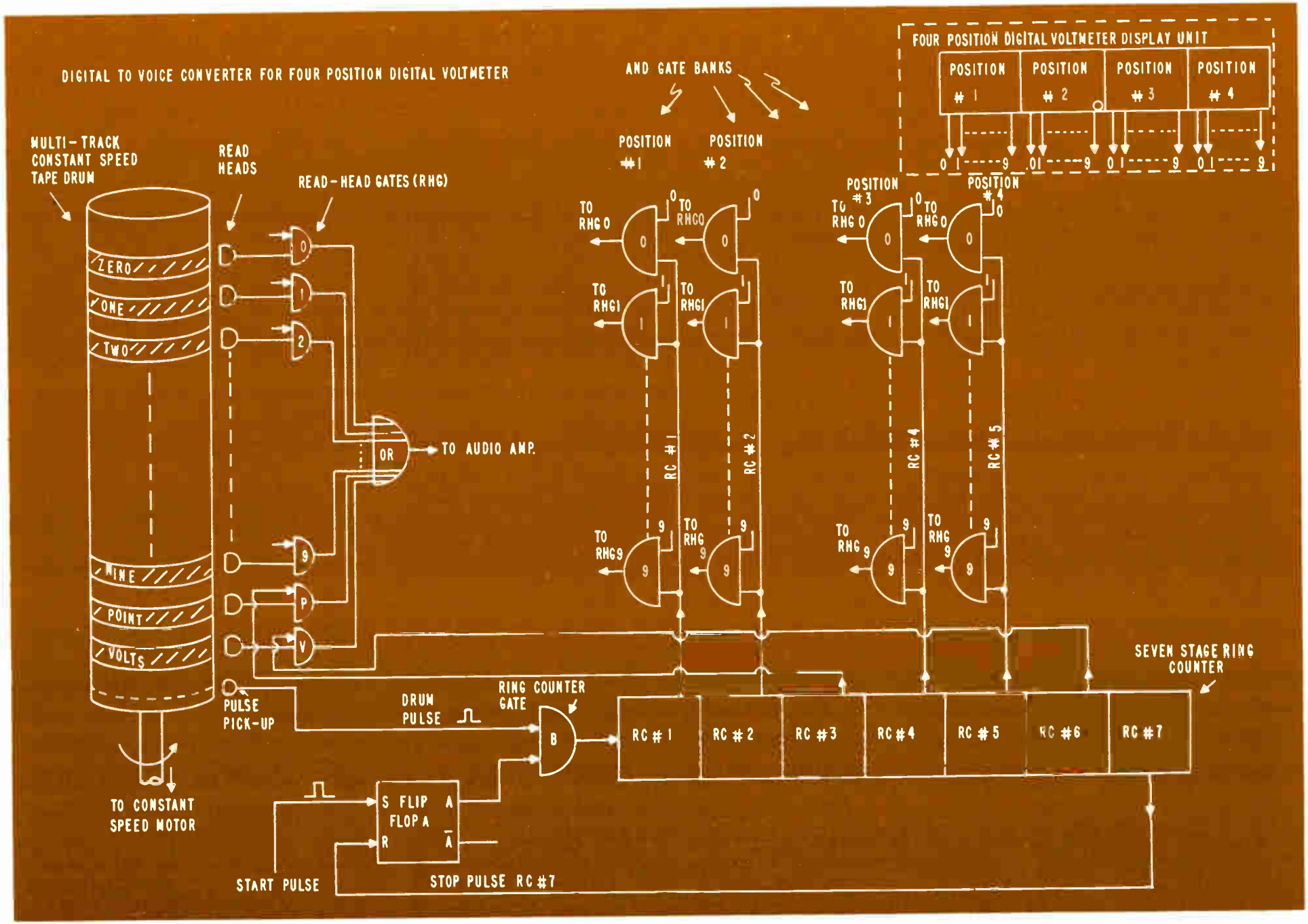
Ring Counters

Sequential scanning of the digital display by the voice converter is realized by use of a ring counter, in conjunction with a sync pulse from the drum. Each drum revolution produces a pulse which, when applied to the ring counter input, progresses through the ring counter with subsequent drum pulses. The outputs of the individual ring counter stages supply the enabling voltage levels to the banks of AND gates corresponding to each display position. As the pulse proceeds through the ring counter, the proper AND gate bank is sampled in the desired order.

A stop pulse is generated at the last stage of the ring counter. This pulse prevents future drum pulses from reaching the ring counter until a start pulse from the digital display is received.

Fig. 1 (right): Diagram is a digital to voice converter for four position digital voltmeter. This can be considered a voice converter building block for sophisticated systems.

By JOHN R. RAWLEY
Electronic Engineer
AEEL
U. S. Naval Air Dev. Center
Johnsville, Pa.



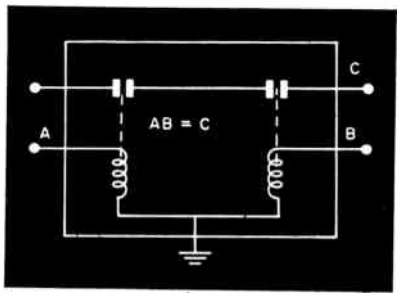
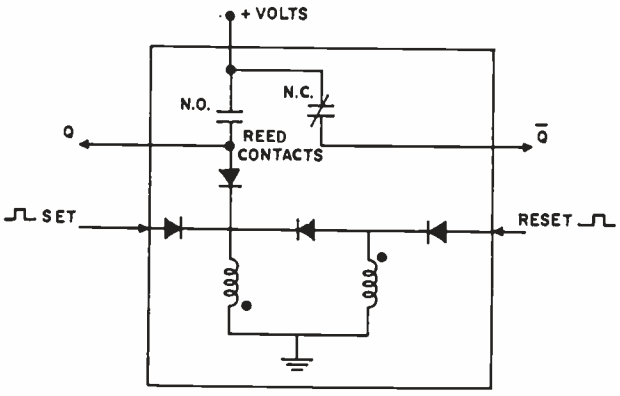


Fig. 2 (left): Reed AND gate is simply two relays in series. Fig. 3 (right): In this flip flop current through both coils cause opposing magnetic fields that cancel, thereby resetting. A Set pulse applies current to one coil only.



Summarizing, the read-head information is sent to the audio amplifier through the read-head-gates which operate with information from the digital display through banks of AND gates. The AND gate banks are sequentially operated by ring counter voltages, which in turn originate from drum pulses.

Figure one is an example of a digital-to-voice converter system for a digital voltmeter having a single range of 00.00 to 99.99 volts. Twelve tracks are used for the 10 numbers and 2 words (volts and point) needed to fully describe the digital display.

The Read Cycle

The read cycle begins with a start pulse from the display unit. The start pulse sets Flip-Flop A, which then places the enabling voltage level on AND gate B. Drum pulses can now enter the ring counter.

The first drum pulse causes ring counter stage 1 to supply the enabling voltage level to all AND gates in the first position or bank. Only one AND gate per bank will have an output. The output will correspond to the number in the display. This output level is applied to the appropriate read-head-gate. At this time, all words on the tape tracks are entering the read-heads, consequently, the read-head-gate receiving the signal from the sampled position will pass the correct audio information to the amplifier.

The second, fourth, and fifth pulses cause this sequence of events to be repeated at display positions 2, 3, and 4 respectively.

Pulses 3 and 6 cause ring counter outputs of stages 3 and 6 to send enabling voltage levels directly to the read-head-gates associated with the words POINT and VOLTS, thus amplifying these words at the correct time.

Ring counter stage number seven generates a stop pulse on pulse number seven. This stop pulse resets Flip-Flop A, stopping future drum pulses from reaching the ring counter until a new start pulse is received.

Fig. 1 can be considered a voice converter building block, allowing sophistication through the addition of tape tracks and extension of the logic. Multi-range devices would require additional selective logic elements along with information concerning decimal point position from the display unit.

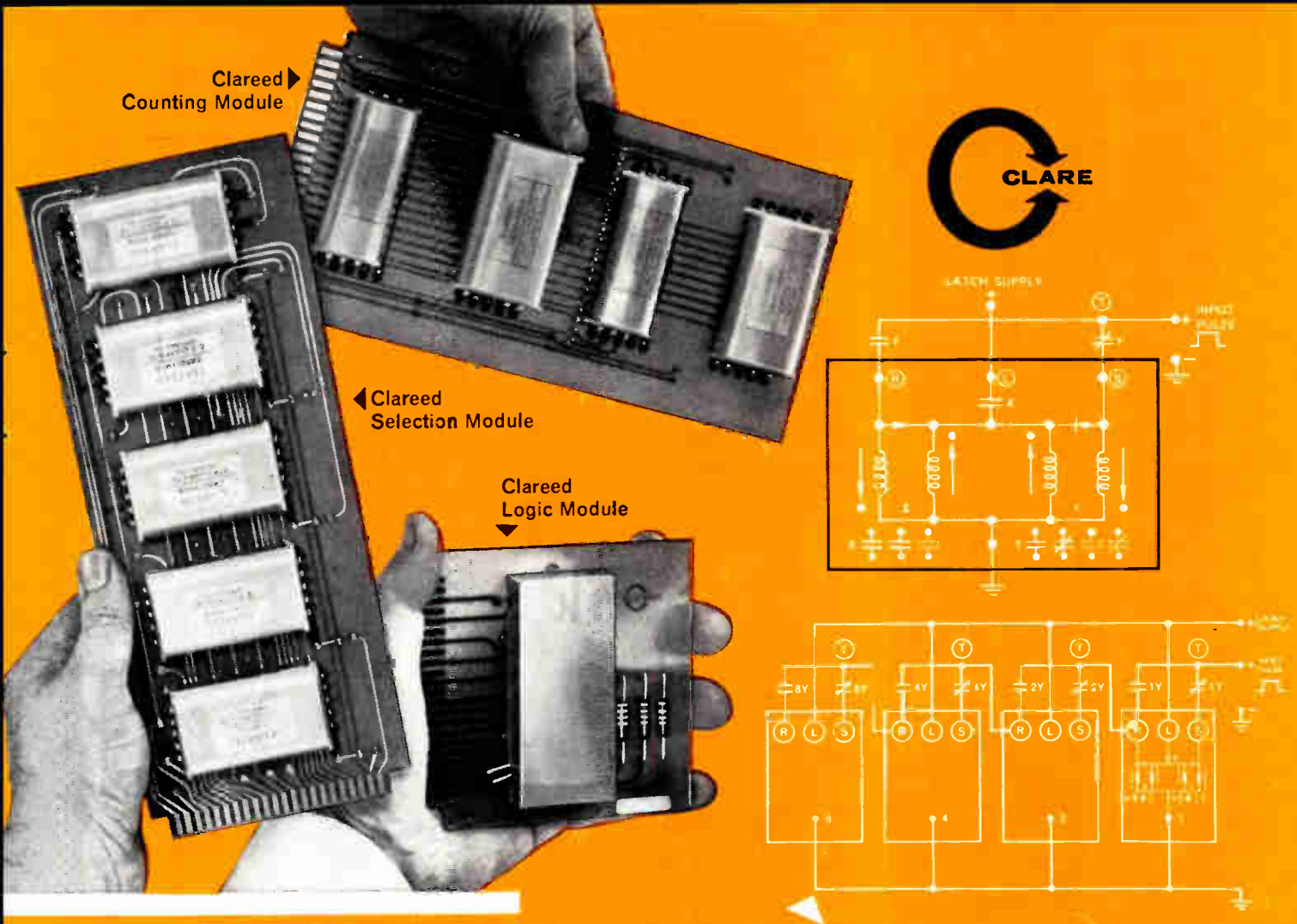
Advantages of Reed Relay Logic

The digital-to-voice converter illustrates two advantages of reed relay logic circuits. Where conventional semiconductor logic elements are limited in information content to two levels or states, the reed can transfer intelligible audio and r-f signals. Thus the audio signal is transferred through the read-head AND gates to the amplifier. The reed relay AND unit, being a mechanical switch, has an Off impedance of more than several hundred megohms, and a small On impedance (milliohms). Switching isolation of this magnitude cannot be realized with semiconductor devices.

The pulsed reed relay ring counter was used in place of a step relay as a sequential circuit selector. The ring counter is lighter, and quieter, requiring less power and no moving parts. Also, the controlled atmosphere of the reed contacts are less susceptible to wear than wafer switch contacts, thereby increasing the reliability.

Operation time of reed contacts fall in the millisecond range, limiting the use of reeds to where speed is not critical. Some features of the reed are: the reed logic circuits are less expensive than their solid state counterparts; reeds can be paralleled indefinitely, yielding almost unlimited fan out capabilities; temperature variations and extremes are not critical to operation; unregulated power supplies will suffice for reed logic networks (this eliminates an expensive problem area in solid state logic systems); transients and noise present no problem to the reed logic element.

Use of reed relay logic circuits permits digital techniques to be practically applied to areas such as: intercom and public address switching networks; elevator control circuits; electronic door controls and combination locks; detection and alarm systems; remote control and remote selection devices; feedback networks; tape recorder controls; tachometers; digital voltmeters; and automotive ignition analyzers.



CLARE

Which one does this?

If you work with control systems which involve counting, selection, or logic functions, take a look at Clareed Control Modules.

You'll see a system approach providing simpler and often more economical solutions than those offered by solid-state or other techniques. You'll find plenty of speed for most applications, and reliability of a very high order.

Clareed Control Modules use magnetic flux to make decisions. Combinations of flux levels and flux polarities, generated by multiple-wound coils, operate glass-encapsulated Clareed switches. Among the advantages of Clareed Control Modules are:

- Multiple-input and multiple-output capabilities, making possible logic at both input and output.
- Complete isolation between input and output. The output is the contact closure. This contact can handle low-level analog signals, other digital signals, and AC or DC power up to 15 va.

For example, consider the Binary Counter shown in the diagram. This counter uses a single-input (T) flip-flop in each of its four stages. The flip-flop may be constructed with twelve isolated terminals. Terminals not used for Counter Control are available for isolated multiple output, with normally-open or normally-closed contacts. Each contact is capable of handling 15 va. This flip-flop circuit is provided by one standard Clareed Counting Module. (Which Clareed Control Module is used? If you said, "Counting," you're right.)

Standard Clareed Control Modules offer useful, uncomplicated ways of performing these functions:

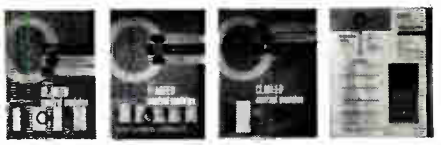
- In counting: Three basic flip-flops which provide binary, binary coded-decimal, decimal, radix(N), ring counters, bi-directional counters and shift register applications.
- In selection: A variety of selection systems, using a single-mode matrix, a single-mode memory matrix, or a two-mode matrix (Mode 1: All crosspoints normally open; Mode 2: All crosspoints normally closed).
- In logic: AND, INCLUSIVE OR, EXCLUSIVE OR, NAND, NOR, EXCLUSIVE NOR, as well as more complex logic in a single module.

Systems using Clareed Control Modules can be easily serviced with a simple multimeter.

For detailed problem analysis and engineering recommendations, write Group 4D4, Application Engineering, C. P. Clare & Co., 3101 Pratt Boulevard, Chicago 45, Illinois. For useful manuals, see offers below.

Take your choice!

Concise: For a terse, time-saving explanation of Clareed Control Modules in counting, selection, and logic, get 8-page Manual 400 by circling number 54 on Reader Service Card.



Complete: For detailed information on Clareed Control Modules in counting, selection, and logic, get Manual 400 plus Application Manuals and Data Sheets on all Clareed Control Modules. Circle number 55 on Reader Service Card.

What Won't You Think Of Next?

Portable iron for Mom? Window washer with wings? Fresh coffee in your boat? Special delivery to the top of the run? Or a plate "whisk-er" for the Bill Klem stylists.

Probably impractical.

Our point is this—your present design problem may seem just as impractical, as the drill, shaver, mixer and other cordless products did a few years ago. But Gould-National research engineers developed a package of concentrated power using NICAD® Hermetically Sealed Rechargeable Cells that helped to make these products a reality.

Have a design problem that could be solved with Nicad portable power? Write us. We may be able to help you solve your problem.

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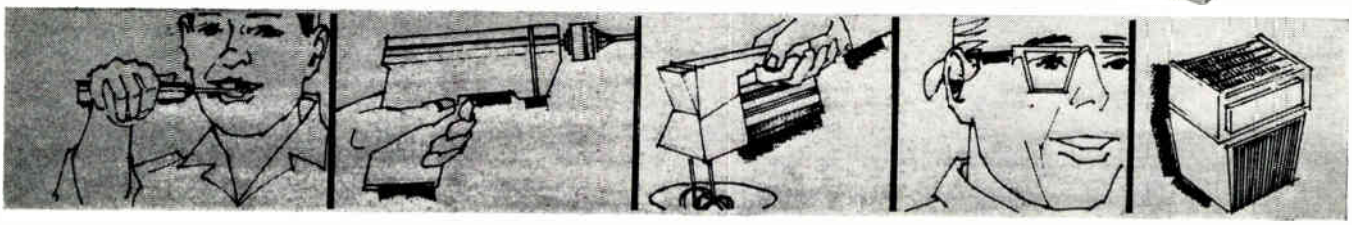

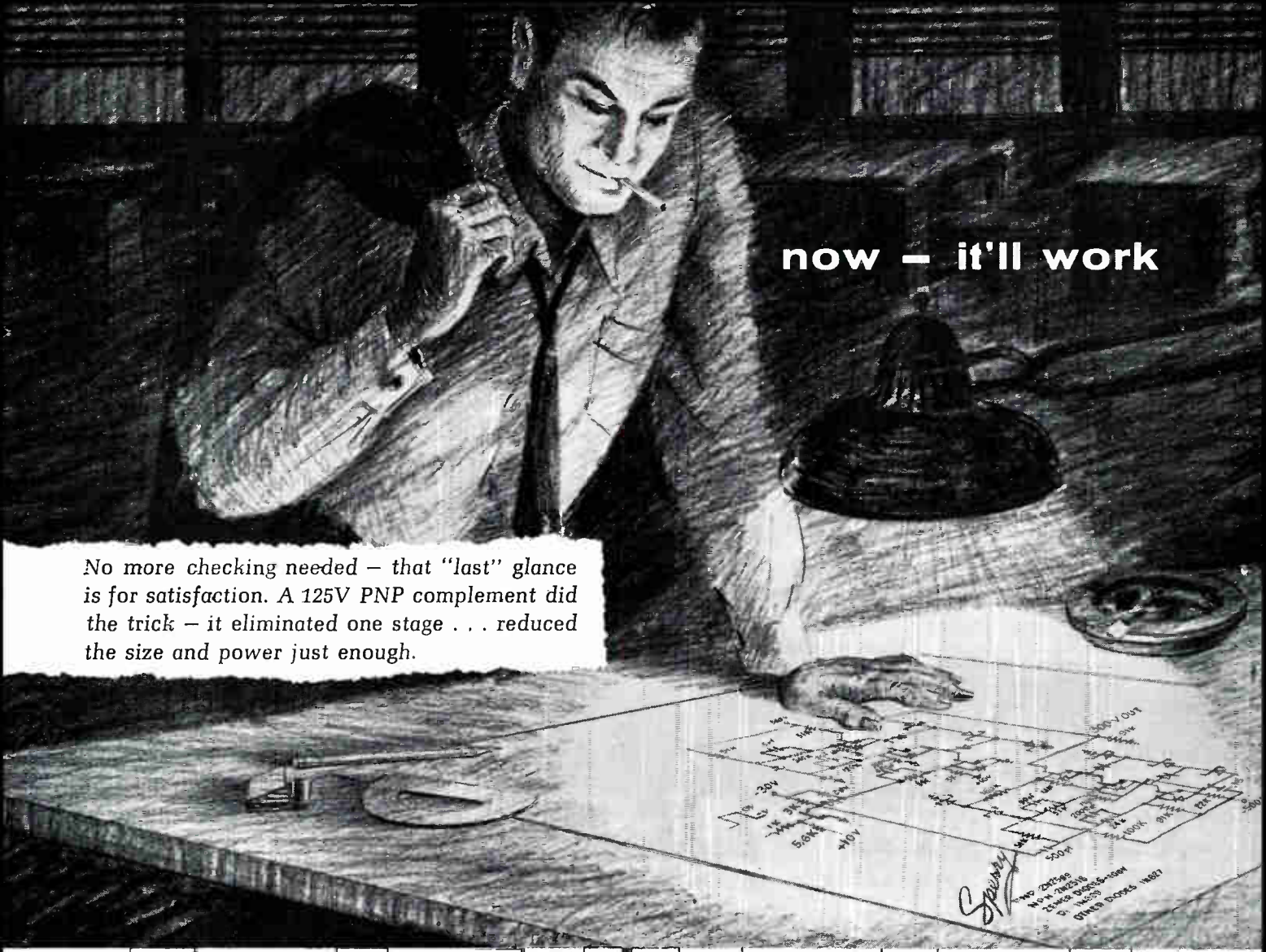

	TO-46 Case	MAXIMUM VOLTAGES BV_{CBO} (Volts)	BV_{CEO} (Volts)	BV_{EBO} (Volts)	I_{CBO} Max. @ 25°C (μA)	h_{FE} Min.	Max.	@ I_C (mA)	V_{CE}(SAT) Max. (Volts)	f_T Typ. (MC)
NPN	2N2518	125	80	8	.005	40	100	5	0.5	175
PNP	2N2599	–125	–80	–7	–.025	40	100	–5	–0.5	90
NPN	2N2519	125	80	8	.005	80	200	5	0.5	200
PNP	2N2600	–125	–80	–7	–.025	80	200	–5	–0.5	120
NPN	2N2459	100	60	8	.002	40	80	5	0.3	175
PNP	2N2590	–100	–60	–7	–.025	40	80	–5	–0.4	75

	TO-46 Case	MAXIMUM VOLTAGES BV_{CBO} (Volts)	BV_{CEO} (Volts)	BV_{EBO} (Volts)	I_{CBO} Max. @ 25°C (μA)	h_{FE} Min.	Max.	@ I_C (mA)	V_{CE}(SAT) Max. (Volts)	f_T Typ. (MC)
NPN	2N2460	100	60	8	002	70	130	5	0.3	200
PNP	2N2591	–100	–60	–7	–.025	70	135	–5	–0.4	100
NPN	2N2461	100	60	8	002	120	180	5	0.3	225
PNP	2N2592	–100	–60	–7	–.025	115	200	–5	–0.4	125
NPN	2N2462	100	60	8	002	170	230	5	0.3	250
PNP	2N2593	–100	–60	–7	–.025	160	275	–5	–0.4	150

31234

Thorough evaluation leads to a good decision. Many problems involving high voltage complementary transistors can be answered with the type numbers listed above – they represent the industry's largest high voltage line of complementary planar transistors. In fact, Sperry Semiconductor produces the industry's first *full line* of PNP/NPN Complementary Silicon Planar Transistors. Notice the close matching characteristics – we make them that way (not just pick a PNP that is close to an NPN). This is another example of Sperry's leadership of PNP low level silicon planar transistors. Our record of reliability is important – it validates our *credentials for the future*. Question them, inspect them, use them – they can help on your military projects and in your industrial control work. Whether you need volume production or personal attention in custom engineering – contact Sperry Semiconductor. ☐ Eastern Regional Office: 69 Hickory Drive, Waltham, Massachusetts; Midwest Regional Office: 3555 West Peterson Avenue, Chicago 45, Illinois; Western Regional Office: 1680 North Vine Street, Hollywood 28, Calif. Sales Representatives: Orbit Electronics, 250 Carroll Street, Fort Worth, Texas; Perrott Associates, Incorporated, 2321 East South Street, Orlando, Fla. ☐ *Keep in touch – with SPERRY SEMICONDUCTOR, Norwalk, Connecticut.*

SPERRY

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Circle 37 on Inquiry Card

NEW TECH DATA

". . . STATE-OF-THE-ART information on Components and Equipment."

Connectors Catalog

Catalog A-6, 96 pages, presents standard-size military electrical connectors. The catalog contains basic information about MS military connectors including nomenclature, construction available, shell types, inserts and contacts. Special chapters cover "How to Select" and "How to Order" MS connectors. Amphenol-Borg Electronics Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle 203 on Inquiry Card

Commutator Catalog

This 12-page catalog is devoted to precious-metal flush contacts and multiple-fingered wipers in precision assemblies. Included in the catalog are standard single-turn units designed for long life, high-speed and ultra-high reliability. In addition a number of special units developed for specific application are given. Computer Instruments Corp., 92 Madison Ave., Hempstead, L. I.

Circle 204 on Inquiry Card

Switches

Successfully Specifying Snap-Action Switches is the title of a pamphlet intended for design engineers, value engineers, purchasing agents and management. This article tells how to prepare a switch specification that will invite more proposals and provide the best quality price combination. Cherry Electrical Prods. Corp., P. O. Box 439, Highland Park, Ill.

Circle 205 on Inquiry Card

Modules Catalog

Catalog 80, 52 pages, contains circuit diagrams and operating characteristics on a complete line of 12-pin digital-logic modules. There are 19 families, 43 modules. Digital Module Dept., Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.

Circle 206 on Inquiry Card

Resistor Catalog

Catalog PR200, 23 pages, describes 7 complete precision wirewound resistor groups. Included are the HR series, SP series subminiature resistors, VA series high-precision resistors, EP series economy precision resistors, Mil-R-93C and Mil-R-9444A resistors, PC resistors, and ceramic bobbin instrument resistors. Complete data for correctly specifying wirewound resistors and a new commercial order code are also included. Shallcross Mfg. Co., Selma, N. C.

Circle 207 on Inquiry Card

Glossary of Recording Terms

This monograph is intended to fulfill a need for a glossary of terms used in magnetic recording. Its aim is to define or explain the more fundamental terms common to a wide range of magnetic recording applications. Many terms listed are defined for the first time. Memorex Corp., 1180 Shulman Ave., Santa Clara, Calif.

Circle 208 on Inquiry Card

Wire Coating

This data describes a new formulation of low-density Tenite polyethylene for high-speed wire coating. The formulation, Tenite Polyethylene 1915E, has been applied at speeds up to 4,000 ft./minute. It may be used for primary insulation and for cable jacketing. Classified as Type I, Grade 5 material under ASTM D-1248-60T, the formulation has a nominal density of 0.918 and a nominal melt index of 0.25. Eastman Chemical Products, Inc., 260 Madison Ave., New York, N. Y.

Circle 209 on Inquiry Card

Potentiometer Chart

The LIN chart provides a new method of selecting linearity and resistance. By using this chart the design engineer can select a standard resistance value and resolution which will enable him to accept the standard linearity shown. Fairchild Controls, 225 Park Ave., Hicksville, L. I., N. Y.

Circle 210 on Inquiry Card

Solders & Coatings

Bulletin No. 7 describes Epoxy silver solders and conductive coatings. The bulletin is a comprehensive technical treatment of paste and pellet form Epoxy solders and liquid form Epoxy conductive coatings. Epoxy E-Solder® can be used to make a conductive bond at room temperature. E-Kote® silver filled paint has a resistivity of 0.001 ohm-cm. It is used for painting electrical connections between components and coating circuit modules and ribbon circuits for electric shielding. Epoxy Products Inc., Waldman, 133 Coit St., Irvington, N. J.

Circle 211 on Inquiry Card

Bolometer

Data is available on a Ferroelectric bolometer that measures electromagnetic radiation from the visible to the far infrared. The detector operates at room temperature and has msec response. Huggins Laboratories, Inc., 999 E. Arques Ave., Sunnyvale, Calif.

Circle 212 on Inquiry Card

Computer Catalog

This illustrated catalog describes a complete line of compatible systems building blocks. It includes general-purpose digital computers, all-silicon logic-circuit modules, amplifiers, multiplexers, analog-to-digital and digital-to-analog converters, and computer-controlled systems. Design features and operating characteristics are given for all products. Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif.

Circle 213 on Inquiry Card

Gear Manual

Design manual #3 presents data on spiroid and helicon gears. It includes chapters on engineering theory, production methods, and application techniques. Included are designing tables covering dimension data, performance ratings, and tooth load components for a wide range of styles and sizes. Spiroid, Div. Illinois Tool Works, Inc., 2501 N. Keeler Ave., Chicago, Ill.

Circle 214 on Inquiry Card

Connector Catalog

This 56-page illustrated catalog lists terminals, splices, and installation tools. It contains illustrations of solderless connectors and dimensional data. Installing tools, both hand and production types, are keyed to the types of fittings for which they are applicable. Military standards and specs. are referenced where pertinent. The catalog also includes several useful tables, such as decimal equivalents, wire-size reference charts, stud size and clearance hole charts, and others. The Thomas & Betts Co., 36 Butler St., Elizabeth 1, N. J.

Circle 215 on Inquiry Card

Curing Agent Chart

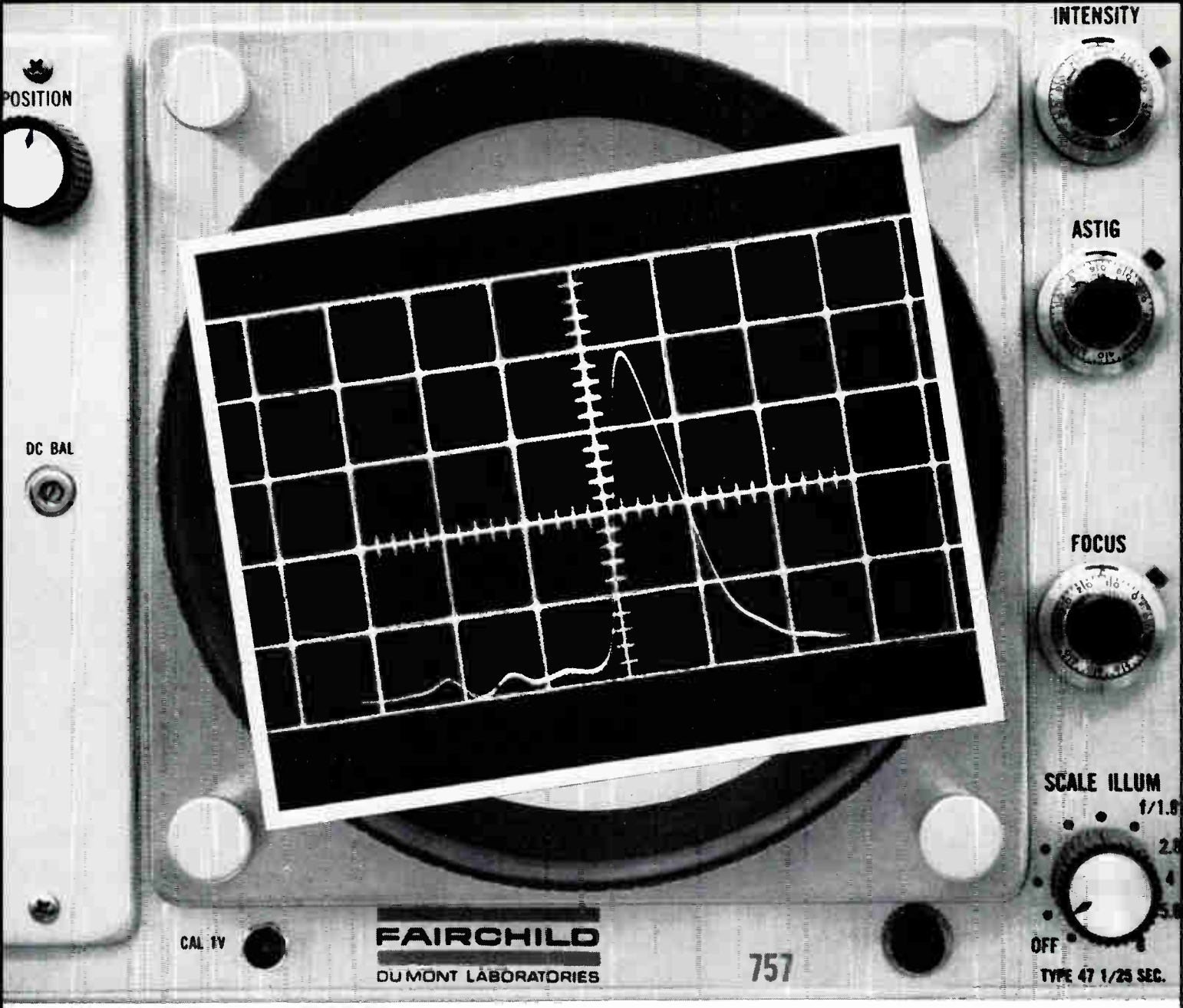
This chart of proprietary curing agents for epoxy resin systems lists some forty-two physical, thermal, chemical, and electrical properties. It is provided with a selector to facilitate the selection of the proper curing agent. Columbia Technical Corp., Woodside, N. Y.

Circle 216 on Inquiry Card

Frequency Standard

This data sheet contains a photo and specs. for the V-4700B rubidium freq. standard. The system consists primarily of a servo in which a crystal oscillator is locked to the electron hyperfine transition freq. found in the rubidium atom. This provides a long-term stability reference. Output freq.: 100KC, 1MC, and 5MC. Unit meets Mil-I-26600. Varian Associates, 611 Hansen Way, Palo Alto, Calif.

Circle 217 on Inquiry Card



Can Your Scope Get This Picture?

To determine the efficiency of a powerful new ruby laser, the engineers had to know the duration and shape of the output pulse. Until now, only a few costly special purpose scopes could put such a fast one-shot pulse on film for study. But the new Fairchild 757 can do it. Equipped with a Fairchild Scope Camera, it recorded the 9 nsec rise time of the 20 megawatt pulse on 4 cm scan. A modified version of the 765H Series high-frequency scope, the 757 employs a new CRT developed by Fairchild's Du Mont Tube Division. The writing rate of this tube—4000 cm/μs—is over three times that of conventional scope CRTs. For versatility the 757 is quickly converted to general purpose work simply by throwing a switch. All signal circuitry is contained in the many plug-ins available for a wide range of precision measurements. (For this picture a single trace, 50 mc plug-in was used.) If you must analyze transients no other scope can capture, use the 757. The 765H Series will handle just about anything else. Ask your Fairchild field sales engineer for a demonstration. And for a new Instrument Catalog write Fairchild Scientific Instruments, Dept. 44, 750 Bloomfield Ave., Clifton, N. J.

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SCIENTIFIC INSTRUMENTS DEPARTMENT

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NEW TECH DATA

Bridge Rectifier

The 10B is a ready-to-install, single-phase rectifier. The new packaged unit is rated at a continuous load current of 10 amp. dc, with voltage ratings from 50 to 600 PRV. The fully-insulated assembly consists of four silicon rectifiers pressed into aluminum heat sinks. The 0.250 quick-disconnect tab terminals are used on both the incoming ac and on the dc output. Specs. are available from Curtis Development & Mfg. Co., 3266 No. 33rd St., Milwaukee, Wis.

Circle 172 on Inquiry Card

Control Ovens

Data is available on noise-free temp. controls for crystals and components. Complete solid-state design features temp. stability of ±0.01°C with fixed amb. conditions. Available for operation with either 12vdc or 27vdc power sources. Package size is 1-15/32 x 1-29/32 x 4 in. high excluding octal base. Barber & Drullard Inc., 633 Delaware Ave., Buffalo, N. Y.

Circle 173 on Inquiry Card

Product Catalog

Catalog 1963A contains photos and specs. for sweep-signal generators, sweep oscillators, pulse generators, microwave amplifiers, attenuators, detectors, samples, levelers, and power supplies. A microwave amplifier selection chart is also included. Alfred Electronics, Stanford Industrial Park, Palo Alto, Calif.

Circle 174 on Inquiry Card

Cooling Blower

The SVA-560-16326 is a high-altitude vane axial blower unit that has been developed for 400 cycle electronic cooling service. The high-slip motor minimizes changes in cooling capacity resulting from altitude changes. Typical air performance is 380 CFM (standard density) at a static pressure of 2.9 in. of water. Tech. data may be obtained from The Torrington Mfg. Co., Torrington, Conn.

Circle 175 on Inquiry Card

Pulse Transformers

Design and performance details for a broad range of precision pulse transformers are described in this brochure. Information simplifies design and procurement problems, gives a starting point in finding the unit necessary for a particular application. Schematic diagrams and spec. tables show exact circuit performance values for a variety of standard coupling transformers, vacuum-tube blocking-oscillator transformers and miniature transistor-blocking oscillator transformers. Electronics Div., Hamilton Watch Co., Lancaster, Pa.

Circle 176 on Inquiry Card

NEW TECH DATA

Industrial Relays

Catalog 64, 20 pages, describes a line of electromagnetic relays. Separated into illustrated sections, the catalog features several new relays. Coil voltages, resistances, time values, contact ratings, terminations, dimensions and other pertinent engineering data are listed for each relay. Also shown are standard enclosures, mountings and Underwriters' Laboratories and Canadian Standards Assoc. labeled relays. Potter & Brumfield, Princeton, Ind.

Circle 177 on Inquiry Card

Ultra Small Relay

The type 2x relay has a case size of 0.5 x 0.4 x 0.2 in. The contacts are rated for 0.5a at 30vdc. The coil sensitivity at pull-in is 150 mw, which allows a coil resistance of 1KΩ for a nominal coil voltage of 26.5 vdc. The vibration resistance is 20g and the shock rating is 75g. Complete specs. are contained in data sheet 9. Couch Ordnance, Inc., 3 Arlington St., North Quincy, Mass.

Circle 178 on Inquiry Card

Micro Inductors

These micro inductors meet Mil-T-27A, Grade 4, Class R. They are packaged in transistor-size cases and offer min. Q's ranging from 30 @ 20KC to 120 @ 200KC. Additional data available from Collins Radio Co., 19700 San Joaquin Rd., Newport Beach, Calif.

Circle 179 on Inquiry Card

Tape Punch-Reader

This brochure provides complete specs. and illustrations of the Series 1010 tapewriter and tapewriter-reader systems. The tapewriter features simultaneous printing and punching of numeric or alphanumeric data on 5, 6, 7, or 8 level tapes. Printed characters appear immediately for quick verification. An illustrated bulletin describes the compact, compatible tape-reader accessor, which permits tape duplication and tape comparisons. Navigation Computer Corp., Valley Forge Ind. Park, Norristown, Pa.

Circle 180 on Inquiry Card

High-Power Triode

A comprehensive bulletin describing the Type 7242 high-power triode, developed for use as a circuit-simplifying passing tube in series regulated power supplies, is available. It simplifies control amplifier circuits in the power supply. Included are electrical and mechanical data, and a number of outline drawings and circuit schematics. Tung-Sol Electric Inc., One Summer Ave., Newark 4, N. J.

Circle 181 on Inquiry Card

NEW TECH DATA

Irons and Tips

A tech. article on considerations involved in the selection of the right soldering iron and tip is available. The article discusses heat content, shape, conductivity and tip materials. It contains cutaway views of soldering irons showing construction features, a table on iron classification, and a table on heat characteristics of tip metals. Ask for Bulletin PT-863 from Alpha Metals, Inc., 56 Water St., Jersey City, N. J.

Circle 182 on Inquiry Card

Transducer Brochure

This brochure lists basic specs. and performance characteristics on pressure, position, and acceleration transducers and instrument systems. Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, Calif.

Circle 183 on Inquiry Card

Wattmeter

Data is available on a 3-phase wattmeter for measuring in ac circuits. The 1% accuracy is maintained over a wide freq. range and is unaffected by harmonic content or power factor. Extreme load unbalance can also be tolerated without impairment of accuracy. AMF Instrument Div., American Machine & Foundry Co., P.O. Box 929, Alexandria, Va.

Circle 184 on Inquiry Card

Mixer Diodes

D5082D and D5082DR are low-noise, high-burnout Ku-band mixer diodes. They have a 10 erg spike burnout rating. The diodes maintain a max. noise figure of 7.5 decibels at 16gc. Additional specs. and data available from Sylvania Electric Products, Inc., 730 Third Ave., New York 17, N. Y.

Circle 185 on Inquiry Card

Test Jack

Data sheet 162 describes a 0.080 in dia. test jack. Insulation is molded of nylon with brass, nickel-plated nut. Contact is heat treated beryllium copper, electro-tin plated. Voltage breakdown is 6kv RMS min. Augat Inc., 33 Perry Ave., Attleboro, Mass.

Circle 186 on Inquiry Card

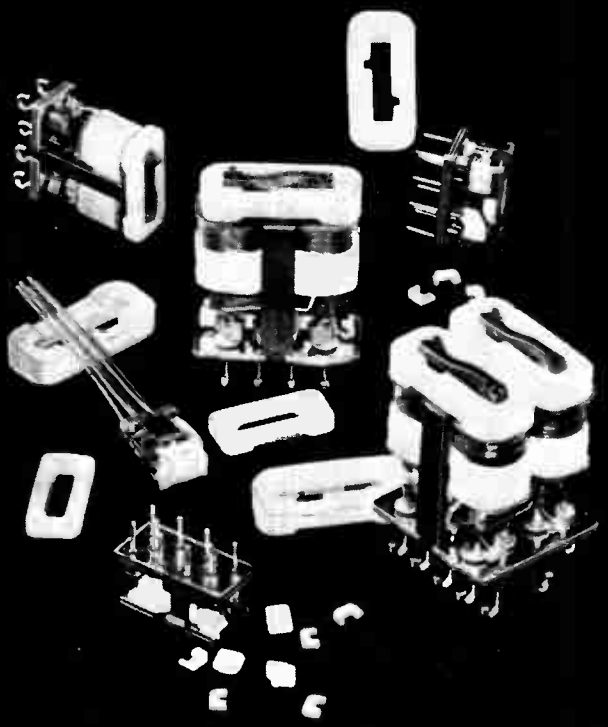
Pressure Transducers

Data is available on a group of Teledyne® low-pressure transducers. Available in pressure ranges from 0-10 through 0.50 psia, the units offer fast response to transient pressures and are built to withstand pressure overloads up to 500 psia on all ranges without damage or recalibration. Tabor Instrument Corp., 107 Goundry St., N. Tonawanda, N. Y.

Circle 187 on Inquiry Card

What good is a getter?

Babcock uses them to increase relay reliability.



Exclusive Babcock Design Feature Provides Lower Contact Resistance & Longer Relay Life

Contact contamination from vaporization is one of the major causes of erratic performance and eventual failure of hermetically sealed relays. After extensive investigation Babcock Relays, in conjunction with Corning Glass Works, has developed an activated getter from Corning's Vycor brand porous glass. During operation, the activated getters prevent relay contacts from being fouled by contaminants emitted at elevated temperatures.

Babcock has subjected relays using Vycor getters to hundreds of thousands of operations at loads varying in excess of 200G's for 11 milliseconds and vibration at 35G's, 3-5,000 cps. It has been determined that up to 99% of organic contaminants remaining after production degassing are adsorbed by the dessicant. Conclusive life testing at 125°C has proven that contact erosion and contamination accumulation on all vital areas within hermetically sealed relays has been substantially reduced. Consistently lower contact resistance is also exhibited due to the reduction in contamination.

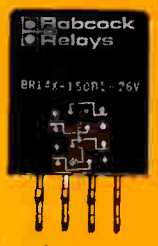
The end result provides Babcock relays with increased performance and efficiency, higher temperature application, and longer, more reliable life.

Babcock reliability rated relays featuring Vycor getters include:

BR-5—Transistor-sized dry circuit to one amp

BR-13—Microminiature, all-welded for dry circuit to 3 amp

BR-17—Half-size magnetic latching for dry circuit to 2 amp operation. Also available as non-latching model.



BR-14—Subminiature 4 PDT available in 10, 7.5 and 5 amp

BR-19—Subminiature all-welded 10 amp relay. BR-20 magnetic latching version also available.

Send for complete catalog.

BABCOCK RELAYS

A DIVISION OF BABCOCK ELECTRONICS CORPORATION
3501 HARBOR BLVD., COSTA MESA, CALIF. • 546-2711

NEW TECH DATA

When to Specify Thermoelectric

"When to Specify Thermoelectric Temperature Stabilization" is the subject of this booklet from Carter-Princeton, 178 Alexander St., Princeton, N. J. The booklet contains data on module and electrical characteristics, selecting modules, thermal leakage calculation, and thermal leakage measurement. It also has a list of thermoelectric definitions. Electronics Div., Carter Products, Inc., 178 Alexander St., Princeton, N. J.

Circle 188 on Inquiry Card

Components & Controls

This 27-page catalog is in the form of data sheets. Material includes data on photoconductive cells, tape and card photoread heads, opto-electronic relays, photochopper relays, and integrated-circuit modules. Each product is shown, and the accompanying data includes description, application, and specs. Opto-Electronic Devices Inc., sub. of Sigma Instruments, Inc., Braintree 85, Mass.

Circle 189 on Inquiry Card

Instrument Motor

Data sheet 1063 describes the Synchron instrument motor, a unit that has withstood temp. fluctuations of 180°F (−40° to 140°F). Features include high-temp. magnet wire, burnished pivots, reamed pivot holes, solid-brass first gear. There are 179 speeds ranging from 360 RPM to one revolution/week. At 1 RPM, torque ratings of 8, 20, and 30 inch-ounces are standard. A 90 inch-ounce static torque may be applied to the output shaft without motor damage. Hansen Mfg. Co., Princeton, Ind.

Circle 190 on Inquiry Card

R-F Transfer Switch

Data is available on a manual r-f transfer switch, designated type-P, which qualifies for applicable military specs. Typical performance with N-type connectors at 7GC is: SWR less than 1.15:1; insertion loss 0.2db and crosstalk in excess of 50db down. Similar performance is attained to 11GC with good broadband characteristics. Transco Products, Inc., 4241 Glencoe Ave., Venice, Calif.

Circle 191 on Inquiry Card

High Temperature Bearings

Data sheet B-2 describes a ball retainer made of reinforced Teflon compounded with a solid lubricant. This allows the bearings to operate at temps. from −325°F. (−185°C.) to +575°F. (302°C.) without conventional lubrication. Developed primarily for aerospace applications, the bearing meets the needs of high-temp. synchros, fans, motors, blowers, pressure switches, tachometer generators, etc. The Barden Corp., 200 Park Ave., Danbury, Conn.

Circle 192 on Inquiry Card

NEW TECH DATA

Laminated Plastic

Grade G-9 is a glass-melamine laminated plastic which qualifies under Mil specs. for Type GME. The plastic has better physical, mechanical and electrical properties than Grade G-5 (military type GMG) glass-melamine laminated plastic. It is made with a continuous filament woven glass fabric base bonded with an improved melamine resin. Specs. available from Taylor Corp., Valley Forge, Pa.

Circle 193 on Inquiry Card

Static Inverters

Bulletin GEA-7644 describes a line of static inverters and freq. changers. The publication includes a discussion of the equipment, spec. charts, pictures of typical models and application, design and features of the new line. General Electric Co., Schenectady 5, N. Y.

Circle 194 on Inquiry Card

Beacon Encoder

Model ADC-ALT-4 is a multiple-turn 15 beacon encoder. It translates shaft rotation into the special Gillam code—a unit-distance code. It has a guaranteed accuracy of ±10 ft. over the range of −1000 to +127,000 ft. The encoder reports out every 100 ft. of elevation. Additional data available from Norden Div., United Aircraft Corp., Norwalk, Conn.

Circle 195 on Inquiry Card

Potentiometers

Data sheet 63560 introduces 3 new single-turn rotary cermet precision potentiometers. They offer reliability and environmental stability, essentially infinite resolution, and long rotational life with no chance for catastrophic failure. These continuous-rotation units have a standard resistance tolerance of ±5%, with a min. tolerance of ±1% available on special request. Helipot Technical Information Service, 2500 Harbor Blvd., Fullerton, Calif.

Circle 196 on Inquiry Card

Contact Tester

Publication #LI-60 describes a dry-circuit contact tester which determines the reliability of switches and relays in making circuit under low voltage, low-current conditions. The illustrated publication contains mechanical and electrical data. The unit is capable of testing contact reliability on both mechanically- and electromagnetically-operated devices, such as switches, relays, pushbutton stations, electrical interlocks, and reed switches. Cutler-Hammer Inc., 436 N. 12th St., Milwaukee, Wisc.

Circle 197 on Inquiry Card

ELECTRONIC INDUSTRIES

NEW PRODUCTS

". . . advancing the STATE-OF-THE-ART in Components & Equipment.

FIXED ATTENUATORS

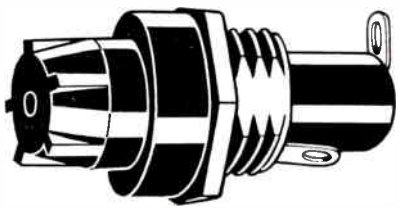
Available in values of 3db, 6db, 10db. 15db, or 20db.

These attenuators have an accuracy of ±0.2db from nominal value and ±0.3db variation with freq. Calibration data is furnished with each unit. They operate over a freq. band of 30MC to 4GC. AST attenuators weigh 3½ oz. and measure 3 x 1¼ x 1-1/3 in. with 1½ in. center-to-center between connectors. Standard units are supplied with type N-male and female connectors, but other types including sub-miniature are available. LEL, Inc., 75 Akron St., Copiague, N. Y.

Circle 140 on Inquiry Card

FUSEHOLDER

Takes ¼ x 1¼ in. fuses. Easily converts to 9/32 x 1¼ in. fuses.



A compact fuseholder, 1⅝ in. long, extends 29/32 in. behind front of panel. Holder can be made drip-proof from front of panel or completely water-proof. Military type meets all environmental conditions and requirements of Mil-F-19207A. The military types use BUSS HLB for ¼ in. fuse and BUSS HCW for 9/32 in. fuse. Commercial types BUSS HLF for ¼ in. fuse and BUSS HLC for 9/32 in. fuse. Bussman Mfg. Div., McGraw-Edison Co., St. Louis, Mo.

Circle 142 on Inquiry Card

RELAY

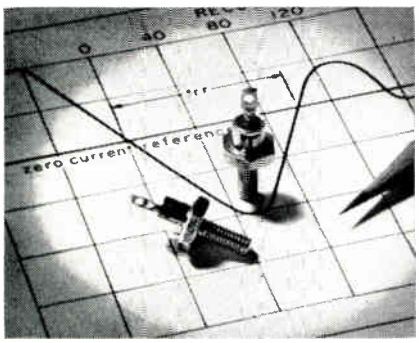
The 100a. relay withstands a 100% overload for 1 min.

The Type 2101 is rated at 100a., non-inductive, at 115v., 60 CPS. Contact arrangement is normally open. Operate and release time average 0.07 and 0.10 sec. This epoxy-molded-head, mercury-displacement relay requires no panels or connectors and can be fastened directly to the desired application point. The unit occupies less than 57 cu. in. Typical applications include electric furnace loads and electric motors The Adams & Westlake Co., Relay Div., Elkhart, Ind.

Circle 144 on Inquiry Card

RECTIFIER

Combines fast-recovery and controlled avalanche in one device.

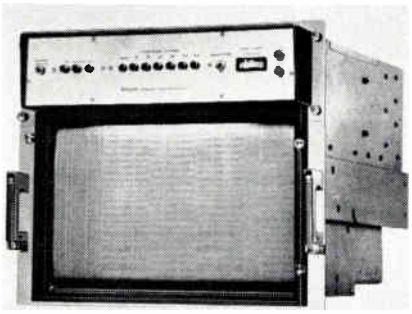


This fast-recovery controlled avalanche silicon rectifier has a max. recovery time of 100nsec. Some units are available with 35nsec. recovery. Forward voltage drop is 1.2v. @ 12a., with reverse avalanche rating up to 600v. Unit is rated at 12a. They are available in stud-mounted or micro packages; all units are rated at 150°C case under operating conditions. In addition to the 12a. series (TFR-1220Z), there are 1, 3, 6, 20 and 30a. units available. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass

Circle 141 on Inquiry Card

OPERATIONS MONITOR

This 150-channel unit records multiple events in sequence against time.

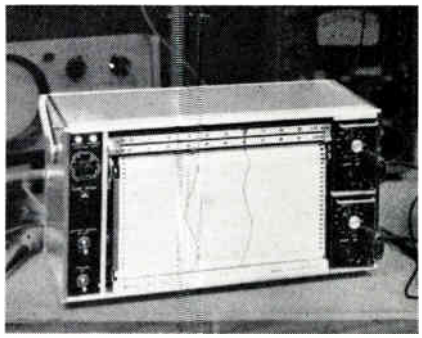


Model 14 3615 00 records on-off, go/no-go, or other 2-state operations in order of occurrence, duration, and time relationship. It can record on all 150 channels simultaneously with time accuracies of 1.25msec. Pulse resolutions as short as 2.5msec are achieveable. Twelve chart speeds ranging from 0.05mm/sec. to 200mm/sec. are available in 2 ranges. A divider switch permits instant switching from one speed range to another. Brush Instruments, div. of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.

Circle 143 on Inquiry Card

STRIP-CHART RECORDER

Has 12 selectable chart speeds and 10 continuously variable input ranges.

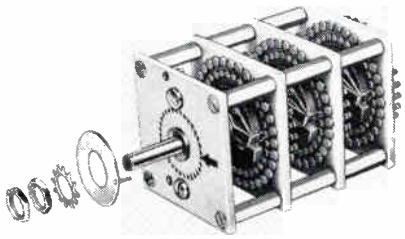


Model 7100A has all solid-state circuitry with dc common-mode rejection of 120db. Chart speed can be varied as follows: 1, 2 in./hr.; 0.1, 0.2, 0.5, 1, 2 in./min.; 0.1, 0.2, 0.5, 1, 2 in./sec. The 10 calibrated input ranges on each channel are for 5, 10, 100, 500mv, and for 1, 5, 10, 50 and 100v. The input circuits have a resistance of 1 megohm at null on all fixed calibrated ranges. Accuracy is better than 0.2% full scale with 0.1% full scale resettability. F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 145 on Inquiry Card

STOP SWITCHES

Operating voltages to 115vdc; make or break currents to 2a.



These adjustable stop switches are for all standard switch applications, circuit experimentation, laboratory work, breadboard set-ups, and for circuitry where the exact number of switch positions might be changed later. A mechanism with knee-action rotor blades assures positive uniform contact pressure. Nominal contact resistance is 0.004Ω. Current capacity to 10a. These switches meet the requirements of Mil-S-3786. Daven Div., McGraw-Edison Co., Livingston, N. J.

Circle 146 on Inquiry Card

UHF PICK-UP PROBE

Sensitive range is from 100 to 1000-MC. Flat transfer impedance of 1Ω.

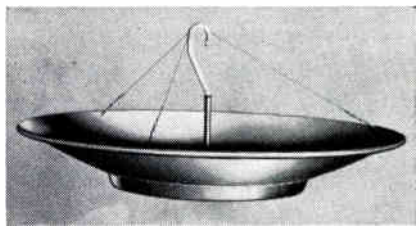
The GCP-5160 UHF pick-up/r-f current probe measures r-f currents from 10 to 1GC. A 1Ω transfer impedance provides max. sensitivity over as broad a freq. range as possible, and facilitates conversion of μa to μv, thus enabling either r-f current or voltage measurements. The probe may be used on power lines carrying up to 250 amps dc or ac. Other features include an r-f shielded case and termination in a BNC connector. Genistron, Inc., 6320 W. Arizona Circle, Los Angeles, Calif.

Circle 147 on Inquiry Card

NEW PRODUCTS

MICROWAVE ANTENNAS

For systems that operate in the 6GC range. Available in 2-14 ft.

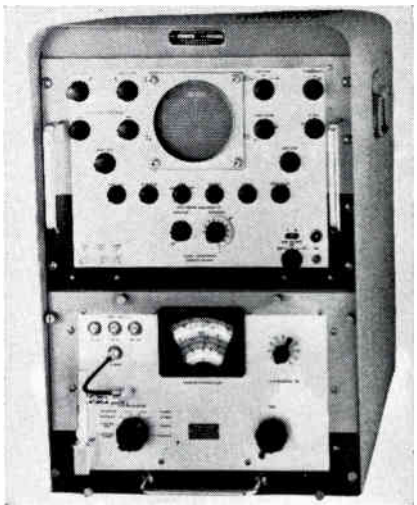


These antennas consist of a sectional horn feed mounted in a precision-spun parabolic reflector. They are used in common carrier, studio-transmitter links, operational fixed, government, and industrial services. Features include high-gain pattern characteristics, symmetrical beamwidths, and low side lobes. The feeds are tuned in 3 broad ranges (over the 5925-7425MC bandwidth) so that the VSWR remains below 1.1:1. The horn is hermetically sealed. Ainslie Corp., 531 Pond St., Braintree, Mass.

Circle 148 on Inquiry Card

SPECTRUM ANALYZER

General-purpose unit covers 10MC-44GC range. Variable resolution, 1KC - 80KC.



Model LA-18M-1 was designed for production and systems checkout of radar transmitters, command receivers and transmitters, telemetry, magnetrons, klystrons and other freq. sources, as well as for use in the laboratory for design of complex filters and antennas. It features high sensitivity and built-in X-Y recorder facilities. Either crystal or variable calibrators can be supplied as standard equipment. An intensifier control provides base line extinction for photographing display. Fast rise and decay presentations are more easily viewed in this mode of operation. Lavoie Laboratories, Inc., Matawan-Freehold Rd., Morganville, N. J.

Circle 149 on Inquiry Card

BELDEN INSTRUMENTATION CABLES KEEP YOUR SIGNALS CLEAN...

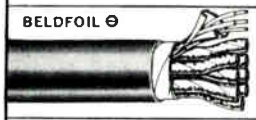
even in noisy environments

Belden electronic wire and cable provide a smooth, reliable path essential for your critical instrumentation signals. The complete Belden line includes cables designed to meet the various electrical, physical, and environmental requirements of your specific applications.

Many Belden cables feature Beldfoil† insulation with the exclusive Belden fold (U.S. Pat. 3,032,604). The benefits of this type of shield include:

1. **Increased electrical integrity**
2. **Reduction of crosstalk to unmeasurable levels**
3. **Reduced cable weight**
4. **Smaller cable diameters**
5. **Easier and faster shield terminations**
6. **Reduced costs**

The cables below are available from your Belden electronics distributor in convenient spool lengths. For other cable designs, request Catalog 863, or send us your specific problem for evaluation by a Belden specialist.

	Trade Number	Description	Nom. O.D. (inch)	Nom. *Cap. (mmf/ft)	Nom. **Cap. (mmf/ft)	DC Resistance OHMS Per 1000' Per Conductor	Features
 BELDFOIL Θ	8434	Tinned copper conductors, polyethylene insulated, black and red conductors under a Beldfoil aluminum-Mylar†† shield, stranded ground wire. Green and white conductors under overall Beldfoil shield, chrome vinyl jacket. AWG & Stranding—25 (7x33) —3 copper, 4 copperweld.	.179	25	40	45	High strength copperweld reinforced conductors 100% coverage Beldfoil shields.
 BELDFOIL Θ	8723	Tinned copper, polypropylene insulated, black and red conductors, under Beldfoil aluminum-Mylar shield. Green and white conductors under a Beldfoil shield, each pair separate, stranded tinned copper drain wire, chrome vinyl jacket. AWG & Stranding—22 (7x30)—copper.	.165	35	62	16	100% Coverage Beldfoil shields 105°C operating temperature.
	8404	Tinned copper, polyethylene insulated, cabled, rayon braid, tinned copper braid shield, chrome vinyl jacket. AWG & Stranding—20 (26x34).	.255	25	45	11	Low DC resistance. Low capacitance.
	8424	Tinned copper, cotton wrap, rubber insulated, rayon braid, tinned copper braid shield, cotton wrap, black rubber jacket. AWG & Stranding—20 (26x34).	.295	55	95	11	Flexible at –40°C. Special high insulation resistance rubber.
	8700	Solid tinned copper, polypropylene insulation, copper braid, black vinyl jacket. AWG & Stranding—28 (solid)—coaxial.	.054	48	—	66	Extremely small coaxial cable 105°C operating temperature. May be steam autoclaved for medical research.
 BELDFOIL	8640 8642	Solid copper, Beldsolt (solderable, no stripping required), Beldfoil aluminum-Mylar shield on each pair, copperweld ground drain wire, white vinyl jacket. AWG & Stranding—26 (solid)—1 pair.	.089 .140	80 80	140 140	41 41	Extremely small. Solderable without stripping. 100% coverage Beldfoil shield. 105°C operating temperature.
BELDFOIL Θ 	8767 8768 8764 8765 8766	#22 Tinned copper, vinyl insulated, cabled in pairs, each pair and its ground wire under Beldfoil aluminum-Mylar shield, overall chrome vinyl jacket. 300 Volts suggested working voltage. Stranding—solid.	.270 .394 .425 .485 .510	40 40 40 40 40	77 77 77 77 77	16 16 16 16 16	100% Coverage Beldfoil shield. Maximum operating temperature 80°C. 3 Pairs to 15 pairs.
 BELDFOIL Θ	8777 8778 8774 8775 8776 8769 8773	#22 Gauge tinned copper, polypropylene insulated, cabled in pairs, each pair and its ground wire under "Z" fold Beldfoil aluminum-Mylar shield, chrome vinyl jacket. Stranding—(7x30).	.270 .394 .425 .485 .510 .620 .760	30 30 30 30 30 30 30	55 55 55 55 55 55 55	16 16 16 16 16 16 16	Excellent high frequency characteristics and mechanical toughness. Maximum operating temperature 105°C. 3 Pairs to 27 pairs.

8-8-3

Belden
WIREMAKER FOR INDUSTRY
SINCE 1902 CHICAGO

†Belden Trademark—Reg. U.S. Pat. Off.
Θ Has Be'den Patented Fold—U.S. Pat. 3,032,604
††duPont Trademark

*Capacitance between conductors.
**Capacitance between 1 conductor and remaining conductors (if any) connected to shield.

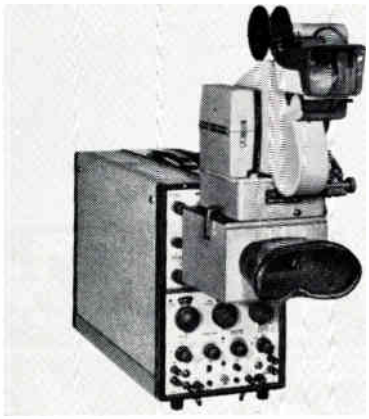
magnet wire • power supply cords • cord sets • portable cordage • control cables • electronic wire

BELDEN MANUFACTURING COMPANY • 415 South Kilpatrick Street • Chicago, Illinois 60644

NEW PRODUCTS

MAGAZINE

Records data, processes film, and views results in 85 sec.

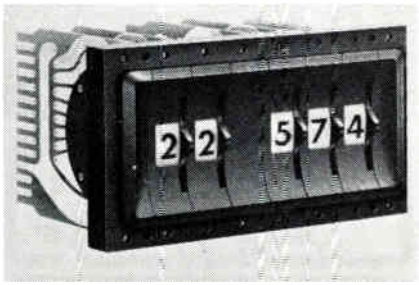


Model 3800P is a pulse-advanced Rapromatic® magazine for film-processing oscilloscope camera systems. Its integrated design enables the user to convert the pulse-type unit to a continuous film system by means of gear train conversion kit—Model 3804. The unit completely develops and affixes the film. It operates at a max. speed of 12 frames/min. Processed film can be removed at any time. Analab Instrument Corp., subs. of The Jerrold Corp., 30 Canfield Rd., Cedar Grove, N. J.

Circle 199 an Inquiry Card

CODED SWITCHES

Designed for operation in destructive and/or explosive environments.



The sealed and lighted Series 400, 500, and 600 coded switches comply with the explosion requirements of Mil-Std-202B, Method 109. The seal prevents ignition of explosive gases or volatile liquids that could be caused by contact arcing. If the long-life lamp burns out, it is replaced by lifting a flip toggle tab. This eliminates the need for complete replacement of the switch module. Switch modules are available with 8, 10, and 12-position thumb-wheels, and in assemblies with as many units or stations as desired. Engineered Electronics Co., Box 58, Santa Ana, Calif.

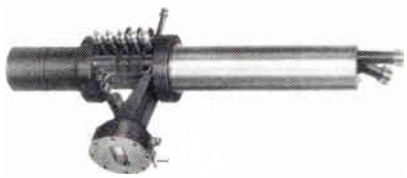
Circle 200 an Inquiry Card

Circle 48 an Inquiry Card

NEW PRODUCTS

AMPLIFIER KLYSTRON

Produces 10KW CW at C-band. Operates at 4.4 to 5.0GC. Min. gain, 53db.

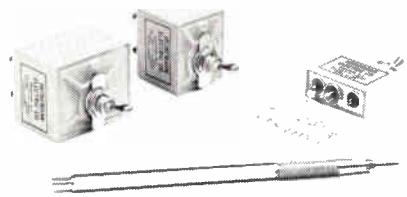


Eimac's 5K50CB is a 5-cavity amplifier. The new tube is ideal for troposcatter communications uses. Improved body cooling results in unusual stability characteristics. The cooling system is designed to accept ethylene glycol and water to provide additional system flexibility. Its electron gun has confined glow configuration to minimize focusing adjustment and contribute to beam stability. Light cathode loading is used to lengthen tube life. Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, Calif.

Circle 150 on Inquiry Card

CIRCUIT BREAKER

The switch is entirely within the breaker's hermetically-sealed case.



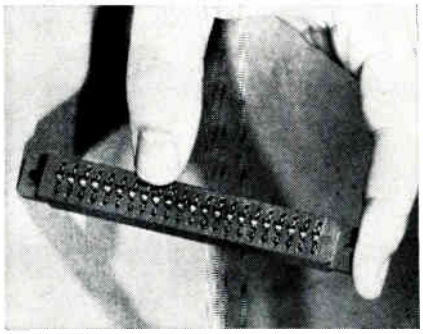
Series SM subminiature circuit breakers are military-type devices. They have no case extensions or separately mounted terminals. The breakers can be stacked top and bottom or side-by-side. On multipole models, switches can be supplied on any or all poles. They are available with either a fast or slow inverse time delay. Non-time-delay models are also available where instantaneous response is required on overloads of any magnitude. Current rating from 0.050 to 20a. Standard max. voltage ratings 240vac, 60 or 400 cycles, or 50vdc. The Heinemann Electric Co., Trenton, N. J.

Circle 151 on Inquiry Card

NEW PRODUCTS

COMPUTER EDGE CONNECTOR

Optional high density or common contact terminations can be provided.

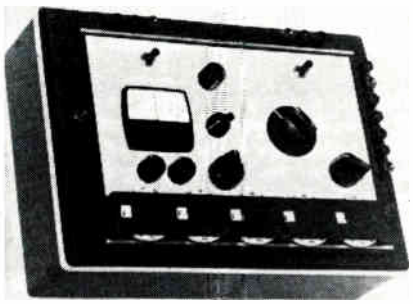


The RD series provides density termination capability of up to 62 contacts for dual-sided boards. Or, it provides a method of common termination for each pair of connector contacts. The connectors are available with contact spacing from 0.100 to 0.156 in. Individual removal and replacement of damaged contacts is simplified. A tool inserted from the front of the connector releases the contact locking fingers and ejects the contact. Methode Electronics, Inc., Reli-Acon Dept., 7447 W. Wilson Ave., Chicago, Ill.

Circle 152 on Inquiry Card

MEASUREMENT FACILITY

Combines a 5-dial dc measurement facility into 1 portable package.



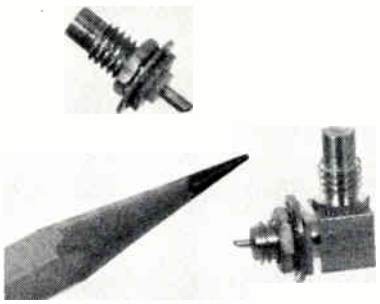
The Model 300 Portametric PVB combines the functions of a potentiometric voltmeter, a pico-ammeter, a wide-range guarded Wheatstone bridge, a 4-terminal Kelvin bridge, a resistance comparison bridge, a ratiometer and a high-sensitivity electronic null detector. It provides better than 5μv dc sensitivity with an input impedance of approx. 1 megohm. Five voltage ranges are provided with full-scale values of 0.5v. with a 1μv min. step to 500v. with a 10mv min. step. Accuracy is ±0.02% of reading. Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, Ore.

Circle 153 on Inquiry Card

NEW PRODUCTS

R-F CONNECTORS

Voltage rating is 500v., and the voltage drop is 4mv at 1 amp dc.



These subminiature right-angle chassis mounting r-f connectors require a mounting hole only half the size needed for other connectors of this type. The unit requires a 0.190 in. dia. hole for mounting, as compared with the 0.312 in. dia. opening normally used for installing this type connector. Matched for use with 50Ω semi-rigid or flexible coaxial cable. Gold plated to exceed requirements of a 150 hr. salt spray test, the units are Teflon insulated to withstand −100°F to 300°F temps. Applied Engineering Products Co., P. O. Box 1194, Stamford, Conn.

Circle 154 on Inquiry Card

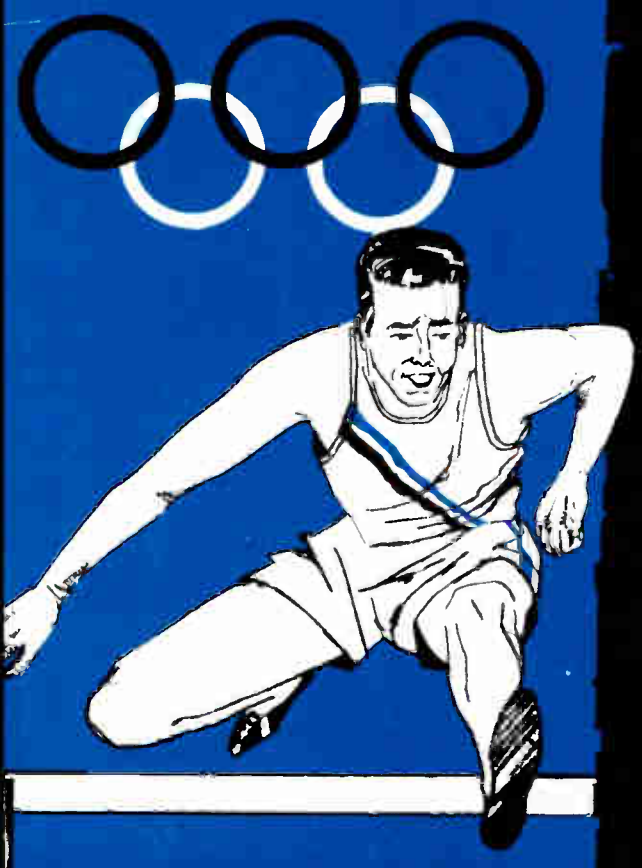
SWEEP MARKER GENERATOR

Five ranges: 3.5-9MC; 7.5-19MC; 16-40MC; 32-85MC and 75-216MC.

Model 369 is a sweep and post injection marker generator. With this unit, circuitry response is not affected by markers and vice versa. Model 369 feeds only the required sweep signal to the circuit input being aligned or tested. At the output, a demodulator cable picks off the signal and feeds it to a mixer stage inside the generator where the markers are added. This combined signal is fed to an oscilloscope. This means the circuitry under test is not affected by the marker signal and traps in the circuitry will not reduce or eliminate the marker. Eico Electronic Instrument Co., 33-00 Northern Blvd., L. I. City 1, N. Y.

Circle 155 on Inquiry Card

WIN A TRIP FOR TWO TO THE 1964 OLYMPICS IN TOKYO



OR ANY OF 49 OTHER PRIZES WORTH $2,000

WIN ANY OF THESE 50 BIG PRIZES

1st Prize:

An expense-paid two-week vacation for two at the 1964 Olympics in Tokyo, Japan including . . . a round trip by *Jet!* . . . luxurious twin bedroom at the Tokyo Hilton! . . . Olympic tickets for each day, including opening and closing ceremonies! . . . $450 for meals and expenses!

2nd Prize:

$500 United States Savings Bond.

3rd Prize:

A $300 gift certificate at the department store of your choice!

4th thru 10th Prizes:

A $100 United States Savings Bond for each winner!

Plus for the top 50 entries . . . a copy of the widely-acclaimed Motorola Integrated Circuit Design Course textbook.

. . . in the

MOTOROLA PNP/NPN SILICON ANNULAR TRANSISTOR COMPLEMENTARY CIRCUIT DESIGN CONTEST!

Here's a chance to enter your own transistor circuit design and win a luxurious expense-paid trip for two to the 1964 Olympics in Tokyo, Japan from October 10 through 24. Entries must be based upon a circuit design using any of Motorola's PNP and NPN silicon annular transistors.

Circuit design entries may be in any area of application — digital (gate, half adder, flip-flop, etc.), amplifier, power supply, instrumentation, timing circuits, etc. Designs which best take advantage of the low leakage, linearity, and broad gain range characteristics of Motorola's high-performance annular-built transistors are especially desired.

To obtain official entry blank, merely fill out the coupon below and mail it to Motorola, or write for an entry form to: Motorola Semiconductor Products Inc., Circuit Design Contest, Box 955, Phoenix, Arizona 85001.

HERE ARE THE RULES FOR THE MOTOROLA PNP/NPN TRANSISTOR COMPLEMENTARY CIRCUIT DESIGN CONTEST

CONTEST RULES: One expense paid trip for two to the 1964 Olympic Games (or $2,500 cash), one $500 U.S. Savings Bond, a $300 gift certificate, seven $100 U.S. Savings Bonds and 50 copies of the Motorola Integrated Circuit Design Course textbook will be awarded to winners under the contest rules.

1. This competition, where not prohibited by local or state law, is open to anyone who resides within the United States of America except employees, representatives, or agents of Motorola Inc., and its related companies and members of their families.

2. Entries must be based upon a circuit design using standard Motorola PNP and NPN silicon annular transistors. Circuits using both PNP and NPN devices in combination (not exceeding 10 transistors) will be considered of higher merit.

3. Each entry submitted must include:
A. Schematic drawing of circuit
B. Brief description of purpose and function of circuit
C. The unique features of the circuit
D. A signed entry blank

4. Merit of design will be weighed with respect to circuit efficiency, performance, size and weight reduction, and the reduction of component count made possible by the design. Consideration will also be given to how the circuit utilizes the low leakage, linearity, and broad gain range characteristics of Motorola annular transistors.

5. Judging will also take into account problems solved with respect to temperature or power supply variations, and elimination of excessively tight component tolerance requirements. Above all, simplicity and economy of design is preferred.

6. Circuit design entries may be in all areas of application — digital, amplifier, power supply, instrumentation, timing circuits, etc.

7. Joint entries are acceptable under the contest rules, however, prize awards will be shared jointly by such entries. There will be no limitation on the number of entries any contestant may submit.

8. Awards will also be judged on the following points:
A. Directness of the circuit design.
Example: The utilization of a minimum number or best combination of components to perform a circuit function.
B. The originality of the circuit design — the newness of the circuit approach.
C. Technical feasibility — the ease with which the entry can be reduced to practice.

9. Screening will be performed by Motorola's Applications Engineering Department. Final judging will be performed by leading electronic authorities outside Motorola. The decision of the judges will be final.

10. Winners will be notified by mail prior to September 1, 1964. A list of winners may be obtained by sending a stamped, self-addressed envelope to Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

11. All entries must be postmarked no later than July 15, 1964, and in Motorola's hands by July 19. Entries should be mailed to Motorola Semiconductor Products Inc., Silicon Circuit Contest, Box 955, Phoenix, Arizona 85001.

The receipt of a circuit from a contestant does not create or imply a confidential relation between the contestant and Motorola Inc. or any of the judges of the contest. The contestant shall retain all patent rights in circuit he submits in this contest, but waives all other rights such as those relating to publication of the circuits. Company clearances required for the submission of proprietary circuits submitted by any contestant shall be the responsibility of the contestant.

Yours may be the winning circuit design — Fill out and mail this coupon today for official entry blank!

MOTOROLA
Semiconductor Products Inc.

BOX 955 • PHOENIX, ARIZONA 85001

61E14

Motorola PNP/NPN Silicon Annular Transistor Complementary Circuit Design Contest Entry

Send me an official Motorola Circuit Design Contest Entry Blank

NAME_____ TITLE_____

COMPANY_____

DIVISION_____

ADDRESS_____

CITY_____ STATE_____ ZIP_____

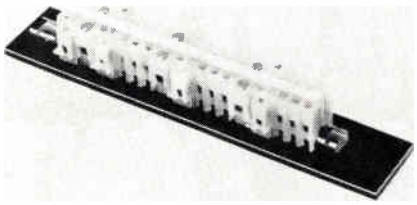
61E14

(I understand that receipt of the entry blank in no way commits me to participate in the circuit design competition.)

NEW PRODUCTS

TERMINAL BLOCKS

Mounts up to 38 connector terminals/ft. Metal parts are shielded.



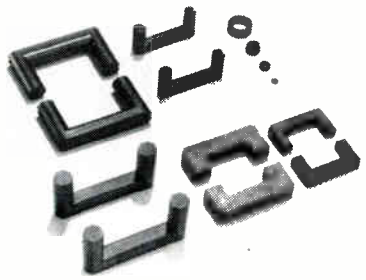
With these terminal blocks, 1-circuit and 2-circuit blocks take 5/8 in., and 3-circuit blocks take 1¼ in. Height is 1-5/16 in. and width ranges from 1⅛ to 1-11/16 in. for the 2-circuit block. Wire up to #4 is admitted by single-circuit blocks. The other 2 blocks take sizes up to #8 and admit 3 #12 stranded conductors readily. The fastening qualities of the mounting channel permit blocks to be snapped in and out any time without interfering with adjoining blocks. Westinghouse Electric Corp., Standard Control Div., Beaver, Pa.

Circle 156 on Inquiry Card

NEW PRODUCTS

FERRITE MATERIAL

High initial permeability and low losses increase flexibility.

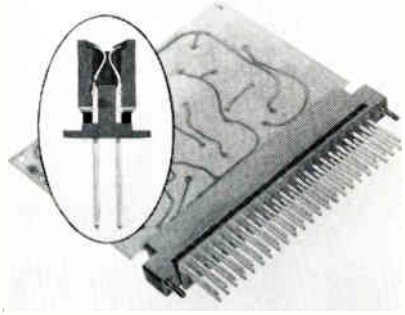


Ferramic® 0-5 material has electrical characteristics which make it effective for high-power, low-loss applications, such as adjustable and fixed inductors and transformers. Initial permeability is about 2400 minimum, with a saturation value of 4700 gauss and a loss factor of approx. 1.0×10^{-5} @ 100kc. These values allow an increase in operating voltage of inductors and transformers without changing core configuration. Input voltage may be decreased while maintaining previous coil inductance. Indiana General Corp., Electronics Div./Ferrites, Keasbey, N. J.

Circle 157 on Inquiry Card

PC RECEPTACLES

Units have 1-piece forged spring contacts. Eliminates welded joints.



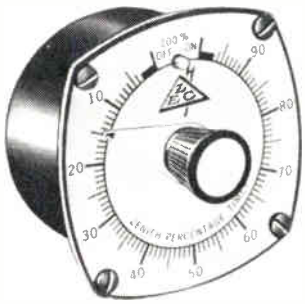
This 1-piece taper leaf spring contact has a 0.045 in. sq. wire-wrap terminal. It is made of phosphor bronze. The spring-tempered phosphor bronze has max. retention characteristics and provides consistent performance under severe operating conditions. The sq. terminal post affords the optimum configuration for highly reliable electrical connections in high-speed wire-wrap production operations. The uni-constructed contacts are available in a selection of standard PC connectors. Precision Connectors Div., Electronic Fittings Corp., 29 Sugar Hollow Rd., Danbury, Conn.

Circle 158 on Inquiry Card

NEW PRODUCTS

PERCENTAGE TIMER

For continuous cycling control of heaters, pumps, ovens, etc.



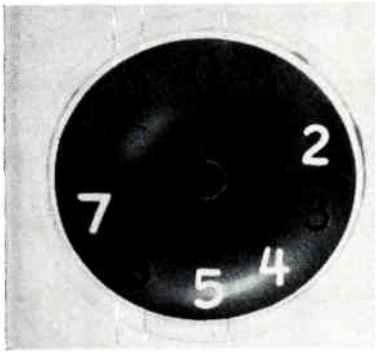
This timer design eliminates engaging cams and latches to assure greater accuracy and reliability without snags, binds or slowdowns. It is dial adjusted for ON time by percentage of total time cycle (from 3% to 97%), and can be used whenever ON or OFF control is desired as a percentage of the primary fixed total cycle time. Available in 12 times cycles ranging from 15 sec. to 24 hrs. Zenith Electric Co., 148 W. Walton St., Chicago, Ill.

Circle 159 on Inquiry Card

NEW PRODUCTS

POSITION INDICATOR

Displays up to 10 independent bits of data simultaneously.

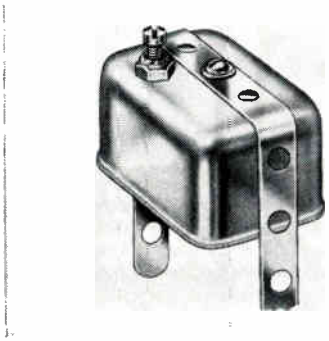


The B-9012 Pixie indicator is a gas-filled, cold-cathode, indicator tube. It contains 10 glow positions or cathodes which are located 36° apart and are visible through numerical perforations. The plate serves as a common anode and functions as an internal bezel with the indicated number determined by the position of the flow discharge. A 12th electrode functions as a keep alive to obtain rapid ionization for applications requiring this feature. Readable up to 10 ft. in high amb. light. Burroughs Corp., Electronic Components Div., Plainfield, N. J.

Circle 201 on Inquiry Card

STARTING SWITCH

For single-phase, split phase or capacitor motors of 1/6 to 1/3 hp.



Switch RM 01620 is for 1/6 to 1/5 hp and RM 02533 is for ¼ to 1/3 hp. These units are quickly and easily installed—internally, externally or remotely. The starting switch is designed to replace the conventional centrifugal-type switch. The switch starts motors within any standard RPM rating, even under the heaviest starting loads. An adjusting screw allows the switch to be used on all motors within the prescribed hp ratings under all voltage conditions. Sorensen Lighted Controls, Inc., 530 Oakwood Ave., W. Hartford, Conn.

Circle 202 on Inquiry Card

NEW PRODUCTS

SENSITIVITY RECORDER

Calibrated accuracy of ±0.5% full scale on 500μv, 1 and 10mv.

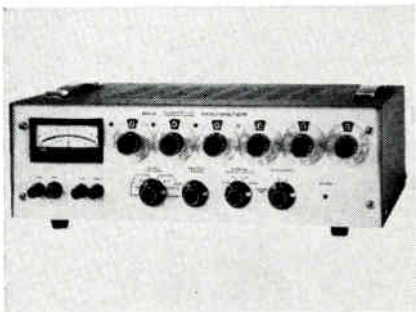
The V.O.M. 7 strip-chart recorder combines 500μv full-scale sensitivity and accuracy in a compact unit. The sensitivity range makes it ideal for gas chromatography work and many other uses where low-level electrical signals are produced. The recorder directly measures and records dc voltage, current, and resistance without external converters. The unit has a 5-speed chart transport, built-in event marker, and 17 different input ranges. Bausch & Lomb, Rochester, N. Y.

Circle 198 on Inquiry Card

NEW PRODUCTS

DIFFERENTIAL VOLTMETER

Measures dc within 0.01% with 0.005% stability from 100mv to 500v.

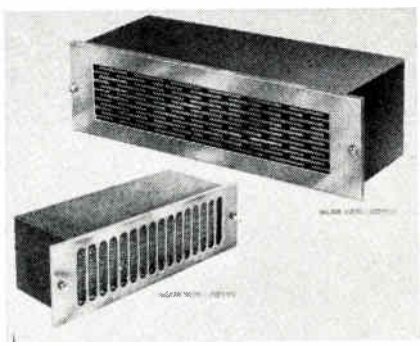


Model 662, a self-contained guarded potentiometer, operates from a 117 or 234v., 50-60 cps power source. It has infinite input impedance at null over its entire range, and offers max. null sensitivity of 100μv full scale with 3μv resolution. Six-dial readout gives at least 5-dial resolution for every voltage setting. It offers ±0.0025% repeatability; a reference voltage supply stability of ±0.0025% indefinitely; a temp. stabilized zener-diode reference; and a 25mvdc output. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

Circle 160 on Inquiry Card

CENTRIFUGAL BLOWERS

Produce 290CFM of filtered air to pressurize electronic rack.

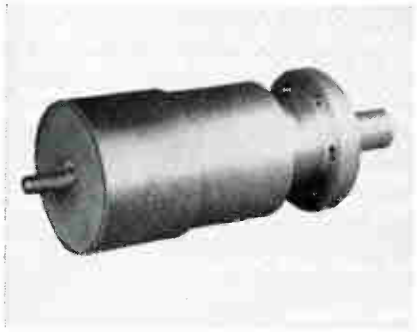


These blowers provide a compact high-velocity packaged blower in a minimum of panel space. The air is exhausted in a vertical position to cool rows of solid-state component cards. Models 2EB350D or 2EB351D bring the air out directly under the cards. For general chimney effect cooling, Models 2EB350A or 2EB351A are recommended. These blowers are powered with a permanent split-capacitor, 115v. 50/60 cps single-phase motor with permanently-lubricated and double-shielded ball bearings/Mil-FF-B-171. McLean Engineering Laboratories, P. O. Box 228, Princeton, N. J.

Circle 161 on Inquiry Card

SERVO REDUCER

For positioning servos, automation actuators, and machine-tool drives.

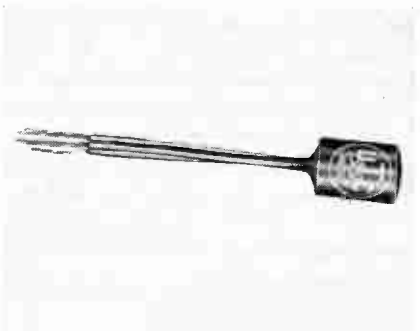


Model HDUS-18 is a size 18 mechanical drive weighing 15 oz. It is capable of high-positioning accuracy and resolution at the 2000 in.-oz. operating torque level. It is designed for a simple modular attachment of electric motor or other prime mover. Stall torques of 4000 in.-oz., and momentary impact torques of 12,000 in.-oz. can be withstood. Standard gear reduction ratio is 104:1, and input and output may be interchanged for speed or inertia multiplication applications. Unit meets Mil environmental specs. United Shoe Machinery Corp., Beverly, Mass.

Circle 166 on Inquiry Card

POWER TRANSFORMERS

Primaries: 28v. 380-1KC; secondaries: 6.3 to 28v., 20ma - 60ma.



The DO-T400 series of 400 cycle power transformers are metal encased, hermetically sealed, and guaranteed to Mil-T-27B, Mil Type TF4RX03YY. They provide max. reliability with small size and weight. Designed for transistor or filament use, they are ideally suited to ground or airborne applications. They are both solderable and weldable. Isolation transformers are electrostatically shielded. Size: 5/16 in. dia. x 13/32 in. height; weight: 1/10 oz. United Transformer Corp., 150 Varick St., New York 13, N. Y.

Circle 167 on Inquiry Card

EDGE CONNECTORS

For use with double-sided 0.062 in. printed - circuit boards.

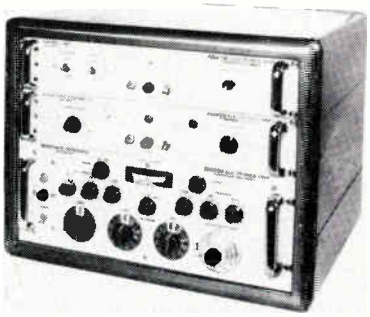
The Twin-Con edge connectors have crimp-on, snap-in pins. Units meet the requirements of military and aerospace uses. They combine the reliability of permanently assembled bifurcated contacts with the convenience and versatility of a crimp-on, snap-in connector. The lead wire side is designed for crimp-on, snap-in removable wire pins inserted into twin-barrel contact receptacles. This permits 2 wires/contact and 4 wires/connector position. It meets Mil-C-21097, latest revision. Cinch Mfg. Co., 1026 S. Homan Ave., Chicago, Ill.

Circle 168 on Inquiry Card

NEW PRODUCTS

RESISTANCE LIMIT BRIDGE

Performs 36,000 GO/NO-GO tests/hr. Tolerance adjustable from 0 to ±30%.



Model 100 is a fully automatic precision resistance limit bridge. It provides test conditions in conformance with Mil-Specs. requirements for carbon composition, film and wire-wound resistors. It tests over a resistance range from 1Ω to 100megohms with resolutions as low as 0.1Ω. Excitation voltage is continuously variable from 0 to 100vdc. Boonton Electronics Corp., Parsippany, N. J.

Circle 169 on Inquiry Card

DIGITAL VOLTMETER

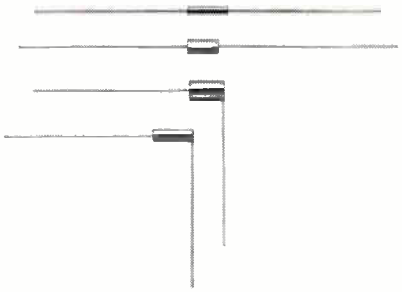
Provides both freq. and dc voltage measurements in one instrument.

The 4 models of Series 990 of digital voltmeters make full use of electronic techniques and dispense with electromechanical switching. Measurement ranges extend from 0 to 750vdc and from 2 cps to 1mc for freq. measurements. Provisions are also included for directly driving a digital printer. Electro Instruments, Inc., 8611 Balboa Ave., San Diego 12, Calif.

Circle 170 on Inquiry Card

RESISTORS

Temp. coefficient precision wire-wound units. Tolerance: 0.005 to 1%.



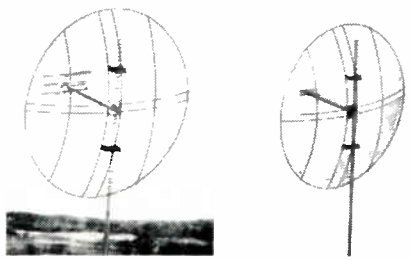
These resistors provide any required temp. coefficient from −10 ppm to +6000 ppm/°C. Typical uses include: zener-diode compensators; temp. network feedback loops; temp. monitoring and related systems; thermal relays and stabilization of LC oscillators. They may also be used for compensation of negative T.C. capacitors in RC networks. Kelvin Sales Co., 5919 Noble Ave., Van Nuys Calif.

Circle 171 on Inquiry Card

NEW PRODUCTS

REFLECTOR ANTENNAS

Four-ft. parabolic antennas for 470-890MC. Feature 17db gain.



Series D-1338T-72 uses a type F 75Ω coaxial output. Operating freq. from 470 to 890MC. Type D-1338T-300 uses 300Ω air dielectric terminals. It operates at translator freqs. from 800-890MC. These antennas are high-gain, highly-directional units designed for fringe and super-fringe reception of UHF stations. Min. gain is 17db over a tuned reference dipole; front-to-back ratio is 20db min. The 75Ω version uses a slot-fed dipole and reflector; the 300Ω type uses a folded dipole feed with a multiple bar reflector. Taco, Sherburne, N. Y.

Circle 162 on Inquiry Card

VARIABLE RESISTOR

Available in bushing or printed-circuit mounted construction.

This ⅜ in. dia. transistor size variable resistor can be furnished in bushing mounting (Type 660) at no sacrifice in size, and in PC mounted construction (Type 660 PC). It uses a cermet element. Features include near infinite resolution; exceptional stability and reliability under extreme temps. and severe environmental conditions; high overload capacity; fully sealed construction; resistance range from 100Ω to 500KΩ and power rating of ¼w. @ 125°C, derated to no load @ 175°C. Series 660 meets or exceeds Mil-R-94B. CTS of Berne, Inc., Berne, Ind.

Circle 163 on Inquiry Card

NEW PRODUCTS

WIDE CHART RECORDER

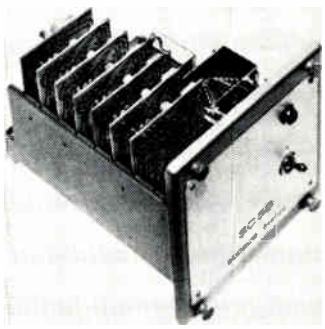
Has 100mm chart width, 4 push-button-selected chart speeds.

Model 7701A single-channel, direct-writing recorder provides increased trace resolution. Plug-in signal conditioning capabilities for dc low-level carrier, ac transducer and other signal inputs are given. Four recording speeds from 0.5-mm/sec. to 50mm/sec. are available. Full-scale freq. response is dc to 300 cps within 3db; linearity better than ±½% of full scale. Sensitivity (with high-gain preamp) is 1μv/chart division. Sanborn Co., 175 Wyman St., Waltham 54, Mass.

Circle 164 on Inquiry Card

IMPULSE SUMMATOR

Receives and stores input pulses and summarizes them.



The SC58 summator receives and stores input signals originating from several different sources. It then scans the storage device and summarizes the impulses on a single counter. A scanning oscillator periodically explores these memories and discharges them. Input signals may be generated by photo-cell systems, electrical impulses or electro-mechanical contacts. Output is to high-speed electronic counter or, with amplification, to an electromagnetic counter. It may be specified for any number of plug-in circuits from 2 to 8. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.

Circle 165 on Inquiry Card

EDITOR'S NOTEBOOK

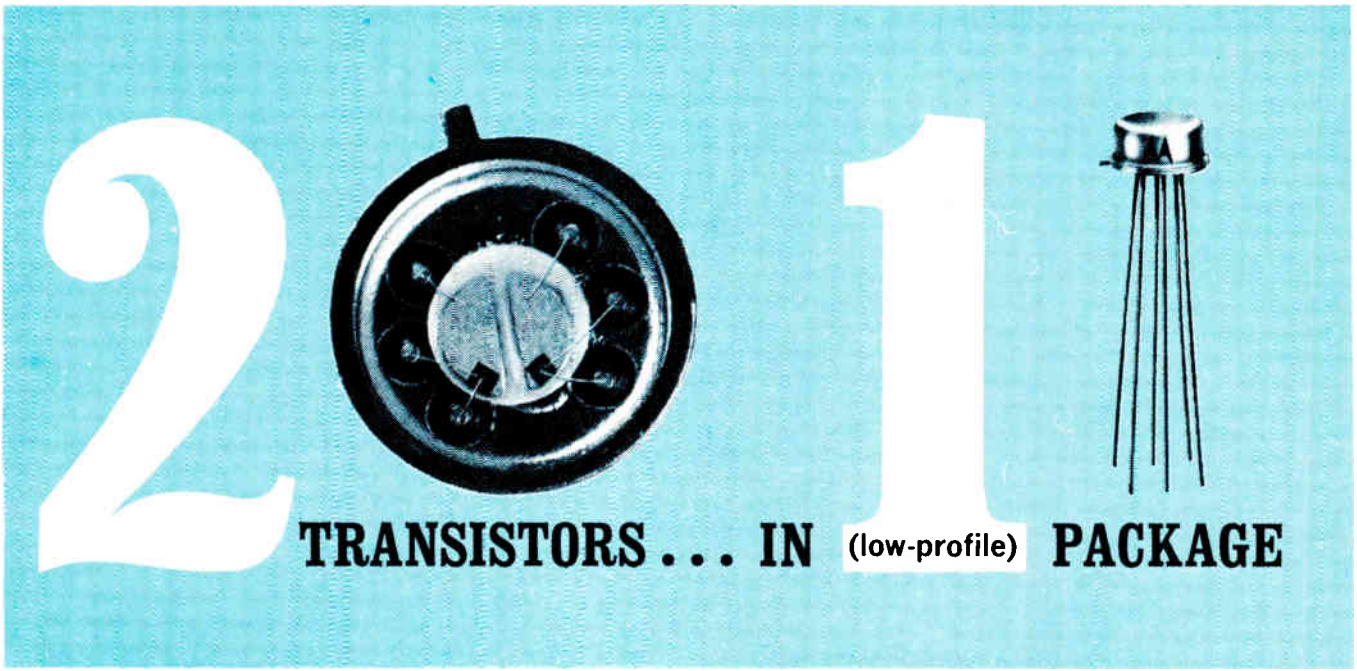
LENS DESIGN TIME has been cut from months to days, and soon hours, thanks to computers. Optical designs are being produced through EDP with quality that exceeds those computed by head and pencil. Donald P. Feder, optical designer with Eastman Kodak Company, said that there are now computer programs with thousands of machine commands that can handle 75% of design process without any bother from the lens designer.

RADAR has determined the mean distance to the sun to better than one part in a million. This is 2,000 times more accurate than optical measure. Future radar systems may have accuracies 100 times greater than this.

A RUGGEDIZED, SOLID-STATE oscilloscope survived a shattering plane crash. The scope, a Tektronix 647, had been in a compact car stowed aboard for a flight to England. The plane crashed at takeoff from Guernsey, Channel Islands. The car trunk, with the scope, was ripped off and the roof crushed in, as the plane smashed through a runway fence. It skidded through two fields. The instrument was intact. Tektronix Engineer John Thompson, aboard but unhurt, said all circuits worked perfectly.

AN UP-ENDED LASER may have many potential uses. University of Michigan engineers say the laser is more stable. Up-ending reduces strain and eliminates the slight curve along its length from gravity. Its continuous beam can detect movement by as little as a single wave-length of the light, about one-thousandths of a millimeter. It is being considered for use in underground nuclear tests.

FOR SALES ENGINEERS working 15 cities, using shortest routes and taking least amount of time, then returning to starting city, there are about 1,307,674,368,000 possible routes. IBM mathematicians, seeking solutions to classic problems, have come up with a computer program for complex scheduling jobs. Called "Traveling Salesman Program," it can give cost-saving data on routing cable, piping or electrical wiring. It can schedule printing of a regional edition of a national publication. By the way—for 20 cities, there are 2,432,902,008,176,640,000 possible routes.



for CONSERVATION OF SPACE

. . . Motorola's Multiple Device Line

Using high-voltage PNP silicon transistors made by the revolutionary new annular* process, Motorola now offers virtually *any* combination of high-speed, high-voltage PNP as well as NPN transistors – in either the low-current, small geometry or the popular higher-current STAR† transistor configuration . . . in the new low-profile TO-5 package!

Silicon PNP or NPN Dual Transistors

Dual Transistors for high-speed and ultra-high-speed switching circuits, and DC to UHF amplifier applications.

PNP: Types MD982 (similar to 2N2904), MD984 (small geometry), MD990 (similar to 2N1132)

NPN: Types MD981 (similar to 2N2218), MD1126 (similar to 2N708), MD1127 (similar to 2N914), MD1128 (similar to 2N834)

Silicon PNP or NPN Darlington Amplifiers

Motorola's capability in the area of Darlington amplifiers is virtually unlimited. Due to the variety of applications, these devices are supplied as "specials" to customer requirements. Also available in the TO-18 package.

Silicon PNP or NPN Differential Amplifiers

Dual transistors matched for differential amplifier and other applications.

- Beta specified at up to four current levels
- Current gain matched as close as 10% at up to two current levels
- $\triangle (V_{BE1} - V_{BE2}) = 10\ \mu V/°C$
- $|V_{BE1} - V_{BE2}|$ as low as 5 mVdc

PNP: types MD1123, MD1124, MD1125

NPN: types MD1120, MD1121, MD1122

Silicon PNP / NPN Complementary Pairs

Dual transistors for high-speed switching circuits and DC to UHF amplifier applications. Available with PNP and NPN STAR transistors (MD985), or PNP and NPN low-current, small-geometry transistors (MD986). Beta specified at up to four current levels with extreme care given to assure reasonable matching.

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

†Trademark of Motorola Inc.

Standard types of multiple devices immediately available from your local Motorola semiconductor distributor. Dual transistors in almost unlimited variety available from your nearest Motorola representative. For additional information, write to: Department TIC-144E14, Box 955, Phoenix, Arizona 85001

MOTOROLA Semiconductor Products Inc.

A SUBSIDIARY OF MOTOROLA INC.

144E14

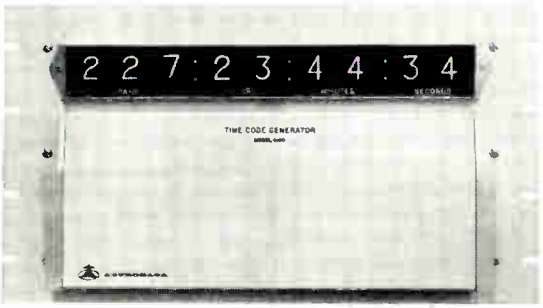
ASTRODATA

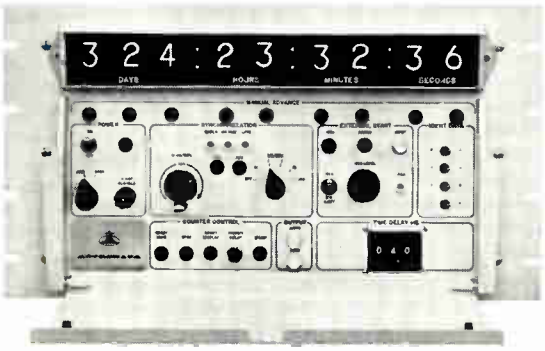
ADVANCED TIME CODE GENERATORS FOR YOUR TIMING SYSTEMS APPLICATIONS

Astrodata's advanced time code generators give you state-of-the-art design for a wide range of timing requirements.

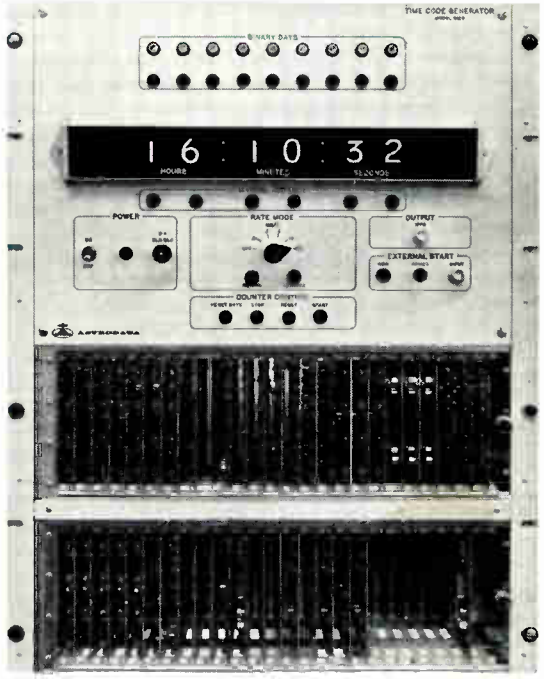
You can select the basic generator most suited to your system. When desired, standard circuit cards can be installed for special requirements or for updating your present system.

All presently used codes can be furnished, or special codes can be devised to provide the timing most compatible with your instrumentation data.

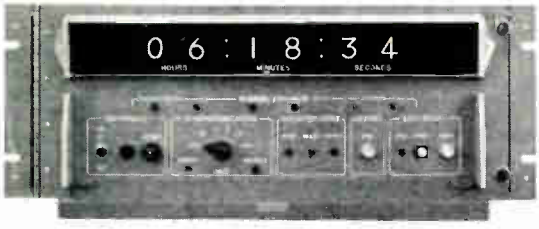




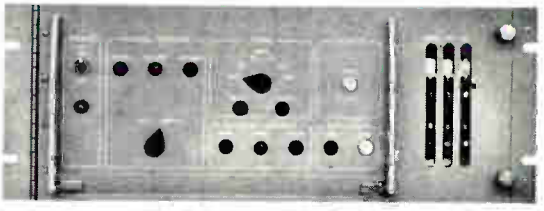
Model 6190 provides up to 10 dc shift and carrier modulated codes simultaneously... drift rate less than 5 parts in 10^9 per day... more than 30 options available... code matrix cards easily replaced to meet changing requirements.



Model 6120 provides up to 8 serial time codes simultaneously ... standard pulse rates... decimal display... stability to 5 parts in 10^9 per day... front access to circuit cards.



Model 6140 provides up to 3 specified code formats simultaneously... drift rate less than 1 part in 10^8 per day... standard pulse rates... decimal display.



Model 6100 provides up to 3 specified code formats simultaneously... drift rate less than 1 part in 10^8 per day... standard pulse rates... binary-coded display.

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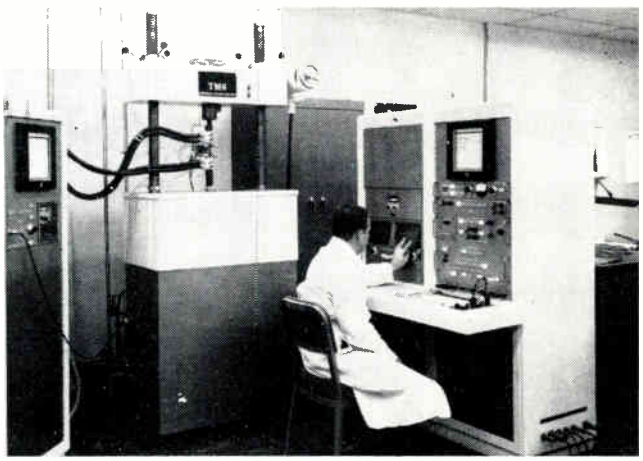
20

WHY COMPONENTS FAIL

This servo-controlled testing machine determines when and why a product fails. The machine, Model TM6, helps study practically any material. It tests for strain, fatigue, hysteresis, etc. The unit is a product of MB Electronics.



The National Reference Group of standard cells maintained by the NBS serves as the physical standard for the volt in the U. S. The emf of cells within the group have varied less than 7 ppm in 50 years. These cells provide the basis on which the Bureau determines emfs of other cells to be used as standards.

Mil. Standard 826 entitled, "Electromagnetic Interference Test Requirements and Test Methods" establishes test methods for testing equipment, systems and sub-systems to determine their electromagnetic interference and susceptibility characteristics. It gives instrumentation and test circuits to be used.

A device using h-f sound waves has been developed by Aeroprojects, Inc. to determine the position of a steam-water layer in a boiling water reactor. The device, except for a probe, is located outside the reactor. At the end of the probe a sensitive vibrating plate interacts with the steam-water layer and transmits data on layer density to an external receiver.

X-ray examinations of small electronic components are made by direct TV display at Bendix, Kansas City Div. Using the system's very-high resolution TV camera, the x-ray image of an object ⅜ x ½ in. is viewed with 30x magnification on a 21 in. TV screen.

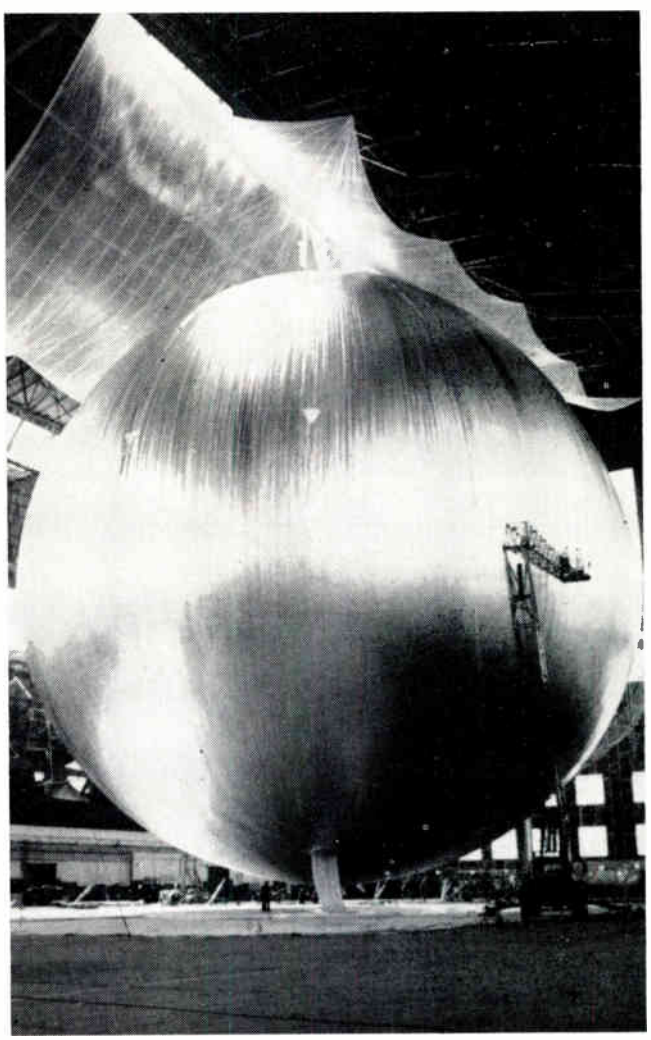
NASA and the DOD have agreed that the instrumentation ships needed to support the programs of both agencies will be in a pool and operated by the DOD. There are now 17 instrumentation ships. By the end of 1967 the pool will total 20 ships—12 equipped for telemetry and 8 for telemetry data acquisition.

A device that measures rpm without connection to rotating parts has been developed by Waters Mfg., Inc., Wayland, Mass. The tachometer, Model 338, is portable and comes complete with a photoelectric source and pickup.

An automatic Gimbal actuation checkout console for the Apollo service module rocket engine has been developed by Interstate Electronics Corp. The system gathers data from hundreds of operational conditions. Since the data is gathered faster than printout devices can handle, the equipment has data-storage elements. These elements receive data and read it out slowly after tests are completed.

SKIN TEST

A proximity measurement device, developed by Westinghouse's Aerospace Div., detects surface movement of Echo/A-12 during static inflation tests. Sensor is actuated by the presence of metallic surface near the end of a retractable probe. The device detects the laminated skin without touching it.



Tunnel diodes can be damaged during soldering or from accidental surges in the design lab. These possibilities make it necessary to have a simple, accurate method of testing the diodes. Complete details for a test adapter that can be used with a standard scope are given.

SCOPE ADAPTER FOR TUNNEL DIODE MEASUREMENTS

IN MANY TUNNEL DIODE APPLICATIONS, circuit designers should have some simple instrument for accurate and quick measurement of tunnel diode parameters. Such an instrument is invaluable for rechecking tunnel diodes which have been subjected to voltage surges or excessive soldering heat. Also, because some commercial tunnel diodes have tolerances as high as ±10% on peak current and ±20% on peak voltage, measurement is sometimes necessary for determination of actual static parameters. This article describes a simple and inexpensive adapter which converts most oscilloscopes into curve tracers.

* * *

The most elementary method of measuring tunnel diode static parameters (I_p, V_p, I_v, V_v, V_F, and V_R) is to use a dc voltmeter and ammeter, and plot a point-by-point graph of the tunnel diode characteristic. This is difficult and time consuming. Also, dc measurement of peak current requires careful circuit design to prevent the diode from switching because of random transients when the diode is dc biased at the peak point.

A much simpler and quicker method for the measurement of tunnel diode parameters is to use a commercial curve tracer to display the characteristic curve. By this method, all static parameters, as well as many intermediate points, can be read at a glance. If a commercial curve tracer is not available, a standard lab scope (Tektronix 535, 545; HP 130B; etc.) can easily be converted into a curve tracer with the adapter shown in Fig. 1. The only requirements for the oscilloscope are that it have external horizontal and vertical inputs, and a horizontal sensitivity of at least 1v. full scale. The vertical sensitivity is not critical because the current-sampling resistor in the adapter can be selected for adequate vertical deflection. The adapter is designed to operate from 117vac.

The adapter operates as follows: As the variable transformer is moved from zero to full voltage, the output of the filament transformer rises from 0 to 4.5v. peak on each side of the center tap ($6.3 \div 2 \times 1.414 = 4.5$). This output is then applied to a full-wave rectifier. The rectified sine wave is applied to the tunnel diode and a current sampling resistor. By monitoring the voltage across the tunnel diode and the current through the diode, a voltage-current characteristic can be shown on the oscilloscope, similar to that in Fig. 2.

As shown in Fig. 2, the portion of the tunnel diode characteristic between the peak and valley points is not displayed. But, all static parameters can still be measured despite the lack of a trace in the negative resistance region. Obtaining a stable trace through the negative resistance region requires slightly more complicated circuitry and careful design to minimize certain lead lengths.[1, 2] Such circuits also require greater scope vertical sensitivity than the adapter described here needs.

The parts values given for Fig. 1 are not critical. Almost any variable transformer (or potentiometer) and filament transformer having adequate voltage and current ratings can be used (5v. or 12.6v. fila-

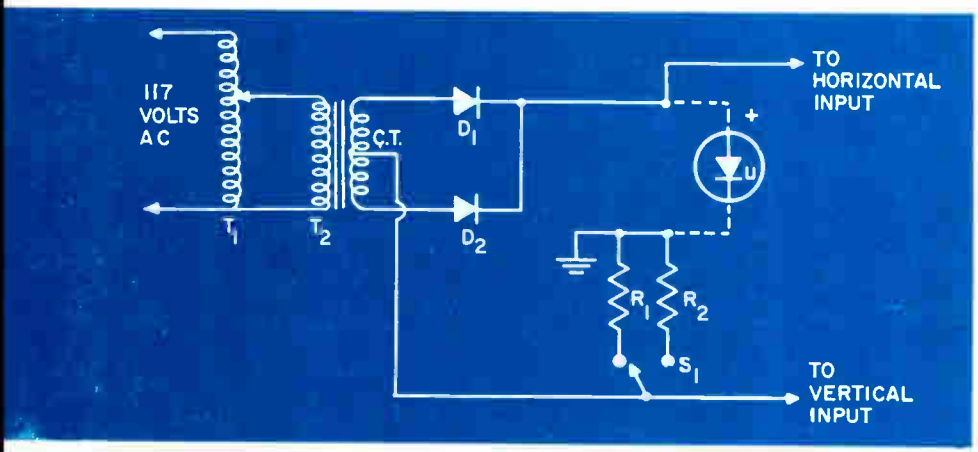


Fig. 1: Schematic shows the circuitry for a diode curve tracer that can be used with a standard oscilloscope. Parts list appears at the end of article.

By FREDERICK M. CARLSON
Radio Corp. of America
Electronic Components & Devices
Somerville, N. J.

ment transformers are satisfactory). Secondary current rating should be at least 0.1a. Although silicon rectifiers are specified to minimize reverse leakage, germanium diodes would do. Excessive reverse leakage results in the scope display going negative at the origin. Even a burned out transistor can be used as a rectifier, provided that one of the two p-n junctions is still good, and it has adequate current-carrying capacity. The current requirements are determined by the maximum peak current of the tunnel diodes to be measured.

Resistors R_1 and R_2 are determined by the vertical sensitivity of the oscilloscope available, the number of graticule divisions, and the peak current of the diodes to be tested. For example, assume that the vertical sensitivity is set at 0.1v. per division. A Tektronix 545 oscilloscope has four vertical divisions on the graticule. If the diodes to be tested have peak currents of 1ma. or 10ma., then R_1 and R_2 must be 400 and 40 respectively for full scale deflection. Other vertical sensitivities may be obtained by using a multi-position wafer switch in place of the toggle switch, and by the addition of more current sampling resistors, or by variation of the vertical sensitivity of the scope. The dissipation rating of the precision current sampling resistors must not be exceeded because the calibration of the entire adapter depends solely on these resistors (if negligible lead and contact resistances are assumed). The oscilloscope, of course, must be calibrated before the adapter is connected.

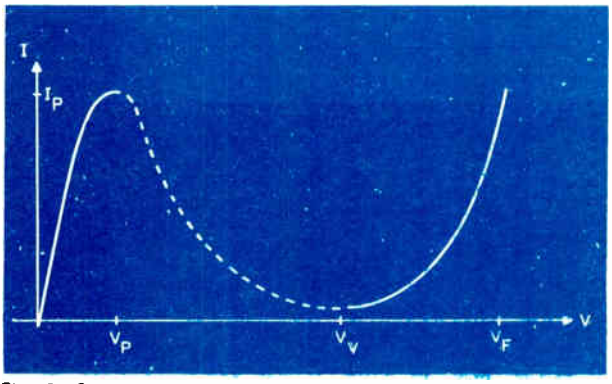


Fig. 2: Static voltage-current characteristic curve of a tunnel diode as it appears on a scope using an adapter.

The basic circuit in Fig. 1 can be used for tunnel diodes having peak currents of about 100 to 200 amperes (e.g., RCA types 40,070, 40,079), provided very heavy duty components were used. Some minor wiring changes would also be needed to minimize lead and contact resistances. Such unwanted resistances can cause appreciable errors in curve tracers for high current tunnel diodes[2].

1. A. M. Goodman, "A Test Set for Displaying the V-I Characteristic of a tunnel Diode," *Review of Scientific Instruments*, March, 1960.
2. "Measurement Circuits," *RCA Tunnel Diode Manual*, May, 1963.

Adapter Parts List

T1 = Variable transformer (Superior No. 10B)*
T2 = Filament transformer, 117v. pri., 6.3v. sec., CT (Stancor P6465)
D1 = D2 = Silicon rectifiers, RCA type 1N3754
R1 = 400 ohms ± 1% (see text)
R2 = 40 ohms ± 1% (see text)
S1 = SPDT toggle switch

*The variable transformer could be replaced with resistive voltage divider placed on the secondary side of filament transformer. Observe power ratings on resistors and transformer.

A TRANSIENT DETECTOR

CHARLES K. ADAMS
McDonnell Aircraft Co.
St. Louis 66, Mo.

Transients are a bug-a-boo of test engineers. They can cause strange things to happen to a system.

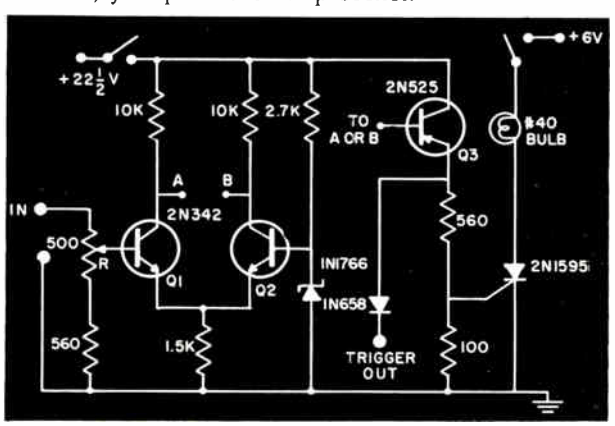
Here is a transient detector capable of detecting a change from the preset voltage of as little as 200 mv., and very short duration. The circuit is a differential amplifier which feeds a transistor switch and a SCR. The input voltage is applied through a voltage divider and then compared against a zener diode. Any difference is amplified and the change is shown across the collectors of Q_1 and Q_2. One collector will swing positive while the other collector swings negative. The base of Q_3 is tied to either point A or B, depending if an overvoltage or undervoltage is being detected.

The circuit can be used for voltages from 6 to 12 volts. To increase the voltage range, use a larger potentiometer at R; or insert a resistor between the pot and the input terminal.

The sensitivity can be increased by using a high gain transistor such as a 2N1193 for Q_3.

A separate battery is used for the bulk because the current drain of the bulb is quite high, and the battery that supplies the transistors should have minimum load. There are several husky 6 volt batteries that can be used for this.

The bulb is placed in a push to test socket, with the NC contacts wired into the circuit. Then, to reset the unit, just push the lamp socket.



A combination of available calibration services and modern equipment have made possible microwave power measurements with accuracies within 1½% under favorable conditions, and around 3% in worst cases. These services, equipment and the methods used are discussed here.

MAKING ACCURATE MICROWAVE POWER MEASUREMENTS

By R. FRED PRAMANN
Section Manager
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1501 Page Mill Road
Palo Alto, Calif.

MANY OF THE CONSIDERATIONS which appear here apply to all microwave power measurements, regardless of measurement instrumentation. But, modern temperature-compensated bolometric type power meters are available to most engineers, and they are accurate. So the specifics here will deal with this type of power meter.

* * *

A single-bridge microwave power meter with a single thermistor in the bolometer mount has a disadvantage. It cannot distinguish between changes in microwave power and changes in temperature environment. The modern temperature-compensated meter uses two self-balancing bridges and two thermistors to separate these effects. Ambient temperature effects become common-mode while microwave power dissipation becomes a differential mode signal. This greatly reduces drift caused by thermal changes. Use of feedback results in an instrument that is accurate and reliable.

Mismatch Loss

Maximum power is delivered to a load only when the load impedance presents a conjugate match to the generator impedance. A special case of this is when the generator and load both have the same impedance as the transmission line. When the match is not conjugate, maximum power will not be delivered to the load. But there is also an ambiguity as to how much power is being delivered because of the phasing of the load and generator impedances. Charts and nomographs are available which give the limits of these mismatch losses [1,2]. A tuner may be used to achieve a match; but, it will introduce loss.

As an example, assume that generator reflection coefficient (ρ) is zero, and that the thermistor mount has a ρ of 0.20 (which is equal to a standing-wave ratio of 1.5). A mismatch loss of $(0.20)^2$ will result. In other words, 4% of the incident power is reflected by the mount. This means that a mount with SWR of 1.5 will cause a reading which is 4% low. Similiarly, and again assuming that generator ρ is zero, a mount with a ρ of 0.10 (SWR = 1.22) will cause 1% of the power to be reflected. Thus, a power meter connected to this mount will read 1% low. It is thus apparent that to achieve SWR extraordinary effort is justified in the design and construction of the mount. The user, too, will be justified in spending the time and effort needed to verify accurately the SWR of the individual mounts in his instrumentation. Fig. 1 shows what is being achieved in a modern coaxial mount.

Note that over most of the instrument range the SWR is less than 1.2; and, indeed, over a very large range it is less than 1.1. Also, only at the high and low frequency ends of the band will much deviation be found from this typical curve. This all means that it will often be unnecessary to consider the use of a tuner with this thermistor mount.

Typical SWR of a waveguide thermistor mount is shown in Fig. 2. Deviation from this typical curve by individual mounts may be large, although in all cases performance well under the specified maximum can be expected. Since the exact value of mount SWR is likely to be important in determining the accuracy of the power measurement, SWR of the specific mount should be measured.

R-F Losses

R-f losses represent power that enters the thermistor mount but is not dissipated in the thermistors. These may be losses in the walls of a waveguide mount or the center conductor of a coaxial mount. They may be losses in the dielectric or losses in poor connections within the mount, radiation, etc. Obviously a power meter can be sensitive only to the power that is delivered to the thermistors.

Another source of error is the *dc-to-microwave substitution error*. This results because the spatial

Coaxial thermistor mount of recent design is shown above.

distributions of current, power, and resistance within the thermistor are different for the dc and r-f powers. Total effect of these two errors can be measured by the National Bureau of Standards and by some commercial standards labs. The results are presented as a figure of merit called the *Effective Efficiency* of a mount. This is defined as a substituted dc power in the thermistors divided by the microwave power dissipated in the thermistor mount.

Another calibration available from NBS, and from some commercial labs, is the *Calibration Factor* of a thermistor mount. This is defined as the substituted dc power in the thermistors divided by the microwave power incident upon the mount. Effective mount efficiency and calibration factor are now available only at X-band frequencies and at some frequencies in the VHF region up to 400 MC. NBS measurements in X-band have a stated accuracy of 1% and those in the VHF region an accuracy of 2%.

Fig. 3 shows the effective efficiency of a number of units of newer coaxial thermistor mount design, compared with units only a few years old. The more recent design gives higher efficiency over the whole band, especially above 10 GC. And, the differences between mean and extremes are smaller. These more modern mounts can be useful in measuring power up to 12.4 GC because the mount efficiency does not hold up. But, SWR becomes high at 12.4 GC, as shown in Fig. 1. To make a measurement with good accuracy it would, thus, be necessary to use a tuner to take care of the mismatch loss, and to take into account the tuner loss.

The break in the curve of the newer mount at about 10.9 GC, and that in the curve of the older one at 10.1 GC, are the locations of resonances in the microwave structure of these mounts. These resonances are very sharp. There may be losses of about 20%. Since they occur in all such thermistor mounts, their presence should be noted and located, to avoid gross errors.

Since calibration service is not available, effective efficiency of these mounts is not known accurately below X-band. It is believed that it increases as frequency declines and in the UHF region is better than 99% for the newer design. Units of this setup have been compared against all of the waveguide thermistor mounts at frequencies below X-band. No indication of inefficiency was found either in the coaxial or waveguide mounts. The coaxial thermistor mount was also compared against a modern crystal mount below 2.6 GC; again, there was no indication of inefficiency.

Fig. 4 shows the effective mount efficiency calibration of a number of X-band waveguide thermistor mounts. These represent fairly the performance which should be expected today in waveguide mounts of con-

(*Continued on page* 128)

Fig. 1: Typical SWR of modern coaxial cable.

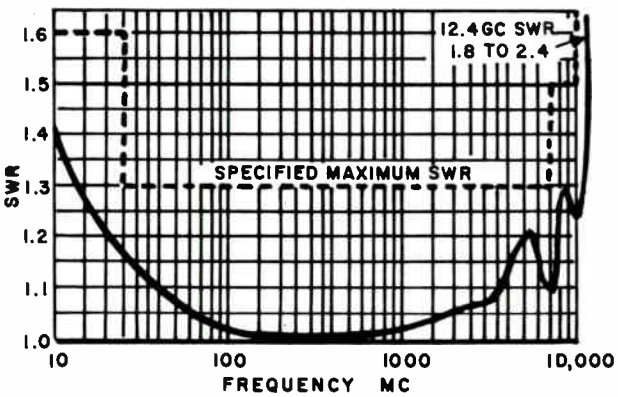
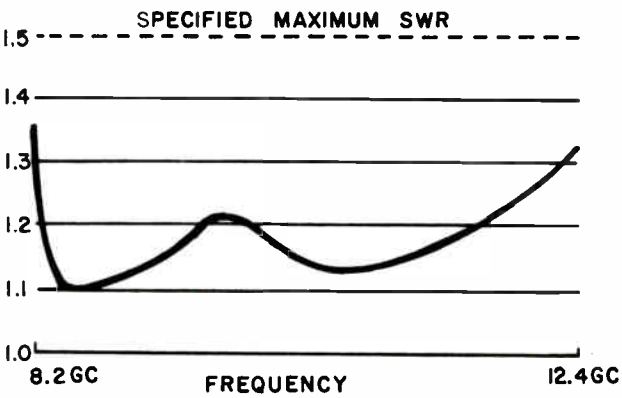
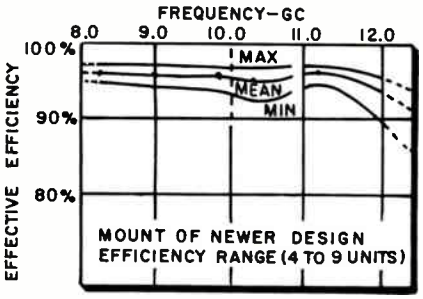


Fig. 2: Typical SWR of a modern waveguide thermistor mount.



MICROWAVE MEASUREMENTS

Waveguide mount of recent design.



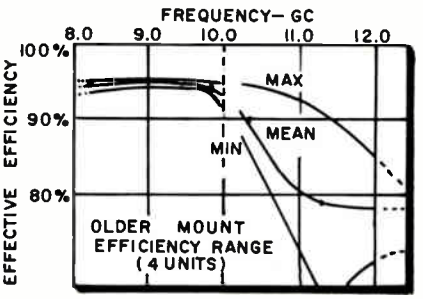


Fig. 3: X Band efficiency range of coaxial thermistor mounts. Mounts are compared.

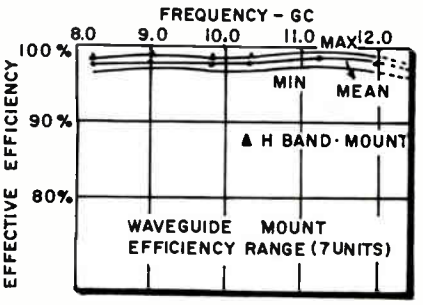


Fig. 4: Efficiency range of modern X-Band waveguide thermistor mounts for temperature-compensated microwave power meters.

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temporary design for temperature-compensated power meters.

Dual Element Bolometer Mount Error

A detailed analysis of this error has been made by Engen[3]. This error does not occur in the waveguide thermistor mounts but must be considered in nearly all coaxial mounts.

Fig. 5(a) shows the circuitry of a coaxial mount. R_{t1} and R_{t2} are the thermistors. Fig. 5(b) shows the equivalent circuit for dc and 10 KC. The thermistors are in series. Thus if the resistance division is unequal, the greatest power will be dissipated in the thermistor with the largest resistance. But, referring to the equivalent circuit for r-f—Fig. 5(c)—the r-f power sees the two thermistors in parallel. Here, if the resistance division is unequal, the greatest power will be dissipated in the thermistor with the least resistance. Unfortunately, the situation of microwave frequencies is not this simple; a different power split may result due to microwave phenomena such as reactance. In any case, Engen has shown that the resulting error is equal to

$$= \left(\frac{1}{\gamma_2} - \frac{1}{\gamma_1}\right) \Delta r,$$

where γ_1 and γ_2 are the "ohms per milliwatt" coefficients of the thermistors, and Δr is the shift in resistance division.

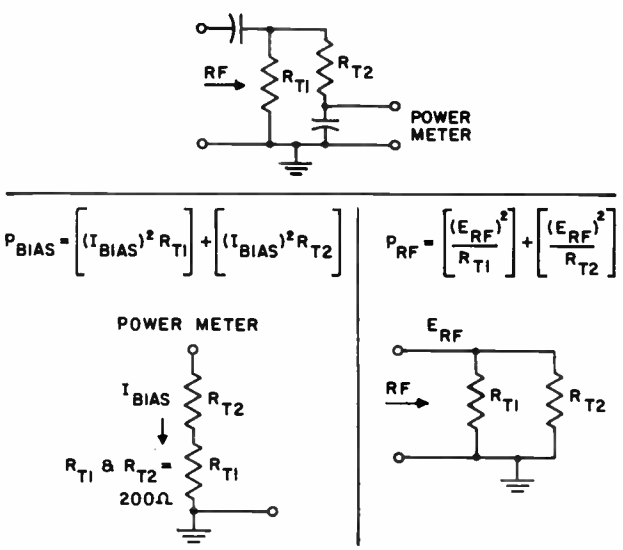


Fig. 5: Coaxial thermistor mount circuitry (top), and equivalent circuits for dc and 10 KC (at left) and for r-f (at right).

This error may be as large as 1% in normal thermistor mounts of older design, and at 10 mw levels. Its presence was one of several reasons why attention was focussed anew on thermistor mount design after the temperature-compensated power meter was developed. As the measured r-f power decreases, this error decreases rapidly; it is not a constant error, but instead a function of r-f power

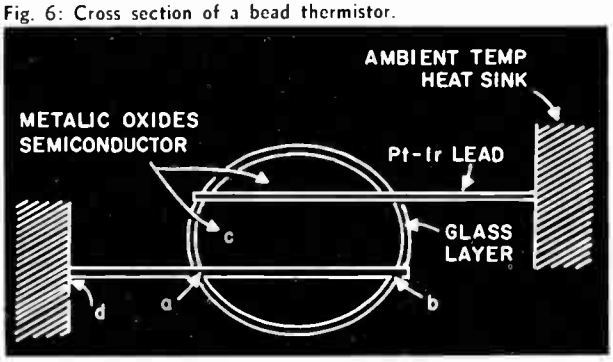
(*Continued on page* 130)

measured. Fortunately, the same methods which yield improved thermal balance in the thermistor mount also are effective in reducing the dual-bolometer error. Initial tests indicate the error in units of recent design and current manufacture has been brought down to a few tenths of a percent.

Thermoelectric Effect Error

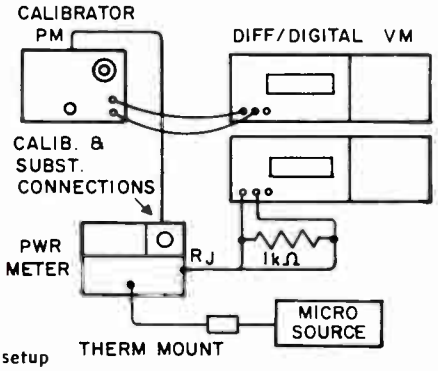
This error is found only in power meters where nearly the total bias power is supplied by ac. It can apparently be explained on the basis of the two thermocouples which are formed by the contact of one thermistor lead to the thermistor oxides, and the contact formed by the other thermistor lead to the thermistor oxide material. The bead thermistor used in thermistor mounts operates more than 100°C above room temperature. These contacts might not be at the same temperature; thus a thermocouple will result. The ac bias power heats the thermistor. If the thermocouples do not cancel completely there will be a small dc current flow. Fig. 6 represents a beam thermistor attached to an ambient temperature heat sink as it is in thermistor mounts. Since much of the heat dissipated in the thermistor is conducted from the bead through the leads, temperature of the lead-thermistor material is an inverse function of lead length. Moreover, a temperature gradient may be presumed between points a and b of the diagram, further complicating the picture.

Fig. 6: Cross section of a bead thermistor.



But, the error is measurable, and with proper manufacturing control will not exceed 0.3 μw. This is significant only on the most sensitive ranges of the power meter. It is also important when a dc calibration or dc substitution measurement is to be made. Where accurate substitution or calibration is needed at low power levels, thermoelectric effect error can be essentially eliminated. This can be done by using a battery and appropriate resistors to supply the substitution or calibration power to the r-f thermistor. By use of a battery, the polarity can easily be in-

The power meter calibrator shown here is a precision constant-current generator.



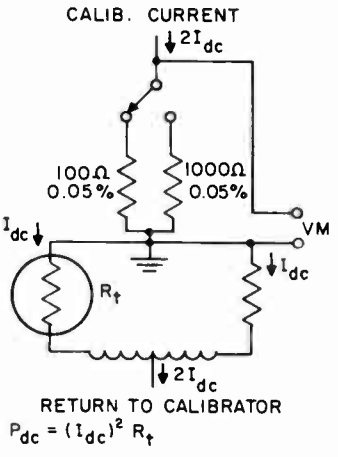


Fig. 7: Power meter dc substitution setup (left). Route of calibration current (right).

verted. Now a thermoelectric current which previously tended to cancel the calibration current will add to it, or vice versa. This method uses the mean value of the dc calibration or substitution current.

Instrumentation Error

Specified accuracy of a power meter refers only to the meter's ability to measure and interpret accurately the information available at the thermistor. At the current state of the art, 3% is a good figure for maximum instrumentation error. Since errors associated with the thermistors and their mount, taken all together, can now be held below this figure, a means of calibrating the meter locally is needed. Where the meter contains circuitry to make dc substitution easy, the use of a dc calibrator can reduce instrumentation error to less than 0.5%.

Fig. 7 shows the calibration method. A substitution measurement is made in two steps. In the first, the calibrator is turned off; the microwave source to be accurately measured is on. The voltage across the 1000 ohm resistor, connected to the recorder jack of the power meter, is noted. In the second step, the

(*Continued on page 132*)

MICROWAVE MEASUREMENTS (Concluded)

microwave source is turned off and the calibrator current is turned on. The calibrator is a precision constant current dc generator, which furnishes a stable current to the thermistor in the thermistor mount. This current is adjusted by the controls on the calibrator until the voltage across the resistor is the same as it was in the first step. The voltmeter, which is connected to the calibrator, measures the voltage resulting from twice the dc substitution current flowing through either a 100 ohm or a 1000 ohm resistor. Value of the dc substituted power is thus $I_{dc}^2 \times R_t$, where R_t is the thermistor resistance. R_t can also be determined with high resolution and accuracy.

Table 1

CHART-PAPERSPEED-RESOLUTION-RUNNING TIME*

Paper Speed In./Sec.	Highest Readable Frequency CPS	Running Time
0.10	5.0	15 hr
0.16	8.0	9 hr 23 min
0.25	12.5	6 hr
0.40	20.0	3 hr 45 min
0.63	31.5	2 hr 22 min
1.0	50.0	1 hr 30 min
1.6	80.0	56 min 15 sec
2.5	125.0	36 min
4.0	200.0	22 min 30 sec
6.3	315.0	14 min 15 sec
10.0	500.0	9 min
16.0	800.0	5 min 36 sec
25.0	1250.0	3 min 36 sec
40.0	2000.0	2 min 12 sec
63.0	3150.0	1 min 24 sec
100.0	5000.0	54 sec

*Based on Line Resolution 0.02 in.—450 ft Rolls of Recording Paper

Conclusion

The temperature-compensated microwave power meter, taken together with modern thermistor mounts, is capable of power measurements whose accuracy is about 3% in worst cases, all error sources considered. Under favorable circumstances, i.e., in the middle range of levels and frequencies, with calibrated mounts, accuracy can be known to be within 1.5%. To achieve this level of accuracy, calibration should be made of the thermistor mount, and calibrator methods should be applied locally to the meter, itself.

References

1. "Microwave Mismatch Error Analysis," *Application Note 56*, Hewlett-Packard Co.
2. The Microwave Engineers' Handbook and Buyers' Guide, 1964, Horizon House-Microwave, Inc., page 14.
3. Engine, C. F., "A DC-RF Substitution Error in Dual Element Bolometer Mounts," *NBS Report* 7934.

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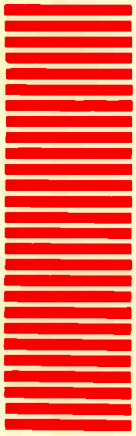

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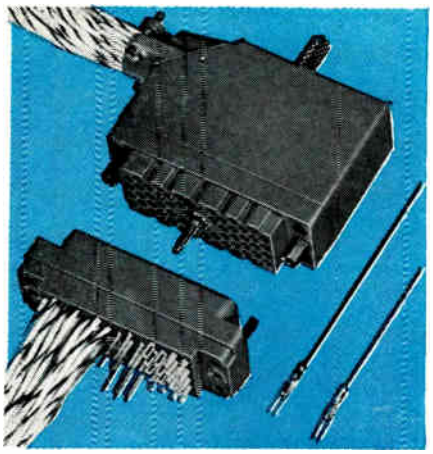

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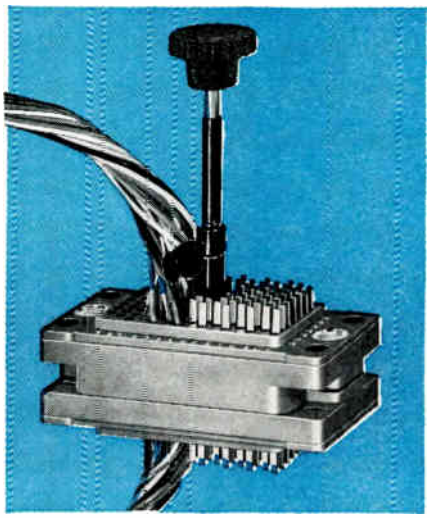

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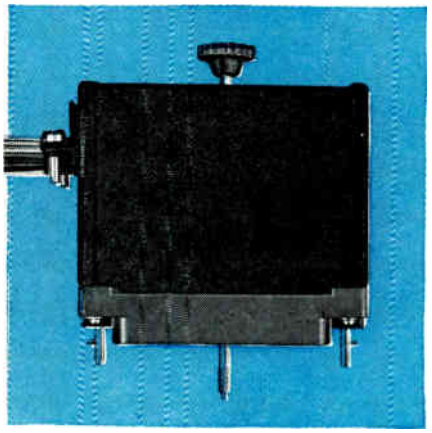

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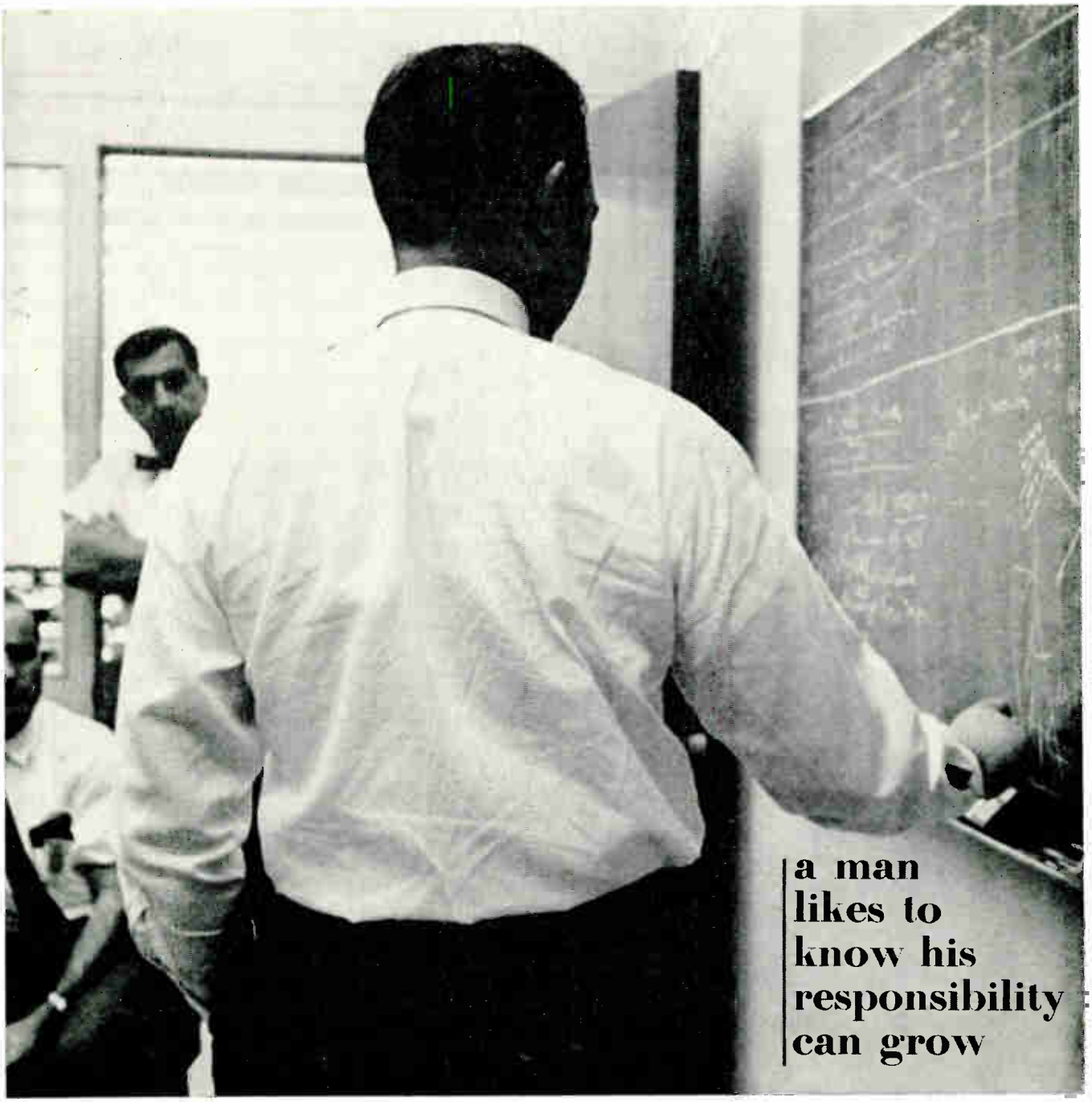

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Reporting late developments affecting the employment picture in the Electronic Industries

ENGINEERS' DATA NEEDS NOT BEING FILLED, SAYER SAYS

Present-day information services are not serving the needs of engineers, according to John S. Sayer, vice president of Auerbach Corp.

"The first thing we must do to improve the service is remove the fallacy that the engineer is outside the system," Mr. Sayer said. "We must begin designing technical and scientific information systems for and around technical men, not for and around some particular concept or hardware."

Mr. Sayer said that the problem could be solved only by beginning work on "information systems that operate in the dynamic mode, anticipating needs, and providing concise packages of correlated and updated data." He said that we must now develop a means to deliver, almost automatically, properly packaged educational, methodological, and specific problem-solution material to the engineer when he needs it.

Mr. Sayer feels the government should:

". . . reorient sponsored research to increase emphasis on defining and solving the total systems problems.

". . . resolve interface and language problems among government information services.

". . . set up programs leading to dynamic information services with the government."

Mr. Sayer said technical societies should:

". . . increase utility of Engineering Index and Engineering Library by orienting them to a more dynamic information system.

". . . start a needs determination program among technical people.

". . . re-examine their position on technical journal content and reduce redundancy, increase availability of information."

Among the things Mr. Sayer called on educators to do were:

". . . develop a strong information and literature tradition in engineering graduates.

". . . re-examine the engineering curriculum and increase student understanding that effective engineering is largely effective finding, use, and reporting of data and information."

RECENT ESSO STUDY REVEALS ENGINEER'S NEEDS, STATUS

A recent study for Esso Research and Engineering Company covers "The Engineer Today—The Supply, His Development Needs, Status and Treatment." Prepared by New England Consultants, Inc., for Esso, the study surveys articles, social science studies, government reports, speeches, and other references. Object of the study was to analyze and summarize what is known about the engineer status and supply.

The report is a summary of the highlights of more than 450 feature publications. Many are annotated in a bibliography with the report. In five parts, the study discusses public attitudes, supply and demand, influences on career decision making, employer and engineer, and status.

LEHIGH GRAD STUDY AIMED AT SOLVING DATA DELUGE

The Lehigh University graduate program for Fall 1964 will include courses for information scientists. They are aimed at helping to overcome the science data "explosion." The new study was disclosed by Dr. Robert D. Stout, dean of the Graduate School.

The interdisciplinary master's degree program is designed to provide a broad practical and theoretical base in science and technology.

Emphasis will be on science subjects needed in understanding the behavior, organization and accessibility of data.

FOR MORE INFORMATION . . . on opportunities described in this section fill out the convenient resume form, page 144.

ALLIES STUDY MILITARY EDP

Officers from Allied Nations learn to use computers in tactical operations through actual programming and operation of a GE 225 computer at the U.S. Army Signal School, Ft. Monmouth, N. J. Left to right are: Capt. Keith P. Morel of Australia, First Lt. John L. Reber, U.S. Army Signal School, and Major Julio Perez, of Chile, at printer.

PROFESSIONAL ACTIVITIES KEY TO ADVANCEMENT

Outside professional activity is one of the factors that help to point out engineers for advancement, according to the Western Electric Company.

Professional activity "indicates a measure of professional maturity, leadership ability, interest and initiative," in the opinion of Western Electric spokesmen. They say these measures correspond to qualifications needed for assignments of growing responsibility.

DENVER GROUP SEEKS SCIENTIFIC COMPLEX

To speed up founding of a scientific complex in Colorado and Wyoming, the Denver Research Institute is exploring the *how* and *why* of university-industry complexes.

The research is an early step in a hoped-for long-term effort designed to spark rapid development. The project, considered for some time, is a follow-up to recent DRI research on past, current and future expectations for Colorado's economy.

Going back to school is a growing 'must.' A corner of the employees' training division is often a post-graduate classroom. Many electronic engineers are stepping over into management. Others are giving civil service a try. Current job outlook may not be promising. The long-range future may hold a different story.

WHERE ARE ELECTRONIC ENGINEERS GOING?

ONCE AGAIN ENGINEERS AND TECHNOLOGIES are being phased out as defense and aerospace contracts decline, while cries of *engineer shortage* change color to *engineer surplus.*

The engineer strata within electronic-aerospace fields have long been thought of as being full of ambiguities and imbalances. Line technicians sometimes are lumped in with graduate engineers in surveys and census data, while graduates often do work ordinarily left to technicians. With cutbacks in aerospace and defense contracts mounting, engineers may find themselves in an overcrowded market in one area, while other U. S. regions still claim "engineer shortage."

Personnel heads observe that technical people are busily crossing three "vocational bridges." First: some draftsmen and technicians gain enough on-job experience and off-job study to qualify as "engineers." Second: many graduate engineers move into higher-paying, higher-level jobs in management and marketing. Third: there is a big surge of engineers and scientists going "back to school" for advanced study.

For these reasons there are about a dozen different definitions of *engineer* which range from technician through salesman to scientist. Hence, one engineering society official complains that National Science Foundation statistics about engineers may be only 56% accurate.

Many Are Salesmen

Several thousand engineers now are salesmen for electronic companies. Such engineers may be manufacturers' representatives, or may work for the companies. Thousands of other engineers hold manage-

By SIDNEY FELDMAN
Associate Editor
ELECTRONIC INDUSTRIES

ment jobs from president through to purchasing director.

Greater numbers of engineers will continue to join marketing and management ranks for higher pay, greater prestige, and maybe more job security. Engineers also are becoming consultants, working for themselves or for firms, for banks or investment houses.

Most engineers who have decided to stay in engineering are participating in a mass "intellectual re-tooling" movement.

"Rehabilitation of engineers with obsolete skills is the most serious problem in engineering today," says Donald Garr, director of engineering, Raytheon Corp. He cites a surplus of engineering technicians in the Boston area, but suggests a shortage of engineers trained in new defense and aerospace technologies. Demand for engineers is changing mainly from narrow components and equipment specialists to broad systems and interdisciplinary generalists.

Firms Have In-House Schools

Many companies conduct in-house classes. Arma Division of American Bosch Arma Corp., Garden City, N. Y., teaches its engineers about subjects ranging from microelectronics to systems engineering theory and application. General Precision Aerospace teaches engineers at the firm's plant in Little Falls, N. J., and sends engineers to Brooklyn Polytechnic Institute, with credits applicable toward advanced degrees in systems engineering. These examples are only a few among many.

At Illinois Institute of Technology, Bell Telephone Co. engineers from 14 states and Canada are preparing for the satellite communications era. More than 1,500 selected trainees, mostly graduate electrical engineers, may be trained in electronic advances over several years. There are many other such programs.

Underlying this need for re-education are two fundamental forces. One is the cumulative effect of new technologies, largely sponsored by Federal researches. The other is the need to develop a new breed of engineer for our evolving aerospace age.

NASA now underwrites grant programs in educational institutions for facilities, training and research, especially at the graduate level. This program, started in 1962, now has nearly 900 graduate students attending 88 schools. For the academic year 1964-65, NASA extends grants to nearly 1100 students working on doctoral degrees in space-related fields at 131 colleges and universities in 47 states. The National Science Foundation also supports broad technical education and re-education programs.

A Mixed Situation

At best, electronic engineer employment presents a mixed situation; it varies from company to company sooner than from area to area. On the West Coast, more than 500 engineers (who may have included technicians) were laid off by Boeing when the Dyna-Soar program was canceled. Yet, Boeing is completing a $16,000,000 aerospace research center. Engineer employment has been high at North American Aviation in California. This firm holds contracts ranging from disarmament studies to modules for the Apollo man-to-moon project.

Lockheed Missiles & Space Co., also in California, is phasing-out operations at Van Nuys and transferring some employees to its main plant at Sunnyvale while laying off others because "there isn't enough aerospace ground equipment business."

In the East, RCA let go about 750 scientists and engineers in the Camden-Moorestown, N. J., area (near Philadelphia) during 1962 and 1963. Some were re-hired at RCA plants elsewhere. Out on Long Island there is a glad and sad story for engineers in two towns. At Bethpage, Grumman Aircraft Engineering has been hiring scientists and engineers for the Orbiting Astronomical Observatory series, and as sub-contractor for Apollo Lunar Excursion Modules.

Next-door at Farmingdale, however, Republic Aviation may phase out F-105 aircraft production by this Fall. Indicative of this mixed situation, Republic has transferred and fired aircraft engineers. It has hired still other engineers for its aerospace R&D Center and Electronics Products Division.

Incentive contracts are said to be discouraging any artificially inflated demand for *stockpiled engineers* paid for by cost-plus government contracts. As an argument, DOD refers to the "importance of the profit motive as incentive to improve performance and to lower costs."

U.S. Funds Back Most Engineers

About 76% of all engineers and scientists employed by the electronic industries are supported by government funds, based on a 1961 survey by Electronic Industries Association (EIA) and the Defense Department.

This report cites about 155,000 engineers and scientists performing all types of electronic work. Of these, 128,000 or 83% work for industry, while 8% work for the Federal Government. Another 5% do research for universities and non-profit organizations—mainly for government. The remainder includes consultants, engineers and scientists between jobs, and those not identifiable by specific activity.

ELECTRONIC INDUSTRIES Professional Profile

Please type or print

The ELECTRONIC INDUSTRIES Job Resume Form for Electronic Engineers

Name _____ Tel. No. _____

Street Address _____ Zone _____

City _____ State _____

☐ Single ☐ Married ☐ Citizen ☐ Non-Citizen Date of Birth _____

Will Relocate ☐ Yes ☐ No. If Yes ☐ Another City ☐ Another State

Salary Desired to Change Jobs in present area _____

Salary Desired to Change Jobs and relocate in another area _____

Professional Memberships _____

College or University	Major	Degree	Dates

RECENT WORK EXPERIENCE

Company	Div. or Dept.	Title	Dates

SIGNIFICANT EXPERIENCE AND OBJECTIVES

STATE ANY FACTS ABOUT YOURSELF THAT WILL HELP A PROSPECTIVE EMPLOYER EVALUATE YOUR EXPERIENCE AND JOB INTERESTS. INCLUDE SIGNIFICANT ACHIEVEMENTS, PUBLISHED PAPERS, AND CAREER GOALS.

Mail to: ELECTRONIC INDUSTRIES—Professional Profile—56th & Chestnut Sts.—Philadelphia, Pa. 19139. This resume is confidential. A copy will be sent only to those Companies advertising for engineering personnel in this issue, whose number you circle below.

800 801 802 803 804 805 806 807 808 809 810

ELECTRONIC ENGINEERS (Concluded)

DOD says it will brief industry representatives in classified advanced long-range development plans on electronics, command and control, missiles, nuclear products, and research. Apparently, it then remains for defense-aerospace contractors to adjust their future needs for plant and personnel accordingly.

Certain trends now indicate where engineers are going in the intermediate transition period, and for the longer-run. Currently, two types of personnel adjustments are being made.

Contractors first may phase-out production workers. Then cancellations or cutbacks may be used to excuse the phasing-out of "unproductive" graduate engineers or non-graduate "engineers," either of whom may be doing technicians' work. However, vital scientists and engineers are kept on "because they were hard to get in the first place and because keeping a nucleus of key technical personnel gives a firm the best gambit for getting new contracts."

Some Switching to Civil Service

Some scientists and engineers are switching from indirect civil service, with government contractors, to work directly through the U. S. Civil Service. Noteworthy, stricter standards for Federal government engineering jobs involving health, safety and welfare, will require an engineering degree or professional registration after July, 1964.

By 1970 *engineer surplus* once again may become severe *engineer shortage,* according to a recent National Science Foundation report.* NSF charts about 250,000 unfilled jobs for scientists and engineers, many in electronic fields.

Total annual increased demand for technical people may run about 101,200 by 1970, says NSF, while the supply rises only about 76,500. In electrical equipment manufacturing, about 100,000 new scientific and engineering jobs will open, including replacements. This report anticipates engineering manpower "shortages" causing postponed or canceled projects and programs, delays, more inefficiency and higher costs.

NSF calls for increased student enrollments and further inducements for graduates to remain as engineers. And, like the same old story in the past, employers again may resort to the "good old days" of pirating and mounting wages and salaries for scientists and engineers.

*"Scientists, Engineers and Technicians in the 1960s—Requirements and Supply."

● A REPRINT of this article is available from ELECTRONIC INDUSTRIES Reader Service Department

WHAT'S NEW

SIMPLIFYING RFI MEASUREMENTS

IN THE PAST, MEASURING RADIO-FREQUENCY INTERFERENCE has been limited to manual scanning and recording of each spurious-output or spurious-response frequency. This time-consuming technique, which required field-intensity meters or generators and skilled personnel, did not always produce accurate readings due to human error. The Capehart Corp., Long Island, N. Y., has developed a method that reduces measuring time, eliminates skilled personnel, and produces a high-degree of accuracy.

This technique automatizes the measurement process to produce data in graphic form. This data may then be analyzed by complex computing equipment. To accomplish this, Capehart developed a modification kit for X-Y recording of r-f. This kit may be used with any standard field-intensity meter or signal generator.

The kit consists of two basic units. The first contains a motor-drive unit which mechanically drives the noise and field-intensity meter dial and also furnishes X- coordinate data for the recorder. The operator selects any one of several drive speeds as required by the different tuning drive ratios of the noise meters being used.

The second unit contains peak-detector and weighting circuits. It provides the output to drive the recorder's Y- coordinate. Special detector-electronic circuits driven by a low-impedance video amplifier provides the very fast charge-time and proper discharge time for accurate peak-value readings. This circuitry permits an impulse generator to be used for continuous amplitude calibration. The operator may choose any one of several discharge-time constants to suit the noise-meter characteristics and recording speed.

A chart furnished with the kit gives recommended values of recording speed and discharge time for the various noise meters now in use. No modification units, such as video output jacks, are required. This unit provides logarithmic records either by oscilloscope photographs or on paper by using an X-Y recorder.

COMPUTER PERSONNEL NEEDS PROJECTED TO 1970

A projection for 1970 estimates a need of some 220,000 computer personnel. Richard H. Brandon, of The Diebold Group, Inc., New York management consulting firm, estimates some 12,500 computers are now in use in the U. S.

He estimates also that 20,000 computers or more will be installed by 1970.

SELECTED FOR THE MINUTEMAN PROJECT

More than 6 million El-Menco Dipped Mica Capacitors have been used in the Minuteman ground support and control equipment.

After 64,000,000 ACTUAL TEST unit-hours at 85°C with 225% of the rated DC voltage applied, no failures of any type occurred.

The accumulated 64 x 10^6 test unit-hours without any failures can be used to calculate many different failure rates depending upon the confidence level desired. However, we shall explore the meaning of the results at a 90% confidence level.

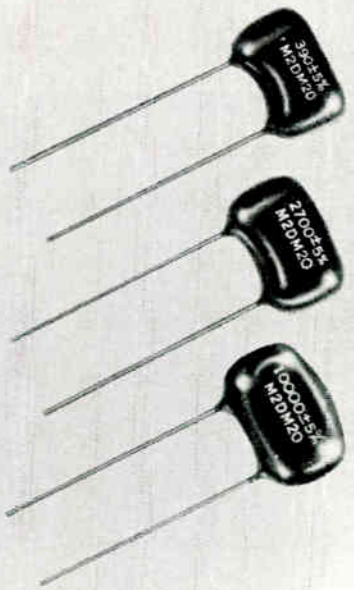
Assuming no acceleration factor for either temperature or voltage, we have verified a failure rate of less than 0.004% per 1000 hours. (Actually, there is a temperature effect and it has been found that, with the DC voltage stress remaining constant, the life decreases approximately 50% for every 10°C rise in temperature. There is also a voltage effect such that, with the temperature stress remaining constant, the life is inversely proportional to the 8th power of the applied DC voltage.)

Assuming no temperature acceleration factor and assuming the voltage acceleration exponent is such as to yield an acceleration factor as low as 100, we have nevertheless verified a failure rate of less than 0.00004% per 1000 hours.

Assuming no temperature acceleration factor and assuming the voltage acceleration factor is on the order of 250 (test results are available to confirm this) we have accumulated sufficient unit-hours to verify a failure rate of less than 0.000015% per 1000 hours!

All above failure rates are calculated at a 90% confidence level!

Write for a complete reliability study on your company letterhead.



DIPPED MICA CAPACITORS TYPE M2DM

THE ELECTRO MOTIVE MFG. CO., INC.

WILLIMANTIC, CONNECTICUT

Dipped Mica • Molded Mica • Silvered Mica Films • Mica Trimmers & Padders
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Exclusive Supplier to Jobbers and Distributors in the U. S. and Canada

West Coast Manufacturers Contact:
COLLINS & HYOE CO., 1020 Corporation Way, Palo Alto, California
5380 Whittier Boulevard, Los Angeles, California

WHAT'S NEW

CRYOGENIC COOLING FOR SPACE

A CRYOGENIC COOLING SYSTEM, which cools infrared detectors and small components in space, is being developed by Aerojet-General Corp., Azusa, Calif.

Here's how the system works. When a vacuum is drawn over the liquid coolant, the coolant solidifies. In its solid form, it cools to −440°F (10°K) and the material is used to cool the components. The solid-coolant block works in the same way as the block of ice in the old-fashioned ice box.

The solution to the problem of long-term cooling in space was found by making use of the most available element in space—the high vacuum. By using this high vacuum in the system, only one moving part is needed. The high vacuum can be used in place of other power sources, increasing reliability. The reliability of this system is expected to be extremely high. In fact, it should operate for one year unattended.

Since no power source is used, no heat will be generated. This eliminates the need for large, heavy, radiators.

NATIONAL RELAY CONFERENCE AT OKLAHOMA STATE U.

The 12th Annual National Relay Conference will be held Tuesday, April 28 through Thursday, April 30, at Oklahoma State University, Stillwater. The Conference is co-sponsored by NARM and the School of Electrical Engineering of OSU. Meetings will be held in the Student Union Building and the Engineering School Auditorium.

Featured this year is a Reliability Workshop. An entire session will be devoted to a workshop on basic reliability requirements of relay customers, with advanced discussions of specifications, test sampling plans, and test failure criteria.

This year's Conference will be divided into five Sessions — each of which will have six 30-minute presentation periods. At Session 1 Philip Garnick, President of NARM, will speak on "The National Association of Relay Manufacturers Today."

Some of the papers to be delivered at the six Sessions include: "Fundamentals of Dynamic Noise Generation in Reed Switch Contacts"; "Some Interesting Results of a Study of Military Relays"; "The Use of Trade Off Parameters for the Application and Manufacturing of Relays"; "Missile Environments — Their Definitions, Measurements, and Test Criteria"; "Relay Testing with Modern Techniques"; "How to Design Sealed Reed Switches"; "Contact Headaches—Why Have Them"; "A Contact Bounce Measuring Instrument with Digital Readout"; "A Mathematical Analysis of the Magnetic Reed Switch"; "Circuits and Relays for Equipment Reliability"; "Relay Microminiaturization and Its Effects on Reliability"; "Relays—Equipment Expectation vs. Equipment Performance."

Copies of all papers are available from Jim Roughan, NARM, P. O. Box 7765, Phoenix, Ariz. Price, $5.00.

EJC ANNOUNCES PUBLICATION OF ENGINEERING THESAURUS

Engineers Joint Council announced publication of its Thesaurus of Engineering Terminology for May 1, 1964 following nearly two years of work. Pre-publication rates for advanced orders are available.

The Thesaurus contains more than 10,000 terms which represent vocabulary of all engineering disciplines.

GD/E TUBES WILL BE USED IN AIR TRAFFIC CONTROL

A new air traffic control radar display system will be operated by the Federal Aviation Agency at its new Great Falls Air Route Traffic Control Center at Malmstrom Air Force Base, Montana. The new FAA center is located at the Air Defense Command's SAGE (Semi-Automatic Ground Environment) Direction Center.

The system will include new CHARACTRON display tubes produced by General Dynamics/Electronics in San Diego. The CHARACTRON is an improved version of a display tube developed for SAGE.

The use of the Charactron, with an anti-reflective implosion shield and proper green ambient light, permits operation with almost normal room light.

Since controllers must use other visual aids such as hand-written flight progress strips, the near-normal ambient light intensity was a necessity for FAA. Normal SAGE operation is with blue ambient light.

LETTERS

to the Editor

More On "The Unemployable Engineer"

Editor, ELECTRONIC INDUSTRIES:

I have read with great interest three articles in the November, 1963 issue of "Electronic Industries." I am greatly perturbed by them all, except the last sentence of your editorial on page 1. The editorial points out that one firm wanted an engineer who had four years of laser design, and that lasers have only been in the investigative stage for the same four years. Since there was only one engineer with those qualifications, only a moron would conclude that there was any real competition for this job. Any sensible person, engineer or no, would realize that the advertiser was shooting for a chance to rob some particular firm of the only man thus worth his salt in this field, to bleed his brains.

In my 40 years of experience, I have twice been approached by firms whose obvious intention was to take advantage of my most recent experience; simply because I had done something for my employer which the other firm wanted to learn about.

I have noted over the years, in your magazine, as well as the various others, that most firms advertise for men with specialized experience. Now, if a man puts in an application for employment, how much credit is given him for his reading so as to broaden his capabilities. . . .

. . . As backup for my argument about firms wanting to lure away specific employees with specific experience, I offer you three items: Your own editorial page, page 1 of the November EI, and two clippings taken from the same issue. One company wants a man in several fields which they refer to as diverse, which is malarkey. Each field mentioned is narrow and specific. Another company wants men experienced in microwave receiver design. How does any engineer who accepts one of these offers know that he will not be dropped after these particular projects and contracts have been completed. This engineer shortage is created by industry seeking to acquire engineers who have,

right now, the experience that they need for a specific contract. . . .

I have one more gripe. The Master of Science in Engineering or Physics degree is without exception obtained on the basis of a thesis. Can you imagine a Master's thesis on a broad range of topics? . . . Then why the emphasis on the MS? Most engineers with five to seven years of useful experience are better qualified to hold the MS degree than many of those who come fresh out of college who stayed there to get the MS, and who have had limited industrial experience during their graduate or undergraduate years. The college of hard knocks is still one of the best schools. . . .

Harry A. Summers,
Cornell University ME '24
Electronics Engineer
Instrumentation, US Navy
1435 Ashland Circle
Norfolk, Va.

The Future of "Reps"

Editor, ELECTRONIC INDUSTRIES:

Your column "MARKETING" in the September issue, entitled "Independent Reps Losing Out, Firms Selling Direct" could very well be misconstrued by readers who are not fully aware of all of the facts.

It is true that as some electronic firms expand and become large enough and financially able to do so, they will swing to direct factory salesmen. On the other hand, there are always other firms entering the market with new products that will find it more expedient and less costly to go to the independent representative system. The newcomer in the field needs the know-how and past experience of these independent salesmen. The latter, being more familiar with their own particular territories, are geared to give the instant promotion and marketing knowledge required to introduce a new product into a given area without the usual loss of time and promotional expenses. The independent sales representative is technically equipped to sell the most complex electronic equipment or components without expensive training by the factory.

Your column states: "Beckman Instruments began selling directly through its offices in 33 U. S. and Canadian cities to strengthen customer relations."

Your attention is called to the September issue of the REPRESENTOR

(*Continued on page* 152)

LETTERS

to the Editor

(*Continued from page* 151)

(copy enclosed) the official publication of the Electronic Representatives Association. In "Letters to the Editor" you will note a letter from Mr. Robert M. Ward, Vice President, Marketing, Beckman Instruments, Inc., to BUSINESS WEEK. We have been given permission to reproduce this letter, which in part states: "The fact is that *one* of our *seven* divisions, the Scientific and Process Instruments Division, switched from *laboratory apparatus dealers* to direct salesmen on *part* of its product line." Mr. Ward goes on to say: "Three important divisions of Beckman Instruments, namely, Offner, Helipot, and Berkeley, owe a great part of their success to and currently sell their products through a network of competent sales reps . . . the alert, progressive manufacturer's representative has learned to serve his principals in ever more effective fashion, and as a consequence, will be an important part of the industry's distribution system."

The article also refers to "holding companies with a national network of regional reps." Actually, representatives who operate within these holding groups also continue to *operate as independent salesmen*, marketing products for other manufacturers whom they represent. In our opinion this type of organization will always be a minority group and poses no threat to the future of the independent representative system.

In the opinion of ERA there will always be the need for independent sales representatives in the electronic industry. One only needs to consider the continuing rate of growth . . . the tremendous amount of research and development underway . . . and the ever widening number of new manufacturers entering the field with new products, to realize that the day when it can be claimed that the "independent reps are losing out" is in the far distant future.

Allen I. Williams,
National President
Electronic Representatives Assoc.
600 S. Michigan Ave.
Chicago 5, Ill.

ELECTRONIC INDUSTRIES

Advertisers — April 1964

This index is published as a convenience.
No liability is assumed for errors or omissions.

EXHIBITS FOR ENGINEERS AT NEW YORK WORLD'S FAIR

Electronic engineers may be interested in scientific exhibits being presented by electronic firms and government agencies at the New York World's Fair, opening April 26, 1964. Some exhibits to be shown are:

Electronic Instrument Landing System, Airborne Instruments Laboratory, for aviation safety, in the Hall of Science.

Radiation of Man, Atomic Energy Commission, discusses X-rays, Geiger counters, electroscopes, at "Atomsville, U.S.A."

Apollo Spacecraft and Lunar Excursion Module, National Aeronautics and Space Administration, at the U. S. Government Pavilion.

International Pen Friend Program, Parker Pen Co., computer will match names and interests of Americans with those of foreign persons for mutual correspondence.

Instant Itineraries, Remington Rand Univac, a 490 Real Time computer will create itineraries for tours of New York City, the United States and the World, at the Transportation and Travel Pavilion.

Brightest Show on Earth, combined electric power & light companies, "Uncle Ben," talking, animated robot will guide visitors through exhibits.

Microwave Horn Antenna, American Telephone & Telegraph Co., will be used to demonstrate regular commercial and closed-circuit television programs.

Color TV and Electronic Hardware, Radio Corporation of America, systems and equipment used on land, sea, in air and space.

Audio-Animatronic Robots, General Electric and Walt Disney Enterprises, programmed on a seven-track tape using techniques and components developed for sequencing Polaris, at the General Electric Pavilion. GE also will display colors programmed by a numerical control system.

EQUIPMENT, MATERIALS, PARTS & COMPONENTS

Who says all females are alike?

All females are supposed to be unpredictable, unreliable, and hard to handle.

Here's one that isn't. It's the "better half" of Amphenol's new Ultra-Mate* connector.

Want go/no-go reliability? The Ultra-Mate connector is more than predictable. You can bet your life on it—which is exactly what astronauts do each time they soar away from the launch pad. Ultra-Mate will mate only if every pin fits snugly into every socket. No mis-connection intermittencies.

Ultra-Mate gets its go/no-go reliability from the female half's hard faced, closed entry receptacle. Ultra-Mate is the only truly environmental space age connector that combines a hard dielectric with front servicing. Any stubby-fingered technician can assemble or disassemble an Ultra-Mate connector in mere seconds.

Take a close look at the female Ultra-Mate. You'll see 55 funnel-shaped openings, one for each contact. These hard-dielectric entryways guide contact-pins smoothly into their sockets.

Now, look a little closer. See those tiny slots fanning out of each entryway? These are the secret of Ultra-Mate's front release system.

Only the standard removal tool will fit into these slots. No wrong-size contacts. No oversize test prods. Ultra-Mate is idiot-proof. And it's fast. Contact positions are clearly marked in front of the dielectric.

Ultra-Mate availability? You can specify Ultra-Mate connectors now in all basic sizes referenced in MIL-C-26500 and MIL-C-38300. Write to: Dick Hall, Vice-President, Marketing, Amphenol, 1830 South 54th Avenue, Chicago 50, Illinois.

*Ultra-Mate is a Trademark of Amphenol-Borg Electronics Corporation

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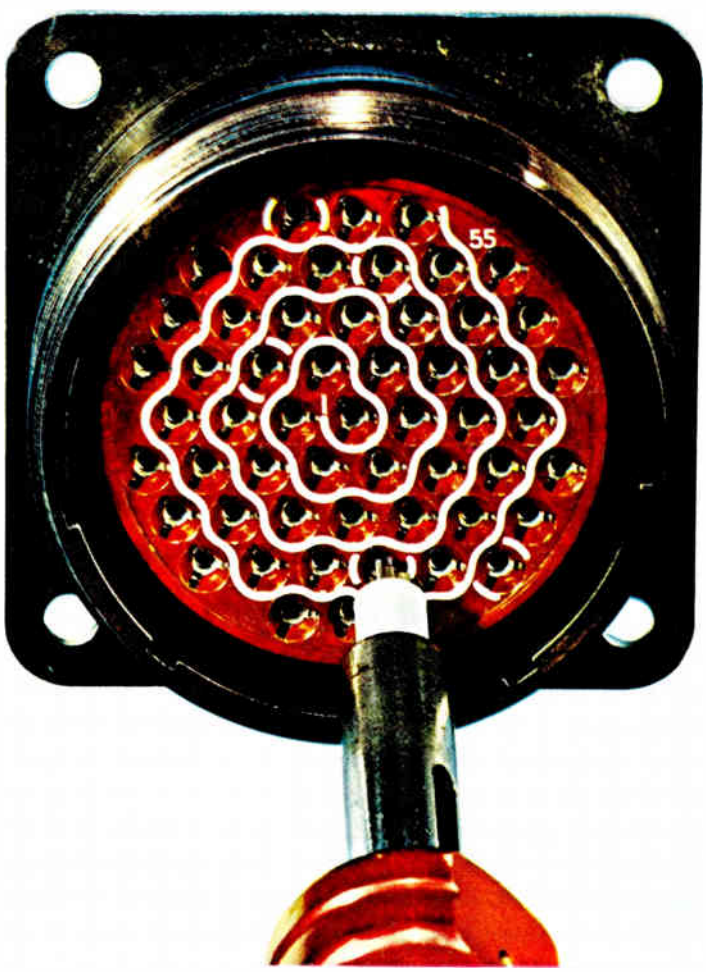
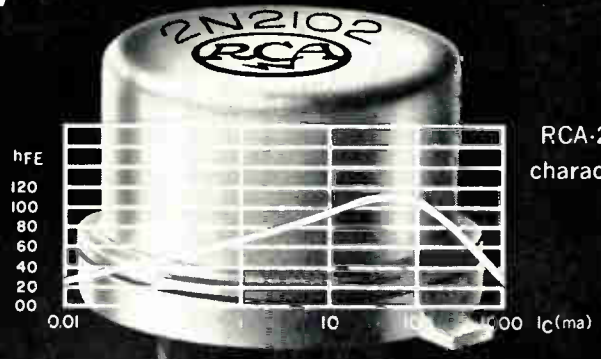


Circle 108 on Inquiry Card

Circle 109 on Inquiry Card →

New—in RCA's Triple-Diffused Silicon Planar 2N2102 Family



RCA-2N2102 typical beta characteristics @ 25°C T_{FA}

2N2102 TYPES. The transistor that rocked the industry for broad application is now available in three packages: 2N2102 (TO-5) brings you multipoint beta control from .01 ma to 1 amp; 2N2895 (TO-18) and 2N2898 (TO-46) bring you multipoint beta control from .01 ma to .5 amp.

CHECK THESE 9 PRACTICAL ANSWERS

RCA-2N2405—V_{CE}(sus) characteristic

HIGH-VOLTAGE TYPES. If your application involves high-operating or transient voltages, the RCA high-voltage types 2N2405 (TO-5), 2N2896 (TO-18), and 2N2899 (TO-48), offer a minimum V_{CEO}(sus) of 90 volts and a minimum V_{CER}(sus) controlled for R_{BE} from 0 to 100 kilohms.

TO EVERY DESIGN PROBLEM

ECONOMY VERSIONS. Many performance benefits and manufacturing controls of RCA's famous 2N2102 are available at attractive prices in 2N2270 (TO-5), 2N2897 (TO-18), and 2N2900 (TO-46).

FROM LOW-LEVEL TO MEDIUM POWER

RCA Solid-Block Metal Header Available in all 9 types

These RCA types offer: P_D max. = up to 5 watts; f_T min. = up to 120 Mc.; Solid Metal Header; Triple-Diffused Silicon Planar Construction. Specify the case, and the performance your design calls for. For more information, call your nearest RCA Field Office. For technical data on specific types, write: Commercial Engineering, RCA Electronic Components and Devices, Harrison, N. J.

AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

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